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Manufacturing decline and house price volatility [☆]

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ABSTRACT

Using a new dataset of all Swedish housing transactions over the 2009-2017 period, we find that manufacturing's share of employment is positively associated with house price growth volatility and negatively associated with risk-adjusted capital gains. Both effects appear to be related to manufacturing's impact on firm concentration and employment volatility. Moreover, they imply that the manufacturing decline since 1970 could account for a 35% reduction in house price volatility.

1. Introduction

Existing work has shown that labor income risk shifts housing demand, potentially generating house price volatility (Adelino et al., 2018). Since manufacturing is a large and volatile sector in most high income countries, its decline as a share of employment and income since the 1970s has important implications for house price risk.[1] We examine this relationship using a new dataset of all property transactions in Sweden over the 2009-2017 period.[2] This is particularly important because other drivers of country-level house price volatility, such as financial crises, tend to be transitory; whereas the decline in the manufacturing share appears to be permanent. The decline in manufacturing also tends to be broadly-based geographically within a country, which is not true in general for other regional drivers of house price growth volatility. Furthermore, as recent work has shown (Kuhn et al., 2018), households with below-median income have historically held few

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[1] Case and Mayer (1996) and Howard and Liebersohn (2018) show that manufacturing has an impact on the level of local and regional house prices. See Charles et al. (2013) and Charles et al. (2018) for an overview of the impact of manufacturing's decline on employment, the labor market, and drug abuse.

[2] See Zhou and Haurin (2010) for an overview of housing characteristics that typically generate volatility. They use American Housing Survey data to show that volatility is typically higher for very high and very low quality homes, atypical homes, "land leveraged" homes, and minority-owned homes.

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assets besides housing. Thus, shifts in house price volatility have substantial implications for portfolio choice and welfare, since house price volatility is associated with consumption volatility.

The dataset we construct allows us to exploit geographic and time variation to identify the impact of manufacturing share on house price growth volatility and risk-adjusted capital gains. Furthermore, it also permits us to evaluate the channels through which dependence on manufacturing affects the housing market. In particular, we measure how house price growth volatility is affected by firm concentration and employment volatility.[3] Our comprehensive geographic coverage enables us to measure volatility and risk-adjusted capital gains at all levels of geography. While most of our findings and simulation exercises focus on regional and national volatility, we will also examine how volatility varies within region.[4]

Our dependent variable in most regression exercises is house price growth volatility. We measure it by first computing capital gains on repeat sales and then applying the Davidian and Carroll (1987) method to obtain a measure of instantaneous volatility with both time and geographic variation.[5] The first exercise estimates the impact of manufacturing share at the region level in 2008 on our measure of volatility for housing transactions between 2009 and 2017. We find that a 10 percentage point (ppt) increase in the manufacturing share implies a 0.85 to 1.51 ppt increase in house price growth volatility. For the median property, this is equivalent to a 12% to 22% increase in house price growth volatility. These results are largely invariant to specification and remain significant whether we adjust standard errors for heteroskedasticity and autocorrelation or cluster them at the narrowest geographic unit. We also show that the results hold when volatility is aggregated up to the regional level in a cross-sectional regression. Furthermore, the dynamic regressions are robust to the inclusion of geographic fixed effects, which capture the impact of Saiz-style (2010) measures of housing supply elasticity on house price volatility. This suggests that the effect measured in our dynamic regressions is likely to be related to demand-driven factors, such as expected future income and employment.

In addition to measuring the impact of manufacturing share on house price growth volatility, we also try to determine the channels that mediate this relationship. The first channel we explore is employment growth volatility, which may be affected by dependence on manufacturing share at the national, regional, or local level. Higher employment volatility could generate fluctuations in housing demand, which would increase house price volatility. This relationship has been documented in existing work for manufacturing share and output volatility (Carvalho and Gabaix, 2013). Additionally, the literature has demonstrated an association between house price growth and manufacturing share (Case and Mayer (1996) and Howard and Liebersohn (2018)). We find that regional variation in employment growth volatility is positively associated with house price growth volatility. In particular, when we include employment growth volatility in a regression of house price growth volatility on manufacturing share of employment, we find that the magnitude of the coefficient on manufacturing share is reduced by 33%. Furthermore, removing manufacturing share doubles the magnitude of the coefficient on employment growth volatility. This suggests that manufacturing share may partially affect house price volatility through employment growth volatility.

Another channel we examine is the impact of firm concentration on house price volatility.[6] In our sample, for instance, 9 of 15 of the largest employers in Sweden are manufacturers, even though manufacturing employs less than 15% of the workers. Thus, employment in areas dominated by manufacturing might be more vulnerable to firm-specific shocks. We test this hypothesis by evaluating how firm concentration affects house price growth volatility. We do this by constructing local Herfindahl-Hirschman Indices (HHIs). A high HHI value implies high firm concentration, indicating that local employment and income are more exposed to firm-specific shocks. Our preferred regression specification includes year-quarter-region fixed effects, time-varying local controls, and property level controls. We find that a one standard deviation increase of the local HHI index is associated with a 1.25 to 1.57 ppt increase in house price growth volatility. For the median property, this is equivalent to a 18% to 23% increase in house price growth volatility. These findings are largely invariant to the choice of specification and are robust to choice of standard error adjustment.[7]

Finally, we evaluate whether the house price growth volatility associated with manufacturing is compensated for by higher capital gains and find that it is not. A 10 ppt increase in manufacturing share is associated with a 0.23 ppt reduction in the housing capital gains Sharpe ratio, which suggests that the decline in manufacturing's share since the 1970s may have made housing a better investment. Similarly, a doubling of firm concentration is associated with a Sharpe ratio reduction of 0.13 ppt.

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[3] We show that the generation of employment growth volatility at least partly explains the relationship between manufacturing share of employment and house price growth volatility. The existing literature has also documented a robust association between income level and volatility, and house price growth volatility (e.g. Hartman-Glaser and Mann (2017), Peng and Thibodeau (2017), and Peng and Thibodeau (2013)).

[4] Flavin and Yamashita (2002) provide the first examination of idiosyncratic volatility at the property level. Giacoletti (2017) documents idiosyncratic variation in house price volatility within the Los Angeles, San Diego, and San Francisco metropolitan areas. Landvoigt et al. (2015) examines San Diego and finds that ZIP codes with lower house prices in 2000 experienced greater capital gains volatility leading up to the Great Recession.

[5] Our selected measure of volatility has been used in finance (e.g. Schwert (1989)), macroeconomics (e.g. McConnell and Perez-Quiros (1990)), and real estate economics (e.g. Goodman and Thibodeau (1998)). Furthermore, Bollerslev et al. (2015) emphasize the importance of using the repeat-sales method when constructing measures of local house prices and house price volatility from microdata.

[6] Since manufacturing firms tend to be large, we might expect the relationship between firm concentration and manufacturing to be positive.

[7] In a separate exercise, we also establish independent evidence for the firm concentration channel by measuring the responsiveness of house price growth volatility to news about individual manufacturers. In addition to this, we perform an exercise using regional news on both manufacturing and housing over the 1850-2017 period to document a long-run relationship between manufacturing and housing. The results from these exercises are available on request.

Beyond our empirical results, we also aggregate our estimates up to the national level and examine the implications of the decades-long decline in manufacturing's share of employment. We show that our results imply a 0.28 ppt decrease in housing capital gains volatility over the 2010-2017 period. In a more speculative exercise, we also show how this could explain part of the reduction in house price growth volatility during the Great Moderation in high income countries, such as Sweden, the U.S., the U.K., and Japan.[8] In particular, the 16 ppt manufacturing employment share reduction in Sweden since 1970 could account for a 2.4 ppt (35%) decline in house price growth volatility. Similarly, the 17.5 ppt decline in manufacturing share in the U.S. since 1970 would account for a 2.5 ppt decline in house price growth volatility. It would also account for volatility reductions of 3.6 ppt in the U.K. and 1.6 ppt in Japan. Furthermore, it is possible that this could have improved the attractiveness of homeownership.

The paper is organized as follows. Section 2 describes the data. Section 3 describes our main empirical specification and results. Section 4 examines the channels through which manufacturing affects house price volatility. Section 5 extends our main result. Section 6 discusses the aggregate implications of our results. And finally, Section 7 concludes.

2. Data

Our main exercises use a new dataset that consists of all property transactions in Sweden over the 2009-2017 period. Each observation contains the sales date, final price, property type, street address, GPS coordinates, number of rooms, and area in square meters. It also contains each property's region, municipality, and parish, which we recover by reverse geocoding its GPS coordinates. Note that we use the term "region" to refer to the largest subnational administrative unit, "municipality" to refer to the second largest, and "parish" to refer to the smallest.[9]

We limit the sample to properties that were sold at least twice over the 2009-2017 period and compute the annualized percentage change (capital gain) for each sales pair. Following Landvoigt et al. (2015), we drop abnormal capital gains ($> 50\%$) and sales pairs with a short holding period ($< 6mo.$). This leaves us with 44,895 properties with at least two sales. Additionally, we compute the time between sales and the number of transactions per parish-quarter.

In addition to property transaction data, we also collect the number of establishments located within commuting distance (25 km) of the GPS coordinate centroid of each parish for the 15 largest employers in Sweden: Volvo, Ericsson, Electrolux, Svenska Cellulosa, Scania, Atlas Copco, Sandvik, SKF, Assa Abloy, Vattenfall, ICA, Securitas, Telia, Axel Johnson, and H&M. The centroid is computed as the average latitude and longitude of all properties located within the same parish. We also compute the distance in kilometers between each property and its parish and region centroids.[10]

Our regressor of interest in most specifications is manufacturing's share of employment at the region level. We use both time-varying (annual) and static measures. For the static case, we always use the 2008 value, which predates our sample and limits potential endogeneity issues. For the dynamic case, we use the contemporaneous value of the manufacturing share for the years it is available (2009-2015). This variable is constructed by Statistics Sweden. In addition to manufacturing's share of employment, we also use manufacturing's share of income and output in different regressions.

We use manufacturing shares, rather than levels or growth rates, because our intent is to capture the effect of manufacturing dependence on house price growth volatility. A high number of individuals employed in manufacturing will not be informative about the impact of manufacturing on house price volatility without knowing the total number of individuals employed in the region. Similarly, a relatively high growth rate in manufacturing employment will be uninformative about house price growth volatility if the manufacturing sector in a given region is small. In a linear specification, controlling for the size of the population or the number of people employed will be insufficient. We would instead need to use ratios or interactions, which is why we have opted to use shares, which are simple and interpretable.[11]

Finally, we collect controls for population density, real per capita income, real per capita income growth, and employment growth for 20 of the 21 subnational regions.[12] These variables are produced by Statistics Sweden. Population density is measured annually and is defined as persons per square kilometer. Real per capita income is measured annually and is used to compute real per capita income growth. Nominal income is deflated to real per capita income using the consumer price index. Employment growth is computed as the percentage change in the number of individuals employed in a given region since the previous quarter. For all level variables, we use either the 2008 value or the time-varying values as controls, depending on the regression specification.

