Spillovers of Regional Housing Market Disruptions in the Great Recession: The Role of Product Replacements by Multi-Market Firms [*]

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Abstract

We study how regional housing market disruptions spill over across regions through the intra-firm network created by multi-market firms. We build up a unique micro-level data that combines barcode-region-level prices and quantities with their firm characteristics and local house prices. Exploiting a sharp differential drop in regional house prices in 2007-09, we find that multi-market firms decrease their local sales in response to not only the direct local negative demand shock but also the negative demand shocks affecting their other markets. In particular, this intra-firm spillover effect is mostly attributed to the uniform product replacement across many markets within firms as the newly introduced products have lower values—sales, prices, and organic sales shares—relative to the destroyed products. To formalize the mechanism and discuss aggregate implications, we build up a general equilibrium model with multi-market firms' endogenous quality adjustments that reflect the product replacement. In the model, firms facing a negative demand shock downgrade their product quality, and in doing so, they do it in multiple markets simultaneously including a market that did not face the direct demand shock, generating the intra-firm spillover. The model calibrated to match our empirical analysis shows that the identified intra-firm spillover effect substantially mitigated the regional consumption inequality during the Great Recession.

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1 Introduction

How do the regional housing market disruptions spill over and affect other distant regions in the economy? The question of how and to what extent housing market disruption affects the economy has been a vital interest in economics and finance fields and among policymakers, especially after the Great Recession. A leading explanation of a large and dramatic fall in consumption and employment in this period has been a sharp drop in consumer demand arising from the housing market disruptions. A set of seminal papers such as Mian et al. (2013) and Mian and Sufi (2014) exploits the variation in housing net worth across regions and find a large effect of change in local housing market conditions on local consumption and non-tradable employment during the Great Recession. Such a local housing market disruption could spill over, propagate, and amplify through the various regional linkages and potentially affect the regional welfare distribution and aggregate dynamics. Given the importance of such spillover, previous studies identified numerous channels that could generate the regional shock spillover, such as trade, bank, and intra-firm establishment network.[1]

What is particularly not well understood in the literature is the role of spatial networks created by *multi-market firms*, firms selling their products in multiple markets, which dominate much of activities in the economy.[2] Given that these firms make their product supply decisions at the firm-level, such firms facing a negative demand shock in one market could change their product supply decision to the other markets.[3] On one hand, when firms face a negative demand shock and cannot sell their products in one market, these firms might sell their products in other markets to keep up with their firm-level sales. In this case, a decrease in demand and sales in one market leads to an increase in sales in the other market. On the other hand, if firms facing a negative demand shock in one market have trouble financing at the firm-level

[1]See, for example, Backus et al. (1992), Frankel and Rose (1998), Kose and Yi (2006), di Giovanni and Levchenko (2010), Acemoglu et al. (2016), Stumpner (2017) for trade network, Cetorelli and Goldberg (2012), Gilje et al. (2016), Cortés and Strahan (2017), Baskaya et al. (2017) for bank network, Kleinert et al. (2015), Cravino and Levchenko (2017), Giroud and Mueller (2017), Gilbert (2017) for intra-firm establishment network.

[2]Based on ACNielsen Retail Scanner database, multi-market firms account for 90% of total number of firms and 99.9% of total sales in 2007 if market is defined as a county (which is our baseline market definition). If we define the market as a state, multi-market firms account for 80% of the total number of firms and 99.9% of total sales in 2007.

[3]Regional connections and shock transmissions generated by multi-market firms are completely different from those generated by multi-establishment firms because multi-market firms connect regions by selling products instead of producing products. This distinction has also been made in studying the pattern of international trade since exporters (multi-market firms) and multinationals (multi-establishment firms) have different incentives to trade. See, e.g. Antràs and Yeaple (2014).

due to the low cash flow, such an increase in financial cost might force these firms to decrease their supply of goods in other markets. Lastly, it is also possible that firms make their decision entirely at the local level and do not spillover the regional shock as in standard macro and trade models.[4]

This paper investigates how the regional housing market disruptions spilled over across regions and affected regional consumption inequality during the Great Recession through the multi-market firms using detailed micro-level data and a general equilibrium model. We construct a unique micro-level data that combines barcode-level prices and quantities from ACNielsen Retail Scanner database and establishment-level information from the National Establishment Time-Series (NETS) database. Our combined dataset contains detailed information on prices and quantities sold in each county by public and private firms and their plant-level information in the United States from 2006 to 2015. For example, if a household purchases Coke at a store, we observe the price, quantity, and variety of Coke purchased, in which county Coke is purchased, and Coca-Cola's plant location and primary industry code. To generate the variation in local consumer demand condition, we follow the seminal work of Mian et al. (2013) and rely on a sudden decrease in local housing price in the Great Recession to generate a sharp drop in local consumer demand. To do so, we supplement our database with county-level house price from the Zillow database.

Armed with the detailed micro-level data and the exogenous variation in local demand condition, we find that a multi-market firm's local sales decrease in response to not only a direct negative local demand shock affecting the local sales, but also the intra-firm spillover shock, or the negative demand shocks affecting its other markets. multi-market firms *decrease* their local county sales growth by 3.5 percentage points when they face a 10 percentage points decrease in housing prices growth from other counties on average, but by only 0.6 percentage points due to the same percentage points decrease in the local county house price growth. This result suggests that firm-level decision, which is largely affected by overall demand conditions in other markets, is more important in explaining a drop in local sales in this period relative to the local demand condition.[5] We confirm our intra-firm spillover results by conducting a

[4]This is a key feature of the standard macro and trade model with constant elasticity of substitution (CES) demand and constant marginal cost, such as Backus et al. (1992) and Melitz (2003)

[5]This is intuitive since many firms in our sample sell to many markets and the measure of spillover shock captures the average demand shock firms face from their all other markets. For example, the median firm in

number of robustness checks such as using housing supply elasticity as an instrumental variable, redefining markets at the state level, and addressing concerns related to clustered regional shocks and other channels such as the supply-side shock and the retailer effect.

In particular, we find that the identified intra-firm spillover effect is mostly due to the uniform product replacement across many markets within firms as the newly introduced products have lower values—sales, prices, and organic sales share—relative to the destroyed products. We exploit the granularity of our barcode-level data to exactly decompose the local firm sales growth into two margins: the extensive margin of sales growth arising from the product entry and exit within firms and the intensive margin that captures the sales growth of common products existed in both pre- and post- demand shock in each region. We regress each margin on the spillover shock and find that the spillover effect on the extensive margin is both economically and statistically significant, explaining more than 90% of the total decrease in local firm sales, whereas the spillover effect on the intensive margin is not statistically significant at the conventional level. Specifically, we show that this intra-firm spillover effect works through the replacement of high-valued products with low-valued products across many markets simultaneously, neither through the change in quantity or variety of products nor through the products replaced only in the local market.

We rationalize our reduced-form empirical findings by building up a simple general equilibrium model with multi-market firm's endogenous product quality adjustment that reflects the product replacement. We interpret the replacement of high-valued products with low-valued products as a quality downgrading in our model since at the barcode-level, firms have to replace high-quality products with low-quality products to decrease their product quality. In the model, firms facing a negative demand shock decrease their product quality because of the scale effect. That is, given that high quality product requires high fixed cost, firms facing a negative demand shock do not have enough revenue to recover the high fixed cost to produce high-quality products and downgrade their product quality.[6] In this downgrading process, such firms choose the uniform product quality across many markets including a market that did not experience a direct demand shock, and this behavior generates the spillover in

our sample sells to 150 markets, and in looking at the local sales growth for this particular firm, we measure the spillover shock by measuring the demand condition this firm faces in all other 149 markets.

[6] Another way to generate the quality downgrading is the non-homothetic preference. It is straightforward to integrate the non-homotheticity in our model as shown in Appendix ...

the model.[7] The model delivers a structural regression equation similar to the reduced-form regression equation used in our empirical analysis and allows us to interpret the reduced-form coefficient in terms of deep structural parameters.

The model calibrated to match our empirical analysis shows that the identified intra-firm spillover effect substantially mitigated the regional consumption inequality during the Great Recession. Given that firms introduce uniform product quality, there is no regional consumption inequality due to the difference in product quality across markets of multi-market firms. To access the welfare consequence of this behavior, we measure the state-level quality-adjusted real consumption growth by leveraging our model and the micro-level data. We compare the measured welfare growth with the one measured using the counterfactual analysis, in which firms choose region-specific product quality and do not spill over regional shock through the intra-firm network. The standard deviation of the quality-adjusted real consumption growth across states increases by at least 10% to at most 48% in our counterfactual analysis relative to our baseline model, highlighting the importance of intra-firm network channel in mitigating the regional consumption inequality.

1.1 Literature Review

Our paper contributes to several strands of literature. A growing literature studies how shocks transmit throughout the economy. This literature focuses on various types of linkages, including input-output and trade networks (Backus et al. (1992), Frankel and Rose (1998), Kose and Yi (2006), di Giovanni and Levchenko (2010), Acemoglu et al. (2012), Acemoglu et al. (2016), Barrot and Sauvagnat (2016), Carvalho et al. (2016), Stumpner (2017), Caliendo et al. (2018), Adao et al. (2018a), Auerbach et al. (2019)), financial networks (Cetorelli and Goldberg (2012), Gilje et al. (2016), Cortés and Strahan (2017), Baskaya et al. (2017)), and social networks (Bailey et al. (2018)). Our paper adds to this literature by showing whether, and how local shocks transmit across regions through multi-market firms whose network is purely based on their markets.

Only a few recent papers investigate various types of intra-firm networks created by

[7] For the parsimony, our model assumes that firms choose the uniform product quality across all markets they sell their products. It is straightforward to micro found this behavior using the market-specific fixed cost as in Appendix ...

firms operating in multiple regions. At the international level, Cravino and Levchenko (2017) shows how multinationals operating in multiple countries could explain international business cycle comovement, while Berman et al. (2015), Cravino and Levchenko (2017), and Ahn and McQuoid (2017) study how exporters transmit shock across countries.[8] In contrast, our paper considers firms selling in multiple local markets within a country.

At the domestic level, Giroud and Mueller (2017) shows that non-tradable establishment-level employment is sensitive to consumer demand shocks in other regions in which the parent firm is operating. Our paper complements their paper in three important dimensions. First, while they find evidence of spillover for the non-tradable sectors, our firms mainly consist of consumer package good producers classified as tradable sectors. Secondly, the nature of network is different in the sense that our spatial network is purely based on firms' markets (i.e. where they sell their products) and that such locations are largely decoupled with their establishment locations.[9] Finally, we emphasize the role of product replacements by firms as a source of spillover, which has direct implications for the household welfare.[10]

Our paper also contributes to the literature that studies the housing market collpase during the Great Recession and its implications for consumer spendings (Mian et al. (2013), Stroebel and Vavra (2016), Kaplan et al. (2016)), employments (Mian and Sufi (2014), Giroud and Mueller (forthcoming)), and regional business cycles (Beraja et al. (2016), Giroud and Mueller (2018)). We contribute to the literature by showing that local demand shocks affect firms' product entry and exiting decisions, which in turn affect consumption and welfare of households in other regions. At least up to our knowledge, this is a channel that has not been studied in this literature.

In terms of implications, our work is related to the literature that studies how local shocks are smoothed out within a country, and to what extent risks are shared across regions through various channels. The literature typically focused on either the role of credit markets for risk sharing (e.g. Asdrubali et al. (1996), Lustig and Nieuwerburgh (2005), Lustig and Nieuwerburgh

[8] The direction of spillover at the international level is somewhat mixed. Berman et al. (2015) show positive association between firm-level exports and domestic sales, while Ahn and McQuoid (2017) and Almunia et al. (2018) show the opposite result.

[9] In our sample, less than 5% of regions where a firm sells its products also have the firm's establishments on average.

[10] In Table A.24-A.25 in the Appendix A, we show that more financially constrained firms also experience strong spillover *through product replacement channel*. This result is consistent with Giroud and Mueller (2017) and Berman et al. (2015) that emphasize the role of financial constraint.

(2010)), or the role of monetary and fiscal union where multiple regions face common policy instruments. For example, Hurst et al. (2016) document that risk-adjusted rates are not equalized across regions within the US despite large regional variation in predictable default risk, and that the national interest rate policy substantially affects welfare by redistributing resources across regions. Our paper provides a novel perspective of mitigating cross-region consumption inequality through firm's decision on product replacements and associated product quality choice.

Finally, our paper contributes to the literature that studies product turnover and R&D decisions by firms as important driver of economic growth and business cycles in macroeconomics and international trade (Broda and Weinstein (2010), Hottman et al. (2016), Jaimovich et al. (2019), Anderson et al. (2017), Argente et al. (2018), Jaravel (2018), Anderson et al. (2018)). We contribute to the literature by showing that product turnover and quality adjustment decisions made at the firm-level generate inter-dependency across regions, generating spillover effects across regions.[11]

The rest of this paper is structured as follows. Section 2 describes the data, Section 3 explains the empirical strategy and construction of variables. Section 4 presents the main spillover and decomposition results. In Section 5, we discuss the mechanism behind our results, namely the channel of uniform product replacements from high- to low-value products. Section 6 provides the multi-market model with firms' endogenous quality adjustment and investigate regional implications. Section 7 concludes. We post all figures and tables at the end of the paper.

2 Data

Our dataset combines barcode-level prices and quantities from ACNielsen Retail Scanner database and establishment-level information from National Establishment Time-Series (NETS) database. Our combined dataset contains detailed information on prices and quantities sold in each county by public and private firms and their plant-level information in the United States

[11] Another related literature is the literature in the industrial organization that documents uniform pricing behavior by retailers (see, for example, DellaVigna and Gentzkow (2017), Cavallo (2018)). While these papers emphasize the role of pricing decision by retailers, we focus on the role of producers' decision on product entry/exit and associated choice of product quality. In the Appendix A, we explicitly show that our results are not driven by retailers.

from 2006 to 2015. This allows us to construct a firm's county-level sales and its connection to other counties where the firm sells products, together with various firm-level information including industry code and plant location. To measure local demand shocks, we further augment our dataset with county-level house price information from Zillow database.

Price and quantity data in each county comes from the ACNielsen Retail Scanner, which was made available by the Kilts Marketing Data Center at the University of Chicago Booth School of Business.[12] The data contain approximately 2.6 million barcode-level product prices and quantities recorded weekly from about 35,000 participating grocery, drug, mass merchandise, convenience, and liquor stores in all U.S. markets. A barcode is a unique universal product code (UPC) assigned to each product and is used to scan and store product information. Participating retail stores use the point-of-sale systems that record information whenever product barcodes are scanned to be purchased. The data begin in 2006 and end in 2015, covering the period of a collapse in house price during the Great Recession. It mainly includes consumer packaged goods, such as food, nonfood grocery items, health and beauty aids, and general merchandise. According to Nielsen, the Retail Scanner covers more than half the total sales volume of US grocery and drug stores and more than 30 percent of all US mass merchandiser sales volume.

There are two notable advantages in using the ACNielsen Retail Scanner database to study multi-market firms' behavior. First, the database records product sales at the barcode level, which is likely to be the most granular way to define the product. This feature allows us to decompose the spillover effect into the conventional supply effect and the net creation effect precisely. Using broader product category classification cannot identify the net creation effect emphasized in this paper.[13] Second, there are fewer problems of measurement errors. For example, compared to similar data that rely on the survey of consumers, the data directly record expenditure when consumers purchase and scan products at stores. Thus, our data do not suffer from non-response and misreporting of households that are common in survey data used

[13]We decompose the sales growth using the broader product group category in the Nielsen data. As shown in Appendix ..., the effect is entirely driven by the product categories existed in pre- and post- shock periods instead of net creation of the categories.

in economic research (Meyer et al. 2015). Also, unlike the most firm-level international trade and balance sheet data that infer the regional (domestic) sales by subtracting other regional (international) sales from total firm sales, Nielsen collects sales information independently from each region. This feature prevents the mechanical regional sales correlation problem raised in Berman et al. (2015) when we conduct structural regression exercise in Section ...

We integrate the prices and quantities of each product with its producer's establishment information using the GS1 US Data Hub and National Establishment Time-Series (NETS). GS1 is the company that issues barcodes to producers.[14] Their data record the company name and address for each barcode-level product, and we use this information to link barcode-level product information with its producer information.[15] NETS is the U.S. establishment-level longitudinal database made available by Walls & Associates. The original source of the data is Dun and Bradstreet (D&B) archival data, which is collected primarily for marketing and credit scoring. The data contains annual plant-level information on location, industry code, and D&B credit and payment rating in 1990-2015. We use these information to compare firms having the same primary industry code, investigate the mechanism behind the spillover results, and address concerns related to a supply-side shock. See, e.g., Neumark et al. (2011) and Barnatchez et al. (2017) for more detailed discussion on NETS.

We supplement our combined database with house price indices at the county-level from Zillow database and housing supply elasticity from Saiz (2010) to capture the local market demand condition. To explore the role of financial friction in generating the spillover, we also combine the industry-level external financial dependence index from Rajan and Zingales (1998). We aggregate variables at the county-firm-level and focus on the period of the Great Recession for the main empirical analyses.

The summary statistics of the final sample used in the regression analyses are reported in Table 1. Our combined data have 4171 number of firms covering 991 number of counties in the United States in 2007-09. Three features of the data are worth highlighting. First, most of firms in our sample sell many products to many counties due to the granularity of our data.

[14] GS1 provides a business with up to 10 barcodes for a $250 initial membership fee and a $50 annual fee. There are significant discounts in the cost per barcode for firms purchasing larger quantities of barcodes (see http://www.gs1us.org/get-started/im-new-to-gs1-us).

[15] We use Reclink2 command available in Stata to merge the GS1 database and NETS database. The detailed description of the merging process is described in Appendix ...

For example, an average firm in our sample sells 54 products to 513 counties. This aspect of the sample is adequate to study the firms' quality changing behavior across markets through product replacement due to the large variation across markets and products in the data we can exploit. Second, there is an extreme firm heterogeneity as documented in Hottman et al. (2016). A firm in 90 percentile of the distribution have about 3000 times more sales, produce about 55 times more products, and sell to about 160 times more counties compared to a firm in 10 percentile of the distribution. Motivated by this empirical evidence, we incorporate the firm heterogeneity in the model as in Section 6. Lastly, there are many firms selling their products in each county. On average, there are 848 firms selling their products in a county, and even a county in 10 percentile of the distribution has 341 firms selling their products. This aspect helps to identify the exogenous shock faced by firms since their initial sales share is small in each market for them to have a large market power to affect the local economic condition. Moreover, this feature turns out to be useful to interpret the parameters of the model with the structural regression equation similar to that of the reduced-form empirical analysis. Section ... discusses this point in detail.

3 Empirical Strategy

Using the detailed micro-level data discussed in the previous section, this section presents how we analyze the spillover effect of the local housing market shock through the linkages created by multi-market firms. We discuss the sales growth decomposition, construction of the region-firm-specific spillover shock, and regression specifications. Our baseline unit of region is county, but we also use state for the robustness check.

