The Missing Internal Devaluation: Nominal and Real Adjustment to the Great Recession within the US*

Giancarlo Corsetti
Cambridge and CEPR

Luca Dedola
European Central Bank and CEPR

Riccardo Trezzi
Federal Reserve Board

Preliminary, May 2017. Not for quote.

*We thank for comments, without implicating, our discussant Omar Rachedi, the participants at the 2017 ESSIM conference, and the participants to the applied micro seminar at the Board of Governord of the Federal Reserve. We thank for superb research assistance Emily Massaro and Giuseppe Floccari. Giancarlo Corsetti acknowledges the generous support of the Centre For Macroeconomics and the Horizon 2020 ADEMU. **The views expressed in this paper are our own, and do not reflect those of the European Central Bank or its Executive Board, the Board of Governors of the Federal Reserve System or any institution to which we are affiliated.**

Abstract

Adjustment in relative prices and wages in response to asymmetric shocks is a key rebalancing mechanism to ensure full employment and macroeconomic stability across regions sharing the same currency. Adjustment through "internal devaluation" rests on a stable link between wage and price inflation, and measures of slack in labor and product regional markets, namely, on stable regional Phillips curves. In this paper we carry out a systematic analysis of price, wage and employment adjustment across US jurisdictions in response to the housing price cycle during the Great Recession. Relative to previous contributions, we offer a detailed decomposition of real exchange rate adjustment distinguishing goods, services and distribution, construction and housing rents, at the disaggregated level of US Metropolitan Statistical Areas (MSAs). For component of the real exchange rate, we are able to relate relative price adjustment to relative sectoral wages (cost) and employment (slack) dynamics. We document that, across US MSAs, real exchange rates (by definition, the relative price of consumption goods and services) does not depreciate in response to asymmetric (and large) negative shocks to housing prices. The relative price of services actually rises with a fall in housing prices, while wages move little in the sector, in spite of large contractions in sectoral employment. This evidence can be reconciled with standard Phillips Curve models if firms' exit during recessions brings about a rise in monopoly power. However, at odds with this interpretation, we find that sectoral labor shares, inversely related to markups, do not significantly respond to housing price cycles.

"*Suppose that a vast housing boom leads to full employment and rising wages in part, but only part, of a currency area, then goes bust. The legacy of those boomtime wage increases will be an uncompetitive tradable sector, and hence the need to get at least relative wages down again.*" (Krugman 2012)

1 Introduction

According to standard theory, adjustment in relative prices and wages in response to asymmetric (supply and demand) shocks is a key rebalancing mechanism in a currency area. Without the option to rely on nominal exchange rate flexibility, "internal devaluation" can nonetheless ensure full employment and macroeconomic stability across states, regions and sub regional areas. Not surprisingly, the topic has become a core issue in the policy debate in the euro area, whereas insufficient relative price (i.e. real exchange rate) adjustment has been singled out as a primary cause for persistent unemployment and macroeconomic underperfomance in some countries. But internal devaluation is not just of interest for academic and policy studies of monetary unions. From a theoretical perspective, the mechanism rests on the tenet that there exists a stable link between wage and price inflation and measures of slack in labor and product markets. In other words, there are well-defined wage and price Phillips curves not only at aggregate level, but also at disaggregated, state and regional, level. In this sense, understanding internal devaluation can provide valuable insight on a defining issue in macroeconomics.

Indeed, several recent contributions have argued that regional business cycles can shed new light on the amplification forces of aggregate fluctuations (see, e.g., Nakamura Steinsson (2014) on fiscal multipliers, Beraja, Hurst and Ospina (2016) on wage Phillips curves, going back to the seminal paper by Blanchard and Katz (1992)). Boom and bust episodes are natural candidates for empirical work on the issue. Mian, Rao and Sufi (2013), Mian and Sufi (2014), Kaplan, Mitman and Violante (2016), among others, have shown that the local housing price bust in the US over the period 2007-2011 have been associated with asymmetric fluctuations in demand and employment. A number of contributions have provided evidence on wages and prices in the wake of large and asymmetric housing shocks, studying adjustment in overall regional nominal wages (Mian and Sufi (2014) and Beraja et al. (2016)), or tracing the response of local store-level sale prices (see, e.g., Kaplan et al. (2016) and Stroebl and Vavra (2014)).

In this paper we contribute to this literature by carrying out a systematic analysis of the evidence on adjustment in prices, costs and economic activity across US jurisdictions in response to the housing price cycle during the Great Recession. Relative to previous contributions, we offer a rich decomposition of real exchange rate adjustment across locations within the US, looking not only at the relative price of overall consumption, but also at sectoral relative prices, distinguishing between goods and services. We further relate sectoral relative price adjustment to its determinants in terms of relative sectoral costs and activity dynamics. To do so, we exploit the dataset of regional consumer price levels, the BEA Regional Price Parity data, combined with regional measures of sectoral costs and activity. To disentangle the effects of housing price shocks on the variables of interest, we focus on the geographical disaggregation of US Metropolitan Statistical Areas (henceforth MSAs). These areas can be thought of as very small open economies, fully integrated in the US national goods and financial markets. Given that trading frictions in these markets are relatively contained, MSAs provide an ideal laboratory to look at the adjustment mechanism through relative wages and prices in an integrated currency area.

To set the stage for our analysis, Figure 1 plots, for the 26 largest MSAs, the weigthed sum of the rate of inflation in goods and services against the change in the value of housing at MSA level, between 2007 and 2011. In the figure, there is no apparent relation between the intensity of the housing bust and inflation at MSA level (see the figure for the details on the calculation). Our econometric work for an extended sample of MSAs will corroborate the same message. We will show that, based on comprehensive measures of relative prices, there is no internal devaluation (i.e., a relative fall in the overall price level) in the areas suffering the deepest contraction in demand, as measured by the deepest fall in housing prices. However, this lack of overall adjustment in the real exchange rate in response to localized demand shocks masks significant heterogeneity in the response of relative prices of goods and services. Specifically, we find that, when housing prices fall, the relative price of goods falls somewhat, but not significantly so; conversely, the relative price of services rises significantly.

Vis-à-vis these results, we document large responses in employment in the service and distribution sectors, but not in goods producing industries (essentially manufacturing). In this respect, it is worth stressing that the local demand for goods falls on a composite of (nationally traded) manufacturing goods and (locally produced) distribution services (in the retail and wholesale trade sectors). Similarly to Mian and Sufi (2014), we find that a local housing price bust only depresses the demands for local goods, and thus employment in distribution and other services. Because manufacturing is highly tradable, there is no differential local demand effect on this sector employment.

In principle our evidence could be reconciled with textbook macroeconomic models of the Phillips curve, if marginal costs and markups adjust differently across sectors. However, our evidence turns out to be puzzling in both respects. In our sectoral measure of wages, we consistently find lack of significant adjustment in manufacturing, services and distribution, and even in the construction sector. Overall, the rise in the relative price of services is also at odds with established evidence on regional wage adjustment, pointing to little correlation (e.g. Mian and Sufi (2014)) or even positive correlation of wages with housing prices (see e.g. Beraja et al. 2016). By the same token, we document that, across all sectors, the response of labor shares (inversely related to markups) to housing prices is insignificant, while the correlation between the number of firms (and establishments) with housing prices is actually positive. This is evidence at odds with interpretations stressing heterogeneous markup adjustment and competitiveness effects—and with the findings in Stroebl and Vavra (2014) of a positive correlation between markups and housing prices based on store-level sales prices.