The aforementioned descriptive statistics at the property and region level are shown in Table 1. As pointed out by Davis and Heathcote (2007), property values consist of both land and structures.[13] The supply of buildable land is inelastic in

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[8] Mack and Martinez-Garcia (2012) find that house price growth volatility experienced a secular decline that coincided with the Great Moderation.

[9] Län, kommun, and församling are Swedish geographic designations that roughly translate to "county," "municipality," and "parish." We avoid the direct translation to county to avoid confusion with U.S. counties. As a share of the country's size, Swedish counties are closer to U.S. states than to U.S. counties.

[10] Since each centroid is defined as the mean GPS coordinates for a region or parish, distance to the centroid may capture distance to the urban or residential center.

[11] In addition to the aforementioned reasons, changes in the manufacturing share and changes in the level of manufacturing employment typically move in the same direction. If, for instance, we compare normalized manufacturing employment shares and normalized differences in levels, we find a correlation of 0.736, suggesting a strong linear relationship.

[12] We omit one region for which the number of housing transactions is insufficient for inclusion in our empirical exercises.

[13] Further work by Davis and Palumbo (2008) suggests that the land-intensity of housing has increased considerably since the 1990s.

Table 1
Descriptive statistics: property and region level.

Variable	Mean	SD	25%	50%	75%	N
Property level statistics						
Area	102.39	46.52	68.00	100.00	128.00	44895
Latitude	59.01	2.16	57.72	59.26	59.56	44895
Longitude	15.82	2.51	13.42	16.21	17.96	44895
Distance to region center (km)	35.22	27.49	14.09	30.23	48.05	44895
Annualized capital gains	9.23	12.39	2.51	8.01	14.92	44895
Capital gains volatility	10.11	10.72	3.12	6.82	12.86	44895
Time between sales (month)	32.19	19.14	17.00	28.00	44.00	44895
Sharpe ratio	1.72	2.00	0.27	1.26	2.36	44895
Region and parish level statistics						
Capital gains volatility (time)	10.61	1.08	9.99	10.36	11.10	33
Capital gains volatility (region)	10.94	1.46	9.97	10.95	11.37	22
Capital gains volatility (time-region)	11.32	4.05	9.12	10.62	12.62	719
Real per capita income growth	2.70	0.27	2.50	2.67	2.88	20
Population density (persons/sqkm)	45.16	66.25	14.20	26.70	49.38	20
Employment growth	0.64	0.23	0.56	0.64	0.78	20
Manufacturing income share	0.28	0.06	0.26	0.29	0.32	20
Manufacturing output share	0.29	0.05	0.27	0.30	0.32	20
Manufacturing employment share	0.27	0.05	0.25	0.27	0.31	20
Employment growth volatility	1.86	0.45	1.67	1.84	2.18	20
Herfindahl-Hirschman Index (HHI)	3600.70	2346.64	1330.85	2583.87	5709.03	90
Transactions	218.28	302.11	67	115	225	6015

Notes: The descriptive statistics are divided into property level and region level groups. Property level statistics include area in square meters, latitude, longitude, distance to region center, annualized return, return volatility, time between sales, and the Sharpe ratio. We use an instantaneous, unbiased estimate of volatility at the property level. Region and parish level statistics include capital gains volatility (by time, region, and time-region), real per capita income growth (annual), population density (annual), employment growth (quarterly), manufacturing income share (annual), manufacturing employment share (annual), and employment growth volatility. Each region level variable is averaged over its time dimension before descriptive statistics are computed. We include the HHI index in the list of region level variables; however, we also compute it at the parish level and include this measure in Table 8 regressions. Finally, we include the number of transactions (quarterly) at the parish level.

densely populated areas and this plausibly increases house price volatility in these areas as land makes up a higher share of the total property value. Additionally, Amior and Halket (2014) finds that richer and more dense regions have higher housing capital gains volatility. While the unconditional relationship between volatility and density differs in our data, we still include population density, per capita income, distance to the city center, and per capita income as controls to deal with the aforementioned confounders.

We show the aggregate time series dimension of volatility for Sweden and its three largest regions in Fig. 1. We also provide additional descriptive statistics for our measure of volatility in Table 1. At a quarterly frequency, the standard deviation of housing capital gains volatility is 1.08 over time, 1.46 across region, and 4.05 across time and region. The overall standard deviation is 10.72, which suggests that much of the variation in our volatility measure is idiosyncratic. We also examine the relationship between regional manufacturing share and manufacturing employment volatility in Fig. 2, which indicates that the two have a positive, linear association.[14]

3. Empirical specification

We first regress property-level housing capital gains, $r_{e_h t_d}$, from repeat sales[15] on region and year fixed effects – γ_{e_r} and ζ_{t_a} – and a vector of property level controls, $X_{e_h t_d}$. Property-level controls include area in square meters, distance to parish centroid, dummies for property type, dummies for number of rooms, number of months between transaction dates, and number of transactions that occurred in the same quarter and parish. Note that capital gains vary at the property-day level, which allows us to measure both the common and idiosyncratic components of time-varying volatility at both high and low frequencies.

We use e and t to denote generic entity and time indices, where $e \in \{e_h, e_p, e_m, e_r\}$. The indices e_h, e_p, e_m, and e_r refer to house (or property), parish, municipality, and region. Similarly, t_d, t_m, t_q, and t_a refer to a daily, monthly, quarterly, and annual frequencies. Where possible, we specify the granularity of the entity and the time period. Otherwise, we will use

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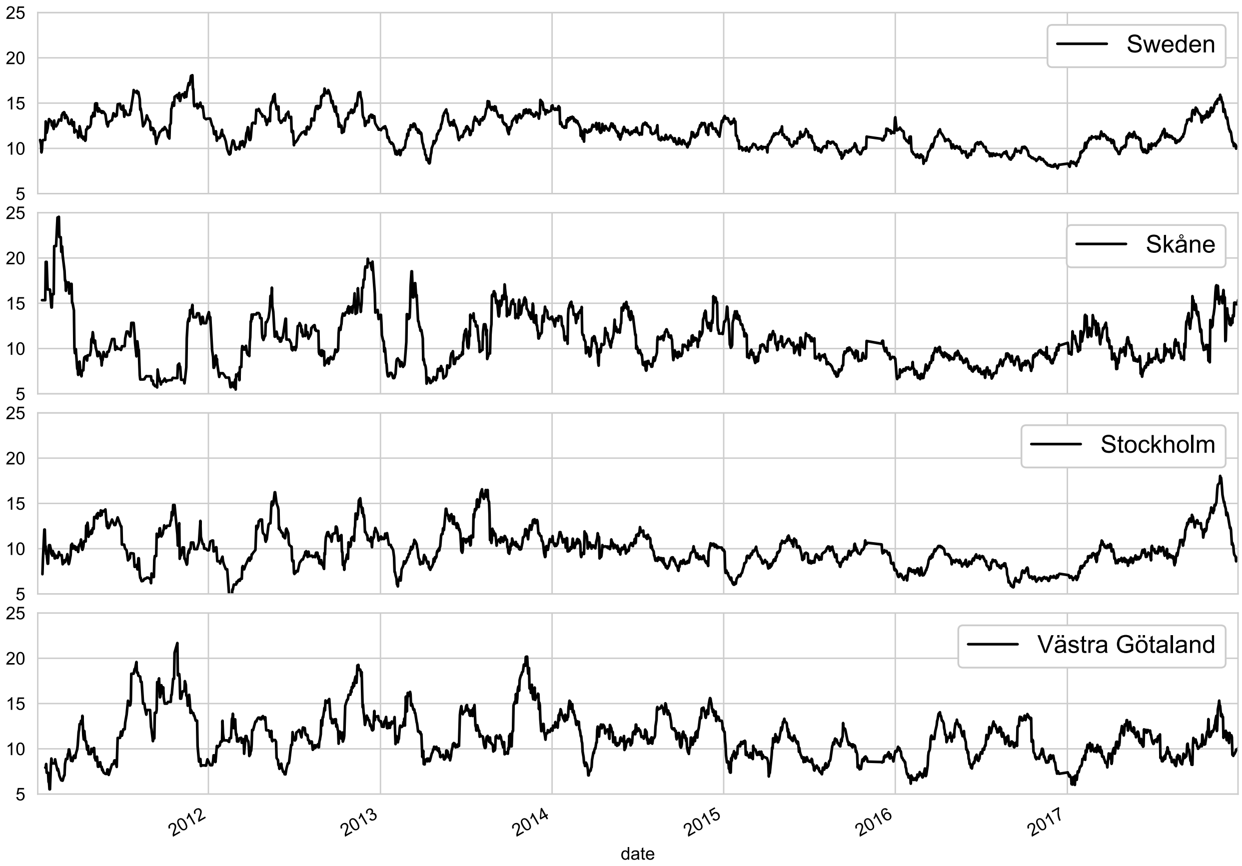
[14] The regional-level correlation is 0.30 between manufacturing employment share and employment growth volatility, 0.47 between manufacturing employment share and housing capital gains volatility, and 0.45 between employment growth volatility and housing capital gains volatility.

[15] Unlike Giacoletti (2017), we do not have access to remodeling expenses and do not differentiate between idiosyncratic volatility generated by non-stochastic, unobserved expenditures and other sources; however, this is unlikely to affect our results, since we are primarily interested in volatility at the parish, region, and national levels. Additionally, our measure does not include the gross dividend, since we do not measure the rent or utility of owner-occupancy. For this reason, we focus on capital gains.



Notes: We first compute the mean instantaneous volatility, $\sigma_{e_h t_d}$, for all properties sold on the same day in each region. This yields a daily time series of mean instantaneous volatility for each region, $\sigma_{e_r t_d}$. We then compute the 30-day rolling mean of the daily series and plot it above for all of Sweden and for the three largest regions.