3.1 Dependent Variables

Let $\text{Sale}_{rf,t}$ denotes the sales in region r for firm f at time t. We measure the region-firm-level sales growth in 2007-09 as follows:

$$\tilde{\Delta}\text{Sale}^{\text{total}}_{rf} \equiv \frac{\text{Sale}_{rf,09} - \text{Sale}_{rf,07}}{\overline{\text{Sale}}_{rf,07-09}} \tag{3.1}$$

where $\overline{\text{Sale}}_{rf,07-09}$ is a simple average sales of firm f in region r across 2007 and 2009. This growth rate, which is a second-order approximation of the log difference growth rate around 0, follows previous papers that measure the employment growth at the establishment-level (e.g. Davis et al. 1996). This growth rate definition provides a symmetric measure around 0 and is bounded between -2 and 2. These features particularly help limit the influence of outliers without arbitrarily winsorizing extreme observations.[16,17]

Given the prevalence of multi-product firms, we investigate the role of product turnover of these firms in the shock spillover. We follow Broda and Weinstein (2010) to decompose the sales growth defined in the equation (3.1) exactly into two margins: continuing product margin associated with products that exist in both pre- and post-shock periods, and replacement margin associated with products that entered and exited in the same period:

$$\tilde{\Delta}\text{Sale}_{rf}^{\text{total}} = \tilde{\Delta}\text{Sale}_{rf}^{\text{continue}} + \tilde{\Delta}\text{Sale}_{rf}^{\text{replace}} \tag{3.2}$$

where $\tilde{\Delta}\text{Sale}_{rf}^{\text{continue}} \equiv \frac{\text{Sale}_{rf,09}^{\text{continue}} - \text{Sale}_{rf,07}^{\text{continue}}}{\text{Sale}_{rf,07-09}}$ and $\tilde{\Delta}\text{Sale}_{rf}^{\text{replace}} \equiv \frac{\text{Sale}_{rf,09}^{\text{enter}} - \text{Sale}_{rf,07}^{\text{exit}}}{\text{Sale}_{rf,07-09}}$. $\text{Sale}_{rf,t}^{\text{continue}}$ is the region-firm-time-specific sales of products that continued in region r throughout the period 2007-09, $\text{Sale}_{rf,07}^{\text{exit}}$ is the region-firm-time-specific sales of products that existed in region r in 2007 but exited in 2009, and $\text{Sale}_{rf,09}^{\text{enter}}$ is the region-firm-time-specific sales of products that didn't exist in region r in 2007 but newly entered in 2009. Note that we use the following identity for the decomposition of the sales growth: $\text{Sale}_{rf,07} = \text{Sale}_{rf,07}^{\text{continue}} + \text{Sale}_{rf,07}^{\text{exit}}$ and $\text{Sale}_{rf,09} = \text{Sale}_{rf,09}^{\text{continue}} + \text{Sale}_{rf,09}^{\text{enter}}$. The products that entered and exited in region r account for less than one-fourth of total sales in 2007 and 2009. Despite its relatively small fraction of total sales, the entered and exited products cause the majority of the spillover effect.

The first margin of the sales growth, $\tilde{\Delta}\text{Sale}_{rf}^{\text{continue}}$, attributed to the continuing products that existed in both pre- and post-shock periods in the region. The second margin of the sales growth, $\tilde{\Delta}\text{Sale}_{rf}^{\text{replace}}$ or *net creation*, arises from the entry and exit of products in the region. In order to exactly decompose the spillover effect into the continuing product margin and the product replacement margin, we regress each of two margins of sales growth on the spillover shock. We also regress each of these margins on local housing market shock to decompose the

[16]Another important benefit of using this growth rate is that it can accommodate both entry and exit of firms at the local market level. Table A.14 in the Appendix A shows the result accommodating these margins.

[17]The qualitative results are robust to using more conventional definition of the sales growth with the denominator equals 2007 sales. See Appendix ...

traditional local housing market effect on sales.

3.2 The Spillover Shock

We follow the specification used in Giroud and Mueller (2017) carefully to measure the spillover shock. Let HP_r denotes a housing price index in region r. Consistent with the measure of sales growth, we measure the region-specific housing price growth in 2007-09 as follows:

$$\tilde{\Delta}\mathrm{HP}_r \equiv \frac{\mathrm{HP}_{r,09} - \mathrm{HP}_{r,07}}{\overline{\mathrm{HP}}_{r,07-09}} \tag{3.3}$$

where $\overline{\mathrm{HP}}_{r,07-09}$ is a simple average of housing price index in region r across 2007 and 2009.[18] $\tilde{\Delta}\mathrm{HP}_r$ measures the local housing price growth emphasized in previous studies.

Given the region-specific housing price growth, we take a weighted average of this growth measure across regions r' within a firm f, excluding the particular region r to measure the spillover shock for region r:

$$\tilde{\Delta}\mathrm{HP}_{rf}\ (\text{other}) \equiv \sum_{r' \neq r} \omega_{r'f} \times \tilde{\Delta}\mathrm{HP}_{r'} \tag{3.4}$$

where $\tilde{\Delta}\mathrm{HP}_{rf}$ (other) is the spillover shock and $\omega_{r'f}$ is the initial sales share defined as $\frac{\mathrm{Sale}_{r'f,07}}{\sum_{r' \neq r} \mathrm{Sale}_{r'f,07}}$. The weight $\omega_{r'f}$ is a firm f's initial sales share in region r', where shares are measured excluding the region r. The weight measures the importance of the region r for firm f and reflects the idea that firms are more likely to be exposed to the change in housing price in a region r' if they initially sold more in region r' relative to other regions.

3.3 Empirical Specification

Our objective is to show how multi-market firms' local sales respond to not only the changes in local house prices in that region, but also to changes in house prices in other regions where the firm sells their products. To achieve this objective, we estimate the following equation:

$$\tilde{\Delta}\mathrm{Sale}^i_{rf} = \beta^i_0 + \beta^i_1 \tilde{\Delta}\mathrm{HP}_r + \beta^i_2 \tilde{\Delta}\mathrm{HP}_{rf}\ (\text{other}) + \mathrm{Controls}_{rf} + \varepsilon^i_{rf} \tag{3.5}$$

[18] Using the conventional measure of housing price growth rate, which uses 2007 housing price as a denominator, does not change the qualitative results. See Appendix ...

where $i = \{\text{total, continue, replace}\}$. $\tilde{\Delta}\text{Sale}^i_{rf}$ is region-firm-level sales growth we measured for all products, continuing products, and introduced and destroyed products as measured in Section 3.1. $\tilde{\Delta}\text{HP}_r$ is region-level growth rate of house price index, and $\tilde{\Delta}\text{HP}_{rf}$ (other) is the the growth rate of house price index that firm f sells to excluding the region r as defined in Section 3.2. Controls_{rf} is the vector of reigon-firm-level control variables. We double cluster standard errors at the state and sector level and weighted the regression by initial county-firm-level sales.

Our coefficient of interest is β^i_2, which measures the spillover effect. Specifically, it is the elasticity of region-firm specific sales growth with respect to average demand shock arising from other regions conditional on local house price growth. If the negative demand shocks in other regions reduces firm's local market sales, then the sign of β^i_2 is positive. The other coefficient, β^i_1, measures the effect of local house price on local sales, which has been studied extensively in previous literature.

The main identification assumption to consistently estimate β^i_2 is that any confounding factors that affect firms' local sales growth are not correlated with the housing price growth in other regions those firms operate. Specifically, we argue that the observed spillover effect is muted in the absence of the linkages created by the multi-market firms. Concerning this assumption, the most evident identification threat is common shocks that simultaneously affect multiple regions firms selling to. For example, suppose some firms historically had been selling to those markets facing common shocks, which lead to a fall in house prices and sales. In this case, such common shocks could explain the positive relationship between the firm's local sales growth, $\tilde{\Delta}\text{Sale}_{rf}$, and the house price growth in other regions firms operate, $\tilde{\Delta}\text{HP}_{rf}$ (other).

We provide a number of supports for the main identification assumption. To estimate the equation (3.5), we include rich set of initial and lagged control variables including region-firm-specific sales, firm-specific sales, number of products firms produce, number of counties firms sell their products, and all region-level controls used in Mian et al. (2013).[19] For many specifications, we include county-specific fixed effect and its interaction with SIC 4-digit industry fixed effect instead of local house prices.[20] With county fixed effects, we effectively

[19]They are pre-recession percentage white, median household income, percentage owner-occupied, percentage with less than high school diploma, percentage with only a high school diploma, unemployment rate, poverty rate, percentage urban, and employment share in a county for two-digit industries.

[20]These industry codes are obtained from the NETS data and identify each firm's primary business line.

compare firms' sales growth in the same county but faced a different degree of house price shock from other markets, making our analysis less vulnerable to the common shocks. Additionally interacting industry fixed effects absorb all the variation that might affect county-sector-level sales growth differentially. This control is particular useful to address concerns related to common sectoral shocks, such as construction boom and bust, that could be correlated with house prices and may differentially affect sales growth of related sectors in our sample.

4 Main Empirical Results

We find that a multi-market firm's local sales decrease in response not only to the direct negative local demand shock hitting the local market, but also to the shocks hitting its other markets, where the latter having six times larger effect. Through the decomposition exercise, we also find that the direct local shock and the spillover shock affect local sales differently; the local shocks affect local sales through continuing products, whereas the spillover shocks affect local sales through net creation.

4.1 Regional Spillover

We begin in Table 2 by estimating equation (3.5) using sales growth of all products as a dependent variable. The first column reports the result using local house price growth with firm fixed effects that observe all firm-level variation. Consistent with Mian et al. (2013) and Kaplan et al. (2016), we find a positive relationship between local housing price growth and local sales growth.[21]

Column (2) shows the regression result of (3.5). The result shows that local sales growth positively responds both to the direct local shock and the spillover shock. However, the estimated elasticity with respect to the spillover shock, 0.35, turns out to be six times larger than that of the direct local shock. This is intuitive if one recalls that the spillover shock captures the *average* demand shock a firm faces from other regions, which proxies (leave-one-out) firm-specific demand shock.[22] In Column (3), we show the estimation result of equation

[21]The magnitude of the estimated coefficient is smaller compared to the previous estimate reported in the previous study. It is because we use region-firm-level variation instead of region-level variation in the data. If we aggregate the data and run the regression at the county-level, our estimated coefficient is larger and similar to that of Kaplan et al. (2016).

[22]Figure A.1 and Figure A.2 present the visualization of regression in Column (2).

(3.5) which includes sector-county interacted fixed effect. We get highly significant positive coefficient of 0.40. This indicates that 1pp decline of the spillover shock reduces local sales growth by 0.40pp.

Importantly, what matters is that a local market is linked to other regions in which a firm is generating sales, not other regions in general. In Column (4), for each county of a firm, we randomly select "other regions" and construct Placebo market linkages. To be more specific, for each county of a given company, we replace all other counties the firm has connection to ($\omega_{r'f} > 0$) with randomly selected county. We then construct the placebo spillover shock and estimate (3.5). We repeat this process 800 times and report the average coefficients and standard errors, respectively. As can be seen in Column (4), the coefficient of the Placebo spillover shock is small and insignificant.

A potential concern of interpreting the spillover shock as "demand shock" from other regions is that house price changes in other regions can directly affect a firm's establishments located in those regions. For example, house price change can be correlated with regional productivity, or it may affect establishment's value that may in turn serve as firm's collateral. However, as we are constructing the shock based on regions where a firm "sells" products (and not where a firm "produces" products), it is unlikely that the shock captures supply-side effect. Yet, to further guarantee that the spillover shock captures "demand shock" from other regions, we construct the spillover shock by *excluding* regions that have establishments of the company. Column (5) provides the result. The estimated coefficient is 0.38, and is highly statistically significant. This shows that the spillover shock can be interpreted as "demand shock" a firm faces from other regions.

In Column (6), we estimate (3.5) by defining state as the unit of local market. We get highly significant positive coefficient given by 0.30. This indicates that negative shocks from other states reduce local sales in the other state of a company. It shows that our spillover result is not particularly driven by firms who have geographically concentrated markets. We will re-visit state-level analysis in more details in Section 4.3.2.

Notice that the spillover shock we construct features the Bartik-type property. Thus, even if local house price change may not be purely exogenous at the local market level, the spillover shock can be viewed as exogenous at the firm-level. Yet, we additionally check the robustness of our result by instrumenting the spillover shock with similarly constructed housing supply elasticity (Saiz (2010)).[23] Column (7) shows the result. As can be seen, we get stronger results with higher estimated coefficient.

In sum, Table 2 provides a strong evidence of positive regional spillover working through multi-market firms' cross-market linkages. We provide further evidence on the robustness of our results in Section 4.3.

4.2 Decomposition

We now decompose local sales growth into two components : those comming from common products existing in both initial and end periods in the local market (intensive margin), and those from net creation of products (extensive margin through product replacement). Our results show that the net creation significantly reacts to the shocks hitting other markets, while the direct local shock only affects intensive margin.

We first estimate equation (3.5) by replacing $\tilde{\Delta}\text{Sale}_{rf}$ with $\tilde{\Delta}\text{Sale}_{rf}^{\text{replace}}$ and $\tilde{\Delta}\text{Sale}_{rf}^{\text{continue}}$, respectively. Columns (1)-(3) in Table 3 show the results. Notice that our definitions of Net $\text{Creation}_{i,r}$ and Common $\text{Products}_{i,r}$ make the estimated coefficients in Column (1) identical to the sum of coefficients in Columns (2) and (3).[24]

As can be seen in Column (2), net creation does not respond to the direct local shock. Instead, it strongly (and positively) responds to the spillover shock with estimated coefficient 0.32. This means that around 90%($\approx 0.32/0.35 \times 100$) of local sales response to the spillover shock can be attributed to the movement of net creation. Correspondingly, sales growth arising from common products significantly and positively responds to the direct local shock, while it does not significantly respond to the spillover shock. Columns (4)-(6) repeat the analyses using equation (3.5). The results are similar. A 1pp decline of the spillover shock reduces net creation by 0.42pp, which is the main reason why local sales respond to the spillover shock.

The decomposition results in this section point out the importance of product entry and exit in local markets as the key channel behind regional spillover. In the next section, we will investigate in depth the mechanism behind these findings.

[23] Specifically, we replace $\tilde{\Delta}\text{HP}_{r'}$ in (3.4) with the county-level housing supply elasticity, and use firm's 2006 local sales as weights.

[24] We present the result decomposing net creation into creation and destruction in Table A.15 in the Appendix A.

4.3 Robustness

In this section, we show the robustness of our results by addressing potential concerns that may confound our findings. First, we show that our spillover results are not driven by retailers through which firms sell products. Second, we show that our results are not confounded by possible clustered regional shocks affecting geographically concentrated markets. Third, to further ensure that our results are not confounded by firms' selection into particular local markets or particular types of customers, we perform additional robustness checks by controlling conditions in "other markets". Finally, we repeat our analyses using ACNielsen Homescan Panel data and show that using 2004 sales share to construct our shock and additionally controlling lagged-dependent variables (i.e. pre-trends in local sales) do not change our results. We present all the tables in this section in the Appendix.

4.3.1 Retailer Effects

One potential concern is that our spillover results may have been driven by retailers through which firms sell products. For example, lower sales growth of Coca-Cola in New York county relative to that of Pepsi might reflect differential performance of retailers selling Coca-Cola's products relative to those selling Pepsi's products. In Table A.3, we address this concern by showing robustness of our results by comparing local sales growth of firms *within* same retailer. Specifically, we add retailer margin and construct county-firm-retailer level sales growth and run the regression by including sector×county×retailer fixed effect.[25] Thus, any county-retailer specific trend in local sales within SIC 4-digit producer sector will be absorbed by such fixed effect. Column (1) shows the result. We have coefficient 0.53, which is highly statistically significant.

However, it is still possible that, for example, lower sales growth of Coca-Cola in CVS in New York county relative to that of Pepsi might have been driven by CVS facing larger Coca-Cola specific negative shocks from CVS stores in other regions. Thus, in Column (2), we additionally include the "average producer-specific demand shock" a retailer faces through its stores in other regions (where the producer's products are sold).[26] It turns out that change

[25] We define retailer using "parent code" in Nielsen Retail Scanner data.

[26] Specifically, we run the following regression:

$$\tilde{\Delta}\text{Sale}_{rfs} = \beta_0 + \beta_2 \tilde{\Delta}\text{HP}_{rf} \text{ (other)} + \beta_3 \tilde{\Delta}\text{HP}_{rfs} \text{ (other)} + \text{Controls}_{rfs} + \epsilon_{rfs}$$

in county-firm-retailer specific sales is mainly driven by firm-level spillover shock, not the retailer-firm specific spillover shock. In Columns (3) and (4), we show the corresponding decomposition results.

4.3.2 Clustered Regional Shocks

Another concern that could potentially confound our spillover results is the possibility of clustered regional shocks affecting geographically concentrated local markets jointly. We address such concern in two ways: (i) we exclude nearby counties when we construct the spillover shocks, (ii) we repeat the analysis by defining local market at the state-level.

(1) Excluding Nearby Counties

In Table A.6 in the Appendix A, we show that the spillover effects remain even if we exclude nearby counties when we construct the spillover shocks. Specifically, when we construct firm f's spillover shock hitting county r, we exclude counties located within radius of 100 miles, 300 miles, and 500 miles, respectively, around county r in Column (1) to Column (3), respectively.[27] In Column (4), we exclude counties that are located in the same state as with county r when we construct the spillover shock. We get robust results.

(2) Defining Local Market at the State-Level

By defining local market at the state-level, we aggregate regional demand shocks within a state (including any clustered regional shock jointly affecting within-state counties) and treat it as a state-level demand shock. Thus, at the state-level, it is less likely that the result is confounded by clustered regional shocks affecting geographically concentrated regions.

Recall that in Column (6) of Table 2, we showed that the spillover effect exists even if we define local market at the state-level. In Table A.7 in the Appendix A, we further verify that the sales growth decomposition result also holds at the state-level. Again, the response of net creation accounts for all the spillover effect.

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where r indicates region (county), f indicates firm (producer), and s indicates retailer. Here, $\tilde{\Delta}\text{HP}_{rfs}$ (other) $\equiv \sum_{r' \neq r} \omega_{r'fs} \times \tilde{\Delta}\text{HP}_{r'}$ where $\omega_{r'fs} \equiv \frac{\text{Sale}_{r'fs,07}}{\sum_{r' \neq r} \text{Sale}_{r'fs,07}}$. $\tilde{\Delta}\text{HP}_{rfs}$ (other) captures average producer f specific demand shock retailer s faces through its stores in other regions (where the producer f's products are sold).

[27] When we construct the spillover shock, we re-normalize the leave-out initial sales weights so that they sum up to one.

4.3.3 Firms' Selection into Particular Local Markets or Customers

Another possible concern is that there can be selection of firms into particular local markets or particular types of customers. To address such concern, we check the robustness of our result by controlling "other market" conditions of firms.

First, it is possible that differential response of local sales of two firms may arise not because of differential local demand shocks they face in their other markets, but because some unobserved characteristics of these firms led one firm to have its major markets located in, for example, the west coast side of the United States while the other to have its major markets in the east coast. Although such variation is one of the very source that generates differential demand shocks across firms (which we utilize),[28] to rule out the possibility of selection effect, we compare firms that share common *largest "other" market*.

Table A.9 shows the result by compare local sales growth of two firms which are not only in the same SIC 4-digit sector but also share common *largest "other" market*.[29] The results are robust under this alternative specification.

Another possibility is that differential response of local sales of two firms may arise not because of differential local demand shocks they face in their other markets, but because they have different types of customers in the other markets. In Table A.10, we show that the results are not driven by making comparison between two firms catering to different types of consumers (i.e. not driven by clientele effects) by including average demographic controls firms face in their other markets.