Taken together, we dub these pieces of evidence the missing internal devaluation puzzle: in facilitating adjustment to local demand shocks, the role played by relative prices appears to be tenous at best at the level of the overall price of consumption. Adjustment has actually worked the wrong way in services. Paradoxically, this is a sector in which, due to a relatively high share of nontradable production, internal devaluation could be expected to be more pronounced. Our findings thus add an important regional dimension to the so-called missing disinflation puzzle, the apparent lack of a connection between the high level of slack and subdued wage and price inflation in the US (and many advanced countries) during the Great Recession of 2008 (see e.g. Williams (2010), IMF 2013 and Ball and Mazumer 2011).[1]

[1] "The surprise [about inflation] is that it's fallen so little, given the depth and duration of the recent downturn. Based on the experience of past severe recessions, I would have expected inflation to fall by twice as much as it has." (John Williams, 2010."Sailing into

We proceed as follows. To establish our main results, in line with Stroebel and Vavra (2014), we run OLS and IV panel estimation at the MSA level, regressing local prices and activity on local housing prices. Since we adopt a panel approach, in the IV specification, we follow Aladangady (AER, forthcoming) and use as instruments housing supply elasticities from Saiz (2010) interacted with the aggregate 10 year US interest rate. The BEA RPP dataset provides consumer prices and their sub-components for goods, services and market rents: we aggregate employment and wages across industries to match as close as possible their price counterparts. It is worth emphasizing that, as a result, our aggregation is different (and more inclusive) than Mian and Sufi (2014). In conducting these exercises, we provide novel evidence that MSA unemployment is negatively correlated with asymmetric housing price shocks. Moreover, using data for the largest MSAs (underlying Figure 1) to extend the sample back to the 1980s, we show that our main results are not specific to the recent housing boom and bust. Namely, for the pre-2007 period, we find that housing price shocks are negatively correlated with service prices.

In a series of robustness exercises, we replicate with our publicly available data the findings by Mian and Sufi (2014) on the effects of housing prices on population, sectoral employment and wages across MSAs—this is similar to what Kaplan et al. (2016) do with respect to the findings by Mian, Rao and Sufi (2013) on local consumption. We confirm that in those MSAs where the housing price bust in 2007-2011 was more pronounced, employment also fell relatively more not only in the construction sector, but also in the nontradable sector as defined by Mian and Sufi (2014). Conversely, employment in the tradable sector (also as defined by these authors) was not affected differentially. We also confirm that overall population, as well as nominal and real wages in the tradable and nontradable sectors (and even in construction) were uncorrelated with asymmetric housing price shocks — Mian and Sufi (2014) do not distinguish wage dynamics across sectors.

This paper is organized as follows. In section 2 we will draw on a simple multi-sector model and open-economy macro to derive a theoretical framework linking internal devaluation to Phillips Curves theory. In sections 3 and 4, we present our empirical model and describe our data in detail. In section 5 we present and discuss our main results. Section 6 concludes deriving some

Headwinds: The Uncertain Outlook for the U.S. Economy') implications for policy and further research.

2 Internal devaluation and relative Phillips Curves

To shed light on the economics and drivers of internal devaluation, in this section we discuss the theoretical underpinning of the real exchange rate across states and regions sharing the same currency. Our starting point is the definition of the real exchange rate across two locations l as the relative price of consumption in the two locations. Since the consumption bundle includes both tradables and nontradables, or, from a different perspective, goods and services, we can naturally perform decompositions of the real exchange rate along one of these lines. To wit, the following is a decomposition of the (log) real exchange rate (ex-rents) for location l as a function of the relative price of goods $(p^l_{G,t} - p_{G,t})$ and services $(p^l_{S,t} - p_{S,t})$ relative to the overall currency area:

$$q^l_t = (1 - \alpha_S)\left(p^l_{G,t} - p_{G,t}\right) + \alpha_S\left(p^l_{S,t} - p_{S,t}\right), \tag{1}$$

where α_S is the share of services, for simplicity assumed to be the same for all l. The price of goods at consumer level can be further decomposed as a combination of the price of (tradable) manufacturing $p^l_{T,t}$, and the price of (nontradable) distribution services, $p^l_{NT,t}$, required to bring the goods to consumers (see Burstein, Neves and Rebelo (2003); Corsetti and Dedola (2005)), namely:

$$p^l_{G,t} = (1 - \delta)\, p^l_{T,t} + \delta p^l_{NT,t}, \tag{2}$$

where δ is the distribution share. For future reference, define the relative price of goods, tradable manufacturing, services and distribution as, respectively, $\widehat{\mathcal{T}}^l_{G,t} = \left(p^l_{G,t} - p_{G,t}\right)$, $\widehat{\mathcal{T}}^l_{T,t} = \left(p^l_{T,t} - p_{T,t}\right)$, $\widehat{\mathcal{T}}^l_{S,t} = \left(p^l_{S,t} - p_{S,t}\right)$ and $\widehat{\mathcal{T}}^l_{N,t} = \left(p^l_{NT,t} - p_{NT,t}\right)$.

In order to link these relative prices to their determinants, we rely on standard New Keynesian Phillips Curve theory (see e.g., Galí 2014). We start by writing inflation in sector $j = T, N, S$ in location l, $\pi^l_{j,t} = p^l_{j,t} - p^l_{j,t-1}$ as a function of expected inflation and current *real* marginal costs (in terms of the aggregate price level p_t) $\widehat{mc}^l_{j,t}$:

$$\pi^l_{j,t} = \beta E_t \pi^l_{j,t+1} + \kappa^l_j\left[\widehat{mc}^l_{j,t} - \left(p^l_{j,t} - p_t\right) + \widehat{\mu}^l_{j,t}\right], \tag{3}$$

where $\widehat{\mu}^l_{j,t}$ is an unobservable component in markup or marginal cost.

For each sector j, we then express local inflation as the differential from the Phillips Curve for aggregate inflation in the same sector $\pi_{j,t}$

$$\pi^l_{j,t} - \pi_{j,t} = \beta E_t \left(\pi^l_{j,t+1} - \pi_{j,t+1}\right) + \kappa^l_j \left[\widehat{mc}^l_{j,t} - \widehat{\mathcal{T}}^l_{j,t} - \widehat{mc}_{j,t} + \widehat{\mu}^l_{j,t} - \widehat{\mu}_{j,t}\right] + \left(\kappa^l_j - \kappa_j\right)\left[\widehat{mc}_{j,t} + \widehat{\mu}_{j,t}\right]. \tag{4}$$

This expression establishes that, for each sector j, inflation differentials across locations are given by the discounted sum of (i) the expected differential in the real marginal cost in terms of the aggregate price level $\left(\widehat{mc}^l_{j,t+s} - \widehat{\mathcal{T}}^l_{j,t+s} - \widehat{mc}_{j,t+s}\right)$, (ii) the expected differential in the markups $\left(\widehat{\mu}^l_{j,t+s} - \widehat{\mu}_{j,t+s}\right)$, and (iii) the differential in the slope of the Phillips curve $\left(\kappa^l_j - \kappa_j\right)\left(\widehat{mc}_{j,t+s} + \widehat{\mu}_{j,t+s}\right)$:

$$\pi^l_{j,t} - \pi_{j,t} = \kappa^l_j \sum_{s=0}^{\infty} \beta^s E_t \left[\left(\widehat{mc}^l_{j,t+s} - \widehat{\mathcal{T}}^l_{j,t+s} - \widehat{mc}_{j,t+s}\right) + \left(\widehat{\mu}^l_{j,t+s} - \widehat{\mu}_{j,t+s}\right)\right] + \left(\kappa^l_j - \kappa_j\right) \sum_{s=0}^{\infty} \beta^s E_t \left[\widehat{mc}_{j,t+s} + \widehat{\mu}_{j,t+s}\right]. \tag{5}$$

For a given slope of the curve, conditional on a fall in housing prices affecting demand, a negative inflation differential (causing real depreciation) would result from either lower relative marginal costs or higher markups.

It is instructive to solve directly for the relative price $\widehat{\mathcal{T}}^l_{j,t}$:

$$\widehat{\mathcal{T}}^l_{j,t} - \widehat{\mathcal{T}}^l_{j,t-1} = \beta E_t \left(\widehat{\mathcal{T}}^l_{j,t+1} - \widehat{\mathcal{T}}^l_{j,t}\right) + \kappa^l_j \left[\widehat{mc}^l_{j,t} - \widehat{\mathcal{T}}^l_{j,t} - \widehat{mc}_{j,t} + \widehat{\mu}^l_{j,t} - \widehat{\mu}_t\right] + \left(\kappa^l_j - \kappa_j\right)\left[\widehat{mc}_t + \widehat{\mu}_t\right];$$

this is an expectational second order difference equation in the price level:

$$\beta E_t \left(\widehat{\mathcal{T}}^l_{j,t+1} - \widehat{\mathcal{T}}^l_{j,t}\right) - \left(\widehat{\mathcal{T}}^l_{j,t} - \widehat{\mathcal{T}}^l_{j,t-1}\right) - \kappa^l_j \widehat{\mathcal{T}}^l_{j,t} = -\kappa^l_j \left[\widehat{MC}^l_{j,t} - \widehat{MC}_{j,t} + \widehat{\mu}^l_{j,t} - \widehat{\mu}_t\right] - \left(\kappa^l_j - \kappa_j\right)\left[\widehat{mc}_t + \widehat{\mu}_t\right],$$

where now $\widehat{MC}^l_{j,t} - \widehat{MC}_{j,t}$ is the marginal cost differential in *nominal* terms.