Fig. 1. Time series housing capital gains volatility.

the indices e and t and indicate that it varies by specification. Note that the results are not sensitive to the specification in Equation (1). Switching to parish-year-quarter fixed effects, for instance, yields nearly identical results.

$$r_{e_h t_d} = X_{e_h t_d}\beta + \gamma_{e_r} + \zeta_{t_a} + \epsilon_{e_h t_d}. \tag{1}$$

After estimating Equation (1), we extract the regression residuals:

$$\hat{\epsilon}_{e_h t_d} = r_{e_h t_d} - X_{e_h t_d}\hat{\beta} - \hat{\gamma}_{e_r} - \hat{\zeta}_{t_a}. \tag{2}$$

We use an unbiased, instantaneous estimator of the standard deviation of $\epsilon_{e_h t_d}$ as our measure of volatility, which was introduced by Davidian and Carroll (1987) and has been widely used in finance, macroeconomics, and urban economics.[16] It contains both time and geographic variation.

$$\hat{\sigma}_{e_h t_d} = \sqrt{\frac{\pi}{2}}\left|\hat{\epsilon}_{e_h t_d}\right|. \tag{3}$$

Note that Equation (2) detrends the national component of capital gains and the region-specific, fixed component, but does not detrend the equivalent components of volatility. Thus, our measure of instantaneous volatility, $\hat{\sigma}_{e_h t_d}$, will vary over time and across geographic location; however, our results are robust to the use of alternative specifications of (2). Since our results do not appear to depend on changes in the dispersion of property-level volatilities within region over time, this suggests that our findings capture the relationship between time-varying volatility in house prices and dependence on manufacturing.

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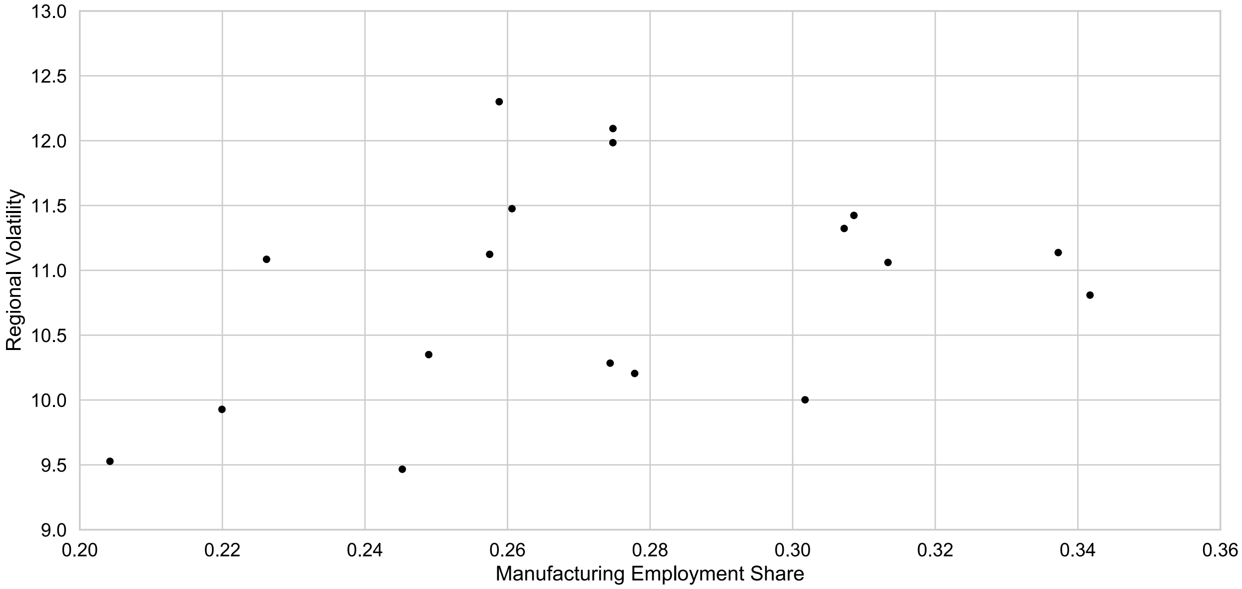
[16] See, e.g., Schwert (1989), McConnell and Perez-Quiros (1990), and Goodman and Thibodeau (1998).



Notes: The plot above compares regional manufacturing employment share and regional housing capital gains volatility. To compute regional manufacturing employment share, we average over the time dimension of our region-year measure of manufacturing employment share. To compute housing capital gains volatility for region e_r, we average over all day-property volatilities, $\sigma_{e_h t_d}$, in region e_r and over the entire sample, yielding σ_{e_r}. The two appear to have a positive, linear association.

Fig. 2. Scatterplot of regional manufacturing employment share and housing capital gains volatility.

The benefit of using our selected measure of volatility is that it can be computed at a point in time and at the property level. Other common measures of volatility must be computed at the region level and on a rolling basis. This is true, for instance, with both the rolling standard deviation of capital gains and autoregression-based volatility measures. While such alternatives may contain less noise, they also either suffer from bias or eliminate much of the variation in the data. Importantly, our findings are robust to the aggregation of the instantaneous measure of volatility, which suggests that they do not rely heavily on this choice. Additionally, the time-variation in our measure – as captured by the 30-day rolling mean of average daily capital gains volatility – is strongly correlated with the 30-day rolling standard deviation of the daily mean of capital gains. For all of Sweden, the correlation between the two series is 0.74. For Stockholm, Västra Götaland, and Skåne – the largest regions in Sweden – the values are 0.71, 0.86, and 0.83, respectively.

3.1. Main results

In this subsection, we test our main hypothesis that dependence on manufacturing increases housing capital gains volatility. We do this by exploiting region and time variation in manufacturing, which Carvalho and Gabaix (2013) identify as a volatile sector.

In Equation (4), $M_{e_r t_a}$ is manufacturing's share of employment, income, or output in region e_r and year t_a; $X_{e_h t_d}$ is a vector of property level controls; Z_{et} is vector of potentially time-varying geographic entity controls; ξ_t is a time fixed effect; and μ_e is a geographic fixed effect. Note that we use the generic entity and time indices, e and t, since geographic unit and frequency vary by regression specification. Furthermore, in some cases, we will use alternate specifications for the fixed effects, including region-time fixed effects and parish fixed effects. For the complete specification for a given regression exercise, see the table note for the corresponding table.

$$\hat{\sigma}_{e_h t_d} = M_{e_r t_a}\zeta + X_{e_h t_d}\theta + Z_{et}\eta + \xi_t + \mu_e + \nu_{e_h t_d}. \tag{4}$$

Table 2 contains our baseline results. Column 1 tests our core hypothesis using manufacturing's share of employment at the region level in 2008. No controls are included. Column 2 adds yearly fixed effects and columns 3-9 include year-quarter fixed effects. Columns 4-9 include property level characteristics as controls: area in square meters, dummies for the number of rooms, dummies for the property type, distance from the region's center in kilometers, the number of months between transaction dates, and the number of transactions that occurred in the same quarter and parish.

Other than $distance\_to\_region\_center_{e_h}$, the distance between a property and its region's GPS centroid, and $months\_between\_transactions_{e_h t_d}$, the number of months between the pair of transactions in a repeat sale, we omit all property

Table 2
Impact of 2008 manufacturing share on house price growth volatility.

	(1) (OLS)	(2) (OLS)	(3) (OLS)	(4) (OLS)	(5) (OLS)	(6) (OLS)	(7) (OLS)	(8) (OLS)	(9) (OLS)
$manufacturing\_employment\_share_{e_r t=2008}$	13.342***	12.807***	12.855***	14.992***	15.087***	8.518***	8.518***		
	(0.771)	(0.771)	(0.770)	(0.927)	(1.630)	(2.802)	(2.993)		
$manufacturing\_income\_share_{e_r t=2008}$								6.918**	
								(2.801)	
$manufacturing\_output\_share_{e_r t=2008}$									9.177**
									(3.976)
$log(population\_density_{e_r t=2008})$					-0.214***				
					(0.074)				
$log(per\_capita\_income_{e_r t=2008})$					2.411*				
					(1.298)				
$log(population\_density_{e_r t_a})$						-0.079	-0.079	-0.093	0.138
						(0.126)	(0.092)	(0.091)	(0.144)
$log(per\_capita\_income_{e_r t_a})$						-2.916	-2.916*	-3.429*	-4.742***
						(2.253)	(1.685)	(1.771)	(1.605)
$per\_capita\_income\_growth_{e_r t_a}$						-0.086	-0.086	-0.070	-0.084
						(0.195)	(0.166)	(0.165)	(0.168)
$employment\_growth_{e_r t_q}$						0.046	0.046	0.048	0.050
						(0.069)	(0.064)	(0.065)	(0.065)
$distance\_to\_region\_center_{e_h}$				0.008***	0.007***	0.014***	0.014***	0.014***	0.014***
				(0.002)	(0.002)	(0.004)	(0.002)	(0.002)	(0.002)
$months\_between\_transactions_{e_h t_d}$				-0.136***	-0.136***	-0.176***	-0.176***	-0.175***	-0.176***
				(0.003)	(0.003)	(0.008)	(0.012)	(0.012)	(0.012)
$transactions_{e_p t_q}$				-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year FE	NO	YES	NO	NO	NO	NO	NO	NO	NO
Year-Quarter FE	NO	NO	YES	YES	YES	YES	YES	YES	YES
Property Controls	NO	NO	NO	YES	YES	YES	YES	YES	YES
Static Region Controls	NO	NO	NO	NO	YES	NO	NO	NO	NO
Time-Varying Region Controls	NO	NO	NO	NO	NO	YES	YES	YES	YES
Standard Errors	NW	NW	NW	NW	NW	NW	CL	NW	NW
Adj. R-squared	0.007	0.014	0.015	0.074	0.074	0.083	0.083	0.083	0.083
N	42,802	42,802	42,802	42,802	42,802	14,949	14,949	14,949	14,949

Notes: The dependent variable is the unbiased estimate of instantaneous house price return volatility at the property level, $\sigma_{e_h t_d}$. We regress $\sigma_{e_h t_d}$ on three measures of manufacturing dependence at the region level in 2008: 1) manufacturing's share of employment; 2) manufacturing's share of income; and 3) manufacturing's share of output. Property controls include area in square meters, dummies for the number of rooms, dummies for the property type, distance from the region's center in kilometers, and the number of months between transaction dates. Static region controls include the log of real per capita income and the log of population density. Time-varying region controls include employment growth (quarterly), the log of per capita income (annual), per capita income growth (annual), and the log of population density (annual), and the number of transactions that occurred in the same parish (quarterly). Note that the time-varying controls are not available at the region level for all periods, which lowers the number of observations in columns 6-9. We cannot include region fixed effects because the regressor of interest is static. Standard errors are either Newey-West (NW) or clustered at the parish level (CL). * $p < .1$, ** $p < .05$, *** $p < .01$.

level controls from the tables to save space and improve readability.[17] Column 5 includes static, region level controls for the log of population density and the log of real per capita income. And finally, columns 6-9 include time-varying controls for the log of real income per capita (annual), the log of population density (annual), real per capita income growth (annual), and employment growth (quarterly). Column 7 clusters standard errors at the parish level. All other columns use heteroskedasticity and autocorrelation robust standard errors.[18] Note that time-varying controls are not available for all years at the region level. Including them forces us to reduce our sample size from 42,802 to 14,949. It also prevents us from using geographic fixed effects in this specification because we only have variation in the regressor of interest at the region level.