Final remark is that the state-level analysis (Column (6) of Table 2) suffers less from potential selection bias that may arise if some unobserved firm-characteristics led firms to be systematically selected into local markets with relatively low (or high) house price growth. In panel (A) of Table A.8, we calculate correlation of state-level house price growth across each firm's 1st, 2nd, 3rd largest markets. Correlation of house price growth between 1st largest and 2nd largest markets is mildly negative (-0.12), while those between 2nd largest and 3rd largest markets are mildly positive (0.12). This means that at the state-level, firms are not systematically experiencing low (high) house price growth in their major markets. In the first

[28] As long as such unobserved firm characteristics are not correlated with house price growth, then they do not pose a problem in identification.

[29] For each county-firm observation (county r, firm f), we define the largest "other" market as a census division that contains county of the firm that has largest initial sales share (excluding county r).

column of panel (B), we measure the ratio of 2nd largest market located in different Census Division with the 1st largest market. This ratio is given by 0.90, meaning that firms' 1st and 2nd major markets are geographically located in distant regions. Such ratio between 1st and 3rd largest markets are 0.92, and that between 2nd and 3rd largest markets is 0.78. These results indicate that firms' major markets are rather idiosyncratically distributed across Census Divisions, implying selection into particular geographical regions is less likely at the state-level.

4.3.4 Using Lagged-initial Sales and Controlling Lagged-dependent Variables

In this section, we repeat our analyses using ACNielsen Homescan Panel data and show that using 2004 sales share to construct our shock and additionally controlling lagged-dependent variables (i.e. pre-trends in local sales) do not change our results. ACNielsen Homescan Panel dataset is constructed by Nielsen from a demographically representatitve sample of approximately 33,000 households in the United States.

To minimize any distortion on the representativeness of the households through which the data is collected, we use the entire ACNielsen Homescan Panel data without combining it with the NETS data. This exercise also guarantees the external validity of our analyses as ACNielsen Retail Scanner dataset and Hoemscan Panel dataset are collected by different entities (i.e. stores versus households, respectively). We collapse the data into state-firm level and perform the analyses.[30]

Columns (1)-(3) of Table A.11 repeats Columns (4)-(6) in Table 3, where the spillover shocks are constructed using firms' 2004 sales share across local markets.[31] We get similar results. In Columns (4)-(6), we additionally control lagged-dependent variables. The results barely changes.

[30] The Nielsen sample is demographically representative not only at the national level but also within subnational regions such as 9 census regions and 52 "scantrack markets" defined by Nielsen. Ideally, we would like to perform the analyses at the scantrack market-firm level, but as we do not have well-defined house price information at the scantrack market level, we perform the analyses at the state-firm level.

[31] All control variables are based on year 2004. Also, we define sector of each company as a combination of three largest product groups based on year 2004 (i.e. companies that share three largest product groups are classified as having common sector). The results are robust to defining sector using a combination of two largest product groups.

4.3.5 Additional Results

As discussed in Adao et al. (2018b) and Borusyak et al. (2018), it is important to consider the presence of correlated errors in shift-share research design. In Table A.12 in the Appendix, we report standard errors accounting for the shift-share correlation structure as in Adao et al. (2018b). The estimated standard errors are more or less similar, and we find statistically significant spillover effects at the conventional level.

In Table A.2 in the Appendix, we show that the observable characteristics of firms are balanced across different levels of the spillover shocks. Specifically, observations with $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) lower than median of the within-county distribution of $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) have similar observable characteristics with those with above median $\tilde{\Delta}\text{HP}_{(07-09)}$ (other). In Table A.13 in the Appendix, we show that our spillover results are robust if we replace $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) with corresponding binary shocks (i.e. Shock (Binary)). Shock (Binary) is an indicator variable that has value 0 if $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) is lower than median of the within-county distribution of $\tilde{\Delta}\text{HP}_{(07-09)}$ (other), and has value 1 if $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) is greater than or equal to median of the within-county distribution of $\tilde{\Delta}\text{HP}_{(07-09)}$ (other). Again, the spillover mainly arises through response of net creation.

5 Mechanism: Uniform Product Replacement from High- to Low-Valued Products

Our result suggests that the product replacement within a firm in a local market is strongly affected by the overall demand conditions the firm faces in its other markets. Importantly, the result implies newly introduced products in the local market generate lower sales compared to the destroyed products, conditional on local demand. In this section, we explore the mechanism behind such findings.

We show that the spillover effect within-firm across regions arises because firms responds to negative demand shocks by replacing high-valued products with low-valued products, and in doing so, they replace products uniformly across many markets.[32] Thus, a region that is

[32] We will formalize why negative demand shocks result in replacement from high- to low-valued products through the lens of the model in Section 6. We argue that this reflects downgrading of product quality resulting from scale effect. If production at the lower quality level requires lower fixed costs, firms find it optimal to downgrade product quality if they face lower demand shocks. Alternatively, nonhomothetic preferences can also

not directly hit by the shock also experience replacement of products from high- to low-valued products, resulting in decline of local sales.

5.1 Replacement from High- to Low-Valued Products

We start by documenting that our result is not driven by a simple reduction in the number of varieties in the local market. More or less, the number of exiting products are similar to the number of entering products. Instead, it is the "value difference" between newly entering products and exiting ones that is driving reduction of local sales growth in response to the spillover shocks. The result is robust under various measures of values, including sales-per-product, unit price, and organic products turnover rates.

(1) Net number of products at the replacement margin do not respond to the spillover shock.

We first investigate whether the response of net creation comes from both entry and exit of products, or from simple reduction of the number of products being sold. We measure the region-firm level net entry in 2007-09 as follows:

$$\text{Net Entry}_{rf} \equiv \text{Entry}_{rf} - \text{Exit}_{rf} \tag{5.1}$$

where $\text{Entry}_{rf} \equiv \frac{\text{Num.UPC}^{\text{enter}}_{rf,09}}{\overline{\text{Num.UPC}}_{rf,07-09}}$ is the number of products that didn't exist in region r in 2007 but newly entered in 2009, and $\text{Exit}_{rf} \equiv \frac{\text{Num.UPC}^{\text{exit}}_{rf,07}}{\overline{\text{Num.UPC}}_{rf,07-09}}$ is the number of products that existed in region r in 2007 but no longer exist in 2009. All measures are normalized by $\overline{\text{Num.UPC}}_{rf,07-09}$, which is a simple average of the total number of products of firm f in region r across 2007 and 2009.

Table 4 summarizes the result. Column (1) and Column (2) show that both the number of products entering and exiting *increase* when the firm faces negative spillover shock (although the response of exit is not statistically significant at the conventional level). Correspondingly, the net entry (i.e. net change in the number of products through product replacements) remains unaffected by the spillover shock, indicated by near-zero coefficient in Column (3). This shows

be a reason why such behavior arises. Allowing nonhomothetic preferences strengthens our result, yet is not sufficient to generate the spillover effect (without scale effect).

that our spillover effects are not driven by simple change in the number of products supplied in the local market.

(2) Firms destroy products with higher values and introduce products with lower values in response to the negative spillover shock.

The fact that the overall number of products introduced is more or less similar to the number of products exited suggests that firms facing negative demand shocks from their other markets typically respond by destroying products that generated higher per-product sales while introducing products with lower per-product sales. To see whether this is indeed the case, we measure sales-per-product at the replacement margin as follows:

$$\tilde{\Delta}\text{Sale-per-UPC}_{rf}^{\text{replace}} \equiv \tilde{\Delta}\text{Sale-per-UPC}_{rf}^{\text{enter}} - \tilde{\Delta}\text{Sale-per-UPC}_{rf}^{\text{exit}} \tag{5.2}$$

where $\tilde{\Delta}\text{Sale-per-UPC}_{rf}^{\text{enter}} \equiv \frac{(\text{Sale}_{rf,09}^{\text{enter}}/\text{Num.UPC}_{rf,09}^{\text{enter}})}{(\overline{\text{Sale}}_{rf,07-09}/\overline{\text{Num.UPC}}_{rf,07-09})}$ is the sales-per-product generated by products that didn't exist in region r in 2007 but newly entered in 2009, and $\tilde{\Delta}\text{Sale-per-UPC}_{rf}^{\text{exit}} \equiv \frac{(\text{Sale}_{rf,07}^{\text{exit}}/\text{Num.UPC}_{rf,07}^{\text{enter}})}{(\overline{\text{Sale}}_{rf,07-09}/\overline{\text{Num.UPC}}_{rf,07-09})}$ is the sales-per-product generated by products that existed in region r in 2007 but no longer exist in 2009. All measures are normalized by $\frac{\overline{\text{Sale}}_{rf,07-09}}{\overline{\text{Num.UPC}}_{rf,07-09}}$, which is a simple average of the per-product sales of firm f in region r across 2007 and 2009.

Table 5 shows the result. Column (1) and Column (2) show that a firm facing negative demand shocks shocks in its other markets responds by introducing products with lower per-product sales and destroying products with higher per-product.[33] As a result, in Column (3), we get significant and large positive coefficient.

In Table A.16 and Table A.17 in the Appendix A, we use alternative measures of values and confirm that firms respond to the negative spillover shock by replacing high-valued products with low-valued products. Table A.16 uses measures of unit prices, and Table A.17 uses proxy of product quality based on group-adjusted unit price and organic product turnover rates.

5.2 Uniform Replacement of Products across Multiple Markets

We now show that when products enter or exit local markets, they do so in multiple markets simultaneously. We start with descriptive statistics that shows simultaneous product replace-

[33]Recall that positive coefficient means that positive spillover shock results in increase of the dependent variable, meaning that negative spillover shock results in decrease of the dependent variable.

ments across multiple markets. Then, we show that the spillover effect we find is essentially driven by products replaced in multiple markets, not from those only replaced in the local market.

(1) When a product is replaced in a local market, it is mostly replaced in multiple markets simultaneously.

Figure 1 calculates the ratio of the number of products that entered (exited) multiple markets among the total number of products that entered (exited) at least one local market. More than 81% of products entered at least more than two local markets conditional on entering at least one local market, and 93% of products exited more than two local markets.

In Table 6, we further ask the following question. Among the total value lost by destruction of products, what is the share of products (in value) that exited more that 50% (90%) of their initially sold markets? It turns that around 90% of products (in value) are destructed in more than half of the initially sold markets. Even if we restrict products to those exited more than 90% of initially sold markets, the share is 64%.

The product creation patterns turn out to be similar as can be seen in Table 7, with the share of products entering more than half of the firm's markets is given by 75%.[34]

(2) The response of net creation to the spillover shock is entirely attributed to the products replaced in multiple markets.

To investigate if the response of net creation to the spillover shock comes from products replaced in multiple markets, we decompose $\tilde{\Delta}\text{Sale}_{rf}^{\text{replace}}$ into two components: (i) $\tilde{\Delta}\text{Sale}_{rf}^{\text{replace, national}}$ which captures local sales growth coming from products replaced in multiple markets, and (ii) $\tilde{\Delta}\text{Sale}_{rf}^{\text{replace, local}}$ which captures local sales growth coming from products replaced in the county only.[35]

Columns (2) and (3) in Table 8 show the results from separate regressions by replacing $\tilde{\Delta}\text{Sale}_{rf}^{\text{replace}}$ with $\tilde{\Delta}\text{Sale}_{rf}^{\text{replace, national}}$ and $\tilde{\Delta}\text{Sale}_{rf}^{\text{replace, local}}$ as a dependent variable. Essentially

[34]Recall that we define product creation (entry) at the local market level to refer to the case when a product was not sold in the initial period (2007), but is sold at the end period (2009). In this sense, we do not exclude the possibility that the product enters a particular market while it existed in other markets in the initial period. In Table A.21 in the Appendix A, we calculate product creation pattern *conditioning on products that were not sold in the initial period at the firm-level* (i.e. firm-level creation). The results are broadly similar.

[35]By construction, $\tilde{\Delta}\text{Sale}_{rf}^{\text{replace}} = \tilde{\Delta}\text{Sale}_{rf}^{\text{replace, national}} + \tilde{\Delta}\text{Sale}_{rf}^{\text{replace, local}}$ holds.

all the spillover effect comes from response of $\tilde{\Delta}\text{Sale}_{rf}^{\text{replace, national}}$. We do get a significant coefficient from $\tilde{\Delta}\text{Sale}_{rf}^{\text{replace, local}}$, but the magnitude of coefficient is close to zero implying economically it is negligible.

In Table A.22 in the Appendix A, we repeat the analysis by defining local market at the state-level. Again, all effects come from response of $\tilde{\Delta}\text{Sale}_{rf}^{\text{replace, national}}$, while the response of $\tilde{\Delta}\text{Sale}_{rf}^{\text{replace, locall}}$ is negligible and statistically insignificant.

To summarize, we confirm that firms replace their products in multple markets simultaneously, and that the spillover effect from net creation comes from products replaced in multiple markets. These evidences suggest that multi-market firms make their decisions at the aggregate level taking into account overall demand conditions from multiple markets, rather than making highly localized decisions.

6 The Model

This section presents a multi-market model with endogenous quality adjustments, which builds up on Handbury (2013) and Faber and Fally (2017). Individuals within each market share a common market-specific income level, and regional demand shocks will be modeled as exogenous change in such income. On the demand side of the model, individuals enjoy utility from both quantity and quality from product bundles produced by continuum of firms. On the firm side, monopolistic competitive firms optimally choose quality of their products and prices.

6.1 Demand

We consider a static economy with R markets indexed by $r \in \mathcal{R} \equiv \{1, 2, ..., R\}$.[36] Each market is populated by a continuum of mass L_r of individuals each endowed with exogenous income I_r and dividends from production sector D_r.[37] We denote the total income of an individual in market r by $y_r \equiv I_r + D_r$. The economy consists of two broad sectors : consumer package goods (CPG) and an outside sector.[38] Similar to Handbury (2013) and Faber and Fally (2017), we consider a two-tier utility where the upper-tier depends on utility from CPG shopping

[36] We use the terminology "market" and "region" interchangeably.

[37] Under the labor market structure described below, wage rate is equal to one. Thus, I_r can be interpreted as exogenous labor endowments, similar to Fajgelbaum et al. (2011). Dividends will be specified after describing production sector.

[38] Consumer package goods (CPG) can be viewed as goods available in stores and supermarkets.

U and the consumption of an outside good z which will be our numeriare. We assume the constant elasticity of substitution (CES) upper-tier utility given by

$$V_r = \left[(1-\alpha)(z_r)^{\frac{\eta_r - 1}{\eta_r}} + \alpha(U_r)^{\frac{\eta_r - 1}{\eta_r}}\right]^{\frac{\eta_r}{\eta_r - 1}} \tag{6.1}$$

where $\eta_r > 1$. [39] As shown in the Appendix, by defining the share of total income y_r allocated to CPG expenditure as Θ_r, we can derive

$$\Theta_r = \frac{\alpha^{\eta_r}}{\alpha^{\eta_r} + (1-\alpha)^{\eta_r}(P_r)^{\eta_r - 1}} \equiv \Theta_r(P_r) \equiv \Theta_r(P_r) \tag{6.2}$$

where P_r is the CPG consumption bundle price index which will be defined below. Note that for a given y_r, increase of P_r decreases CPG expenditure share. We define total CPG expenditure as

$$E_r \equiv \Theta_r y_r \tag{6.3}$$

We assume the following CES utility, U^r, for the CPG consumption :

$$U_r = \left[\int_{f\in G_r} (q_{rf}\zeta_{rf})^{\frac{\sigma_r - 1}{\sigma_r}} df\right]^{\frac{\sigma_r}{\sigma_r - 1}} \tag{6.4}$$

where f deonotes a firm (i.e. CPG producer), G_r denotes the set of firms selling in market r, q_{rf} is the quantity of product bundle produced by firm f consumed by an individual in market r, ζ_{rf} refers to the perceived quality (or appeal, taste) of firm f's product bundle in market r, and σ_r refers to the elasticity of substitution between product bundles in market r. Following Faber and Fally (2017), we assume that the perceived quality $\log \zeta_{rf}$ depends on an intrinsic quality choice $\log \phi_f$ by firm f and a multiplicative term γ_r :

$$\log \zeta_{rf} \equiv \gamma_r \log \phi_f \tag{6.5}$$

Important assumption we make here is that firm f's choice of intrinsic product quality, ϕ_f, does not vary across markets and thus do not have market subscript r. In the Appendix F, we extend the model by allowing firms to optimally choose whether to uniformly adjust

[39] The CES upper-tier utility allows aggregate regional CPG expenditure to vary even under fixed y_r, mainly through change in P_r.

quality of their products and replace them in all their markets (*uniform quality strategy*), or adjust quality and replace products market-specifically (*market-specific quality strategy*), and show that firms optimally choose uniform quality strategy as long as fixed costs associated with market-specific quality adjustment are sufficiently high, or they sell in sufficiently many markets that they find less profitable to pay recurring market-specific fixed costs. We assume that change in quality of product bundle involves replacement of products in the bundle. That is, quality of product bundle changes due to exiting of original products and entry of new products.[40]

Individuals solve for their optimal CPG consumption bundle by maximizing (6.4) subject to budget constraints given by

$$\int_{f\in G_r} p_{rf} q_{rf} df \leq \Theta_r y_r \equiv E_r \tag{6.6}$$

where p_{rf} is the price index of firm f's product bundle in market r.

By defining individual expenditure on firm f's product bundle in market r as

$$s_{rf} \equiv p_{rf} q_{rf} \tag{6.7}$$

the optimality implies

$$\begin{aligned} s_{rf} &= \frac{\left(\frac{\zeta_{rf}}{p_{rf}}\right)^{\sigma_r - 1}}{\int_{f\in G_r} \left(\frac{\zeta_{rf}}{p_{rf}}\right)^{\sigma_r - 1} df} E_r \\ &= (\zeta_{rf})^{\sigma_r - 1} \left(\frac{p_{rf}}{P_r}\right)^{1-\sigma_r} E_r \end{aligned} \tag{6.8}$$

where the (quality adjusted) CPG price index is given by

$$P_r \equiv \left[\int_{f\in G_r} (p_{rf})^{1-\sigma_r} (\zeta_{rf})^{\sigma_r - 1} df\right]^{\frac{1}{1-\sigma_r}} \tag{6.9}$$

[40]Thus, our interpretation of "change in quality of product bundle" is different from "change in product appeal *within-UPC*" (e.g. Hottman et al. (2016)), in the sense that we are considering change in quality of product bundle arising from entry and exiting of UPCs consisting the product bundle.

with

$$E_r = P_r U_r \tag{6.10}$$

6.2 Outside Good Production and Labor Market

We assume a unit of outside good is produced with a unit of labor input. Labor market is perfect competitive and not separated across CPG goods production and outside good production. This implies the cost of labor (wage) equals unity.

6.3 CPG Production: Environments

In the economy, there is a continuum of measure N firms who produce differentiated CPG bundles. We abstract firm's entry and exit decision to be consistent with our empirical analysis, where we only considered existing firms in both pre- and post-shock periods.[41]

6.3.1 Market Collection

We start by defining a *market collection* of a firm. A firm's market collection is defined as the set of markets where the firm sells its product. To be consistent with our empirical analysis, we assume that each firm's market collection is given and fixed. Empirically, this assumption reflects historical persistency of firms' markets (Bronnenberg et al. (2009, 2012)). We denote each firm's market collection by k, and the set of market collections of all firms in the economy by $\mathcal{K}_{\mathcal{R}}$.[42] We denote by N^k the total measure of firms with market k, with

$$N = \sum_{k \in \mathcal{K}_{\mathcal{R}}} N^k \tag{6.11}$$

[41] We still allow firms not to operate, if they find it optimal.