The above equation has the following general solution:

$$\widehat{\mathcal{T}}^l_{j,t} = \nu_1 \widehat{\mathcal{T}}^l_{j,t-1} + \kappa^l_j \sum_{s=0}^{\infty} \nu_2^{-s-1} E_t \left[\left(\widehat{MC}^l_{j,t+s} - \widehat{MC}_{j,t+s} \right) + \left(\widehat{\mu}^l_{j,t+s} - \widehat{\mu}_{j,t+s} \right) \right] + \tag{6}$$

$$\left(\kappa^l_j - \kappa_j \right) \sum_{s=0}^{\infty} \nu_{j,2}^{-s-1} E_t \left[\widehat{mc}_{j,t+s} + \widehat{\mu}_{j,t+s} \right]$$

where $0 < \nu_1 < 1 < \beta^{-1} < \nu_2$ solve the standard characteristic equation:

$$\beta \nu^2 - \left[1 + \beta + \kappa^l_j \right] \nu + 1 = 0,$$

namely:

$$\nu_{1,2} = \frac{1 + \beta + \kappa^l_j \pm \sqrt{\left[1 + \beta + \kappa^l_j \right]^2 - 4\beta}}{2\beta}.$$

The equation for $\widehat{\mathcal{T}}^l_{j,t}$ is at the heart of the adjustment mechanism based on "internal devaluation". Asymmetric shocks affecting relative *nominal* marginal costs will be absorbed through movements in relative prices, with a speed inversely related to the slope of the local and sector specific Phillips curve κ^l_j (the larger κ^l_j the closer ν_1 to zero). To the extent that the PC slope differential is uncorrelated with housing prices, a depreciation in the relative price $\widehat{\mathcal{T}}^l_{j,t}$ conditional on an asymmetric bust in housing prices results from conditionally lower relative *nominal* marginal costs and/or markups. It is also possible, however, that the slope may respond to local cyclical conditions and become correlated with housing prices across jurisdictions. In this case, it would be reasonable to expect a steeper curve $\left(\kappa^l_j > \kappa_j \right)$, i.e., more price responsiveness, in areas where the recessionary shock is larger. This would reinforce the hypothesis that local shocks should be associated with re-equilibrating relative price adjustment, as relative prices become more sensitive to local costs and markups.

Assuming that nominal wages are a good proxy for nominal marginal costs, the testable implication is that appreciation in the relative price $\widehat{\mathcal{T}}^l_{j,t} = \left(p^l_{j,t} - p_{j,t} \right)$ can result from an expected increase in relative nominal wages. Indeed, the bulk of the literature on the NKPC assumes that nominal marginal costs are equal to nominal wages $(w^l_{j,t})$ adjusted by the nominal marginal product of labor $(MPL^l_{j,t})$:

$$\widehat{MC}^l_{j,t} = w^l_{j,t} - MPL^l_{j,t}.$$

In turn, the latter is assumed to be a function of measures of the "employment gap," namely, deviations of employment from its flexible-price (potential) level; the exact relation can also account for the presence of nominal wage rigidities (see e.g., Galí textbook and Beraja et al. 2016 for a regional application). For instance, with a production function using only labor H_j^l, $Y_j^l = A_j^l \left(H_j^l\right)^{\alpha_j}$, we have the following expression for nominal marginal costs:

$$\widehat{MC}_{j,t}^{l} = w_{j,t}^{l} - \frac{1}{\alpha_j} a_{j,t}^{l} + \frac{1-\alpha_j}{\alpha_j} y_{j,t}^{l} = w_{j,t}^{l} - \left(y_{j,t}^{l} - h_{j,t}^{l}\right),$$

where the last term on the right hand side is the unit labor costs. When the production function is the same across jurisdictions l, the differential in nominal marginal costs can then be expressed as the differential in unit labor costs:

$$\widehat{MC}_{j,t}^{l} - \widehat{MC}_{j,t} = \left(w_{j,t}^{l} + h_{j,t}^{l} - y_{j,t}^{l}\right) - \left(w_{j,t} + h_{j,t} - y_{j,t}\right).$$

It is worth stressing that the same expression arises if the production function includes the same proportion of intermediate inputs with the same price across locations, i.e., $Y_j^l = A_j^l \left(H_j^l\right)^{\alpha_j} \left(X_j^l\right)^{1-\alpha_j}$. How would a demand shock driven by local housing prices affect marginal costs? Clearly, local demand shocks would impinge on the demand for labor and on the wage.

In our empirical analysis we will rely on evidence on the adjustment of total unit labor costs across MSAs, because we lack data on real sectoral GDP. However, since we have sectoral data on nominal GDP and labor compensation, we can compute labor shares which, under the same prior assumptions, are proportional to the inverse of overall markups:

$$Markup_j^l = \frac{P_j^l}{W_j^l / \left(\alpha_j Y_j^l / H_j^l\right)} = \alpha_j \left(\frac{W_j^l H_j^l}{P_j^l Y_j^l}\right)^{-1}.$$

Therefore, looking at relative labor shares we can gauge evidence on markup adjustment; under sticky prices, relative markups should be countercyclical in response to local demand fluctuations driven by housing prices.

As a final remark, it is worth stressing that market rents, being directly related to housing market prices, are unlikely to obey a Phillips Curve relationship (in their dynamics and determinants) of the kind we use for goods and services. This will be a key maintained assumption throughout our study, implying that an assessment of internal devaluation as adjustment mechanism should be based on movements of the real exchange rates not driven by adjustment in rents.

2.1 From Theory to the Empirical Framework

Under the assumption that the slope of the Phillips curve is the same across all locations, $\kappa_j^l = \kappa_j$,[2] the equilibrium solution for the relative price $\widehat{\mathcal{T}}_{j,t}^l$ simplifies as follows,

$$\widehat{\mathcal{T}}_{j,t}^l = \nu_{j1}\widehat{\mathcal{T}}_{j,t-1}^l + \kappa_j\left[\overline{\mathcal{MC}}_{j,t}^l + \overline{\mu}_{j,t}^l\right]$$

where we have defined

$$\overline{\mathcal{MC}}_{j,t}^l = \sum_{s=0}^{\infty} \nu_{j2}^{-s-1} E_t\left(\widehat{MC}_{j,t+s}^l - \widehat{MC}_{j,t+s}\right)$$
$$\overline{\mu}_{j,t}^l = \sum_{s=0}^{\infty} \nu_{j2}^{-s-1} E_t\left(\widehat{\mu}_{j,t+s}^l - \widehat{\mu}_{j,t+s}\right),$$

and now the coefficients ν_{j1}, ν_{j2} are explicitly recognized as sector specific. The equation for $\widehat{\mathcal{T}}_{j,t}^l$ cannot be directly estimated as the term $\left[\overline{\mathcal{MC}}_{j,t}^l + \overline{\mu}_{j,t}^l\right]$ is unobservable. However, under the assumption that the term $\left[\overline{\mathcal{MC}}_{j,t}^l + \overline{\mu}_{j,t}^l\right]$ is a linear function of some state variables s_{t-1} and current structural shocks ε_t

$$\left[\overline{\mathcal{MC}}_{j,t}^l + \overline{\mu}_{j,t}^l\right] = \phi_0^l + \phi_1^{l\prime} s_{t-1} + \phi_2^{\prime}\varepsilon_t,$$

where ε_t includes the demand shock ε_t^d, and that

$$\varepsilon_t^d = \delta_{j,0}^l + \delta_{j,1} hp_t^l + u_{jt},$$

where $\delta_{j,1} \neq 0$, and by definition $E\left(u_{jt}\left|hp_t^l\right.\right) = 0$, we can derive the following panel regression model linking the sectoral relative price $\widehat{\mathcal{T}}_{j,t}^l$ to the (log) level of housing prices in location l :

$$\widehat{\mathcal{T}}_{j,t}^l = \nu_{j1}\widehat{\mathcal{T}}_{j,t-1}^l + \widetilde{\phi}_0^l + \kappa_j \phi_2^d \delta_1 hp_t^l + \eta_t$$

[2] Unfortunately the limited time series dimension of our dataset forces us to impose homogeneous slope coefficients across MSAs in our panel estimates.