Our preferred specifications are given in columns 5 and 6. The coefficients on manufacturing employment share are positive and significant at the 1% level and indicate that an increase in manufacturing's employment share by 10 ppt would increase house price growth volatility by between .85 and 1.51 ppt, depending on specification. It may, however, be more instructive to compare the region with the lowest manufacturing share of employment in 2008, Stockholm (0.145), to the region with the highest, Kalmar (0.366). This would translate into a 1.88 to 3.34 ppt increase in house price growth volatility. For the median property, this is equivalent to a 28% to 49% increase in house price growth volatility. Finally, our results for manufacturing's share of income and output at the region level in 2008 are both significant at the 1% level and quantitatively

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[17] Note that $months\_between\_transactions_{e_h t_d}$ is negative and significant at 1% in all specifications, which coincides with findings for the U.S. in Giacoletti (2017).

[18] As a convention, we provide heteroskedasticity and autocorrelation robust standard errors for all results. We also include separate cluster robust standard errors for each table's main result. Neither choice yields consistently smaller standard errors.

Table 3

Impact of time-varying manufacturing share and employment volatility on house price growth volatility.

	(1) (OLS)	(2) (IV)	(3) (OLS)	(4) (OLS)	(5) (OLS)	(6) (OLS)	(7) (OLS)	(8) (OLS)	(9) (OLS)	(10) (OLS)
$manufacturing\_employment\_share_{e_r t_a}$	15.283***	15.570***	14.279***	14.397***	18.817***	8.369***	9.494***	9.494***	12.563***	
	(1.291)	(1.180)	(1.332)	(1.321)	(1.669)	(3.181)	(3.557)	(0.330)	(1.959)	
$employment\_growth\_volatility_{e_r}$									1.094***	2.181***
									(0.254)	(0.213)
$log(population\_density_{e_r t_a})$						-0.019	0.014	0.014		
						(0.131)	(0.152)	(0.017)		
$log(per\_capita\_income_{e_r t_a})$						-4.084*	-1.719	-1.719***		
						(2.124)	(2.890)	(0.483)		
$employment\_growth_{e_r t_q}$						0.049	0.057	0.057		
						(0.069)	(0.069)	(0.064)		
$per\_capita\_income\_growth_{e_r t_a}$						-0.068	-0.175	-0.175		
						(0.195)	(0.200)	(0.132)		
$employment\_growth_{e_r t_q}$						0.049	0.057	0.057		
						(0.069)	(0.069)	(0.064)		
$distance\_to\_region\_center_{e_h}$					0.005	0.014***	0.014***	0.014***	0.004	0.007**
					(0.003)	(0.004)	(0.005)	(0.001)	(0.003)	(0.003)
$months\_between\_transactions_{e_h t_d}$					-0.128***	-0.176***	-0.175***	-0.175***	-0.128***	-0.127***
					(0.006)	(0.008)	(0.008)	(0.012)	(0.006)	(0.006)
$transactions_{e_p t_q}$					-0.001***	-0.001***	-0.000	-0.000***	-0.001***	-0.001***
					(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year FE	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO
Year-Quarter FE	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES
Property Controls	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES
Time-Varying Region Controls	NO	NO	NO	NO	NO	YES	YES	YES	NO	NO
Parish FE	NO	NO	NO	NO	NO	NO	YES	YES	NO	NO
Standard Errors	NW	NW	NW	NW	NW	NW	NW	CL	NW	NW
Adj. R-squared	0.007	0.007	0.010	0.011	0.062	0.083	0.089	0.089	0.062	0.061
N	24,252	24,252	24,252	24,252	24,252	14,949	14,949	14,949	24,252	24,252

Notes: The dependent variable is the unbiased estimate of instantaneous house price return volatility at the property level, $\sigma_{e_h t_d}$. We regress $\sigma_{e_h t_d}$ on manufacturing's employment share at the region level. Property level controls include area in square meters, dummies for the number of rooms, dummies for the property type, distance from the region's center in kilometers, and the number of months between transaction dates. Time-varying region controls include employment growth (quarterly), the log per capita income (annual), per capita income growth (annual), the log of population density (annual), and the number of transactions that occurred in the same parish (quarterly). Note that the time-varying controls are not available at the region level for all periods, which lowers the number of observations in columns 6-8. Columns 7-8 include parish fixed effects. Columns 9 and 10 include employment growth volatility at the region level, computed as the standard deviation of employment growth over the 2009-2017 period. Standard errors are either Newey-West (NW) or clustered at the parish level (CL). * $p < .1$, ** $p < .05$, *** $p < .01$.

similar to our baseline results. They also hold and explain a high share of variation in aggregate and local volatility in a separate cross-sectional regression.[19]

We next extend our initial result by using a time-varying (annual) measure of the manufacturing share in columns 1-8 of Table 3.[20] This enables us to include parish fixed effects to soak up cross-sectional variation that could comove with manufacturing's share. We also include time-varying region level controls, year-quarter fixed effects, and property level controls in our preferred specifications, which are shown in columns 5 and 8. To ensure that reverse causality and omitted variables are unlikely to drive our main results, we perform an IV estimation (column 2). There, we instrument manufacturing employment with its lag, as well as the EUR-SDR exchange rate and the USD-SDR exchange rate.[21] The Special Drawing Right (SDR) is an IMF-maintained reserve asset with a value that is determined by a basket of currencies that does not include the Swedish Krona (SEK). We use currency pairs that include the SDR, rather than the SEK to capture the exogenous component of movements in the USD-SEK and EUR-SEK exchange rates. This provides us with a shock to foreign demand for Swedish goods. All other columns use OLS. Furthermore, all columns use heteroskedasticity and autocorrelation robust standard errors, except column 8, which clusters standard errors at the parish level.

Again, we find that the impact of manufacturing's share of employment on house price growth volatility remains positive and is statistically significant in all specifications. The magnitude of the effect is similar to what we identified in Table 2. Namely, a 10 ppt increase in manufacturing share is associated with a 0.84 to 1.88 ppt increase in house price growth volatility. We also confirm this in a separate robustness test, which uses manufacturing employment share measured at the

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[19] We perform a separate cross-sectional regression of the region mean of property volatility on the average manufacturing shares of income, output, and employment. The regression on output yields the largest coefficient (16.93) and adjusted R-squared (0.352).

[20] Note that the time-varying controls are not available at the region level for all periods, which lowers the number of observations in columns 6-9.

[21] We include an IV specification in panel regressions where the manufacturing employment share has a time dimension; however, we cannot use it in all empirical exercises, since many use a static regressor of interest.

Table 4
Impact of time-varying, municipal-level manufacturing share on house price growth volatility.

	(1) (OLS)	(2) (OLS)	(3) (OLS)	(4) (OLS)	(5) (OLS)	(6) (OLS)	(7) (OLS)
$manufacturing\_employment\_share_{e_m t_a}$	7.349^{***}	6.811^{***}	7.079^{***}	5.473^{***}	5.377^{***}	5.242^{***}	5.242^{***}
	(0.499)	(0.499)	(0.603)	(1.050)	(1.206)	(0.711)	(0.164)
$\log(per\_capita\_income_{e_r t_a})$				-6.732^{***}	-3.565		
				(1.788)	(2.750)		
$\log(population\_density_{e_r t_a})$				0.030	0.049		
				(0.130)	(0.148)		
$\log(per\_capita\_income_{e_r t_a})$				-6.732^{***}	-3.565		
				(1.788)	(2.750)		
$distance\_to\_region\_center_{e_h}$			0.008^{***}	0.007	0.009^{*}	0.010^{***}	0.010^{***}
			(0.002)	(0.004)	(0.005)	(0.003)	(0.000)
$months\_between\_transactions_{e_h t_d}$			-0.132^{***}	-0.172^{***}	-0.171^{***}	-0.137^{***}	-0.137^{***}
			(0.004)	(0.008)	(0.008)	(0.003)	(0.010)
$transactions_{e_p t_q}$			-0.001^{***}	-0.002^{***}	-0.001	-0.001^{*}	-0.001^{*}
			(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Year-Quarter FE	NO	YES	YES	YES	YES	NO	NO
Region-Year-Quarter FE	NO	NO	NO	NO	NO	YES	YES
Property Controls	NO	NO	YES	YES	YES	YES	YES
Time-Varying Region Controls	NO	NO	NO	YES	YES	NO	NO
Parish FE	NO	NO	NO	NO	YES	YES	YES
Standard Errors	NW	NW	NW	NW	NW	NW	CL
Adj. R-squared	0.006	0.011	0.070	0.089	0.101	0.123	0.123
N	40,296	40,296	40,296	12,616	12,616	40,296	40,296

Notes: The dependent variable is the unbiased estimate of instantaneous house price return volatility at the property level, $\sigma_{e_h t_d}$. We regress $\sigma_{e_h t_d}$ on manufacturing's employment share, measured yearly and at the municipal level. Property level controls include area in square meters, dummies for the number of rooms, dummies for the property type, distance from the region's center in kilometers, and the number of months between transaction dates. Time-varying region controls include per capita income growth (annual), the log of population density (annual), and the number of transactions that occurred in the same parish (quarterly). Note that the time-varying controls are not available at the region level for all periods, which lowers the number of observations in 5-6. Standard errors are either Newey-West (NW) or are clustered at the parish level (CL). The results are also robust to clustering at the municipal level. * $p < .1$, ** $p < .05$, *** $p < .01$.

Table 5
Regional impact of employment volatility and manufacturing share on house price growth volatility.