[42] For example, consider a three-market economy $\mathcal{R} = \{1, 2, 3\}$. One example of $\mathcal{K}_{\mathcal{R}}$ is $2^{\mathcal{R}}$, the set of all possible subsets of $\mathcal{R}$. $\mathcal{K}_{\mathcal{R}} = 2^{\mathcal{R}}$ holds if we can always find at least one firm selling in any market collection in the economy. Another example is $\mathcal{K}_{\mathcal{R}} = \{\{1, 3\}, \{2, 3\}\} \subseteq 2^{\mathcal{R}}$, which means that each firm either has market collection $\{1, 3\}$ or $\{2, 3\}$. If a firm has market collection $\{1, 3\}$, the firm can only serves market 1 and market 3 (but not allowed to serve, for example, $\{1\}$ (only market 1), $\{1, 2\}$ (markets 1 and 2), $\{1, 2, 3\}$ (all markets 1, 2, 3), and etc.).

6.3.2 Timing of Events

The timing of events is as follows. First, each firm draws productivity a from a cumulative distribution $\Psi(a)$. The draws are independent across firms and market collections they have. Second, each firm decides whether to operate or not. Third, each firm simultaneously chooses optimal quality and prices. Finally, production occurs and markets clear subject to monopolistic competition.

We index firms (and product bundles produced by them) with $a^k \equiv (a, k)$ since all relevant firm-level decisions are uniquely determined by firm's productivity and market collection. Also, we denote quality of product bundle produced by firm a^k as $\phi(a^k)$.

6.3.3 Cost Structures

There are two cost components: a variable and a fixed cost (both in terms of labor). Following Faber and Fally (2017), we allow both the marginal and the fixed costs of production increase in the quality of the good being produced. The latter captures potential overhead costs such as design, R&D, and marketing which do not directly depend on the quantities being produced but affect the quality of the product. In turn, variable costs depend on the level of quality of the production as well as the entrepreneur's productivity, as in Melitz (2003).

As in Faber and Fally (2017), we assume the marginal cost of production of a firm a^k as

$$mc(\phi(a^k)) \equiv \frac{c(\phi(a^k))}{a} \tag{6.12}$$

where

$$c(\phi) = \phi^{\xi} \tag{6.13}$$

The parameter ξ captures the elasticity of the cost increase to the level of quality.

The total fixed costs are given by $f(\phi) + f_0$, where $f(\phi)$ is the part of fixed costs that directly depends on quality. We assume a simple log-linear parametrization given by

$$f(\phi) = b\beta\phi^{\frac{1}{\beta}} \tag{6.14}$$

with $\beta > 0$.

6.4 CPG Production: Equilibrium Conditions

We now characterize firms' optimal quality and prices. Although firms choose uniform product quality that applies to all their markets, we allow them to choose market-specific prices.

6.5 Price and Quality Choice

Firm a^k optimally chooses intrinsic quality of product (i.e. product attribute) ϕ which applies uniformly across its markets, and market-specific price p_r. We denote quality choice and market-specific price by $\phi(a^k)$ and $p_r(a^k)$, respectively, to be explicit that they depend on $a^k \equiv (a, k)$.

By combining (6.7), (6.8) and (6.5), we have firm a^k's sales and quantity sold in market r given by

$$\begin{aligned} S_r(a^k) &\equiv s_r(a^k)L_r \\ &\equiv p_r(a^k)q_r(a^k)L_r \\ &= \phi(a^k)^{(\sigma_r-1)\gamma_r}p_r(a^k)^{1-\sigma_r}A_rL_r \end{aligned} \tag{6.15}$$

and

$$\begin{aligned} Q_r(a^k) &\equiv q_r(a^k)L_r \\ &= \phi(a^k)^{(\sigma_r-1)\gamma_r}p_r(a^k)^{-\sigma_r}A_rL_r \end{aligned} \tag{6.16}$$

where $A_r \equiv (P_r)^{\sigma_r-1}\Theta_r y_r$.

The quality and price setting problem by firm a^k can be formally written as follows:

$$\max_{\phi(a^k),\{p_r(a^k)\}_{r\in k}} \pi(a^k) = \sum_{r\in k}\left(p_r(a^k) - \frac{c(\phi(a^k))}{a}\right)Q_r(a^k) - f(\phi(a^k)) - f_0 \tag{6.17}$$

subject to demand condition in (6.16).

We can show that the optimal price is

$$p_r(a^k) = mc(\phi(a^k))\frac{\sigma_r}{\sigma_r - 1} \tag{6.18}$$

with the markup

$$\mu_r(a^k) \equiv \frac{p_r(a^k)}{mc(\phi_{(r)}(a^k))} = \frac{p_r(a^k)}{mc(\phi(a^k))} = \frac{\sigma_r}{\sigma_r - 1} \equiv \mu_r \tag{6.19}$$

The optimal quality is given by

$$\phi(a^k) = \left[\frac{1}{b}\sum_{r \in k} \rho_r S_r(a^k)[\gamma_r - \xi]\right]^\beta \tag{6.20}$$

where

$$\rho_r \equiv \frac{1}{\mu_r} = \frac{\sigma_r - 1}{\sigma_r} \tag{6.21}$$

is the inverse-markup in market r.

By combining (6.17), (6.14), and (6.20), we can derive the optimal profit as

$$\pi(a^k) = \sum_{r \in k} \frac{1}{\sigma_r}\left[1 - \beta\left(\gamma_r - \xi\right)\left(\sigma_r - 1\right)\right] S_r(a^k) - f_0 \tag{6.22}$$

The expression of sales of a firm with a^k in market r, $S_r(a^k)$, is derived using (6.15) and (6.20) as

$$\begin{aligned} S_r(a^k) &= \phi(a^k)^{(\sigma_r - 1)(\gamma_r - \xi)}\left[\frac{\mu_r}{a}\right]^{1-\sigma_r} A_r L_r \\ &= \left[\frac{1}{b}\sum_{r \in k} \rho_r S_r(a^k)[\gamma_r - \xi]\right]^{\beta(\sigma_r - 1)(\gamma_r - \xi)} \left[\frac{\mu_r}{a}\right]^{1-\sigma_r} A_r L_r \end{aligned} \tag{6.23}$$

The optimal price of a firm with a^k in market r is

$$\begin{aligned} p_r(a^k) &= \frac{\phi(a^k)^\xi}{a}\mu_r \\ &= \frac{1}{a}\left[\frac{1}{b}\sum_{r \in k} \rho_r S_r(a^k)[\gamma_r - \xi]\right]^{\beta\xi} \mu_r \end{aligned} \tag{6.24}$$

We can prove that under sufficiently small $\beta > 0$, the equilibrium is unique.

Proposition 1. *(Uniqueness of the Optimal Price and Quality)*

If $\beta > 0$ *is sufficiently small that* $\beta(\gamma_r - \xi)(\sigma_r - 1) < 1$*, the optimal price and quality is uniquely determined.*

Proof. This is a special case of Corollary 2 in Hyun (2019). Proof can be found in the Appendix of Hyun (2019). □

6.5.1 Productivity and the Optimal Quality and Sales

We can show that as long as there is not too much heterogeneity in σ_r and β is sufficiently small (to avoid offsetting feedback effects), the equilibrium quality $\phi(a^k)$ and sales $S_r(a^k)$ increase monotonically with firm productivity a.

Proposition 2. *(Productivity and Quality, Sales under Uniform Quality Choice)*

Consider a firm choosing uniform quality. If $\beta > 0$ *is sufficiently small that* $\beta(\gamma_r - \xi)(\sigma_r - 1) < 1$*, we have*

$$\frac{\partial \log \phi(a^k)}{\partial \log a} > 0 \tag{6.25}$$

$$\frac{\partial \log S_r(a^k)}{\partial \log a} > 0 \tag{6.26}$$

Proof. This is a special case of Corollary 4 in Hyun (2019). Proof can be found in the Appendix of Hyun (2019). □

Corollary 3. *Under the conditions in Proposition 2, the optimal profit* $\pi(a^k)$ *strictly monotonically increases with firm productivity* a*.*

Proof. It is immediate from equation (6.22) and $\frac{\partial \log S_r(a^k)}{\partial \log a} > 0$. □

6.5.2 Choice between Operation vs. Non-operation

Due to monotonicity of $\pi(a^k)$, firms with market collection k only produce if their realized productivities are above a cutoff productivity $\overline{a_k}$ defined by

$$\pi(\overline{a_k}^k) = 0 \tag{6.27}$$

where $\overline{a_k}^k \equiv (\overline{a_k}, k)$. The fraction of firms with $a \geq \overline{a_k}$ is $\vartheta(\overline{a_k}^k) \equiv 1 - \Psi(\overline{a_k}) \equiv \vartheta^k$. Since the total number (measure) of firms with market collection k is given by N^k, the total number of active firms eventually serving market collection k is given by $\vartheta^k N^k$.

Thus, the ex-ante profit for each market collection k is given by

$$\begin{aligned} \Pi^k &= \int_a \pi(a^k) I(a^k) d\Psi(a) \\ &= \int_{a \geq \overline{a_k}} \pi(a^k) d\Psi(a) \end{aligned} \tag{6.28}$$

where $I(a^k) = \begin{cases} 1 & \text{if } a \geq \overline{a_k} \\ 0 & o.w. \end{cases}$.

Let $\mathcal{M}^r \equiv \{k \in \mathcal{K}_{\mathcal{R}} : r \in k\}$ denote the set of market collections that contain market r. Then, the equilibrium CPG price in market r is expressed as

$$\begin{aligned} P_r &= \left[\int_{f(a^k) \in G_r} \left(\phi(a^k)^{-(\gamma_r - \xi)} \frac{\mu_r}{a} \right)^{1-\sigma_r} df(a^k) \right]^{\frac{1}{1-\sigma_r}} \\ &= \left[\sum_{k \in \mathcal{M}^r} N^k \int_{a \geq \overline{a_k}} \left(\phi(a^k)^{-(\gamma_r - \xi)} \frac{\mu_r}{a} \right)^{1-\sigma_r} d\Psi(a) \right]^{\frac{1}{1-\sigma_r}} \end{aligned} \tag{6.29}$$

6.6 Profits and Dividends

Since we do not allow entry and exit of CPG producers, there are aggregate profits in the economy. The aggregate profits in the economy are given by

$$\overline{\Pi} \equiv \sum_{k \in \mathcal{K}_{\mathcal{R}}} \Pi^k N^k \tag{6.30}$$

We assume that the share of total profits are rebated to the consumers as dividends. For simplicity, we assume individuals receive dividends proportional to the exogenous income endowments they have. Thus, individual in market r receives dividend D_r given by

$$D_r \equiv \frac{I_r}{\sum_{r \in \mathcal{R}} I_r L_r} \overline{\Pi} \tag{6.31}$$

which implies

$$y_r = I_r + D_r = I_r \left(1 + \frac{\overline{\Pi}}{\sum_{r\in\mathcal{R}} I_r L_r}\right) \tag{6.32}$$

6.7 Bridging the Empirics and the Theory: Structural Equation of Market Interdependency

In this section, we derive a structural equation that connects a firm's local sales growth with its average sales growth in other markets. This equation will allow us structurally interpret our reduced-form empirical analyses. The magnitude of spillover is determined by 4 structural parameters that govern elasticities of market share and costs with respect to the change in product quality.

To derive the relationship between a firm's local sales and its sales from other markets, we use equation (6.23). The derivation can be found in the Appendix D.

Define $\Gamma_r \equiv (\sigma_r - 1)(\gamma_r - \xi)$. Denote a firm's initial local sales as $S_{0,r}(a^k)$ and define $\omega_{0,r}(a^k) \equiv \frac{\rho_r[\gamma_r-\xi]S_{0,r}(a^k)}{\sum_{r'\in k}\rho_{r'}[\gamma_{r'}-\xi]S_{0,r'}(a^k)}$, where $\sum_{r\in k}\omega_{0,r}(a^k) = 1$. If we assume no regional heterogeneity in preference parameters (i.e. $\gamma_r = \gamma$ and $\sigma_r = \sigma$ for all $r \in \mathcal{R}$), $\omega_{0,r}(a^k) = \frac{S_{0,r}(a^k)}{\sum_{r'\in k} S_{0,r'}(a^k)}$ is an initial sales weight.

By defining growth rate of a variable y as $\hat{y} \equiv \log y/y_0$, we can show that

$$\hat{S}_r(a^k) = \frac{\beta\Gamma_r\left(1-\omega_{0,r}(a^k)\right)}{1-\beta\Gamma_r\omega_{0,r}(a^k)}\sum_{l\in k\&l\neq r}\omega^r_{0,l}(a^k)\hat{S}_l(a^k) + \frac{1}{1-\beta\Gamma_r\omega_{0,r}(a^k)}(\hat{A}_r + \hat{L}_r) \tag{6.33}$$

where $\sum_{r'\in k\&r'\neq r}\omega_{0,r'}(a^k) = 1-\omega_{0,r}(a^k)$, and $\omega^r_{0,l}(a^k) \equiv \frac{\omega_{0,l}(a^k)}{1-\omega_{0,r}(a^k)}$ with $\sum_{l\in k\&l\neq r}\omega^r_{0,l}(a^k) = 1$. Again, if we assume $\gamma_r = \gamma$ and $\sigma_r = \sigma$ for all $r \in \mathcal{R}$, $\omega^r_{0,l}(a^k) = \frac{S_{0,l}(a^k)}{\sum_{r'\in k\&r'\neq r} S_{0,r'}(a^k)}$ is the leave-out initial sales weight which we used in our reduced-form empirical analysis.

Let's assume $\sigma_r = \sigma$ and $\gamma_r = \gamma$ for all $r \in \mathcal{R}$ and denote $\Gamma \equiv (\sigma-1)(\gamma-\xi)$. As long as a firm sells in many markets, we can treat $\omega_{0,r}(a^k) \approx 0$.[43] In this case, (6.33) can be written as

$$\hat{S}_r(a^k) = \Upsilon \sum_{l\in k\&l\neq r}\omega^r_{0,l}(a^k)\hat{S}_l(a^k) + (\hat{A}_r + \hat{L}_r) \tag{6.34}$$

[43]In our data, $\omega_{0,r}(a^k)$ is less than 0.005 on average.

where

$$\Upsilon \approx \underbrace{\beta}_{\substack{\text{Inverse-elasticity of} \\ \text{fixed cost w.r.t } \phi}} \times \underbrace{(\sigma - 1)(\gamma - \xi)}_{\substack{\text{Elasticity of} \\ \text{market share w.r.t } \phi}} \tag{6.35}$$

Equation (6.35) summarizes how structural parameters determine the magnitude of spillovers. Higher β implies lower elasticity of fixed cost with respect to quality change. This implies lower sensitivity of the cost-side of quality change, inducing more sensitive quality change to the shock. This generates stronger spillover.

Higher $(\sigma - 1)(\gamma - \xi)$ captures higher elasticity of market shares with respect to intrinsic quality change.[44] As can be seen from (6.15), $(\sigma - 1)$ captures how the market shares respond to change in households' perceived quality ζ conditional on prices. In turn, $(\gamma - \xi)$ reflects the trade off arising from changing intrinsic quality, between its effect on perceived quality and price. Specifically, γ captures elasticity of perceived quality $\zeta(\phi)$ with respect to change in intrinsic quality, while ξ reflects elasticity of marginal cost $\frac{c(\phi)}{a}$ which passes through to the price (as can be seen from (6.24)). In sum, higher $(\sigma - 1)(\gamma - \xi)$ implies higher sensitivity of the revenue-side of quality change, inducing firms to increase (decrease) their quality more to the same magnitude of postive (negative) demand shocks.

6.7.1 Estimation of the Structural Equation

We now estimate equation (6.34) and get the empirical counterpart of Υ, $\hat{\Upsilon}$. This can be easily done since equation (6.34) can be viewed as a variant of equation (3.5), where we replace the spillover shock with the leave-out average sales growth from the firm's other markets. Hence, we can estimate Υ by regressing firms' local sales growth with their leave-out average sales growth, where we instrument the latter with the spillover shock.

Table 9 presents the result. In Column (1), we simply regress firms' local sales growth on their leave-out average sales growth from other markets, where we include Sector+Region fixed effects. We get coefficient of 0.99, meaning that local sales growth are highly correlated across regions within a firm. In Column (2), we instrument leave-out average sales growth with the

[44] This can be seen from (6.23), where market share in r is $\frac{S_r(a^k)}{\Theta_r y_r L_r} = \phi(a^k)^{(\sigma_r - 1)(\gamma_r - \xi)} \left[\frac{\mu_r}{a}\right]^{1-\sigma_r} (P_r)^{\sigma_r - 1}$. Thus the elasticity of market share with respect to quality change is $(\sigma_r - 1)(\gamma_r - \xi)$.

spillover shock. The estimated coefficient is 0.72.

In Column (3) and Column (4), we repeat the analyses with Sector×Region fixed effects as in Column (3) of Table 2 in our main regression. We get slightly larger estimate of $\hat{\Upsilon}$ given by 0.86, but face a weak IV problem with the first-stage F statistics given by 7.9. To avoid the possibility of bias and inconsistency of the estimate, we use 0.72 as our preferred estimate of $\hat{\Upsilon}$.[45]

6.8 Model Implications: Partial Equilibrium Responses to the Exogenous Change in Income

What are the effects of demand shocks in other markets on a local market not directly hit by such shocks? Given the lack of analytical solutions, full general equilibrium effects must be calculated numerically. Yet, we can derive partial equilibrium responses of optimal quality, local sales, local CPG price index, local CPG expenditure, and local welfare to change in income level in other markets. It is partial equilibrium in the sense that we shut down several general equilibrium adjustments including the effect through change in dividends. Thus, we treat y_r as exogenous during the partial equilibrium analysis.

Theorem 4. *(Exogenous Change in Local Income and Response of Quality and Local Sales)*

Let $r \in k$. Suppose (i) β is sufficiently small that $\beta(\sigma_r - 1)(\gamma_r - \xi) < 1$ and (ii) P_r, D_r are fixed. Then, $\frac{\partial \log \phi(a^k)}{\partial \log y_r} > 0$ and $\frac{\partial \log S_r(a^k)}{\partial \log y_r} > 0$.

The results also hold by relaxing (ii) by allowing P_r to vary with y_r, as long as such variations are sufficiently small.

Proof. Proof can be found in the Appendix D. □

Theorem 5. *(Change in Quality and Response of Local Sales)*

Let $r \in k$. Suppose (i) y_r is fixed (i.e. there is no direct local shock) and (ii) P_r is fixed. Then, $\frac{\partial \log S_r(a^k)}{\partial \log \phi(a^k)} > 0$.

Proof. Proof can be found in the Appendix D. □

[45] In Table A.23 in the Appendix A, we present decomposition of sales growth into extensive margin of product replacement (net creation) and intensive margin of continuing products. Again, all the effect comes from the extensive margin.

Theorem 6. *(Change in Quality and Response of Local CPG Prices, CPG Expenditure, and Welfare)*

Let $r \in k$. Suppose (i) y_r is fixed (i.e. there is no direct local shock) and (ii) we fix the number of active firms in each market by shutting down change in $\overline{a_k}$ for all $k \in \mathcal{K}_{\mathcal{R}}$. Then, $\frac{\partial \log P_r}{\partial \log \phi(a^k)} < 0$, $\frac{\partial \log E_r}{\partial \log \phi(a^k)} > 0$, and $\frac{\partial \log V_r}{\partial \log \phi(a^k)} > 0$.