This panel equation can yield a consistent estimate of the sector specific parameter $\widehat{\kappa_j \phi_2^d \delta_1}$ across locations if we have a set of MSA-specific instruments z_t^l for hp_t^l, uncorrelated with the (omitted) term $\nu_1 \widehat{\mathcal{T}}_{j,t-1}^l + \eta_t$, where η_t is a function of all the other shocks which potentially affect also housing prices. In the next section, we draw from the literature and propose instruments based on the housing supply elasticities from Saiz (2010).

3 Model specification

In our empirical investigation, we estimate the elasticity of local sectoral relative prices, costs, employment and activity to shocks to local house prices. Our empirical model follows closely Mian, Rao and Sufi (2013), Mian and Sufi (2014) and Stroebl and Vavra (2014). All regressions are run at the MSA level of geographical disaggregation. We run an ordinary least squares (OLS) specification and an instrumental variable (IV) one. Our baseline strategy consists of regressing the log-level of the dependent variable on the log-level of local house prices, controlling for other MSA observables.

Our OLS regression specification can be formally expressed as:

$$y_{l,t} = \alpha_l + \gamma_t + \beta \cdot hp_{l,t} + \theta X_{l,t} + \varepsilon_{l,t}, \tag{7}$$

where $y_{l,t}$ is the log of the dependent variable in the MSA l in year t, α_l and γ_t are MSAs and years fixed effects respectively, $hp_{l,t}$ is the MSA log of house prices, $X_{l,t}$ is a matrix of demographic controls, and $\varepsilon_{l,t}$ is an error term. In our main analysis, the dependent variables are the log of MSA consumer price levels $p_{j,t}^l$, in each sector $j = G, S, NT$; the log of nominal (and real consumption) wages $w_{j,t}^l$, again for each sector $j = G, S, NT$, and the log of sectoral employment, number of firms and establishments, and labor shares. We also look at additional variables, including population, unemployment and unit labor costs at MSA level, and we use our data to reproduce the estimates for the same sectoral aggregations in Mian and Sufi (2014). Because we include the time fixed effects γ_t, the coefficient of interest β yields the elasticity of $y_{l,t}$ to $hp_{l,t}$ in deviations from their cross-sectional means. By way of example, when the dependent variable is $p_{j,t}^l$, β can be effectively interpreted as the elasticity of the relative price $\widehat{\mathcal{T}}_{j,t}^l = \left(p_{j,t}^l - p_{j,t}\right)$ to $hp_{l,t} - hp_t$, or as an estimate of $\widehat{\kappa_j \delta_1}$.

In order to address possible endogeneity issues in using $hp_{l,t}$, e.g., due to omitting $\widehat{\mathcal{T}}^{l}_{j,t-1}$ from the regression for relative prices, we rely on an instrumental variable model, closely following Mian and Sufi (2014) and Stroebl and Vavra (2014).[3] As discussed by these authors, housing prices respond to both demand and supply shocks—to the extent that supply shocks also affect our variable of interest, they confound the transmission of demand movements (see a formal derivation in Stroebl and Vavra (2014)). The solution consists of instrumenting $hp_{l,t}$ using the estimates of housing supply elasticities from Saiz (2010) interacted with a time-varying variable, the 10-year US interest rate, as in Aladangady (AER, forthcoming). The Saiz (2010) instrument is available at the MSA level, but not necessarily for every MSA. For consistency, we report our OLS and IV estimates for the same set of MSAs, the one covered by Saiz (2010). Our OLS results are nonetheless insensitive to extending the sample to all MSAs.

4 Data

Regional consumer price levels are from the BEA Regional Price Parity dataset; employment and payroll data are from the Census County Business Patterns (CBP) dataset while sectoral number of firms and establishments are from the Census SUSB; finally nominal GDP is from BEA. House prices are provided by at the zip code level by Core Logic. We use CBP data at the two-digit industry level in our benchmark analysis, as well as at the four-digit industry level when we compare our results with those in Mian and Sufi (2014).[4] In our benchmark analysis we classify industries into four categories (goods, services, distribution, and construction) in order to ensure comparability with the RPP price data. In replicating Mian and Sufi (2014), we place each of the four-digit industries into one of four categories: non-tradable, tradable, construction, and other.

Data for MSAs relative price parities, personal income, and nominal GDP are provided by the regional economic accounts of the BEA.[5] Personal income consists of the income that persons receive in return for their provision

[3] Stroebl and Vavra (2014) also includes some estimates with panel regressions like ours.

[4] County data at the four-digit industry level is at times suppressed for confidentiality reasons. However, in these situations the Census Bureau provides a "flag" that tells us of the range within which the employment number lies.

[5] All data are available at: https://www.bea.gov/regional/.

of labor, land, and capital used in current production as well as other income, such as personal current transfer receipts. It is calculated as the sum of wages and salaries, supplements to wages and salaries, proprietors' income with inventory valuation (IVA) and capital consumption adjustments (CCAdj), rental income of persons with capital consumption adjustment (CCAdj), personal dividend income, personal interest income, and personal current transfer receipts, less contributions for government social insurance plus the adjustment for residence. Real personal income is personal income at RPPs divided by the national PCE price index. It is estimated for states, state metro/nonmetro portions, metropolitan statistical areas, and the combined nonmetropolitan portion of the United States. Real per capita personal income is the real personal income divided by midyear population.

Gross domestic product (GDP) by metropolitan area is the measure of the market value of all final goods and services produced within a metropolitan area in a particular period of time. In concept, an industry's GDP by metropolitan area, referred to as the MSA "value added", is equivalent to its gross output (sales or receipts and other operating income, commodity taxes, and inventory change) minus its intermediate inputs (consumption of goods and services purchased from other U.S. industries or imported). GDP by metropolitan area is the metropolitan area counterpart of the nation's, BEA's featured measure of U.S. production.

Regional price parities (RPPs) are regional price levels expressed as a percentage of the overall national price level for a given year. The price levels (constructed using Personal Consumption Expenditure weights) are determined by the average prices paid by consumers for the mix of goods and services consumed in each region. Taking the ratio of RPPs shows the difference in price levels across regions. RPPs are estimated for states, state metro/nonmetro portions, metropolitan statistical areas, and the combined nonmetropolitan portion of the United States. Regional prices are provided disaggregating the Personal Consumption Expenditure categories in three items: goods, services excluding rents, and services rents. Goods refer to durable and nondurable consumption goods, including apparel, education, food and beverages, housing, medical goods, recreation, transportation, and other goods. Services excluding rents categories include education, food away from home, housing services (excluding rents), medical, recreation, transportation, and other services. Rents RPPs are estimated only for observed tenants' rents and do not include imputed owner-occupied rent values.

The RPP dataset covers 381 MSAs over the period 2008 - 2014. However, since the Saiz elasticity is available only for a subset of MSAs, we can effectively rely only on a sample of 224 MSAs. Moreover, for a number of these MSAs the BEA imputes the same price parities for goods and services (but not for rents prices, which are different across all 381 MSAs). Therefore, in our baseline analysis, we take a conservative approach and focus on the subset of the largest MSAs whose price parities for both goods and services are different from those of all other MSAs for at least two years over the period 2008-2011. Our baseline sample so includes only 77 MSAs—however, our main results are unchanged when we use the whole sample comprising 224 MSAs.