	(1) (OLS)	(2) (OLS)	(3) (OLS)	(4) (OLS)	(5) (OLS)	(6) (OLS)	(7) (OLS)
$manufacturing\_employment\_share_{e_r}$	13.160^{**}				10.343^{*}		
	(5.836)				(5.853)		
$manufacturing\_income\_share_{e_r}$		14.501^{***}				12.789^{***}	
		(4.582)				(4.394)	
$manufacturing\_output\_share_{e_r}$			16.925^{***}				14.334^{**}
			(5.027)				(5.565)
$employment\_growth\_volatility_{e_r}$				1.350^{**}	1.020	1.017^{*}	0.658
				(0.635)	(0.629)	(0.546)	(0.616)
Adj. R-squared	0.177	0.322	0.352	0.156	0.245	0.404	0.357
N	20	20	20	20	20	20	20

Notes: The dependent variable, σ_{e_r}, is the unbiased estimate of instantaneous house price return volatility at the property level, $\sigma_{e_h t_d}$, averaged over properties and time (2009-2015) within each region. We regress σ_{e_r} on the standard deviations of employment growth over the 2009-2015 period, as well as manufacturing employment, income, and output. In each case, we average the measure of manufacturing share over the time dimension within each region. All specifications use OLS. Standard errors are shown in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$.

municipal level, rather than the region level. The results are given in Table 4 and qualitatively confirm our findings at the regional level. We also estimate these regressions at the commuting zone-level and, again, confirm our main results.[22]

Finally, it is worth noting that there is substantial persistence in aggregate housing capital gains volatility at a daily frequency, as has been documented in Bollerslev et al. (2015) and can be seen in Fig. 1. While our analysis is performed at a lower frequency and at the property level, we follow Bollerslev et al. (2015) and use heteroskedasticity and autocorrelation robust standard errors to ensure that the significance of our results is not overstated. We also perform the same exercises in a setting where the regressor of interest predates our measure of volatility (Table 2) and where identification is purely cross-sectional (Table 5). In both cases, our estimates and their significance remain largely unchanged from the fully dynamic specification.

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[22] The results for the commuting zone-level are available on request.

Table 6
Impact of employment volatility and manufacturing share on aggregate house price growth volatility.

	(1) (OLS)	(2) (OLS)	(3) (OLS)	(4) (OLS)	(5) (OLS)	(6) (OLS)	(7) (OLS)
$manufacturing\_employment\_share_{e_r t_a}$	13.234^{***}				9.064^{**}		
	(4.219)				(4.387)		
$manufacturing\_income\_share_{e_r t_a}$		13.069^{***}				10.425^{***}	
		(3.677)				(3.728)	
$manufacturing\_output\_share_{e_r t_a}$			19.843^{***}				16.368^{***}
			(3.830)				(4.167)
$employment\_growth\_volatility_{e_r}$				1.834^{***}	1.528^{***}	1.545^{***}	1.042^{**}
				(0.467)	(0.488)	(0.475)	(0.502)
Adj. R-squared	0.019	0.025	0.054	0.031	0.038	0.045	0.060
N	458	458	458	458	458	458	458

Notes: The dependent variable, $\sigma_{e_r t_q}$, is the unbiased estimate of instantaneous house price return volatility at the property level, $\sigma_{e_h t_d}$, aggregated by computing the mean for each region-quarter. We regress $\sigma_{e_r t_q}$ on the standard deviations of employment growth over the 2009-2015 period, as well as annual manufacturing employment, income, and output. All specifications use OLS. Standard errors are shown in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$.

4. Channels

In this section, we explore two potential channels through which the manufacturing employment share might affect house price growth volatility: employment growth volatility and firm concentration. As Carvalho and Gabaix (2013) have demonstrated, manufacturing is a relatively volatile sector. Consequently, an increase in manufacturing's share of employment in a given region will tend to increase volatility in employment and income within that region, which might translate into volatility in demand in the local housing market. Furthermore, dependence on manufacturing also tends to concentrate employment, which may increase the sensitivity of local housing demand to firm-specific shocks. We will test each of these channels more formally in this section.

4.1. Employment growth volatility

We first test the hypothesis that employment growth volatility is one of the channels through which manufacturing share affects house price growth volatility. In columns 9-10 of Table 3, we include employment growth volatility as a regressor. We compute this control as the standard deviation of region level employment growth over the 2009-2017 period. Comparing columns 5 and 9, we can see that manufacturing's employment share remains significant, but its magnitude declines from 18.8 to 12.6. Similarly, removing manufacturing's employment share in column 10 increases the magnitude of employment growth volatility from 1.1 to 2.43. Note that these results are also robust to clustering standard errors at the parish level.[23] This suggests that the impact that manufacturing's share of employment has on house price growth volatility may be related to the impact it has on employment growth volatility.[24]

We also consider whether manufacturing explains a substantial share of the cross-sectional variation in region-level volatility. We do this in a set of cross-sectional regressions, shown in Table 5, where we regress the region level mean of property volatility on the region level employment growth volatility and manufacturing share. Note that the measure of volatility captures instantaneous differences in variation over time, even though the regression itself is cross-sectional. Columns 1-3 provide the estimates for the manufacturing shares of employment, income, and output on regional house price volatility. In each case, we average manufacturing share observations over the time dimension. The magnitudes of the estimates are similar to those in Table 3. Column 4 shows results for employment growth volatility in isolation. Columns 5-7 include employment growth volatility, manufacturing employment, income, and output share, respectively.[25] Column 6 yields an adjusted R-squared of 0.40, which suggests that manufacturing share and employment growth volatility explain a high share of the aggregate and regional volatility. In addition to this, we also directly regress employment growth volatility on each of the different manufacturing shares. We find that all have a positive association. The largest impact comes from manufacturing's output share and indicates that a 10 ppt increase is associated with employment growth volatility that is 0.40 standard deviations higher.

We also study the time series dimension of volatility separately in Table 6. Here, we average over all of the day-property volatilities in a given region and quarter, yielding a quarterly time series for housing capital gains volatility in each region.

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[23] For the sake of readability, we omit this and several other robustness checks from the table; however, all results are available on request.

[24] Note that the estimates for manufacturing income share and manufacturing output share are larger and more statistically significant than manufacturing employment share in cross-sectional regressions that include employment growth volatility. This suggests that the relationship between house price growth volatility and manufacturing does not come entirely through employment volatility.

[25] Note that the different measures of manufacturing share are highly collinear, and employment growth volatility and the manufacturing share variables are also highly collinear, but less so. Since none of the specifications included contain multiple manufacturing shares as regressors, the collinearity is not severe enough to cause conditioning problems.

Table 7
(Alt. vol.) Impact of employment volatility and manufacturing share on aggregate house price growth volatility.

	(1) (OLS)	(2) (OLS)	(3) (OLS)	(4) (OLS)	(5) (OLS)	(6) (OLS)	(7) (OLS)
$manufacturing\_employment\_share_{e_r t_a}$	19.558***				15.638***		
	(4.436)				(4.672)		
$manufacturing\_income\_share_{e_r t_a}$		13.660***				10.532***	
		(3.944)				(4.039)	
$manufacturing\_output\_share_{e_r t_a}$			18.267***				14.050***
			(4.155)				(4.558)
$employment\_growth\_volatility_{e_r}$				1.921***	1.337**	1.580***	1.210**
				(0.503)	(0.527)	(0.517)	(0.549)
Adj. R-squared	0.040	0.024	0.040	0.030	0.052	0.043	0.048
N	441	441	441	441	441	441	441

Notes: The dependent variable, $\sigma_{e_r t_q}$, uses an alternative formulation of volatility. To compute it, we first calculate the mean housing capital gain in each year-month-region. We then compute the standard deviation of the mean capital gains for each year-quarter-region. This yields $\sigma_{e_r t_q}$, which we regress on the standard deviations of employment growth over the 2009-2015 period, as well as annual manufacturing employment, income, and output. All specifications use OLS. Standard errors are shown in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$.

We use the same specifications as in the cross-sectional regressions and find similar results: manufacturing's employment share, income share, and output share are strongly and positively associated with aggregate capital gains volatility.[26] To further demonstrate the robustness of these results, we repeat the exercise in Table 7, but with an alternate measure of volatility as the dependent variable. Instead of aggregating the property-day volatilities, we first compute mean of the housing capital gains in each month and region. We then compute the quarterly standard deviation over the means as an alternate measure of volatility and repeat the same set of regressions, yielding similar results. Note that these results also hold if we use manufacturing at the municipal level, rather than regional level, as we do in Table 4.

4.2. Firm concentration

Another channel through which manufacturing may affect the housing market is through the concentration of employment and income. In particular, higher firm concentration will tend to leave the local or regional housing market exposed to firm-specific shocks. Indeed, at the regional level, manufacturing share and firm concentration have a 0.536 correlation; however, firm concentration is available at the local level, where it may be more relevant for house price volatility, which we exploit in our next exercise, shown in Table 8. Here, we measure the impact of firm concentration on house price growth volatility. The purpose of this exercise is to demonstrate that high firm concentration, an attribute of the manufacturing sector, could plausibly explain increased house price growth volatility. If it does not, then we may rule it out as a candidate channel. The regressor of interest in all specifications is the Herfindahl-Hirschman Index (HHI) at the parish level,[27] which we compute as follows:

$$hhi_{e_p} = s_0^2 + \ldots + s_F^2. \tag{5}$$

Note that s_l is firm l's share of establishments in parish e_p.[28] We compute this using data on the number of establishments within commuting distance (25 km) of each parish's GPS centroid for each of the 15 largest employers in Sweden: Volvo, Ericsson, Electrolux, Svenska Cellulosa, Scania, Atlas Copco, Sandvik, SKF, Assa Abloy, Vattenfall, ICA, Securitas, Telia, Axel Johnson, and H&M. Using the narrowest geographic unit, parish, allows us to include region-year-quarter fixed effects in columns 7-9, which absorb all permanent and region level variation in volatility. We use two different regression specifications:

$$\hat{\sigma}_{e_h t_d} = log(hhi_{e_p})\zeta + X_{e_h t_d}\theta + Z_{e_p t}\eta + \xi_t + \mu_e + \nu_{e_h t_d}. \tag{6}$$

The first specification, given in Equation (6), includes parish level controls, $Z_{e_p t}$; time fixed effects, ξ_t; and region fixed effects, μ_e. Note that we index parish-level variables using e_p. The second specification, given in (7), replaces region and year-quarter fixed effects with region-year-quarter fixed effects, $\kappa_{e_r t_q}$:

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[26] We also conduct a separate exercise in which we compute the mean volatility across all transactions in a given day. We then regress this daily time series measure of volatility on the national manufacturing share. Even purely exploiting time series variation, we find that the relationship is positive and significant at the 1% level. The relationship also persists if we instead perform the aggregation at a lower frequency, such as a quarterly frequency.

[27] At the region level, HHI and manufacturing's employment share are positively correlated (0.536); however, only HHI can be constructed at the parish level.

[28] Since we cannot compute market share or employment share at the parish level, we instead use a measure of establishment share for the largest firms in Sweden. Note that we use parish, rather than region, since parish is a narrower geographic unit and is available for establishment location data; however, the results are not sensitive to the choice of geographic unit or the commuting distance assumption.