Proof. Proof can be found in the Appendix D. $\square$

Suppose there is a negative income shock hitting market $r' \in k$. Theorem 4 implies this induces a firm selling in market r' to downgrade quality and experience lower sales in market r'. In turn, Theorem 5 implies that such quality downgrading results in lower sales in market $r(\neq r') \in k$, which is not directly hit by the income shock. This is consistent with our empirical findings of regional spillovers through quality downgrading.

Finally, Theorem 6 shed lights on the aggregate consequences of regional spillovers through the lens of the model. It implies quality downgrading (induced by negative income shock in market r') increases "quality-adjusted" CPG price index in market r, which in turn reduces total CPG expenditure and the welfare in market r. This means that (at least under partial equilibrium context) our model generates positive comovements in regional CPG consumption and sales through regional linkages created by multi-market firms. This is a new source of regional business cycle comovement our paper emphasizes. Also, our model implies a market not directly hit by negative shock also experiences welfare loss through quality downgrading by multi-market firms.

In the Appendix E, we present the counterfactual economy where all firms choose market-specific quality. In contrast to the uniform quality choice, market-specific quality choice generates independence across markets. The independence across markets under market-specific quality choice is summarized by Proposition 9 in the Appendix E.

6.9 General Equilibrium Analysis

To derive aggregate implications of our findings, we calibrate the model to match key moments of our micro-level analyses and perform counterfactual analysis. We show that the channel we propose generated a sizable redistributional effect across regions through the uniform adjustment of product quality during the Great Recession.

6.9.1 Calibration

In this exercise, we define local market at the state-level. This reduces computational burden and allows us to exactly match firm-level spatial networks across states. We include both single-market firms and multi-market firms in our analysis, which give us 5186 firms at most selling in 49 states.[46] Each firm's market collection k is directly obtained from the data as the collection of states where the firm sells products. There are 2775 unique market collections in the data.

As we are not considering firm-level entry and exit, productivity heterogeneity plays little role in our model. Thus, in the numerical exercise, we do not introduce productivity heterogeneity and instead assume that $\Psi(a)$ is a degenerated distribution at $a = \bar{a}$, where we normalize $\bar{a} = 1$. Although we do not allow productivity heterogeneity, we do (approximately) match the pooled distribution of the state-firm level sales in the following way. Note that in the model, the state-level CPG expenditure $E_r L_r$ is equal to the aggregate state-level CPG producers' sales:

$$E_r L_r = \sum_{k \in \mathcal{M}^r} N^k \int_{a \geq \overline{a_k}} S_r(a^k) d\Psi(a) = \sum_{k \in \mathcal{M}^r} N^k S_r(a^k) \tag{6.36}$$

where the second equality reflects our assumption $a = 1$. Note that the empirical counterpart of $\sum_{k \in \mathcal{M}^r} N^k S_r(a^k)$ is $\sum_f S_{rf}$. Thus, by choosing initial I_r in the model so as to satisfy

$$I_{0,r} \propto \frac{\sum_f S_{rf,07}}{L_r} \tag{6.37}$$

we can match the pooled distribution of the "average state-firm level sales" (averaged across firms within state).[47] This approximates the pooled distribution of the state-firm level sales.[48] For the L_r, we use the 2005 state-level population (in thousands) obtained from the 2005

[46] States included in our exercise can be found in Table 12.

[47] Recall that $E_r L_r = \Theta_r y_r = \Theta_r I_r \left(1 + \frac{\overline{\Pi}}{\sum_{r \in \mathcal{R}} I_r L_r}\right)$. Thus, we have $I_r = \frac{\sum_{k \in \mathcal{M}^r} N^k S_r(a^k)}{\Theta_r L_r \left(1 + \frac{\overline{\Pi}}{\sum_{r \in \mathcal{R}} I_r L_r}\right)}$, where Θ_r is determined endogenously. Although Θ_r could differ across markets, such variation turns out to be mild. Thus, we simply use approximation (6.37), where we replace $\sum_{k \in \mathcal{M}^r} N^k S_r(a^k)$ with its empirical counterpart $\sum_f S_{rf}$.

[48] To be more formal, we are matching the distribution of $\frac{\sum_{k \in \mathcal{M}^r} N^k S_r(a^k)}{N_r}$ (with allowing N_r duplicates) using the distribution of $\frac{\sum_f S_{rf}}{N_r}$ (with allowing N_r duplicates), where $N_r \equiv \sum_{k \in \mathcal{M}^r} N^k$ is the number of firms in market r.

American Community Survey.[49]

For the exogenous local demand shock, $\hat{I}_r$, we use state-level house price growth multiplied by 0.23 as a proxy of exogenous demand shock. 0.23 is the consumption elasticity with respect to house price shock reported by Berger et al. (2018).[50]

Now, for the parameters, we start by estimating Υ using our state-firm level data.[51] The estimated Υ using IV regression is presented in Column (2) of Table 10. The estimate of Υ is 0.61, which is slightly lower than the county-firm level regression.

The second structural equation we use is the relationship between firm's local price and the average sales across all its markets. We can easily drive the following equation :

$$\hat{p}_r(a^k) = \beta\xi \sum_{r\in k} \omega_{0,r}(a^k)\hat{S}_r(a^k) \tag{6.38}$$

We obtain the estimate of $\beta\xi$ by regressing firm's local price on its average sales growth across all its markets. While doing so, we use the average sales growth in the firm's *other markets* in place of the average sales growth across *all its markets* to rule out possible confounding factors affecting local price and local sales simultaneously.[52] We instrument the average sales growth in other markets using the spillover shocks as in estimation of Υ. Column (4) of Table 10 presents the IV estimate of $\beta\xi$, given by 0.37.

We cannot identify all four parameters because we only have two structural equations. Thus, we bring the estimated values for σ and ξ from Faber and Fally (2017).[53] These values are $\sigma = 2.2$ and $\xi = 0.82$. Then we can deduce γ and β by combining these values with our estimate on Υ and $\beta \times \xi$.

For the elasticity of substitution parameter η in the upper-tier utility, we do not have a

[49] We introduced L_r to reflect relative size of population across states. Thus, we abstract cross-state migration or population growth by assuming L_r is fixed.

[50] One caveat is the elasticity reported by Berger et al. (2018) measures aggregate consumption elasticity with respect to the aggregate house price shock, which may differ from regional elasticity. For our purpose, this number itself plays little role since we are using this elasticity as a parsimonious way to normalize house price growth into income growth, which in our model, translates into expenditure growth.

[51] Even at the state-firm level, $\omega_{0,r}(a^k)$ is around 0.05 on average. Thus, we use the approximation relationship between Υ and the structural parameters in equation (6.35). Adjusting for $\omega_{0,r}(a^k)$ to obtain the exact relationship between Υ and structural parameters in (6.34) does not change the result.

[52] Using the firm's average sales growth including all its markets gives us similar results.

[53] Note that these parameters are estimated at the Product Module-Firm level in Faber and Fally (2017). Thus, we are assuming that elasticity of substitution across firms within product module is similar to that across firms. We are in progress of estimating these parameters using our data at the state-firm level.

good estimate. Thus, we use $\eta = 1$ which implies Cobb-Douglas upper-tier utility function. If we use larger η, we find stronger mitigation of regional consumption and welfare inequality. Thus, this is a conservative approach. Finally, we set the CPG expenditure share parameter α to 0.20, which is close to the United States counterpart.[54]

We summarize the calibration strategy and results in Table 11.

6.9.2 Results: Aggregate Implications

The result is summarized in Table 12. The table shows that the channel we propose generated a sizable redistributional effect across regions in terms of welfare during the Great Recession. We use two measures of welfare, (i) quality-adjusted real CPG consumption U_r (i.e. "CPG welfare") and (ii) real (composite) consumption aggregating CPG goods and the outside good V_r (i.e. "overall welfare").

The first measure captures the welfare effect arising through CPG consumption, which our empirical and theoretical analyses mainly focused on. Yet, households could switch their consumption to other types of goods if they find CPG products less appealing due to the quality change. Overall effects incorporating such substitutions are captured by $\hat{V}_r$. We view our measure of $\hat{V}_r$ as the lower-bound of the welfare effect since we are assuming our channel exists only in CPG consumption, while in reality, similar mechanism could exist in other types of consumption. Also, we would like to emphasize that assuming Cobb-Douglas upper-tier utility is a conservative choice, and that introducing larger elasticity of substitution across CPG and outside goods strengthens our results below. Similar to $\hat{V}_r$ serving as the lower-bound, we view $\hat{U}_r$ as the upper-bound of the welfare effect.

We first focus on CPG welfare $\hat{U}_r$. States that experienced increase of local house prices such as Iowa (IA), Louisiana (LA), Montana (MT), North Dakota (ND), Oklahoma (OK), and South Dakota (SD) experienced large decline of CPG welfare due to spillovers from states that were hit by large housing market disruptions. For example, the benchmark model implies Oklahoma experienced 1.26% *loss* of CPG welfare, while under counterfactual economy, they could have experienced 1.14% *increase* of CPG welfare. This reflects the fact that regions not

[54] This number is calculated based on the BLS report *Consumer Expenditures in 2007*. We categorize the following major categories as CPG expenditure: Food, Alcoholic beverages, Apparel and services, Personal care products and services, Tobacco products and smoking supplies.

directly hit by negative shocks could also experience decline of welfare due to uniform quality downgrading by multi-market firms.

While states less hit by negative shocks experience deterioration of welfare due to spillovers from severely hit states, the opposite holds for states that went through severe negative shocks. For example, Arizona (AZ) experienced 10.70% decline of CPG welfare under the benchmark model, while it could have been much worse with 12.93% loss of CPG welfare under the counterfactual economy. similarly, California (CA) experienced 9.67% decline of CPG welfare under the benchmark model, while it could have been experiencing 11.27% loss of welfare in the counterfactual economy. This means that states that were hit by severe negative shocks benefit from less hit regions since multi-market firms downgrade product quality less under the benchmark compared to the counterfactual economy.

On average, the absolute difference in CPG welfare growth between the benchmark and the counterfactual economy is given by 1.17 percentage point. Since the average decline of CPG welfare in the benchmark economy is 5.80%, this implies that shutting down our channel generates additional 20% increase (decrease) of welfare in regions hit by larger-than-average (smaller-than-average) negative regional shocks.

The dispersion of welfare growth across states can be summarized by the standard deviation of welfare growth across states. Under the benchmark model with our channel, the standard deviation is 2.96, while under the counterfactual economy, it is given by 4.38. Thus, the result implies that the standard deviation of the welfare growth across states increases by 48% in the counterfactual economy. This highlights the importance of intra-firm network channel in alleviating the regional consumption inequality.

Even if we take into account potential substitution to the outside good, we still find non-negligible welfare consequences. States such as Iowa (IA), Louisiana (LA), Montana (MT), North Dakota (ND) and South Dakota (SD) could have experienced overall welfare increase under the counterfactual economy, while they actually experienced decline of welfare due to our channel. For example, South Dakota (SD) experienced 0.24% *loss* of overall welfare in the benchmark, while it could have experienced 0.18% *increase* of welfare under the counterfactual economy.

In contrast, Arizona (AZ) and California (CA) could have experienced overall welfare loss of 9.62% and 8.36%, respectively, while they actually experienced smaller welfare decline of

9.16% and 8.03%. The average absolute difference in welfare growth between the two economies is given by 0.24 percentage point. Since the average decline of overall welfare in the benchmark economy is 4.22%, this implies that shutting down our channel generates additional 6% increase (decrease) of overall welfare in regions hit by larger-than-average (smaller-than-average) negative regional shocks. Finally, the standard deviation of the overall welfare growth across states increases by 10% if we move from the benchmark (2.98) to the counterfactual economy (3.27).

In sum, the multi-market firms' product replacement decisions, which involve uniform quality adjustments, mitigates regional consumption and welfare inequality. The standard deviation of welfare growth, measured by quality-adjusted real consumption growth, across states increases by at least 10% to at most 48% by moving from the benchmark to the counterfactual economy. .

7 Conclusion

This paper investigated how regional housing market disruptions spilled over across counties and states through within-firm networks created by multi-market firms. By exploiting a sharp differential drop in local house prices during the Great Recession, we showed that firms' local sales decrease in response to the negative demand shocks affecting their other markets, and that this is driven by the entry and exit of products within firms. We showed that this reflects replacement from high- to low-valued products, where firms uniformly replace products in multiple markets. To formalize our mechanism and discuss aggregate implications, we proposed a simple model with firms' endogenous quality adjustments. In the model, negative demand shocks lead firms to downgrade their product quality, and in doing so, they replace their products in multiple markets uniformly. We calibrated the model to match our micro-level data and performed counterfactual analysis in the context of the Great Recession. Our result shows that the channel we propose generated a substantial cross-region transmission of regional housing market disruptions, inducing distributional consequences across regions at the aggregate level. In particular, regions that went through a moderate decline in demand experienced exacerbation of welfare loss due to our channel, while regions severely hit by the shock experienced alleviation of welfare loss.

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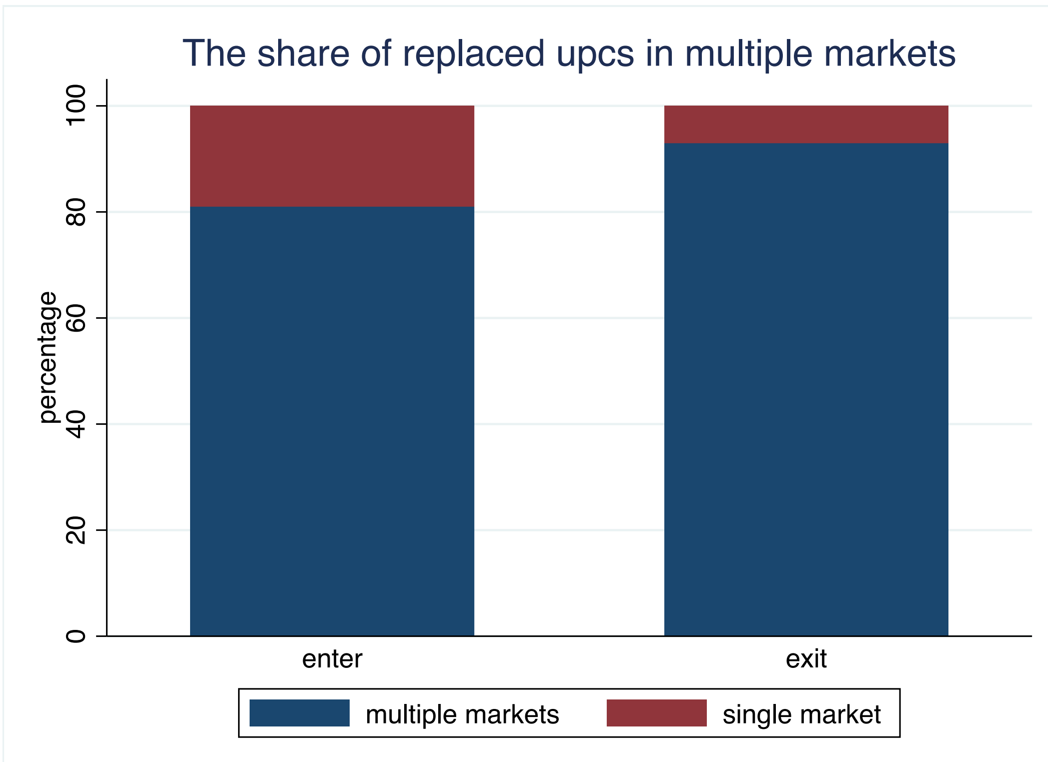
Figure 1: Ratio of Products Entering and Exiting Multiple Markets



Note. The left bar plots the ratio of the number of products entering multiple local markets relative to the total number of products entering at least one local market. The right bar plots the ratio of the number of products exiting multiple local markets relative to the total number of products exiting at least one local market. A Product enters a local market if it did not exist in the local market in year 2007, but exists in the local market in year 2009. Product exits a local market if it existed in the local market in year 2007, but no longer exists in the local market in year 2009.

Table 1: Summary Statistics

Variable	Obs	Mean	Std. Dev.	P10	P50	P90
Panel A: County-firm variables						
$\tilde{\Delta}\text{HP}_{rf,07-09}$ (other)	840681	-.169	.042	-.209	-.170	-.122
$\tilde{\Delta}\text{Sale}^{\text{total}}_{rf,07-09}$	840681	-.041	.799	-1.176	.017	.942
$\tilde{\Delta}\text{Sale}^{\text{continue}}_{rf,07-09}$	840681	-.061	.543	-.702	-.037	.534
$\tilde{\Delta}\text{Sale}^{\text{replace}}_{rf,07-09}$	840681	.021	.53	-.528	0	.571
$\text{Sales}_{rf,07}$ (in thousand dollar)	840681	65.423	739.854	.107	2.346	70.288
$\text{Sales}^{\text{exist}}_{rf,07}$ (in thousand dollar)	840681	56.524	631.472	.061	1.639	58.916
$\text{Sales}^{\text{exit}}_{rf,07}$ (in thousand dollar)	840681	8.899	129.795	0	.197	8.684
$\text{Sales}_{rf,09}$ (in thousand dollar)	840681	68.068	768.49	.071	2.347	74.756
$\text{Sales}^{\text{exist}}_{rf,09}$ (in thousand dollar)	840681	52.375	528.692	.037	1.475	56.332
$\text{Sales}^{\text{enter}}_{rf,09}$ (in thousand dollar)	840681	15.693	283.807	0	.216	14.266
# of UPCs in 2007	840681	34.18	106.989	1	9	70
Panel B: Firm variables						
$\tilde{\Delta}\text{HP}_{f,07-09}$	4171	-.161	.087	-.269	-.156	-.067
$\text{Sale}_{f,07}$ (in million dollar)	4171	15.586	147.974	.005	.278	14.677
# of UPCs in 2007	4171	54.239	231.783	2	12	110
# of counties in 2007	4171	513.243	669.991	10	155	1655
# of product groups in 2007	4171	2.701	3.421	1	2	6
Panel C: County variables						
$\tilde{\Delta}\text{HP}_{r,07-09}$	991	-.092	.138	-.258	-.079	.044
$\text{Sale}_{r,07}$ (in million dollar)	991	55.499	131.941	.524	15.849	143.861
# of UPCs in 2007	991	28995.06	15382.66	7994	28730	49854
# of firms in 2007	991	848.316	353.868	341	876	1306

Note. All the sales and house price variables are defined in Section 3. $\tilde{\Delta}\text{Sale}^{\text{total}}_{rf,07-09}$ is the county-firm sales growth in 2007-09, $\tilde{\Delta}\text{Sale}^{\text{replace}}_{rf,07-09}$ is the county-firm sales growth arising from product replacements in 2007-09, and $\tilde{\Delta}\text{Sale}^{\text{continue}}_{rf,07-09}$ is the county-firm sales growth arising from continuing products in 2007-09. $\text{Sale}_{rf,07}$ is the total county-firm sales in 2007, $\text{Sale}^{\text{exist}}_{rf,07}$ is the 2007 sales of products existed in both 2007 and 2009, and $\text{Sale}^{\text{exit}}_{rf,07}$ is the 2007 sales of products existed in 2007 but exited in 2009. $\text{Sale}_{rf,09}$ is the total sales in 2009, $\text{Sale}^{\text{exist}}_{rf,09}$ is the 2009 sales of products existed in both 2007 and 2009, and $\text{Sale}^{\text{enter}}_{rf,09}$ is sales of products newly entered in 2009. $\tilde{\Delta}\text{HP}_{r,07-09}$ is the county-level house price growth between 2007 and 2009, $\tilde{\Delta}\text{HP}_{f,07-09}$ is the firm-level exposure of house price growth, which is defined as 2007 sales share weighted average of $\tilde{\Delta}\text{HP}_{r,07-09}$ across counties where the firm generates sales, and $\tilde{\Delta}\text{HP}_{rf,07-09}$ (other) is the spillover shock defined as the initial sales-weighted $\tilde{\Delta}\text{HP}_{r,07-09}$ in the other counties where the firm generates sales. Firm variables are measured including information from all regions (i.e. including regions without house price information).