Finally, for the 26 MSAs with the largest population we were able to obtain longer time series for relative consumer prices and house values, starting in 1984. The source of the consumer prices for this complementary dataset is the BLS and the data refer to CPI inflation rates.[6]

5 Evidence on (the lack of) internal devaluation

In this section, we present and discuss our main findings. Based on the empirical model presented above, we will document the effects of housing price movements driving local demand on relative prices across MSAs. We do so by looking at the price of the overall consumption basket, the MSA equivalent of the real exchange rate for a country, as well as at its disaggregated component by sector and/or type of goods. Our main empirical results are shown in Tables 1 through 9 (further results are in the appendix).

[6]The list of the 26 MSAs includes: Chicago-Gary-Kenosha, IL-IN-WI (CMSA), Los Angeles-Riverside-Orange County, CA (CMSA), New York-Northern New Jersey-Long Island, NY-NJ-CT-PA (CMSA), Atlanta, GA (MSA), Boston-Brockton-Nashua, MA-NH-ME-CT (MSA), Cleveland-Akron, OH (CMSA), Dallas-Fort Worth, TX, Detroit-Ann Arbor-Flint, MI (CMSA), Houston-Galveston-Brazoria, TX (CMSA), Miami-Fort Lauderdale, FL (CMSA), Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD (CMSA), San Francisco-Oakland-San Jose, CA (CMSA), Seattle-Tacoma-Bremerton, WA (CMSA), Washington-Baltimore, DC-MD-VA-WV(CMSA), Anchorage, AK (MSA), Cincinnati-Hamilton, OH-KY-IN (CMSA), Denver-Boulder-Greeley, CO (CMSA), Honolulu, HI (MSA), Kansas City, MO-KS (MSA), Milwaukee-Racine, WI (CMSA), Minneapolis-St. Paul, MN-WI (MSA), Pittsburgh, PA (MSA), Portland-Salem, OR-WA (CMSA), St. Louis, MO-IL (MSA), San Diego, CA (MSA), Tampa-St. Petersburg-Clearwater, FL (MSA). All data are available at: https://www.bls.gov/cpi/cpifact8.htm.

Table 1 shows our key results. Asymmetric shocks to housing prices are positively (although not significantly) correlated with the relative price of consumption goods $\widehat{\mathcal{T}}^l_{G,t} = \left(p^l_{G,t} - p_{G,t}\right)$; but negatively and significantly correlated with the relative price of consumption services (ex-rent) $\widehat{\mathcal{T}}^l_{S,t} = \left(p^l_{S,t} - p_{S,t}\right)$. The elasticities from our IV estimates are equal to 0.06 and -0.11, respectively. Namely, the relative prices of goods and services appear to respond in different directions, possibly offsetting each other's effect on the overall real exchange rate. Indeed, the elasticity of the overall relative price of consumption (the MSA consumption real exchange rate) is small and insignificant, in both our OLS and IV estimates— relative market rents are positively but insignificantly correlated with housing price shocks, with an IV elasticity equal to 0.08.

These results are confirmed and refined in our sample including the 26 largest (most populous) MSAs, for which we also benefit from the availability of much longer time series (from 1984 on). Estimates are shown in Table 2, where we contrast the whole sample (upper panel), with the pre-crisis period (bottom panel). An apparent difference relative to our baseline sample is that the elasticity of rents, also positive, is now much larger and statistically significant—possibly reflecting the fact that rents are computed in a different way. In the sample of the largest MSA, the BLS includes imputed owner occupied rents, which are excluded in the BEA RPP dataset. In turn, the high elasticity of rents is the main driver of the elasticity of the overall CPI to housing prices, which is also higher than in our baseline, and statistically significant.

From Table 2, it is also apparent that our most puzzling result, a negative elasticity of services to housing prices, is not a feature specific to the recent bust, but holds even for the sample ending in 2006. In this pre-crisis sample, the IV estimate for services (excluding rents) is -0.15, similar the its OLS counterpart and somewhat smaller than the elasticity in the full sample. This finding is relevant also in relation to possible concerns that our results may reflect spurious correlations between trends in the prices of housing and services like health care—nonetheless, recall that we include time fixed effects in all our regressions, thus controlling for common trends. For goods prices, we confirm a positive relation that is generally not significant—it becomes statistically significant only for nondurables in the pre-crisis sample.

The response of sectoral employment to housing prices is shown in Table 3. Also this table is organized in two panels—the first uses our sectoral definitions, which matches closely the composition of the consumer price indices for goods and services; the second uses the less comprehensive sectoral definitions adopted by Mian and Sufi (2014), for comparative purposes. The elasticity of employment is high and statistically significant in the service and distribution sectors. In contrast, in the goods sector, both the OLS and the IV estimates are positive, but the IV estimates are insignificant and much lower than their OLS counterparts. Not surprisingly, the highest elasticity is for the construction sector.

These results are best appreciated in light of the fact that employment in the service sector mainly reflects local demand; employment in pure tradables mainly reflects national demand—and local demand falls on a composite of nationally traded goods and local distribution services. Similarly to Mian and Sufi (2014), we find that a local housing price bust only depresses demand for the local components of services and goods, and thus employment in services and distribution. Because goods production is highly tradable, there is no significant local demand effect on employment this sector.

Despite the strong employment elasticity documented in Table 3, the evidence in Table 4 and 5 point to little correlation between housing prices and nominal and real consumption wages (deflated with the overall RPP), respectively. In particular, the tables document lack of adjustment in wages across all sectors, with even negative, but insignificant, IV estimates for the goods, services and distribution sectors. Remarkably, the correlation is also insignificant in the construction sector—although the point estimates are positive in our IV estimates, and much larger (in absolute value) than the OLS point estimates (in some cases negative). The bottom panels of these tables confirm the results by Mian and Sufi (2014), using their definitions of tradables and non tradables (less comprehensive than ours)—though these authors do not distinguish wage dynamics across sectors.[7]

These results cast doubts on the possibility of reconciling the different relative price adjustment across sectors documented in Tables 1 and 2, with textbook macroeconomic models of the Phillips curve, by virtue of a different behavior of marginal costs at sectoral level. Wage elasticities are not significantly different across the goods and service sectors, and they have the same (negative) sign.

[7]Interestingly, the OLS estimates for wages in the narrowly defined nontradables are significantly *negative*, pointing to a perverse response of wages to the fall in employment in this sector.

In Table 6 we provide evidence on total nominal wages, unit labor costs (total compensation divided by real GDP), the total labor share (compensation divided by nominal GDP) and unemployment. Only the latter displays a significant and negative elasticity to housing price shocks; overall measures of costs are instead not significantly related to housing dynamics. The evidence in Table 7 complements the unemployment response in Table 3, showing that overall population was not correlated with housing shocks. Together, these two pieces of evidences rule out labor supply adjustment via migration—that could have offset the fall in local labor demand associated with falling local housing prices.

A last and important adjustment margin to consider is markups—whose role is stressed in recent work by Stroebl and Vavra (2014) based on store-level sales prices. We conclude this section by presenting two pieces of evidence that can shed light on the behavior of markups. First, in Table 8 and 9 we show the response to housing prices of the number of establishments and firms across sectors. A large reduction in this number—i.e. a large exit of firms from a sector—could be correlated to a decrease in competition and a relative increase in markups. In both tables, the correlation of net entry with housing prices is positive across all sectors. OLS and IV estimates tend to be very similar, though the latter are in general less statistically significant (only in the goods and distribution sectors in the case of establishments and in the goods and construction sectors in the case of firms). Strikingly, the IV estimates are not significant for the service sector. In this sense, the tables do not provide any (admittedly prima facie) evidence of strong competitiveness effects specific to this sector (that could be consistent with a relative increase in markups). In addition, following Stroebl and Vavra (2014), we also re-estimate the regressions in Table 1 controlling for the number of establishments. As shown in Table 11, our main results remain the same.

Second, we present evidence on a more direct measure of markups, namely, sectoral labor shares, which (as shown in Section 2) are inversely related to markups. Table 10 shows that labor shares are not strongly related to housing prices, with both OLS and especially IV estimates largely insignificant. Under the assumptions in Section 2, this finding, combined with the increase in the relative price of services, would be consistent with an increase in unit labor costs in services, reflecting a larger contraction in real output than in nominal labor compensation. Unfortunately the lack of local deflators for sectoral production does not allow us to provide independent evidence on this hypothesis at this stage.