Table 8
Impact of firm concentration on house price growth volatility.

	(1) (OLS)	(2) (OLS)	(3) (OLS)	(4) (OLS)	(5) (OLS)	(6) (OLS)	(7) (OLS)	(8) (OLS)	(9) (OLS)
$log(hhi_{e_p})$	1.150^{***}	1.079^{***}	1.154^{***}	1.546^{***}	0.968^{***}	1.635^{***}	1.572^{***}	1.572^{***}	1.250^{***}
	(0.069)	(0.068)	(0.081)	(0.128)	(0.211)	(0.271)	(0.260)	(0.437)	(0.201)
$log(parish\_size_{e_p t_q})$						0.553^{**}	0.493^{**}	0.493	0.433^{**}
						(0.257)	(0.223)	(0.456)	(0.174)
$mean\_distance\_to\_region\_center_{e_p t_q}$						-0.012^{**}	-0.011^{**}	-0.011	-0.009^{**}
						(0.005)	(0.005)	(0.009)	(0.004)
$mean\_distance\_to\_parish\_center_{e_p t_q}$						-0.029^{***}	-0.028^{***}	-0.028^{**}	-0.023^{***}
						(0.008)	(0.008)	(0.011)	(0.006)
$distance\_to\_region\_center_{e_h}$				0.002	0.009^{***}	0.013^{***}	0.014^{***}	0.014^{***}	0.015^{***}
				(0.003)	(0.003)	(0.003)	(0.003)	(0.001)	(0.003)
$distance\_to\_parish\_center_{e_h}$				-0.000	-0.001	-0.000	-0.000	-0.000	-0.000
				(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$months\_between\_transactions_{e_h t_d}$				-0.121^{***}	-0.123^{***}	-0.124^{***}	-0.127^{***}	-0.127^{***}	-0.140^{***}
				(0.004)	(0.004)	(0.004)	(0.004)	(0.010)	(0.003)
$transactions_{e_p t_q}$				-0.000^{**}	-0.000^{**}	-0.000^{**}	-0.000^{**}	-0.000^{**}	-0.000^{***}
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year FE	NO	YES	NO	NO	NO	NO	NO	NO	NO
Year-Quarter FE	NO	NO	YES	YES	YES	YES	NO	NO	NO
Property Controls	NO	NO	NO	YES	YES	YES	YES	YES	YES
Time-Varying Parish Controls	NO	NO	NO	NO	NO	YES	YES	YES	YES
Region FE	NO	NO	NO	NO	YES	YES	NO	NO	NO
Region x Year-Quarter FE	NO	NO	NO	NO	NO	NO	YES	YES	YES
Year $\geq$ 2015	NO	NO	YES	YES	YES	YES	YES	YES	NO
Standard Errors	NW	NW	NW	NW	NW	NW	NW	CL	NW
Adj. R-squared	0.006	0.012	0.010	0.064	0.084	0.085	0.105	0.105	0.101
N	44,676	44,676	27,972	27,972	27,972	27,972	27,972	27,972	44,676

Notes: The dependent variable is the unbiased estimate of instantaneous house price return volatility at the property level, $\sigma_{e_h t_d}$. We compute the centroid of a parish as the mean longitude and latitude of properties located within it in our dataset. We then regress $\sigma_{e_h t_d}$ on the parish level HHI index. The HHI index is computed using the number of establishments present in a given parish for each of the largest 15 employers in Sweden: Volvo, Ericsson, Electrolux, Svenska Cellulosa, Scania, Atlas Copco, Sandvik, SKF, Assa Abloy, Vattenfall, ICA, Securitas, Telia, Axel Johnson, and H&M. Property level controls include area in square meters, dummies for the number of rooms, dummies for the property type, and the number of months between transaction dates. For columns 3-8, we limit the sample to 2015-2017 to avoid possible issues with endogeneity, since the firm location data is only available for 2017. Columns 5 and 6 include region fixed effects. Columns 7-9 include region-year-quarter fixed effects. Columns 6-9 include additional parish level controls: the average property size, the average distance to the parish's centroid in kilometers, the average distance to the region's centroid in kilometers, the log of the number of properties located in the parish, and the number of transactions that occurred in the same parish (quarterly). Standard errors are either Newey-West (NW) or are clustered at the parish level (CL). * $p < .1$, ** $p < .05$, *** $p < .01$.

$$\hat{\sigma}_{e_h t_d} = log(hhi_{e_p})\zeta + X_{e_h t_d}\theta + Z_{e_p t}\eta + \kappa_{e_r t_q} + \nu_{e_h t_d}. \tag{7}$$

In column 1 of Table 8, we perform the regression with no controls. We next add year fixed effects in column 2 and year-quarter fixed effects in columns 3-6. In columns 3-8, we limit the sample to cover only years 2015-2017. This is to limit potential endogeneity issues, since our measure of firm concentration is only available for 2017. Importantly, however, our specifications with the most extensive set of controls and region-year-quarter fixed effects, shown in columns 6-9, suggest that this does not appear to bias the coefficient estimates upward in the full sample. Column 8 clusters standard errors at the parish level. All other columns use heteroskedasticity and autocorrelation robust standard errors. For all estimates, we find a positive, quantitatively similar effect that is significant at the 1% level. Our preferred specifications in columns 7 and 9 suggest that a doubling of firm concentration is associated with a 1.25 to 1.57 ppt increase in house price growth volatility. For the median property, this is equivalent to an 18% to 23% increase in house price growth volatility.

5. Compensation for excess volatility

Thus far, we have shown that manufacturing is associated with increased house price volatility. It remains unclear, however, whether homeowners are compensated for this increased volatility with higher house price growth. We might expect this to be the case in equity markets; however, it may not be true in the housing market, where location choices are not primarily determined by expected return and volatility. Peng and Thibodeau (2017), for instance, have shown that other sources of house price volatility, such as zip-code level median income in the U.S., are not compensated for by increased house price appreciation.

Measuring the Sharpe ratio is one way to identify the extent to which homeowners are compensated for higher volatility:

$$S_{e_h t_d} = \frac{E[r_{e_h t_d} - r^{*}]}{\sigma_{e_h t_d}}. \tag{8}$$

Table 9
Impact of time-varying manufacturing share and employment volatility on Sharpe ratio for housing capital gains.

	(1) (OLS)	(2) (IV)	(3) (OLS)	(4) (OLS)	(5) (OLS)	(6) (OLS)	(7) (OLS)	(8) (OLS)	(9) (OLS)	(10) (OLS)
$manufacturing\_employment\_share_{e_r t_a}$	-4.057***	-4.3610***	-3.439***	-3.481***	-2.297***	0.293	-0.179	-0.179***	-2.271***	
	(0.226)	(0.201)	(0.211)	(0.209)	(0.230)	(0.431)	(0.486)	(0.068)	(0.313)	
$employment\_growth\_volatility_{e_r}$									-0.005	-0.201**
									(0.052)	(0.089)
$\log(population\_density_{e_r t_a})$						-0.094***	-0.066***	-0.066***		
						(0.019)	(0.022)	(0.003)		
$\log(per\_capita\_income_{e_r t_a})$						2.607***	2.205***	2.205***		
						(0.317)	(0.436)	(0.083)		
$employment\_growth_{e_r t_q}$						-0.011	-0.010	-0.010		
						(0.010)	(0.010)	(0.010)		
$per\_capita\_income\_growth_{e_r t_a}$						-0.007	0.015	0.015		
						(0.029)	(0.031)	(0.023)		
$employment\_growth_{e_r t_q}$						-0.011	-0.010	-0.010		
						(0.010)	(0.010)	(0.010)		
$distance\_to\_region\_center_{e_h}$					-0.002***	-0.002***	-0.000	-0.000***	-0.002***	-0.002***
					(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
$months\_between\_transactions_{e_h t_d}$					0.008***	0.009***	0.009***	0.009***	0.008***	0.008***
					(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
$transactions_{e_p t_q}$					0.000***	0.000	-0.000	-0.000***	0.000*	0.000**
					(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year FE	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO
Year-Quarter FE	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES
Property Controls	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES
Time-Varying Region Controls	NO	NO	NO	NO	NO	YES	YES	YES	NO	NO
Parish FE	NO	NO	NO	NO	NO	NO	YES	YES	NO	NO
Standard Errors	NW	NW	NW	NW	NW	NW	NW	CL	NW	NW
Adj. R-squared	0.018	0.020	0.054	0.056	0.073	0.039	0.045	0.045	0.072	0.070
N	22,891	22,891	22,891	22,891	22,891	14,266	14,266	14,266	22,891	22,891

Notes: The dependent variable is the realized Sharpe ratio at the property level, $S_{e_h t_d}$. We regress $S_{e_h t_d}$ on the yearly manufacturing employment share at the region level. Property level controls include area in square meters, dummies for the number of rooms, dummies for the property type, distance from the region's center in kilometers, and the number of months between transaction dates. Time-varying region controls include employment growth (quarterly), the log per capita income (annual), per capita income growth (annual), the log of population density (annual), and the number of transactions that occurred in the same parish (quarterly). Note that the time-varying controls are not available at the region level for all periods, which lowers the number of observations in 6-8. Columns 7-8 include parish fixed effects. Columns 9 and 10 include employment growth volatility at the region level, computed as the standard deviation of employment growth over the 2009-2017 period. Standard errors are either Newey-West (NW) or clustered at the parish level (CL). * $p < .1$, ** $p < .05$, *** $p < .01$.

Here, $S_{e_h t_d}$ is the Sharpe ratio for property h on day d, $r_{e_h t_d}$ is the housing capital gain, r^* is the return to the safe asset, and $\sigma_{e_h t_d}$ is the standard deviation of the housing capital gain. The Sharpe ratio was originally developed to measure mutual fund performance (Sharpe, 1966) and can be interpreted here as the expected housing capital gain in excess of the risk free rate per unit of volatility.

We approximate the housing return with the housing capital gain at the property level,[29] and use the annualized return to three month Swedish government bonds as the risk free rate. Finally, we again adopt the property-level measure of instantaneous volatility introduced in Equation (3) for $\sigma_{e_h t_d}$.

Our specification for the Sharpe ratio regressions is given below.

$$S_{e_h t_d} = M_{e_r t_a}\zeta + X_{e_h t_d}\theta + Z_{e_r t}\eta + \xi_t + \mu_e + \nu_{e_h t_d}. \tag{9}$$

Note that $S_{e_h t_d}$ is the realized Sharpe ratio for property e_h at time t_d; $M_{e_r t_a}$ is manufacturing's share of employment, income, or output in region e_r at time t_a; $X_{e_h t_d}$ is a vector of property level controls; $Z_{e_r t}$ is vector of region level controls; ξ_t is a time fixed effect; and μ_e is a geographic entity fixed effect. All reported Sharpe ratios are annualized.