Table 2: Regional Spillovers through multi-market firms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				$\tilde{\Delta}\text{Sale}_{(07-09)}(\%)$			
			OLS			State-level	IV
$\tilde{\Delta}\text{HP}_{(07-09)}(\%)$	0.060**	0.059**					
	(0.028)	(0.028)					
$\tilde{\Delta}\text{HP}_{(07-09)}(\%)$ (other)		0.345***	0.398***			0.303***	0.601***
		(0.110)	(0.105)			(0.113)	(0.139)
$\tilde{\Delta}\text{HP}_{(07-09)}(\%)$ (other, placebo)				-0.006			
				(0.379)			
$\tilde{\Delta}\text{HP}_{(07-09)}(\%)$ (other, exclude)					0.384***		
					(0.091)		
Sector FE	-	✓	-	-	-	-	-
Region Controls	✓	✓	-	-	-	-	-
Firm FE	✓	-	-	-	-	-	-
Region-Firm Controls	-	✓	✓	✓	✓	✓	✓
Sector x Region FE	-	-	✓	✓	✓	✓	✓
R^2	0.608	0.201	0.392	0.392	0.398	0.357	0.036
Observations	840681	840681	840681	840681	821503	83610	448604

Note. $\tilde{\Delta}\text{Sale}_{(07-09)}$ is the county-firm specific sales growth between 2007 and 2009, $\tilde{\Delta}\text{HP}_{(07-09)}$ is the county-level house price growth between 2007 and 2009, and $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) is the initial sales-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales. $\tilde{\Delta}\text{HP}_{(07-09)}$ (other, placebo) is the Placebo spillover shock. $\tilde{\Delta}\text{HP}_{(07-09)}$ (other, exclude) is the initial sales-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales and the firm has no establishments. Sectors are defined based on SIC 4-digit. Region controls include pre-recession percentage white, median household income, percentage owner-occupied, percentage with less than high school diploma, percentage with only a high school diploma, unemployment rate, poverty rate, percentage urban, and employment share in a county for 2-digit industries. Region-Firm controls include log of initial county-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by county-firm specific initial sales. Standard errors are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table 3: Decomposition of Sales Growth: Net Creation vs. Continuing Products

	(1)	(2)	(3)
	$\tilde{\Delta}\text{Sale}_{(07-09)}(\%)$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}(\%)$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}(\%)$
$\tilde{\Delta}\text{HP}_{(07-09)}(\%)$	0.059**	0.009	0.051**
	(0.028)	(0.014)	(0.024)
$\tilde{\Delta}\text{HP}_{(07-09)}(\%)$ (other)	0.345***	0.320***	0.025
	(0.110)	(0.093)	(0.067)
Sector FE	✓	✓	✓
Region Controls	✓	✓	✓
Region-Firm Controls	✓	✓	✓
Sector x Region FE	-	-	-
R^2	0.201	0.284	0.223
Observations	840681	840681	840681
	(4)	(5)	(6)
	$\tilde{\Delta}\text{Sale}_{(07-09)}(\%)$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}(\%)$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}(\%)$
$\tilde{\Delta}\text{HP}_{(07-09)}(\%)$ (other)	0.398***	0.419***	-0.021
	(0.105)	(0.102)	(0.045)
Sector FE	-	-	-
Region Controls	-	-	-
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
R^2	0.392	0.408	0.427
Observations	840681	840681	840681

Note. $\tilde{\Delta}\text{Sale}_{(07-09)}$ is the county-firm specific sales growth between 2007 and 2009, $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$ is the county-firm specific sales growth between 2007 and 2009 arising from product replacements (net creation), $\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$ is the county-firm specific sales growth between 2007 and 2009 arising from continuing products, $\tilde{\Delta}\text{HP}_{(07-09)}$ is the county-level house price growth between 2007 and 2009, and $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) is the initial sales-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales. Sectors are defined based on SIC 4-digit. Region controls include pre-recession percentage white, median household income, percentage owner-occupied, percentage with less than high school diploma, percentage with only a high school diploma, unemployment rate, poverty rate, percentage urban, and employment share in a county for 2-digit industries. Region-Firm controls include log of initial county-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by county-firm specific initial sales. Standard errors (in parentheses) are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table 4: Response of Number of Products Entering and Exiting

	(1)	(2)	(3)
	$\text{Entry}_{(07-09)}$	$\text{Exit}_{(07-09)}$	$\text{Net Entry}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	-0.143**	-0.102	-0.041
	(0.054)	(0.099)	(0.138)
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
R^2	0.546	0.482	0.351
Observations	840681	840681	840681

Note. $\text{Entry}_{(07-09)}$, $\text{Exit}_{(07-09)}$, and $\text{Net Entry}_{(07-09)}$ are constructed as in equation (5.1). $\tilde{\Delta}\text{HP}_{07-09}$ (other) is the initial sales-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales. Sectors are defined based on SIC 4-digit. Region-Firm controls include log of initial county-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by county-firm specific initial sales. Standard errors (in parentheses) are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table 5: Response of Sales-per-UPC at the Replacement Margin

	(1)	(2)	(3)
	Sale-per-UPC$^{\text{enter}}_{(07-09)}$	Sale-per-UPC$^{\text{exit}}_{(07-09)}$	$\tilde{\Delta}$Sale-per-UPC$^{\text{replace}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	0.468**	-0.500**	0.968**
	(0.214)	(0.212)	(0.415)
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
R^2	0.466	0.458	0.392
Observations	464423	464423	464423

Note. Sale-per-UPC$^{\text{enter}}_{(07-09)}$, Sale-per-UPC$^{\text{exit}}_{(07-09)}$, and Sale-per-UPC$^{\text{replace}}_{(07-09)}$ are constructed as in equation (5.2). $\tilde{\Delta}\text{HP}_{07-09}$ (other) is the initial sales-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales. Sectors are defined based on SIC 4-digit. Region-Firm controls include log of initial county-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by county-firm specific initial sales. Standard errors (in parentheses) are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table 6: Destruction Patterns

Exits (>50%) of Mkt	Exits (>90%) of Mkt	Share (among Tot. Values in 2007)
0.90	0.64	0.14

Note. Among the total value lost by destruction of products in local markets, we calculate the share of products (in value) that exited more than 50% (90%) of their initially sold markets. The last column shows the share of total value lost by destruction relative to total values in 2007.

Table 7: Creation Patterns

Enters (>50%) of Mkt	Enters (>90%) of Mkt	Share (among Tot. Values in 2009)
0.75	0.27	0.23

Note. Among the total value generated by creation of products in local markets, we calculate the share of products (in value) that entered more than 50% (90%) of the firm's overall market in 2009. The last column shows the share of total value generated by creation relative to total values in 2009.

Table 8: Net Creation Decomposition (County-level)

	(1) $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	(2) $\tilde{\Delta}\text{Sale}^{\text{replace, national}}_{(07-09)}$	(3) $\tilde{\Delta}\text{Sale}^{\text{replace, local}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	0.419^{***}	0.418^{***}	0.001^{***}
	(0.102)	(0.102)	(0.000)
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
R^2	0.408	0.408	0.272
Observations	840681	840681	840681

$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$ is the county-firm specific sales growth between 2007 and 2009 arising from product replacements (net creation), $\tilde{\Delta}\text{Sale}^{\text{replace, national}}_{(07-09)}$ is the county-firm specific sales growth between 2007 and 2009 arising from products replaced in multiple counties, and $\tilde{\Delta}\text{Sale}^{\text{replace, local}}_{(07-09)}$ is the county-firm specific sales growth between 2007 and 2009 arising from products only replaced in the county. $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) is the initial sales-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales. Sectors are defined based on SIC 4-digit. Region-Firm controls include log of initial county-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by county-firm specific initial sales. Standard errors are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table 9: Regression of the Structural Equation

	(1)	(2)	(3)	(4)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}_{(07-09)}$
$\tilde{\Delta}\text{Sale}_{(07-09)}$ (other)	0.990***	0.723***	0.996***	0.862***
	(0.007)	(0.197)	(0.008)	(0.212)
IV	-	✓	-	✓
First-stage F stat	-	11.5	-	7.9
Region-Firm Controls	✓	✓	✓	✓
Sector + Region FE	✓	✓	-	-
Sector x Region FE	-	-	✓	✓
R^2	0.629	0.493	0.762	0.611
Observations	840681	840681	840681	840681

Note. $\tilde{\Delta}\text{Sale}_{(07-09)}$ is the county-firm specific sales growth between 2007 and 2009, $\tilde{\Delta}\text{Sale}_{(07-09)}$ (other) is the initial sales-weighted average local sales growth between 2007 and 2009 in the other counties where the firm generates sales. In Column (2) and Column (4), we instrument $\tilde{\Delta}\text{Sale}_{(07-09)}$ (other) using $\tilde{\Delta}\text{HP}_{(07-09)}$ (other), which is the initial sales-weighted house price growth between 2007 and 2009 in the other states where the firm generates sales. Sectors are defined based on SIC 4-digit. Region-Firm controls include log of initial state-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by county-firm specific initial sales. Standard errors are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table 10: Regression of the Structural Equation: State-Firm level

	(1)	(2)	(3)	(4)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Price}_{(07-09)}$	$\tilde{\Delta}\text{Price}_{(07-09)}$
$\tilde{\Delta}\text{Sale}_{(07-09)}$ (other)	0.839***	0.605***	0.129***	0.367**
	(0.053)	(0.194)	(0.022)	(0.152)
IV	-	✓	-	✓
First-stage F stat	-	56.1	-	56.1
Region-Firm Controls	✓	✓	✓	✓
Sector + Region FE	✓	✓	-	-
R^2	0.612	0.464	0.324	-0.063
Observations	88249	88249	83251	88206

Note. $\tilde{\Delta}\text{Sale}_{(07-09)}$ is the state-firm specific sales growth between 2007 and 2009, $\tilde{\Delta}\text{Price}_{(07-09)}$ is the state-firm specific price growth between 2007 and 2009 defined in the Appendix C, and $\tilde{\Delta}\text{Sale}_{(07-09)}$ (other) is the initial sales-weighted average local sales growth between 2007 and 2009 in the other states where the firm generates sales. In Column (2) and Column (4), we instrument $\Delta\text{Sale}_{(07-09)}$ (other) using $\Delta\text{HP}_{(07-09)}$ (other), which is the initial sales-weighted house price growth between 2007 and 2009 in the other states where the firm generates sales. Sectors are defined based on SIC 4-digit. Region-Firm controls include log of initial state-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by state-firm specific initial sales. Standard errors are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table 11: Calibration

Parameter	Value	Description	Source
Υ	0.61	Elasticity of Firm's Local Sales wrt Avg. Sales	Own Estimation
$\beta \times \xi$	0.37	Elasticity of Firm's Local Price wrt Avg. Sales	Own Estimation
σ	2.20	EoS across Firm's Product Bundle	Faber & Fally (2017)
ξ	0.82	Elasticity of Marginal Cost wrt Quality	Faber & Fally (2017)
β	0.45	Elasticity of Fixed Cost wrt Quality	Derived
γ	1.95	Elasticity of Perceived Quality wrt Quality	Derived
b (benchmark)	1	Fixed Cost Parameter	Normalize
b (counterfactual)	0.04	Fixed Cost Parameter	Matched s.t. Avg. Quality Equal Benchmark
η	1	EoS across CPG and Outside Goods	Cobb-Douglas
α	0.20	CPG Share Parameter	Matched so that CPG share equals 0.20 under η

Table 12: Results: Redistributional Consequence at the Aggregate Level

State	$\hat{HP}_r(\%)$	$\hat{I}_r(\%)$	$\hat{U}_r(\%)$ Benchmark	$\hat{U}_r(\%)$ Counterfactual	$\hat{U}_r(\%)$ Abs. Diff.	$\hat{V}_r(\%)$ Benchmark	$\hat{V}_r(\%)$ Counterfactual	$\hat{V}_r(\%)$ Abs. Diff.	Pop. Weight (%)
AL	-7.88	-1.81	-3.81	-2.72	1.08	-2.22	-2.00	0.22	1.55
AZ	-38.13	-8.77	-10.70	-12.93	2.23	-9.16	-9.62	0.46	2.03
AR	-4.68	-1.08	-3.06	-1.62	1.44	-1.48	-1.19	0.29	0.94
CA	-33.11	-7.61	-9.67	-11.27	1.59	-8.03	-8.36	0.33	12.31
CO	-5.53	-1.27	-3.30	-1.91	1.39	-1.68	-1.40	0.28	1.59
CT	-13.04	-3.00	-4.98	-4.49	0.49	-3.40	-3.30	0.10	1.18
DE	-8.14	-1.87	-3.85	-2.81	1.04	-2.27	-2.06	0.21	0.29
DC	-11.91	-2.74	-4.71	-4.10	0.60	-3.14	-3.01	0.12	0.18
FL	-43.19	-9.93	-11.83	-14.60	2.77	-10.32	-10.89	0.57	6.07
GA	-17.11	-3.93	-5.89	-5.88	0.01	-4.33	-4.33	0.00	3.08
ID	-14.74	-3.39	-5.38	-5.07	0.31	-3.79	-3.73	0.06	0.49
IL	-20.33	-4.68	-6.63	-6.97	0.34	-5.07	-5.14	0.07	4.34
IN	-8.76	-2.02	-4.00	-3.03	0.97	-2.42	-2.22	0.20	2.13
IA	0.18	0.04	-1.99	0.06	2.05	-0.37	0.05	0.41	1.00
KS	-3.59	-0.83	-2.82	-1.24	1.57	-1.23	-0.91	0.32	0.93
KY	-2.36	-0.54	-2.54	-0.82	1.72	-0.95	-0.60	0.35	1.42
LA	1.28	0.30	-1.74	0.45	2.19	-0.12	0.33	0.44	1.53
ME	-14.07	-3.24	-5.19	-4.84	0.35	-3.63	-3.56	0.07	0.45
MD	-22.93	-5.27	-7.20	-7.85	0.65	-5.66	-5.80	0.13	1.91
MA	-10.19	-2.34	-4.34	-3.51	0.82	-2.75	-2.58	0.17	2.16
MI	-29.68	-6.83	-8.73	-10.12	1.39	-7.21	-7.50	0.29	3.44
MN	-16.95	-3.90	-5.85	-5.83	0.03	-4.30	-4.29	0.01	1.74
MS	-4.51	-1.04	-3.03	-1.56	1.47	-1.44	-1.14	0.30	0.99
MO	-6.47	-1.49	-3.48	-2.24	1.24	-1.89	-1.64	0.25	1.97
MT	0.06	0.01	-2.04	0.02	2.06	-0.40	0.01	0.42	0.32
NE	-1.67	-0.38	-2.41	-0.58	1.83	-0.79	-0.42	0.37	0.60
NV	-54.06	-12.43	-14.29	-18.16	3.87	-12.81	-13.61	0.80	0.83
NH	-13.11	-3.02	-4.97	-4.52	0.46	-3.41	-3.32	0.09	0.44
NJ	-17.26	-3.97	-5.94	-5.93	0.01	-4.37	-4.37	0.00	2.97
NM	-5.18	-1.19	-3.21	-1.79	1.42	-1.60	-1.31	0.29	0.66
NY	-15.23	-3.50	-5.47	-5.24	0.23	-3.90	-3.85	0.05	6.51
NC	-6.23	-1.43	-3.42	-2.15	1.27	-1.83	-1.58	0.26	2.94
ND	1.72	0.39	-1.61	0.60	2.21	-0.01	0.43	0.45	0.21
OH	-9.11	-2.10	-4.07	-3.15	0.93	-2.50	-2.31	0.19	3.89
OK	3.27	0.75	-1.26	1.14	2.40	0.34	0.83	0.48	1.20
OR	-15.86	-3.65	-5.67	-5.45	0.22	-4.06	-4.01	0.04	1.24
PA	-4.56	-1.05	-3.04	-1.58	1.46	-1.45	-1.16	0.30	4.18
RI	-18.61	-4.28	-6.20	-6.39	0.19	-4.67	-4.71	0.04	0.36
SC	-8.37	-1.92	-3.90	-2.89	1.01	-2.32	-2.12	0.21	1.44
SD	0.72	0.16	-1.85	0.25	2.10	-0.24	0.18	0.43	0.26
TN	-5.76	-1.33	-3.31	-1.99	1.31	-1.73	-1.46	0.27	2.03
TX	-5.93	-1.36	-3.39	-2.05	1.34	-1.77	-1.50	0.27	7.77
UT	-10.82	-2.49	-4.47	-3.73	0.74	-2.89	-2.74	0.15	0.85
VT	-7.40	-1.70	-3.68	-2.56	1.12	-2.10	-1.87	0.23	0.21
VA	-15.83	-3.64	-5.60	-5.44	0.16	-4.04	-4.01	0.03	2.56
WA	-17.97	-4.13	-6.16	-6.17	0.01	-4.54	-4.55	0.00	2.15
WV	-4.02	-0.92	-2.90	-1.39	1.51	-1.32	-1.02	0.31	0.62
WI	-7.07	-1.63	-3.62	-2.44	1.17	-2.03	-1.79	0.24	1.88
WY	-1.32	-0.30	-2.33	-0.46	1.88	-0.71	-0.33	0.38	0.17
Mean	-16.61	-3.82	-5.80	-5.67	1.17	-4.22	-4.20	0.24	Sum: 100
Std	12.95	2.98	2.96	4.38		2.98	3.27		

Note. $\hat{HP}_r(\%)$ is the state-level house price growth $\tilde{\Delta}HP_{(07-09)}$. $\hat{I}_r(\%)$ is the exogenous regional income growth which is calculated as $\hat{HP}_r(\%) \times 0.23$. Benchmark indicates the model with uniform quality choice in Section 6, and counterfactual indicates the model with market-specific quality choice in the Appendix E. $\hat{U}_r(\%)$ is the welfare growth from CPG expenditure ("CPG welfare"), and $\hat{V}_r(\%)$ is the welfare growth from both CPG and outside good expenditure ("overall welfare"). Summary statistics are weighted by population.