To summarize the results in this section: Based on comprehensive data on prices at MSA level, we fail to find any convincing evidence of internal devaluation, i.e. adjustment in the overall price level, across MSAs, in the face of a large local demand shocks during the housing bust in 2007-2011. Moreover, we find that an important component of the overall relative price of consumption, the relative price of services, moves in the 'wrong' direction: it rises in response to a recessionary demand shock. The response of relative prices of services does not seem to be related to standard measures of costs, or markups (competitiveness). The behavior of this sector is especially puzzling, as one would expect that a relative large share of nontradability in production would make relative prices much more sensitive to local demand shocks than in the (tradable) good sector.

6 Concluding remarks

In this paper we have shown evidence that, across regions in US, there has been virtually no internal real eachange rate adjustment during the global crisis. Even when the housing bust in 2007-2011 created large local demand shocks, the relative price of consumption basket displays little movements at local level. Looking at the different component of this basket, adjustment tends to have the correct sign—a drop in demand causes relative prices to fall—for goods (although our estimates are mostly insignificant) but not for services.

The results from our econometric estimates are puzzling in light of macro and international theory, at both aggregate and disaggregated (by sector) level. According to conventional wisdom, the bulk of adjustment should fall in sectors with the largest incidence of nontradability in production. Consistently, we find that, besides construction, the elasticity of employment is highest in services and distribution. However, we also find that adjustment falls almost exclusively on employment. The relative price of services, if anything, exacerbates the adverse propagation of the shocks on the economic activity.

This evidence raises important issues in this European debate. In a mature currency area like the US, lack of real exchange rate adjustment, however puzzling, has prevented neither recovery at national level, nor rebalancing across states and regional convergence along the recovery. Conversely, in Europe, insufficient real exchange rate adjustment has been singled out as a major factor hampering recovery and keeping the countries in the periphery, worst hit by the crisis, in a persistent state of underemployment. Estimates of the real exchange rate depreciation required to restore full employment vary widely, often as high as 30 percent.

A key question is whether, similarly to the US, relative price changes may not be expected to be a key margin for employment adjustment across the euro area—a conclusion which would not be warranted given the evidence of an ongoing correction (whether or not deemed sufficient) in Europe. A conjecture consistent with the evidence is that the need for relative price adjustment could be stronger in monetary unions, like the euro area, which lack sufficiently developed institutions and adjustment mechanisms—e.g., a common fiscal and monetary policy targeting an appropriate macroeconomic stance at aggregate level, so to contain the persistence of recessions; fiscal transfers and market-based instruments enhancing risk sharing; a financial policy effective in containing the effects of systemic financial crisis and prevent disruptive economic and financial fragmentation.

References

[**1**] Aditya Aladangady. Housing Wealth and Consumption: Evidence from Geographically-linked Microdata. *American Economic Review, forthcoming.*

[**2**] Martin Beraja, Erik Hurst, and Juan Ospina. The Aggregate Implications of Regional Business Cycles. NBER Working Papers 21956, National Bureau of Economic Research, Inc, February 2016.

[**3**] Burstein Ariel, Joao Neves, and Sergio Rebelo, "Distribution Costs and Real Exchange Rate Dynamics During Exchange-Rate-Based Stabilizations". *Journal of Monetary Economics*, 50: 1189—1214, 2003.

[**4**] Olivier Jean Blanchard and Lawrence F. Katz. Regional Evolutions. *Brookings Papers on Economic Activity*, 23(1):1–76, 1992.

[**5**] Giancarlo Corsetti and Luca Dedola. A macroeconomic model of international price discrimination. *Journal of International Economics*, 67(1):129–155, September 2005.

[**6**] Jordi Galí. Introduction to Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework. In Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework, Introductory Chapters. Princeton University Press, 2008. URL: https://ideas.repec.org/h/pup/chapts/8654-1.html.

[**7**] Greg Kaplan, Kurt Mitman, and Giovanni L. Violante. Non-durable Consumption and Housing Net Worth in the Great Recession: Evidence from Easily Accessible Data. *NBER Working Papers* 22232, National Bureau of Economic Research, Inc, May 2016.

[**8**] Paul Krugman. Revenge of the Optimum Currency Area. In NBER Macroeconomics Annual 2012, Volume 27, NBER Chapters, pages 439–448. National Bureau of Economic Research, Inc, 2012.

[**9**] Atif Mian and Amir Sufi. What Explains the 2007–2009 Drop in Employment? *Econometrica*, 82:2197–2223, November 2014.

[**10**] Atif Mian, Kamalesh Rao, and Amir Sufi. Household Balance Sheets, Consumption, and the Economic Slump. *The Quarterly Journal of Economics*, 128(4):1687–1726, 2013.

[**11**] Emi Nakamura and John Steinsson. Fiscal Stimulus in a Monetary Union: Evidence from US Regions. *American Economic Review*, 104(3):753–92, March 2014.

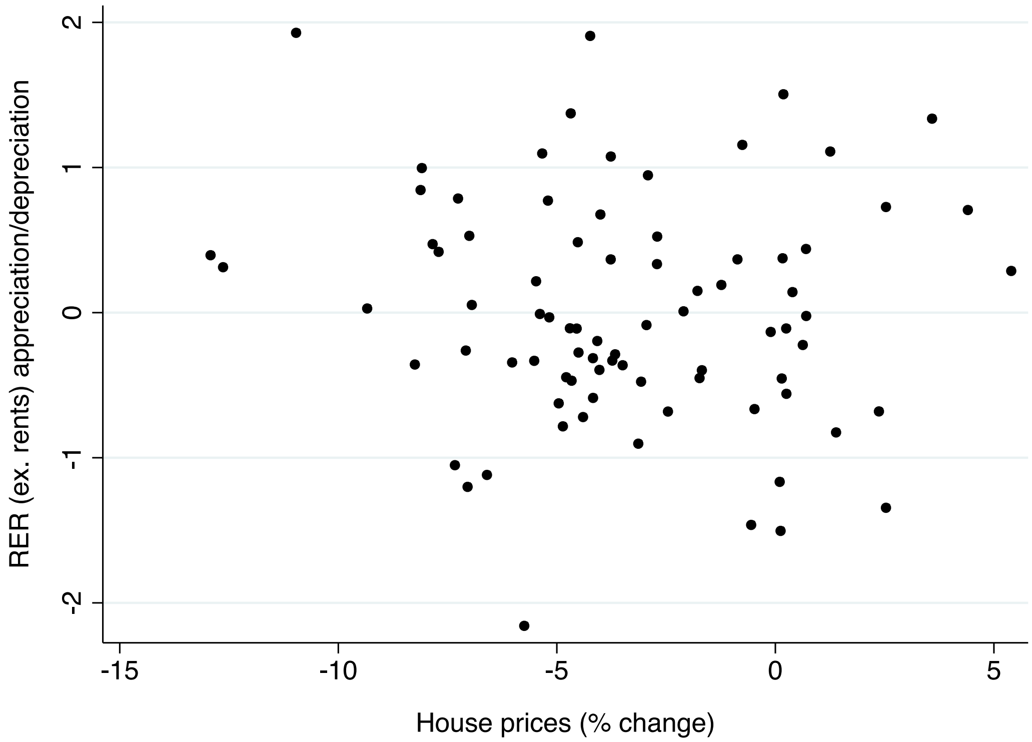
[**12**] Albert Saiz. The Geographic Determinants of Housing Supply. *The Quarterly Journal of Economics*, 125(3):1253–1296, 2010.

[**13**] Stephanie Schmitt-Grohé and Martín Uribe. Pegs, Downward Wage Rigidity, and Unemployment: The Role of Financial Structure. *NBER Working Papers* 18223, National Bureau of Economic Research, Inc, July 2012.

[**14**] Johannes Stroebel and Joseph Vavra. House Prices, Local Demand, and Retail Prices. *NBER Working Papers* 20710, National Bureau of Economic Research, Inc, November 2014.

Figures and Tables

Figure 1: Change in house prices and RER appreciation/depreciation.