The median Sharpe ratio in our sample is 1.26, which exceeds historical equity performance, and is likely related to the period we cover, where house price growth was high and the risk free rate was low and sometimes negative. Sharpe ratios estimated for Sweden and other countries over longer time horizons have typically been below unity (e.g. Favilukis et al. (2017); Jórda et al. (2017); Flavin and Yamashita (2002)); however, Nordic countries have generally had high housing Sharpe ratios since the 1950s (Jórda et al., 2017). The housing Sharpe ratio in the U.S. during the late 1990s and early 2000s was similar to our estimate for Sweden; and several state housing markets are likely to have exceeded it. See Lo (2003) for a comparison of Sharpe ratio estimates for different categories of assets.

Our findings are summarized in Table 9. Note that the specifications in columns 1-10 are identical to those used in the volatility regressions, which were shown in Table 3, except that our dependent variable is now the housing capital gains

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[29] Note that we do not have access to remodeling costs, so we follow the literature by using house price growth to approximate the house price return.

Sharpe ratio. In all cases with significant estimates, the sign on the region-level manufacturing share of employment is negative, suggesting that an increase in the manufacturing share is associated with a decrease in the Sharpe ratio. This implies that the increase in house price volatility associated with manufacturing is not fully compensated for by increased house price appreciation.

Note that this finding is less robust than our original results for house price growth volatility. In particular, including time-varying region controls requires us to drop the 38% of the sample for which such controls are not available. When we do this, the results remain significant when standard errors are clustered at the parish level, but not when we use Newey-West standard errors. Overall, 7 of 9 specifications yield estimates that are significant at a 1% level. Our preferred specifications, given in columns 5 and 8, are both significant at the 1% level and suggest that a 10 ppt increase in the manufacturing share is associated with a 0.02 to 0.23 ppt decrease in the Sharpe ratio. Again, moving from the region with the lowest share of manufacturing employment in 2008, Stockholm (0.145), to the region with the highest, Kalmar (0.366), would translate into a 0.04 to 0.51 ppt decrease in the Sharpe ratio. For the median home, this effect amounts to a 4% to 40% reduction in the Sharpe ratio.

Furthermore, columns 9 and 10 indicate that part of the effect of manufacturing on the Sharpe ratio comes through employment growth volatility. In particular, upon removing manufacturing share in column 10, the impact of employment growth volatility becomes significant and increases in magnitude from -0.05 to -0.20. Thus, a one standard deviation increase in employment growth volatility is associated with a 0.09 decrease in the Sharpe ratio. In terms of house price growth volatility, this effect is similar to moving from the region with the lowest manufacturing share to the region with the highest.

Finally, we consider the impact of firm concentration on the Sharpe ratio. If volatility in manufacturing emerges from the effect it has on concentrating employment, income, and output, then we might expect measures of firm concentration to be associated with the volatility and Sharpe ratio of housing capital gains. We have already shown the former. We will show the latter in the exercise below, where we re-use the specification given in Equation (7), but change the dependent variable to the Sharpe ratio, $S_{e_h t_d}$, as shown in Equation (10):

$$S_{e_h t_d} = log(hhi_{e_p})\zeta + X_{e_h t_d}\theta + Z_{e_p t}\eta + \kappa_{e_r t_q} + \nu_{e_h t_d}. \tag{10}$$

The results for this exercise are given in Table 10. Here, we again find strong evidence that homeowners are not compensated for the increased volatility associated with firm concentration. In particular, 6 out of 9 specifications are significant at the 1% level and 1 is significant at the 10% level. Our preferred specification in column 9 suggests that a doubling of firm concentration is associated with a 0.131 ppt decrease in the Sharpe ratio. For the median property, this is equivalent to an 10% decrease in the Sharpe ratio.

6. Aggregate effects of manufacturing decline

Between 2010 and 2017, the manufacturing employment share in Sweden fell from 12% to 10%. According to our baseline specification, this implies a reduction in housing capital gains volatility of approximately 0.31 ppt. In the data, the annual measure of housing capital gains volatility fell by 0.14 ppt over the same period. Fig. 3 plots normalized housing capital gains volatility against the normalized manufacturing share of employment in Sweden over a longer period (1984-2012). While it is difficult to make a compelling case for identification in a time series setting, there appears to be a positive, linear relationship between the two variables at the national level, which coincides with that we measure more carefully in our regression exercises with microdata.

In the remainder of this section, we consider the aggregate implications of our volatility findings and will also speculate on their implications for events outside of our sample period. Here, we show that effects estimated at the regional level translate into volatility in national level house price indices. Thus, the relationship between manufacturing and house price volatility should also persist at the aggregate level. We use our estimates to compute a rough approximation of what this implies regarding the effect of long run decline in manufacturing share on house price growth volatility in four countries.

Our main empirical exercise established a statistically robust and economically significant relationship between dependence on manufacturing and house price volatility at the region level. We then proposed channels through which dependence on manufacturing might translate into house price volatility and demonstrated that those channels have empirical relevance. Given the lack of exogenous variation in the data, we refrain from making strong claims about causality; however, we can plausibly rule out reverse causality and have carefully controlled for confounders through the use of a large set of granular fixed effects and local controls. We have also exploited specifications with lags and demand shocks, and have employed IV to provide evidence against alternative hypotheses.

In this subsection, we will examine the implications of these findings for aggregate house price volatility. Note that most of our effects were measured at the level of the largest subnational administrative unit, which we referred to as “region” throughout the paper. There are 21 such regions in Sweden, three of which account for 53% of the country’s housing transactions. Consequently, movements in apparently regional factors, such as manufacturing share or employment volatility, may translate into aggregate movements in house price volatility. This is particularly likely to be true for manufacturing, which has experienced a secular decline across all regions since 1970.

Table 10
Impact of firm concentration on Sharpe ratio for housing capital gains.

	(1) (OLS)	(2) (OLS)	(3) (OLS)	(4) (OLS)	(5) (OLS)	(6) (OLS)	(7) (OLS)	(8) (OLS)	(9) (OLS)
$log(hhi_{e_p})$	-0.399***	-0.351***	-0.373***	-0.265***	-0.114***	-0.085*	-0.065	-0.065	-0.131***
	(0.016)	(0.015)	(0.018)	(0.025)	(0.034)	(0.047)	(0.046)	(0.052)	(0.036)
$log(parish\_size_{e_p t_q})$						0.008	0.025	0.025	0.016
						(0.043)	(0.041)	(0.061)	(0.032)
$mean\_distance\_to\_region\_center_{e_p t_q}$						-0.000	-0.001	-0.001	-0.001
						(0.001)	(0.001)	(0.001)	(0.001)
$mean\_distance\_to\_parish\_center_{e_p t_q}$						0.000	0.000	0.000	0.001
						(0.001)	(0.001)	(0.002)	(0.001)
$distance\_to\_region\_center_{e_h}$				-0.001**	-0.002***	-0.002***	-0.002***	-0.002***	-0.003***
				(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
$distance\_to\_parish\_center_{e_h}$				0.000	-0.000	-0.000	-0.000	-0.000	-0.000
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$months\_between\_transactions_{e_h t_d}$				0.008***	0.008***	0.008***	0.009***	0.009***	0.014***
				(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)
$transactions_{e_p t_q}$				0.000**	0.000	0.000	0.000	0.000	0.000*
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year FE	NO	YES	NO	NO	NO	NO	NO	NO	NO
Year-Quarter FE	NO	NO	YES	YES	YES	YES	NO	NO	NO
Property Controls	NO	NO	NO	YES	YES	YES	YES	YES	YES
Time-Varying Parish Controls	NO	NO	NO	NO	NO	YES	YES	YES	YES
Region FE	NO	NO	NO	NO	YES	YES	NO	NO	NO
Region x Year-Quarter FE	NO	NO	NO	NO	NO	NO	YES	YES	YES
Year $\geq$ 2015	NO	NO	YES	YES	YES	YES	YES	YES	NO
Standard Errors	NW	NW	NW	NW	NW	NW	NW	CL	NW
Adj. R-squared	0.021	0.064	0.063	0.074	0.082	0.082	0.084	0.084	0.099
N	41,392	41,392	22,891	22,891	22,891	22,891	22,891	22,891	41,392

Notes: The dependent variable is the instantaneous, realized Sharpe ratio, $S_{e_h t_d}$. We compute the centroid of a parish as the mean longitude and latitude of properties located within it in our dataset. We then regress $S_{e_h t_d}$ on the parish level HHI index. The HHI index is computed using the number of establishments present in a given parish for each of the largest 15 employers in Sweden: Volvo, Ericsson, Electrolux, Svenska Cellulosa, Scania, Atlas Copco, Sandvik, SKF, Assa Abloy, Vattenfall, ICA, Securitas, Telia, Axel Johnson, and H&M. Property level controls include area in square meters, dummies for the number of rooms, dummies for the property type, and the number of months between transaction dates. For columns 3-8, we limit the sample to 2015-2017 to avoid possible issues with endogeneity, since the firm location data is only available for 2017. Columns 5 and 6 include region fixed effects. Columns 7-9 include region-year-quarter fixed effects. Columns 6-9 include additional parish level controls: the average property size, the average distance to the parish's centroid in kilometers, the average distance to the region's centroid in kilometers, the log of the number of properties located in the parish, and the number of transactions that occurred in the same parish (quarterly). Standard errors are either Newey-West (NW) or are clustered at the parish level (CL). * $p < .1$, ** $p < .05$, *** $p < .01$.