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Appendix C Measuring Values : Price and Quality

Let $p_{r,u,g,f,t}$ refer to the unit price of a product, where r region, u indicates product, c product group (category), f firm, and t time. We first define *county-firm-category* specific price for classification $i \in$ {common, exit, enter} at time t, $p^i_{r,g,f,t}$, as

$$p^i_{r,g,f,t} \equiv \Pi_{u \in \Omega_{i,r,t}} \left(p_{r,u,g,f,t}^{\omega_{u,i}^{r,g,f,t}} \right) \tag{C.1}$$

where we use either $\omega_{u,i}^{r,g,f,t} \equiv \frac{1}{N^i_{r,g,f,t}}$ (equal weight) or $\omega_{u,i}^{r,g,f,t} \equiv \frac{S_{r,u,g,f,t}}{\sum_{u' \in \Omega_{i,r,t}} S_{r,u',g,f,t}} \equiv \frac{S_{r,u,g,f,t}}{S^i_{r,g,f,t}}$ (sales weight). $\Omega_{i,r,07}$ indicates set of products in 2007 in county r that either commonly exist in both periods ($i =$ common) or exit in 2009 ($i =$ exit), and $\Omega_{i,r,09}$ indicates set of products that either commonly exist in both periods ($i =$ common) or newly enter in 2009 ($i =$ enter). Now by aggregating across i, we define *county-firm-category* specific price $p_{r,g,f,t}$ at time t as

$$p_{r,g,f,t} \equiv \Pi_i \left(p^i_{r,g,f,t} \right)^{\omega_i^{r,g,f,t}} \tag{C.2}$$

where $\omega_i^{r,g,f,t} \equiv \frac{S^i_{r,g,f,t}}{\sum_{i'} S^{i'}_{r,g,f,t}} \equiv \frac{S^i_{r,g,f,t}}{S_{r,g,f,t}}$. Similarly, *county-category* specific price $p_{r,g,t}$ at time t is defined as

$$p_{r,g,t} \equiv \Pi_f \left(p_{r,g,f,t}^{\omega_f^{r,g,t}} \right) \tag{C.3}$$

where $\omega_f^{r,g,t} \equiv \frac{S_{r,g,f,t}}{\sum_{f'} S_{r,g,f',t}} \equiv \frac{S_{r,g,f,t}}{S_{r,g,t}}$.

We define *county-firm-category* specific quality for classification $i \in$ {common, exit, enter} at time t, $\phi^i_{r,g,f,t}$, as

$$\phi^i_{r,g,f,t} \equiv \frac{p^i_{r,g,f,t}}{p_{r,g,t}} \tag{C.4}$$

This captures how far the prices of products (classified as i) in category c produced by firm f are from the average price level of products in the same category in county r at time t.

We define *county-firm* specific price and quality for classification $i \in$ {common, exit, enter} at time t, $p^i_{r,f,t}$ and $\phi^i_{r,f,t}$, as

$$p^i_{r,f,t} \equiv \Pi_g \left(p^i_{r,g,f,t}\right)^{\omega^{r,f,t}_{g,i}} \tag{C.5}$$

$$\phi^i_{r,f,t} \equiv \Pi_g \left(\phi^i_{r,g,f,t}\right)^{\omega^{r,f,t}_{g,i}} \tag{C.6}$$

where $\omega^{r,f,t}_{g,i} \equiv \frac{S^i_{r,g,f,t}}{\sum_{g'} S^i_{g',r,f,t}} \equiv \frac{S^i_{r,g,f,t}}{S^i_{r,f,t}}$.

Finally, we define *county-firm* specific quality and price at time t, $p_{r,f,t}$ and $\phi_{r,f,t}$, as

$$p_{r,f,t} \equiv \Pi_i \left(p^i_{r,g,f,t}\right)^{\omega^{r,f,t}_{i}} \tag{C.7}$$

$$\phi_{r,f,t} \equiv \Pi_i \left(\phi^i_{r,g,f,t}\right)^{\omega^{r,f,t}_{i}} \tag{C.8}$$

where $\omega^{r,f,t}_{i} \equiv \frac{S^i_{r,f,t}}{\sum_{i'} S^{i'}_{r,f,t}} \equiv \frac{S^i_{r,f,t}}{S_{r,f,t}}$.

In addition to the benchmark price and quality measures, we also consider "size-adjusted" measures based on the unit price *after adjusting package size and unit differences*. Finally, under the rationale that organic products have higher quality compared to the non-organic products, we also measure value of products based on organic product turnover rates.

Appendix D Derivations and Proofs

D.1 Upper-tier Optimaliy

The upper-tier problem is given as follows:

$$\max_{z_r, U_r} V_r = \left[(1-\alpha)(z_r)^{\frac{\eta_r - 1}{\eta_r}} + \alpha(U_r)^{\frac{\eta_r - 1}{\eta_r}}\right]^{\frac{\eta_r}{\eta_r - 1}} \quad s.t. \quad z_r + P_r U_r \leq y_r$$

where P_r is the CPG consumption bundle price index, U_r is utility from CPG consumption, and z_r is outside expenditure used as numeraire.

The Lagrangian is

$$\mathcal{L}_r = \left[(1-\alpha)(z_r)^{\frac{\eta_r - 1}{\eta_r}} + \alpha(U_r)^{\frac{\eta_r - 1}{\eta_r}}\right]^{\frac{\eta_r}{\eta_r - 1}} + \Lambda_r \left[y_r - z_r - P_r U_r\right]$$

The first-order conditions are given by

$$\partial U_r \ : \ (V_r)^{\frac{1}{\eta_r}}(\alpha)(U_r)^{-\frac{1}{\eta_r}} = \Lambda_r P_r \tag{D.1}$$

$$\partial z_r \ : \ (V_r)^{\frac{1}{\eta_r}}(1-\alpha)(z_r)^{-\frac{1}{\eta_r}} = \Lambda_r \tag{D.2}$$

which implies

$$\alpha(U_r)^{\frac{\eta_r - 1}{\eta_r}} = (\Lambda_r)^{1-\eta_r}(P_r)^{1-\eta_r}[V_r]^{\frac{\eta_r - 1}{\eta_r}}\alpha^{\eta_r}$$

$$(1-\alpha)(z_r)^{\frac{\eta_r - 1}{\eta_r}} = (\Lambda_r)^{1-\eta_r}[V_r]^{\frac{\eta_r - 1}{\eta_r}}(1-\alpha)^{\eta_r}$$

Thus,

$$\begin{aligned}
(V_r)^{\frac{\eta_r - 1}{\eta_r}} &= (1-\alpha)(z_r)^{\frac{\eta_r - 1}{\eta_r}} + \alpha(U_r)^{\frac{\eta_r - 1}{\eta_r}} \\
&= (\Lambda_r)^{1-\eta_r}(V_r)^{\frac{\eta_r - 1}{\eta_r}}\left[(1-\alpha)^{\eta_r} + (P_r)^{1-\eta_r}\alpha^{\eta_r}\right]
\end{aligned}$$

which gives us the upper-tier price index $\mathcal{P}_r^V$ defined by

$$\mathcal{P}_r^V \equiv (\Lambda_r)^{-1} \equiv \left[(1-\alpha)^{\eta_r} + (P_r)^{1-\eta_r}\alpha^{\eta_r}\right]^{\frac{1}{1-\eta_r}} \tag{D.3}$$

which also satisfies

$$
\begin{aligned}
y_r &= z_r + P_r U_r \\
&= \mathcal{P}_r^V V_r
\end{aligned}
$$

By combining (D.1) and (D.2), we have

$$
P_r = \frac{\alpha (U_r)^{-\frac{1}{\eta_r}}}{(1-\alpha)(z_r)^{-\frac{1}{\eta_r}}}
$$

or

$$
P_r U_r = \left(\frac{\alpha}{1-\alpha}\right) (z_r)^{\frac{1}{\eta_r}} (U_r)^{1-\frac{1}{\eta_r}}
$$

Since $z_r = y_r - P_r U_r$,

$$
P_r U_r = \left(\frac{\alpha}{1-\alpha}\right) (y_r - P_r U_r)^{\frac{1}{\eta_r}} (U_r)^{1-\frac{1}{\eta_r}}
$$

Thus, we have

$$
\frac{P_r U_r}{y_r} = \left(\frac{\alpha}{1-\alpha}\right) (\frac{y_r - P_r U_r}{y_r})^{\frac{1}{\eta_r}} (\frac{U_r}{y_r})^{1-\frac{1}{\eta_r}}
$$

which implies

$$
1 = \left(\frac{\alpha}{1-\alpha}\right) (\frac{y_r}{P_r U_r} - 1)^{\frac{1}{\eta_r}} (\frac{1}{P_r})^{1-\frac{1}{\eta_r}}
$$

By defining CPG expenditure as $E_r \equiv P_r U_r$, CPG expenditure share as $\Theta_r \equiv \frac{E_r}{y_r}$, and by rearranging terms, we get

$$
\Theta_r = \frac{\alpha^{\eta_r}}{\alpha^{\eta_r} + (1-\alpha)^{\eta_r} (P_r)^{\eta_r - 1}} \equiv \Theta_r(P_r) \tag{D.4}
$$

This implies for a given level of y_r, Θ_r is decreasing with P_r. Thus, if negative demand shocks in other markets induce increase in P_r (while market r income remains fixed at y_r), then both CPG expenditure level and its share decrease in market r.

D.2 Equivalent Discrete-Choice Model

In this section, we show how the discretized version of the utility function (6.4) given by

$$U_r = \left[\sum_{f \in G_r} \left(q_{rf} \zeta_{rf} \right)^{\frac{\sigma_r - 1}{\sigma_r}} \right]^{\frac{\sigma_r}{\sigma_r - 1}}$$

can be derived as aggregation of heterogeneous consumers buying only one product bundle (corresponding to one firm). We follow proof by Faber and Fally (2017), which in turn is based on Anderson et al. (1987). Without loss of generality, we consider market r, where for notational simplicity, we omit the market subscript r.

Suppose that a consumer h with total income y has utility given by

$$U_{y,h} = \max_{f \in G, q_{f,y,h}} \left[\log q_{f,y,h} + \log \zeta_{f,y} + \mu_y \epsilon_{f,y,h} \right] \tag{D.5}$$

subject to the budget constraint

$$p_f q_{f,y,h} \leq E_y$$

where E_y refers to total income allocated to CPG expenditure, $\log \zeta_{f,y}$ is a quality shifter associated with y and firm f, and $\mu_y \epsilon_{f,y,h}$ is a specific taste shock for each consumer h with y associated with firm f.

With these preferences, each consumer h consumes a unique product bundle produced by firm f^* determined by

$$f^* = \arg\max_{f \in G} \left[\log E_y - \log p_f + \log \zeta_{f,y} + \mu_y \epsilon_{f,y,h} \right]$$

implying that the choice of firm f by individual h does not depend on E_y. Thus, the problem can be expressed as

$$f^* = \arg\max_{f \in G} \left[-\log p_f + \log \zeta_{f,y} + \mu_y \epsilon_{f,y,h} \right] \tag{D.6}$$

Suppose that we have a large number of consumers and that $\epsilon_{f,y,h}$ is i.i.d. and drawn from a Gumbel distribution (type-II extreme value distribution) as in Anderson et al. (1987).

This implies that a share

$$s_{f,y} = \frac{\left(\frac{\zeta_{f,y}}{p_f}\right)^{\frac{1}{\mu_y}}}{\sum_{f' \in G}\left(\frac{\zeta_{f',y}}{p_{f'}}\right)^{\frac{1}{\mu_y}}}$$

of consumers will choose product bundle produced by firm $f \in G$. As consumer with y choosing firm f has expenditure on that firm's product bundle given by E_y, we get the following aggregate expenditures for firm f's product bundle associated with y:

$$s_{f,y} = \frac{\left(\frac{\zeta_{f,y}}{p_f}\right)^{\sigma_y - 1}}{\sum_{f' \in G}\left(\frac{\zeta_{f',y}}{p_{f'}}\right)^{\sigma_y - 1}} E_y \tag{D.7}$$

where $\sigma_y \equiv 1 + \frac{1}{\mu_y}$ denotes the elasticity of substitution between firms f on aggregate for consumers with y. Notice that (D.7) is exactly the discretized version of (6.8). This shows that utility described in (D.5) is equivalent to the consumption patterns obtained with the preferences described in (6.4) (except for the discrete vs. continuum measure of firms).

D.3 Structural Interpretation of Regression Equation - Derivation

D.3.1 Firm-level Spillover

From (6.23), we can derive the relationship between a firm's local sales and its sales from other markets. Define $\Gamma_r \equiv (\sigma_r - 1)(\gamma_r - \xi)$, $B_r(a) \equiv \left[\frac{\mu_r}{a}\right]^{1-\sigma_r}$ and $X(a^k) \equiv \left[\frac{1}{b}\sum_{r \in k} \rho_r S_r(a^k)[\gamma_r - \xi]\right]$, where $A_r \equiv (P_r)^{\sigma_r - 1}\Theta_r y_r$. Denote a firm's initial local sales as $S_{0,r}(a^k)$.

Put logarithm in both side of (6.23):

$$\log S_r(a^k) = \beta\Gamma_r \log X(a^k) + \log B_r(a) + \log(A_r L_r)$$

By defining $\hat{y} \equiv \log y/y_0$, we have

$$\hat{S}_r(a^k) = \beta\Gamma_r \hat{X}^k(a^k) + (\hat{A}_r + \hat{L}_r)$$

Now lets derive $\hat{X}(a^k)$. Denote the initial state as

$$X_0(a^k) = \frac{1}{b}\sum_{r\in k}\rho_r[\gamma_r - \xi]S_{0,r}(a^k)$$

By using $y = y_0 e^{\hat{y}}$, we get

$$\hat{X}(a^k) = \sum_{r\in k}\omega_{0,r}(a^k)\hat{S}_r(a^k)$$

where $\omega_{0,r}(a^k) \equiv \frac{\rho_r[\gamma_r-\xi]S_{0,r}(a^k)}{\sum_{r'\in k}\rho_{r'}[\gamma_{r'}-\xi]S_{0,r'}(a^k)}$ with $\sum_{r\in k}\omega_{0,r}(a^k) = 1$. Note that if $\gamma_r = \gamma$ and $\sigma_r = \sigma$ for all $r \in \mathcal{R}$, $\omega_{0,r}(a^k) = \frac{S_{0,r}(a^k)}{\sum_{r'\in k}S_{0,r'}(a^k)}$ becomes the initial sales weight.

By rearranging terms, we get

$$\hat{S}_r(a^k) = \frac{\beta\Gamma_r\left(1-\omega_{0,r}(a^k)\right)}{1-\beta\Gamma_r\omega_{0,r}(a^k)}\sum_{l\in k\&l\neq r}\omega^r_{0,l}(a^k)\hat{S}_l(a^k) + \frac{1}{1-\beta\Gamma_r\omega_{0,r}(a^k)}(\hat{A}_r + \hat{L}_r) \qquad \text{(D.8)}$$

where $\sum_{r'\in k\&r'\neq r}\omega_{0,r'}(a^k) = 1-\omega_{0,r}(a^k)$, $\omega^r_{0,l}(a^k) \equiv \frac{\omega_{0,l}(a^k)}{1-\omega_{0,r}(a^k)}$ with $\sum_{l\in k\&l\neq r}\omega^r_{0,l}(a^k) = 1$. Again, if $\gamma_r = \gamma$ and $\sigma_r = \sigma$ for all $r \in \mathcal{R}$, $\omega^r_{0,l}(a^k) = \frac{S_{0,l}(a^k)}{\sum_{r'\in k\&r'\neq r}S_{0,r'}(a^k)}$ is the leave-out initial sales weight which we used in our empirical analysis.

D.4 Model Implications: Partial Equilibrium Responses to the Exogenous Change in Income - Proofs

Recall that under the partial equilibrium analyses, we shut down general equilibrium adjustments through change in dividends D_r, and thus treat y_r as exogenous.

D.4.1 Exogenous Change in Local Income and Response of Quality and Local Sales

Claim :

Let $r \in k$. Suppose (i) β is sufficiently small that $\beta[\sigma_r - 1][\gamma_r - \xi] < 1$ and (ii) P_r is fixed. Then $\frac{\partial \log\phi(a^k)}{\partial \log y_r} > 0$ and $\frac{\partial \log S_r(a^k)}{\partial \log y_r} > 0$. The results also hold by relaxing (ii) by allowing P_r to vary with y_r, as long as such variations are sufficiently small.

Proof :

Define

$$\Gamma_r \equiv [\sigma_r - 1][\gamma_r - \xi] \qquad \text{(D.9)}$$

By using the expression on the optimal quality (6.20), we have that

$$b\phi(a^k)^{\frac{1}{\beta}} = \sum_{r\in k}\left(1-\frac{1}{\mu_r}\right)[\sigma_r-1][\gamma_r-\xi]S_r(a^k)$$

where we used $\frac{1}{\mu_r-1} = \frac{1}{\frac{\sigma_r}{\sigma_r-1}-1} = \sigma_r - 1$. Then, we can rewrite the above equation as

$$b\exp(\frac{1}{\beta}\log\phi(a^k)) = \sum_{r\in k}\left(1-\frac{1}{\mu_r}\right)\Gamma_r\exp(\log(S_r(a^k)))$$

Differentiation with respect to $\log y_r$ gives us

$$b\phi(a^k)^{\frac{1}{\beta}}\frac{1}{\beta}\frac{\partial\log\phi(a^k)}{\partial\log y_r} = \sum_{r'\in k}\left(1-\frac{1}{\mu_{r'}}\right)\Gamma_{r'}S_{r'}(a^k)\frac{\partial\log S_{r'}(a^k)}{\partial\log y_r} \tag{D.10}$$

Also, recall from (6.23) that

$$S_{r'}(a^k) = \phi(a^k)^{(\sigma_{r'}-1)(\gamma_{r'}-\xi)}\left[\frac{\mu_{r'}}{a}\right]^{1-\sigma_{r'}}A_{r'}L_{r'}$$

where $A_{r'} \equiv (P_{r'})^{\sigma_{r'}-1}\Theta_{r'}y_{r'}$. This can be rewritten as

$$\log S_{r'}(a^k) = \Gamma_{r'}\log\phi(a^k) + (1-\sigma_{r'})\log\frac{\mu_{r'}}{a} + \log A_{r'} + \log L_{r'}$$

Differentiation with respect to $\log y_r$ gives us

$$\frac{\partial\log S_{r'}(a^k)}{\partial\log y_r} = \Gamma_{r'}\frac{\partial\log\phi(a^k)}{\partial\log y_r} + \frac{\partial\log A_{r'}}{\partial\log y_r} \tag{D.11}$$

By combining (D.10) and (D.11), we have

$$b\phi(a^k)^{\frac{1}{\beta}}\frac{1}{\beta}\frac{\partial\log\phi(a^k)}{\partial\log y_r} = \sum_{r'\in k}\left(1-\frac{1}{\mu_{r'}}\right)\Gamma_{r'}S_{r'}(a^k)\left[\Gamma_{r'}\frac{\partial\log\phi(a^k)}{\partial\log y_r} + \frac{\partial\log A_{r'}}{\partial\log y_r}\right]$$

which implies

$$\frac{1}{\beta}\left[b\phi(a^k)^{\frac{1}{\beta}} - \sum_{r'\in k}\left(1-\frac{1}{\mu_{r'}}\right)\Gamma_{r'}S_{r'}(a^k)\cdot\beta\Gamma_{r'}\right]\frac{\partial\log\phi(a^k)}{\partial\log y_r} = \sum_{r'\in k}\left(1-\frac{1}{\mu_{r'}}\right)\Gamma_{r'}S_{r'}(a^k)\left[\frac{\partial\log A_{r'}}{\partial\log y_r}\right] \tag{D.12}$$