Note: The above figure shows the correlation between CPI inflation rates at the MSA level and the change in local house prices. Each dot on the chart is an MSA in a given year. The figure refers to the 27 largest metropolitan areas in the US. The vertical axis plots the CPI inflation rate for all items less shelter (the RER excluding rents appreciation/depreciation) relative to the aggregate average (simple average of the 27 areas); the horizontal axis shows the percent change in house prices. The "CPI less rent of shelter" index has been calculated as an aggregate of (i) CPI services less rents of shelter, (ii) CPI of durable goods, and (iii) CPI of non durable goods. The weights of (i), (ii), and (iii) are assumed to be the same across MSAs and equal to 30.356, 9.250, and 27.133 respectively. **Source:** CPI indexes at MSA level are provided by the Bureau of Labor Statistics (available at: https://www.bls.gov/cex/csxmsa.htm). House prices data come from CoreLogic (available at: http://www.corelogic.com).

Table 1: Effect of house price change on Regional Price Parities (RPP).

	All		Goods		Services		Rents	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
[1em] Log House Prices	0.04	-0.01	0.02	0.06	0.02	-0.11	0.07	0.08
	[0.02]**	[0.04]	[0.02]	[0.04]	[0.03]	[0.06]*	[0.04]	[0.09]
[1em] Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	308	308	308	308	308	308	308	308
R^2	0.07	0.03	0.03	-0.01	0.05	-0.12	0.40	0.40

Standard errors in brackets

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

Note: robust standard errors are clustered by Metropolitan Statistical Area (MSA). "OLS" refers to Ordinary Least Squares. "IV" refers to Instrumental Variables. The above regressions refer to the time period 2008-2011. "Services" refers to services excluding rents. "Rents" refer to actual rents, excluding owners equivalent rents. The dependent variable is the log of Regional Price Parity (RPP) (for "All items", "Goods", "Services", and "Rents"). RPPs are calculated using PCE inflation definitions and weights. Regional price parities (RPPs) are regional price levels expressed as a percentage of the overall national price level for a given year. The price levels are determined by the average prices paid by consumers for the mix of goods and services consumed in each region. "House Prices" refers to the log of house price index in each MSA. All regressions include time and MSA fixed effects, and a set of demographics controls. In the IV the instrument is based on the estimates of housing supply elasticities from Saiz (2010) interacted with a time-varying variable, the 10-year US interest rate. **Source:** RPPs data come from the BEA regional economic account dataset (available at: https://www.bea.gov/regional/). House prices data come from CoreLogic (available at: http://www.corelogic.com).

Table 2: Effect of house price change on local prices.

Full sample

	All		Durables		Non durables		Rents		Services	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
House Prices	0.11	0.29	0.05	0.17	0.02	0.06	0.26	0.60	-0.13	-0.27
	[0.01]***	[0.05]***	[0.05]	[0.17]	[0.02]	[0.06]	[0.03]***	[0.08]***	[0.02]***	[0.07]***
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	793	731	792	730	792	730	792	730	792	730
R^2	0.99	-	0.67	-	0.99	-	0.98	-	0.57	-

Pre-2006

	All		Durables		Non durables		Rents		Services	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
House Prices	0.10	0.26	0.05	0.21	0.03	0.11	0.23	0.50	-0.12	-0.15
	[0.02]***	[0.06]***	[0.04]	[0.18]	[0.01]**	[0.06]*	[0.03]***	[0.09]***	[0.02]***	[0.08]*
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	577	531	576	530	576	530	576	530	576	530
R^2	0.99	-	0.76	-	0.99	-	0.97	-	0.63	-

Note: robust standard errors clustered by Metropolitan Statistical Area (MSA) in brackets. "OLS" refers to Ordinary Least Squares. "IV" refers to Instrumental Variables. "D" refers to durable goods. "ND" refers to non-durable goods. "Rents" refers to actual plus owner equivalent rents. The upper panel refers to the period 1984-2011; the bottom panel refers to the pre-2006 period. The dependent variable is the log of MSAs CPI indexes. "House Prices" refers to the log of house price index in each MSA. All regressions include time and MSA fixed effects, and a set of demographics controls. **Source:** CPI indexes at MSA level are provided by the Bureau of Labor Statistics (available at: https://www.bls.gov/cex/csxmsa.htm). House prices data come from CoreLogic (available at: http://www.corelogic.com).

Table 3: Effect of house price change on change in local employment (2-digit level) .

	Goods		Services		Distribution		Construction	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
House Prices	0.30	0.09	0.16	0.26	0.17	0.43	0.96	1.35
	[0.12]**	[0.30]	[0.05]***	[0.13]**	[0.03]***	[0.09]***	[0.13]***	[0.33]***
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	303	303	303	303	303	303	303	303
R^2	0.81	-	0.37	-	0.83	-	0.87	-

	Tradable		Non Tradable		Construction		Other	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
House Prices	0.31	0.09	0.19	0.44	0.96	1.35	0.13	0.22
	[0.12]**	[0.31]	[0.05]***	[0.11]***	[0.13]***	[0.33]***	[0.05]***	[0.12]*
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	303	303	303	303	303	303	303	303
R^2	0.80	-	0.61	-	0.87	-	0.31	-

Standard errors in brackets

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

Note: robust standard errors clustered by Metropolitan Statistical Area (MSA) in brackets. “OLS” refers to Ordinary Least Squares. “IV” refers to Instrumental Variables. The above regressions refer to the time period 2008-2011. The dependent variable is the log of MSAs employment (at 2-digit NAICS level of disaggregation). “House Prices” refers to the log of house price. All regressions include time and MSA fixed effects, and a set of demographics controls. The IV instrument is based on housing supply elasticities from Saiz (2010) interacted with the 10-year US interest rate. **Source:** employment data are from the Census County Business Patterns (available at: https://www.census.gov/programs-surveys/cbp.html). House prices data come from CoreLogic (available at: http://www.corelogic.com).

Table 4: Effect of house price change on nominal wages (2-digit level).

	Goods		Services		Distribution		Construction	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
House Prices	-0.01	-0.17	0.04	-0.08	-0.06	-0.13	0.03	0.19
	[0.06]	[0.18]	[0.04]	[0.19]	[0.06]	[0.11]	[0.07]	[0.11]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	303	303	303	303	303	303	303	303
R^2	0.73	-	0.68	-	0.69	-	0.58	-

	Tradable		Non Tradable		Construction		Other	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
House Prices	-0.02	-0.19	-0.05	-0.08	0.03	0.19	0.05	-0.05
	[0.06]	[0.17]	[0.03]*	[0.09]	[0.07]	[0.11]	[0.04]	[0.16]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	303	303	303	303	303	303	303	303
R^2	0.73	-	0.66	-	0.58	-	0.66	-

Standard errors in brackets

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

Note: robust standard errors clustered by Metropolitan Statistical Area (MSA) in brackets. "OLS" refers to Ordinary Least Squares. "IV" refers to Instrumental Variables. The above regressions refer to the time period 2008-2011. The dependent variable is the log of MSAs nominal payrolls (at 2-digit NAICS level of disaggregation). "House Prices" refers to the log of house price. All regressions include time and MSA fixed effects, and a set of demographics controls. The IV instrument is based on housing supply elasticities from Saiz (2010) interacted with the 10-year US interest rate. **Source:** payroll data are from the Census County Business Patterns (available at: https://www.census.gov/programs-surveys/cbp.html). House prices data come from CoreLogic (available at: http://www.corelogic.com).

Table 5: Effect of house price change on real wages (2-digit level).

	Goods		Services		Distribution		Construction	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
House Prices	-0.05	-0.16	0.00	-0.08	-0.10	-0.13	-0.01	0.19
	[0.07]	[0.18]	[0.05]	[0.19]	[0.06]	[0.10]	[0.08]	[0.12]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	303	303	303	303	303	303	303	303
R^2	0.73	-	0.68	-	0.70	-	0.58	-

	Tradable		Non Tradable		Construction		Other	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
House Prices	-0.06	-0.18	-0.09	-0.07	-0.01	0.19	0.01	-0.05
	[0.07]	[0.18]	[0.03]***	[0.09]	[0.08]	[0.12]	[0.04]	[0.17]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	303	303	303	303	303	303	303	303
R^2	0.73	-	0.66	-	0.58	-	0.66	-

Standard errors in brackets

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

Note: robust standard errors clustered by Metropolitan Statistical Area (MSA) in brackets. “OLS” refers to Ordinary Least Squares. “IV” refers to Instrumental Variables. The above regressions refer to the time period 2008-2011. The dependent variable is the log of MSAs real payrolls (at 2-digit NAICS level of disaggregation), deflated with the RPPs. “House Prices” refers to the log of house price. All regressions include time and MSA fixed effects, and a set of demographics controls. The IV instrument is based on housing supply elasticities from Saiz (2010) interacted with the 10-year US interest rate. **Source:** payroll data are from the Census County Business Patterns (available at: https://www.census.gov/programs-surveys/cbp.html). House prices data come from CoreLogic (available at: http://www.corelogic.com).