We first note that national house price indices are typically computed at the regional level and then aggregated using transaction shares. This implies that a house price index can be decomposed into its regional parts as follows:

$$P_t = \alpha_1 p_{1t} + ... + \alpha_n p_{nt} \tag{11}$$

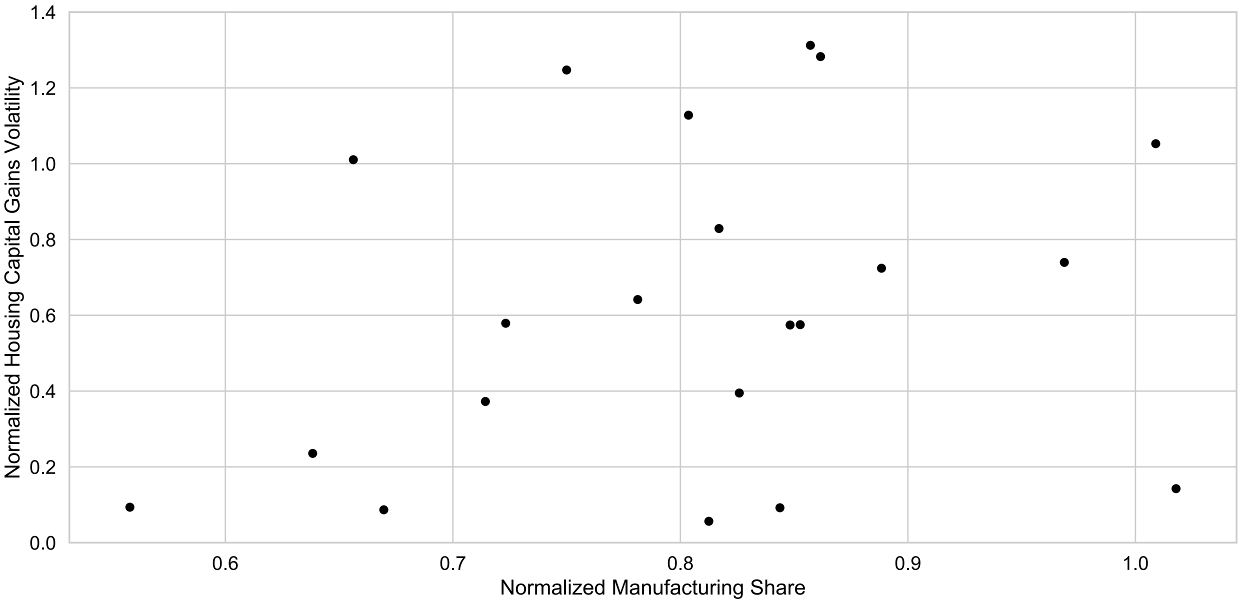
In Equation (11), P_t is the aggregate house price in period t, p_{it} is the house price in region i, and α_i is the transaction share of region i. Note that n is the number of regions and $\sum_i^n \alpha_i = 1$. This implies that the variance of the aggregate index can be decomposed as follows:

$$\sigma^2_{P_t} = \sum_{i=1}^{n} \alpha_i^2 \sigma^2_{p_{it}} + \sum_{1<i\leq j} \alpha_i \alpha_j \sigma_{p_{it},p_{jt}}. \tag{12}$$

For simplicity, assume that house price variances are identical across region in period 0 (e.g. $\sigma_{p_{10}} = ... = \sigma_{p_{n0}}$) and all covariance terms are zero. Now, consider an increase in the house price variance in region j in period 1. We may write the implied percentage change in the national house price index as follows:

$$\frac{\Delta\sigma_{P_1}}{\sigma_{P_0}} = \frac{\alpha_j^2}{\sum_{i=1}^{n} \alpha_i^2} \frac{\Delta\sigma^2_{p_{j1}}}{\sigma^2_{P_{j0}}}. \tag{13}$$

This suggests that a 10% increase in the variance of region j would translate into a $0.10 * \alpha_j^2 / \sum_{i=1}^{n} \alpha_i^2$ percent increase in aggregate house price variance. For example, a 10% house price variance increase in the Stockholm region, which has a transaction share of 0.27, would yield a 6.1% increase ($0.10 * 0.27^2/0.122$) in national house price variance. This implies that reductions in the manufacturing share at the regional level can translate into substantial reductions in national-level house price volatility.



Notes: The plot above shows normalized housing capital gains volatility plotted against the normalized manufacturing share of employment in Sweden over the period between 1984-2012. The manufacturing share of employment is computed at the national level. Housing capital gains volatility is computed using an autoregressive measure of instantaneous volatility. Both variables are normalized by their 1984 levels. In particular, we compute the absolute value of the residual of an AR(1) model in national house price growth. We then drop outliers, which are primarily concentrated around recessions, from the plot.

Fig. 3. Scatterplot of manufacturing share and housing capital gains volatility in Sweden.

We have set the covariance terms to zero to simplify the expression; however, in practice, the covariance terms are positive, which would increase the size of the effects we measure in this exercise.[30] Thus, the effect size we report is likely to be the lower bound, but is sufficient to demonstrate that movements in regional prices can have an impact on "aggregate" house prices.

Above, we have 1) measured the impact of manufacturing at the regional-level using microdata; and 2) demonstrated that fluctuations at that level can plausibly translate into national level aggregate fluctuations. We now combine this with our empirical findings to simulate the national level implications for house price volatility in Sweden, the U.S., the U.K., and Japan. We will focus exclusively on the partial effects that would have been generated by the manufacturing share reductions in each country.

Fig. 4 plots the results of this simulation exercise.[31] In each case, we use the estimated relationship between manufacturing employment share[32] and house price volatility estimated in this paper. We interact this measure with the manufacturing employment share for the country being simulated. Each series can be interpreted as the cumulative percentage point change in house price volatility since 1970. All countries experienced a decline in manufacturing share, implying volatility declines of between 1.6 and 3.6 ppt. The decline for Sweden (2.4 ppt) is approximately 35% of its 2009-2017 volatility level. While we have the manufacturing share for other countries, we do not have microdata to estimate the size of the effect separately. We also do not have access to microdata for Sweden over the simulation period. Consequently, the exercise should be treated as speculative – especially for U.S., U.K., and Japan – but can provide a rough approximation of the long-run decline in manufacturing dependence on house price growth volatility.

7. Conclusion

Using a new dataset of all Swedish housing transactions over the 2009-2017 period, we document a statistically robust and economically significant association between regional dependence on manufacturing and house price growth volatility. We show that this relationship can plausibly be accounted for by manufacturing's impact on firm concentration and employment volatility. In addition to this, we show that such volatility increases are not compensated for in the form of higher house price growth. Rather, manufacturing is associated with lower housing return Sharpe ratios.

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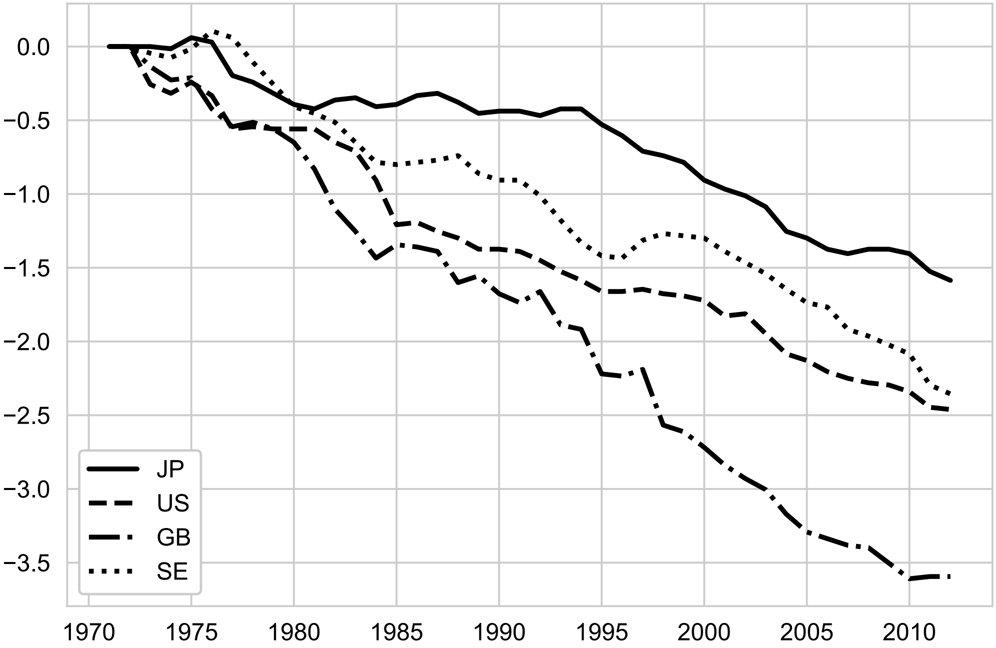
[30] Additionally, the shock exposure we study – which partly drives covariance in house prices across region – also positively covaries.

[31] Importantly, we capture only the partial decline attributable to the reduction in manufacturing share. In certain periods, this decline was dominated by other sources of volatility. Most notably, house price volatility increased sharply in the U.S., U.K., and Sweden around the Great Recession. It also increased in Sweden during the early 1990s.

[32] For each country, we use the U.S. Bureau of Labor Statistics' "Percent of Employment in Manufacturing" series.



Notes: This plot shows the simulated partial declines in house price volatility for Japan, the United States, the United Kingdom, and Sweden since 1970. Each series is constructed using the manufacturing employment share for each country, computed by the U.S. Bureau of Labor Statistics, as well as the estimated relationship between employment share change and house price volatility for Sweden. Note that this captures only the partial contribution of manufacturing share to house price volatility and should not be interpreted as a total volatility series. Notably, there are increases in house price volatility around the Great Recession that are unrelated to exposure to regional microeconomic shocks and, thus, are not included in the simulation. There was also a substantial increase in house price volatility in Sweden in the 1990s that was unrelated to movements in manufacturing's share.

Fig. 4. Impact of manufacturing share decline on house price volatility (ppts).

We also examine the implications of our results for the national-level manufacturing share declines that have occurred in high income countries since the 1970s. Our results suggest that the manufacturing share decline could explain part of the reduction in house price growth volatility during the Great Moderation. In particular, the 16 ppt reduction in Sweden's manufacturing since 1970 could account for a 2.4 ppt (35%) decline in house price growth volatility. Similarly, the 17.5 ppt decline in manufacturing share in the U.S. since 1970 would account for a 2.5 ppt decline in house price growth volatility. It would also account for volatility reductions of 3.6 ppt in the U.K. and 1.6 ppt in Japan. This has welfare implications because house price volatility induces individual consumption volatility. This can happen through several channels, including binding collateral constraints and the housing wealth effect on consumption. House price volatility is particularly important because housing is the dominant asset for a large share of the population (Kuhn et al., 2018).

Finally, note that we focus on manufacturing for two reasons. First, in most high income countries, manufacturing shares have exhibited a downward trend since at least the 1970s. Thus, obtaining clean estimates of the impact of a manufacturing share decline using microdata could also be useful for explaining long-term macroeconomic trends. Second, the only other comparably volatile sector is finance, which is small and narrowly concentrated geographically, making it impossible to conduct a comparable exercise. It is, however, possible that a more granular decomposition of sectors into narrower classifications could provide an interesting extension. Declining public sector employment, for example, might have the opposite effect, increasing housing capital gains volatility. However, we leave these questions to future work.

Appendix A. Supplementary material

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.red.2021.06.005.

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