Table 6: Effect of house price change on unemployment, wages, labor share, and unit labor cost.

	Unemployment		Wage/employee		Labor Share		ULC	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
House Prices	-0.07	-0.09	0.04	-0.06	1.19	1.83	1.82	1.57
	[0.01]***	[0.02]***	[0.04]	[0.12]	[1.58]	[2.11]	[2.12]	[1.78]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	276	276	303	303	308	308	308	308
R^2	0.91	-	0.77	-	0.07	-	0.11	-

Standard errors in brackets

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

Note: robust standard errors clustered by Metropolitan Statistical Area (MSA) in brackets. "OLS" refers to Ordinary Least Squares. "IV" refers to Instrumental Variables. The above regressions refer to the time period 2008-2011. "Unemployment" refers to the unemployment rate in each MSA. "Wage/employee" refers to the payroll per employee. "Labor share" refers to total compensation divided by nominal GDP. "ULC" refers to Unit Labor Cost, that is total compensation divided by nominal GDP. "House Prices" refers to the log of house price index in each MSA. All regressions include time and MSA fixed effects, and a set of demographics controls. The IV instrument is based on housing supply elasticities from Saiz (2010) interacted with the 10-year US interest rate. **Source:** payroll data are from the Census County Business Patterns (available at: https://www.census.gov/programs-surveys/cbp.html). Unemployment figures at MSA level are provided by the Bureau of Labor Statistics (avilable at: https://www.bls.gov/web/metro/laummtrk.htm). GDP data are provided by the Regional Economics Account of the BEA. House prices data come from CoreLogic (available at: http://www.corelogic.com).

Table 7: Effect of house price change on total population.

	Population	
	OLS	IV
House Prices	-0.01	-0.01
	[0.02]	[0.02]
Observations	308	308
R^2	0.64	-

Standard errors in brackets
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: robust standard errors clustered by Metropolitan Statistical Area (MSA) in brackets. "OLS" refers to Ordinary Least Squares. "IV" refers to Instrumental Variables. The above regressions refer to the time period 2008-2011. The dependent variable is the log of total population in each MSA. "House Prices" refers to the log of house price index in each MSA. All regressions include time and MSA fixed effects, and a set of demographics controls. The IV instrument is based on housing supply elasticities from Saiz (2010) interacted with the 10-year US interest rate. **Source:** population data come from US Census (available at: https://www.census.gov/). House prices data come from CoreLogic (available at: http://www.corelogic.com).

Table 8: Effect of house price change on number of establishments.

	Goods		Services		Distribution		Construction	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
House Prices	0.22	0.26	0.08	0.09	0.07	0.14	0.22	0.18
	[0.06]***	[0.13]**	[0.02]***	[0.06]	[0.03]***	[0.07]**	[0.04]***	[0.12]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	296	296	296	296	296	296	296	296
R^2	0.83	-	0.58	-	0.79	-	0.80	-

Standard errors in brackets
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: robust standard errors clustered by Metropolitan Statistical Area (MSA) in brackets. “OLS” refers to Ordinary Least Squares. “IV” refers to Instrumental Variables. The above regressions refer to the time period 2008-2011. The dependent variable is the log of the number of establishments in each MSA. “House Prices” refers to the log of house price index in each MSA. All regressions include time and MSA fixed effects, and a set of demographics controls. The IV instrument is based on housing supply elasticities from Saiz (2010) interacted with the 10-year US interest rate. **Source:** sectoral number of establishments are from the Census Statistics of US Business (SUSB) (available at: https://www.census.gov/programs-surveys/susb.html). House prices data come from CoreLogic (available at: http://www.corelogic.com).

Table 9: Effect of house price change on number of firms.

	Goods		Services		Distribution		Construction	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
House Prices	0.21	0.23	0.08	0.09	0.06	0.10	0.25	0.22
	[0.07]***	[0.13]*	[0.02]***	[0.06]	[0.03]*	[0.07]	[0.04]***	[0.13]*
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	296	296	296	296	296	296	296	296
R^2	0.82	-	0.58	-	0.85	-	0.78	-

Standard errors in brackets
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: robust standard errors clustered by Metropolitan Statistical Area (MSA) in brackets. "OLS" refers to Ordinary Least Squares. "IV" refers to Instrumental Variables. The above regressions refer to the time period 2008-2011. The dependent variable is the log of the number of firms in each MSA. "House Prices" refers to the log of house price index in each MSA. All regressions include time and MSA fixed effects, and a set of demographics controls. The IV instrument is based on housing supply elasticities from Saiz (2010) interacted with the 10-year US interest rate. **Source:** sectoral number of firms are from the Census Statistics of US Business (SUSB) (available at: https://www.census.gov/programs-surveys/susb.html). House prices data come from CoreLogic (available at: http://www.corelogic.com).

Table 10: Effect of house price change on labor shares.

	Goods		Services		Distribution		Construction	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
House Prices	14.25	-7.56	-0.74	3.23	0.49	0.07	-0.02	-0.02
	[14.48]	[8.47]	[2.26]	[5.07]	[0.28]*	[0.50]	[0.01]***	[0.02]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	265	256	298	296	299	298	252	248
R^2	0.02	-	0.04	-	0.03	-	0.43	-

Standard errors in brackets
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: robust standard errors clustered by Metropolitan Statistical Area (MSA) in brackets. "OLS" refers to Ordinary Least Squares. "IV" refers to Instrumental Variables. The above regressions refer to the time period 2008-2011. The dependent variable is the labor share in each MSA. "Labor share" refers to total compensation divided by nominal GDP. The IV instrument is based on housing supply elasticities from Saiz (2010) interacted with the 10-year US interest rate. **Source:** payroll data are from the Census County Business Patterns (available at: https://www.census.gov/programs-surveys/cbp.html). GDP data are provided by the Regional Economics Account of the BEA. House prices data come from CoreLogic (available at: http://www.corelogic.com).

Table 11: Effect of house price change on RPPs - controlling for number of establishments.

	All		Goods		Services		Rents	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
House Prices	0.02	-0.03	0.01	0.06	0.01	-0.14	0.03	0.04
	[0.02]	[0.05]	[0.02]	[0.05]	[0.03]	[0.08]*	[0.04]	[0.09]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	296	296	296	296	296	296	296	296
R^2	0.12	-	0.04	-	0.07	-	0.41	-

Standard errors in brackets

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

Note: robust standard errors are clustered by Metropolitan Statistical Area (MSA). "OLS" refers to Ordinary Least Squares. "IV" refers to Instrumental Variables. The above regressions refer to the time period 2008-2011. "Services" refers to services excluding rents. "Rents" refer to actual rents, excluding owners equivalent rents. The dependent variable is the log of Regional Price Paritty (RPP) (for "All items", "Goods", "Services", and "Rents"). RPPs are calculated using PCE inflation definitions and weights. Regional price parities (RPPs) are regional price levels expressed as a percentage of the overall national price level for a given year. The price levels are determined by the average prices paid by consumers for the mix of goods and services consumed in each region. "House Prices" refers to the log of house price index in each MSA. All regressions include time and MSA fixed effects, a set of demographics controls and the total number of establishments as a control. In the IV the instrument is based on the estimates of housing supply elasticities from Saiz (2010) interacted with a time-varying variable, the 10-year US interest rate. **Source:** RPPs data come from the BEA regional economic account dataset (available at: https://www.bea.gov/regional/). House prices data come from CoreLogic (available at: http://www.corelogic.com).