By using the expression on the optimal quality (6.20), we know that $b\phi(a^k)^{\frac{1}{\beta}} = \sum_{r'\in k}\left(1-\frac{1}{\mu_{r'}}\right)\Gamma_{r'}S_{r'}(a^k)$. Under $\beta\Gamma_r \equiv \beta(\sigma_r - 1)(\gamma_r - \xi) < 1$ for all $r \in k$, we have

$$b\phi(a^k)^{\frac{1}{\beta}} = \sum_{r'\in k}\left(1-\frac{1}{\mu_{r'}}\right)\Gamma_{r'}S_{r'}(a^k) > \sum_{r'\in k}\left(1-\frac{1}{\mu_{r'}}\right)\Gamma_{r'}S_{r'}(a^k)\cdot\beta\Gamma_{r'}$$

Thus, we have

$$\begin{aligned}
&\frac{1}{\beta}\left[b\phi(a^k)^{\frac{1}{\beta}} - \sum_{r'\in k}\left(1-\frac{1}{\mu_{r'}}\right)\Gamma_{r'}S_{r'}(a^k)\cdot\beta\Gamma_{r'}\right]\\
=&\frac{1}{\beta}\left[\sum_{r'\in k}\left(1-\frac{1}{\mu_{r'}}\right)\Gamma_{r'}S_{r'}(a^k)\left[1-\beta\Gamma_{r'}\right]\right]\\
>&0
\end{aligned}$$

on the left hand side of equation (D.12). Finally, under fixed P_r, we can easily see that $\frac{\partial\log A_r}{\partial\log y_r} = 1$ and $\frac{\partial\log A_{r'}}{\partial\log y_r} = 0$ if $r' \neq r$, implying

$$\begin{aligned}
\sum_{r'\in k}\left(1-\frac{1}{\mu_{r'}}\right)\Gamma_{r'}S_{r'}(a^k)\left[\frac{\partial\log A_{r'}}{\partial\log y_r}\right] &= \left(1-\frac{1}{\mu_r}\right)\Gamma_r S_r(a^k)\left[\frac{\partial\log A_r}{\partial\log y_r}\right]\\
&= \left(1-\frac{1}{\mu_r}\right)\Gamma_r S_r(a^k) > 0
\end{aligned}$$

Thus, we conclude that $\frac{\partial\log\phi(a^k)}{\partial\log y_r} > 0$.[55]

Also, notice that due to continuity, this the argument can be extended to the case with varying P_r, as long as such variations are sufficiently small. For example, suppose we allow general equilibrium adjustment in P_r due to change in y_r. Then,

$$\frac{\partial\log A_r}{\partial\log y_r} = \left[(\sigma_r - 1) + \frac{\partial\log\Theta_r}{\partial\log P_r}\right]\frac{\partial\log P_r}{\partial\log y_r} + 1$$

where we know from (6.2) that $\frac{\partial\log\Theta_r}{\partial\log P_r} = -\frac{(1-\alpha)^{\eta_r}(P_r)^{\eta_r-1}}{\alpha^{\eta_r}+(1-\alpha)^{\eta_r}(P_r)^{\eta_r-1}}(\eta_r - 1) = -(1-\Theta_r)(\eta_r - 1) < 0$. We can see that as long as $1 > -\left[(\sigma_r - 1) + \frac{\partial\log\Theta_r}{\partial\log P_r}\right]\frac{\partial\log P_r}{\partial\log y_r}$, we have $\frac{\partial\log\phi(a^k)}{\partial\log y_r} > 0$.[56]

Finally, we can clearly see from (D.11) that $\frac{\partial\log S_r(a^k)}{\partial\log y_r} > 0$.

[55] Recall that we restrict the model parameters to ensure $\phi(a^k) > 1$ in the equilibrium.

[56] If all firms are symmetric in market r (i.e. all firms have the same $a^k \equiv (a,k)$), which implies $P_r = \phi(a^k)^{-(\gamma_r-\xi)}\frac{1}{a}\frac{\sigma_r}{\sigma_r-1}\left[\sum_{k\in\mathcal{M}^r}N^k\right]^{\frac{1}{1-\sigma_r}}$, and if we further assume $\frac{\partial\log\Theta_r}{\partial\log P_r} = 0$ and fix the number of firms N^k for

D.4.2 Change in Quality and Response of Local Sales

Claim :

Let $r \in k$. Suppose (i) y_r is fixed (i.e. there is no direct local shock) and (ii) P_r is fixed. Then, $\frac{\partial \log S_r(a^k)}{\partial \log \phi(a^k)} > 0$.

Proof :

Recall from (6.23) that

$$S_r(a^k) = \phi(a^k)^{(\sigma_r - 1)(\gamma_r - \xi)} \left[\frac{\mu_r}{a}\right]^{1-\sigma_r} A_r L_r$$

with $A_r \equiv (P_r)^{\sigma_r - 1}\Theta_r y_r$.

Then, we have

$$\begin{aligned}\frac{\partial \log S_r(a^k)}{\partial \log \phi(a^k)} &= (\sigma_r - 1)(\gamma_r - \xi) + \frac{\partial \log A_r}{\partial \log \phi(a^k)} \\ &= (\sigma_r - 1)(\gamma_r - \xi) + \left(\sigma_r - 1 + \frac{\partial \log \Theta_r}{\partial \log P_r}\right)\frac{\partial \log P_r}{\partial \log \phi(a^k)}\end{aligned} \tag{D.13}$$

where $\frac{\partial \log \Theta_r}{\partial \log P_r} = -\frac{(1-\alpha)^{\eta_r}(P_r)^{\eta_r - 1}}{\alpha^{\eta_r} + (1-\alpha)^{\eta_r}(P_r)^{\eta_r-1}}(\eta_r - 1) = -(1-\Theta_r)(\eta_r - 1) < 0$.

Since we are assuming P_r is fixed (i.e. $\frac{\partial \log P_r}{\partial \log \phi(a^k)} = 0$), we get

$$\frac{\partial \log S_r(a^k)}{\partial \log \phi(a^k)} = (\sigma_r - 1)(\gamma_r - \xi) > 0 \tag{D.14}$$

D.4.3 Change in Quality and Response of Local CPG Prices, CPG Expenditure, and Welfare

Claim :

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all $k \in \mathcal{M}^r$, we can show that $\frac{\partial \log \phi(a^k)}{\partial \log y_r} > 0$ always holds even if we allow P_r to vary with y_r. This is because

$$\frac{\partial \log A_r}{\partial \log y_r} = \left[(\sigma_r - 1) + \frac{\partial \log \Theta_r}{\partial \log P_r}\right]\frac{\partial \log P_r}{\partial \log y_r} + 1 = -\Gamma_r \frac{\partial \log \phi(a^k)}{\partial \log y_r} + 1$$

which implies

$$\frac{\partial \log \phi(a^k)}{\partial \log y_r} = \frac{\beta\left(1 - \frac{1}{\mu_r}\right)\Gamma_r S_r(a^k)}{\left[\left(1 - \frac{1}{\mu_r}\right)\Gamma_r S_r(a^k) + \sum_{r' \in k \& r' \neq r}\left(1 - \frac{1}{\mu_{r'}}\right)\Gamma_{r'} S_{r'}(a^k)\left[1 - \beta\Gamma_{r'}\right]\right]} > 0$$

Let $r \in k$. Suppose (i) y_r is fixed (i.e. there is no direct local shock) and (ii) we fix the number of active firms in each market by shutting down change in $\overline{a_k}$ for all $k \in \mathcal{K}_{\mathcal{R}}$. Then, $\frac{\partial \log P_r}{\partial \log \phi(a^k)} < 0$, $\frac{\partial \log E_r}{\partial \log \phi(a^k)} > 0$, and $\frac{\partial \log V_r}{\partial \log \phi(a^k)} > 0$.

Proof :

We can rewrite equation (6.29) as

$$\exp(\log P_r) = \left[\sum_{k \in \mathcal{M}^r} N^k \int_{a \geq \overline{a_k}} \left(\exp\{-(\gamma_r - \xi) \log \phi(a^k)\} \frac{1}{a} \frac{\sigma_r}{\sigma_r - 1} \right)^{1-\sigma_r} d\Psi(a) \right]^{\frac{1}{1-\sigma_r}}$$

By differentiating with respect to $\log \phi(a^k)$, we get

$$\begin{aligned} P_r \frac{\partial \log P_r}{\partial \log \phi(a^k)} =& \frac{1}{1-\sigma_r} (P_r)^{\sigma_r} N^k (1-\sigma_r) \left(\phi(a^k)^{-(\gamma_r - \xi)} \frac{1}{a} \frac{\sigma_r}{\sigma_r - 1} \right)^{-\sigma_r} \phi^s(a^k)^{-(\gamma_r - \xi)} \{-(\gamma_r - \xi)\} \frac{1}{a} \frac{\sigma_r}{\sigma_r - 1} \\ =& (P_r)^{\sigma_r} N^k \phi(a^k)^{(\sigma_r - 1)(\gamma_r - \xi)} \left(\frac{\mu_r}{a^k} \right)^{1-\sigma_r} \{-(\gamma_r - \xi)\} \end{aligned}$$

which implies

$$\frac{\partial \log P_r}{\partial \log \phi(a^k)} = -(\gamma_r - \xi) N^k \phi(a^k)^{(\sigma_r - 1)(\gamma_r - \xi)} \left(\frac{\mu_r}{a^k} \right)^{1-\sigma_r} (P_r)^{\sigma_r - 1} < 0 \tag{D.15}$$

Note that while deriving the above equation, we used the assumption $\frac{\partial \log \overline{a_k}}{\partial \log \phi(a^k)} = 0$.

By the definition of total CPG expenditure in market r, $E_r \equiv \Theta_r y_r$, and from the fact that $\frac{\partial \log \Theta_r}{\partial \log P_r} < 0$ and $\frac{\partial \log P_r}{\partial \log \phi(a^k)} < 0$, we have

$$\frac{\partial \log E_r}{\partial \log \phi(a^k)} = \frac{\partial \log \Theta_r}{\partial \log P_r} \frac{\partial \log P_r}{\partial \log \phi(a^k)} > 0 \tag{D.16}$$

Recall from (D.3) that the upper-tier price index is defined by $\mathcal{P}_r^V \equiv \left[(1-\alpha)^{\eta_r} + (P_r)^{1-\eta_r} \alpha^{\eta_r} \right]^{\frac{1}{1-\eta_r}}$. Also, recall $y_r = z_r + P_r U_r = \mathcal{P}_r^V V_r$. Since

$$\frac{\partial \log \mathcal{P}_r^V}{\partial \log \phi(a^k)} = (\mathcal{P}_r^V)^{\eta_r - 1} (P_r)^{1-\eta_r} \alpha^{\eta_r} \frac{\partial \log P_r}{\partial \log \phi(a^k)} < 0$$

we have

$$\frac{\partial \log V_r}{\partial \log \phi(a^k)} = -\frac{\partial \log \mathcal{P}_r^V}{\partial \log \phi(a^k)} > 0 \tag{D.17}$$

Appendix E Counterfactual: Market-specific Quality Choice

In this section, we describe the counterfactual economy where all firms choose market-specific quality as well as market-specific prices.

E.1 Price and Quality Choice

We denote market-specific choice of quality by $\phi_r(a^k)$. To distinguish optimal prices under market-specific quality with those under uniform quality, we denote optimal price under market-specific quality by $p_r^m(a^k)$. We denote corresponding quantity, sales, and profit by $Q_r^m(a^k)$, $S_r^m(a^k)$, and $\pi^m(a^k)$.

We allow potentially different fixed costs structure between uniform quality and market-specific quality. If a firm chooses market-specific quality, the firm potentially supplies different levels of quality across its markets incurring market-specific fixed costs. We assume for supplying ϕ_r quality of product bundle in market r, the firm pays fixed costs of $f^m(\phi_r) + f_{0r}^m$. We let the term f_{0r}^m capture both market-specific and firm-wise fixed cost that do not depend on the choice of quality. Superscript m is used to indicate cost associated with market-specific quality strategy. We parametrize $f^m(\phi_r)$ as

$$f^m(\phi_r) \equiv b_m \beta_m (\phi_r)^{\frac{1}{\beta_m}} \tag{E.1}$$

where we allow fixed cost parameters b_m and β_m under market-specific quality to have different values from corresponding parameters b and β under uniform quality.[57]

The price and quality choice problem of firm a^k under market-specific quality is formally written as follows:

$$\max_{\{\phi_r(a^k), p_r^m(a^k)\}_{r \in k}} \pi^m(a^k) = \sum_{r \in k} \left[\left(p_r^m(a^k) - \frac{c(\phi_r(a^k))}{a} \right) Q_r^m(a^k) - f^m(\phi_r(a^k)) - f_{0r}^m \right] \tag{E.2}$$

[57]Only for the cases of b_m and β_m we use subscript m instead of superscript to avoid notational confusion with raising power of b and β.

subject to demand condition

$$Q_r^m(a^k) = \phi_r(a^k)^{(\sigma_r-1)\gamma_r} p_r^m(a^k)^{-\sigma_r} A_r L_r \tag{E.3}$$

We can show that the optimal price is

$$p_r^m(a^k) = mc(\phi_r(a^k)) \frac{\sigma_r}{\sigma_r - 1} \tag{E.4}$$

and the optimal quality for market $r \in k$ is given by

$$\phi_r(a^k) = \left[\frac{1}{b_m} \rho_r S_r^m(a^k)[\gamma_r - \xi] \right]^{\beta_m} \tag{E.5}$$

where

$$S_r^m(a^k) = \phi_r(a^k)^{(\sigma_r-1)\gamma_r} p_r^m(a^k)^{1-\sigma_r} A_r L_r \tag{E.6}$$

The profit under market-specific quality can be rearranged as

$$\pi^m(a^k) = \sum_{r \in k} \left[(1 - \rho_r)\, S_r^m(a^k) - f^m(\phi_r(a^k)) - f_{0r}^m \right]$$

By plugging (E.5) into (E.1), we obtain the expression of equilibrium fixed cost for quality adjustments as $f^m(\phi_r(a^k)) = \beta_m \rho_r S_r^m(a^k)[\gamma_r - \xi]$. By combining these two equations, we obtain

$$\pi^m(a^k) = \sum_{r \in k} \left[\frac{1}{\sigma_r} \left[1 - \beta_m(\gamma_r - \xi)(\sigma_r - 1)\right] S_r^m(a^k) - f_{0r}^m \right] \tag{E.7}$$

The expression of sales of a firm with a^k in market r, $S_r^m(a^k)$, is derived using (E.6) and (E.5) as

$$\begin{aligned} S_r^m(a^k) &= \phi_r(a^k)^{(\sigma_r-1)(\gamma_r-\xi)} \left[\frac{\mu_r}{a}\right]^{1-\sigma_r} A_r L_r \\ &= \left[\frac{1}{b_m} \rho_r S_r^m(a^k)[\gamma_r - \xi] \right]^{\beta_m(\sigma_r-1)(\gamma_r-\xi)} \left[\frac{\mu_r}{a}\right]^{1-\sigma_r} A_r L_r \end{aligned} \tag{E.8}$$

This implies

$$S_r^m(a^k) = \left[\frac{1}{b_m}\rho_r(\gamma_r - \xi)\right]^{\frac{\beta_m(\sigma_r-1)(\gamma_r-\xi)}{1-\beta_m(\sigma_r-1)(\gamma_r-\xi)}} \left[\frac{\mu_r}{a}\right]^{\frac{1-\sigma_r}{1-\beta_m(\sigma_r-1)(\gamma_r-\xi)}} (A^r L_r)^{\frac{1}{1-\beta_m(\sigma_r-1)(\gamma_r-\xi)}} \tag{E.9}$$

where we assume $\beta_m > 0$ is sufficiently small that $\beta_m(\sigma^r - 1)(\gamma^r - \xi) < 1$.

The optimal price of a firm with a^k in market r is

$$\begin{aligned} p_r^m(a^k) &= \frac{\phi_r(a^k)^\xi}{a}\frac{\sigma_r}{\sigma_r - 1} \\ &= \frac{1}{a}\left[\frac{1}{b_m}\rho_r S_r^m(a^k)[\gamma_r - \xi]\right]^{\beta_m \xi}\left(\frac{\sigma_r}{\sigma_r - 1}\right) \end{aligned} \tag{E.10}$$

E.2 Productivity and the Optimal Quality and Sales

Note from (E.9) that $S_r^m(a^k)$ depends on a only through the term $\frac{\mu_r}{a}$. This implies that if $a^k = a^{k'}$ (i.e. firms with market k and market k' both have productivity a), then $S_r^m(a^k) = S_r^m(a^{k'})$ (even if $k \neq k'$). Also, it is clear from (E.9) that $\frac{\partial \log S_r^m(a^k)}{\partial \log a} > 0$ as long as $\beta_m(\sigma_r - 1)(\gamma_r - \xi) < 1$. Also, from (E.5) and (E.10), we have that if $a^k = a^{k'}$, then $\phi_r(a^k) = \phi_r(a^{k'})$ and $p_r^m(a^k) = p_r^m(a^{k'})$ (even if $k \neq k'$). These results imply that regardless of market collection a firm has, each firm's optimal quality and price in market r only depends on local market condition and the realized productivity a under market-specific quality strategy. We summarize these results below.

Proposition 7. *(Productivity and Quality, Sales under Market-specific Quality Choice)*

Under market-specific quality choice, we have $S_r^m(a^k) = S_r^m(a^{k'})$, $\phi_r(a^k) = \phi_r(a^{k'})$, and $p_r^m(a^k) = p_r^m(a^{k'})$ if $a^k = a^{k'}$ where $r \in k$ and $r \in k'$.

Also, if $\beta_m > 0$ is sufficiently small that $\beta_m(\sigma_r - 1)(\gamma_r - \xi) < 1$, we have

$$\frac{\partial \log \phi_r(a^k)}{\partial \log a} > 0 \tag{E.11}$$

$$\frac{\partial \log S_r^m(a^k)}{\partial \log a} > 0 \tag{E.12}$$

Proof. We only need to prove $\frac{\partial \log \phi_r(a^k)}{\partial \log a} > 0$. We know $\frac{\partial \log S_r^m(a^k)}{\partial \log a} > 0$ under $\beta_m(\sigma_r - 1)(\gamma_r - \xi) < 1$. Note that (E.5) implies $\frac{\partial \log \phi_r(a^k)}{\partial \log S_r^m(a^k)} > 0$. Thus, we have $\frac{\partial \log \phi_r(a^k)}{\partial \log a} = \frac{\partial \log \phi_r(a^k)}{\partial \log S_r^m(a^k)}\frac{\partial \log S_r^m(a^k)}{\partial \log a} > 0$. □

Corollary 8. *Under the conditions in Proposition 4, the equilibrium profit* $\pi^m(a^k)$ *under market-specific quality strictly monotonically increases with firm productivity* a*.*

Proof. It is immediate from equation (*E.7*) and $\frac{\partial \log S_r^m(a^k)}{\partial \log a} > 0$. □

E.3 Market Independence under Market-specific Quality

In contrast to the case under uniform quality choice, we can show that (firm-level) market independence arises under market-specific quality strategy.

Proposition 9. *(Independence across Markets under Market-specific Quality Choice)*

Consider a firm under market-specific quality. Let $r, r' \in k$ *and* $r \neq r'$*. Suppose we shut down general equilibrium adjustments by fixing* P_r *and* D_r *(and thus treat* y_r *as exogenous). Then,* $\frac{\partial \log S_r^m(a^k)}{\partial \log y_{r'}} = 0$*,* $\frac{\partial \log \phi_r(a^k)}{\partial \log y_{r'}} = 0$*, and* $\frac{\partial \log p_r^m(a^k)}{\partial \log y_{r'}} = 0$*.*

Proof. $\frac{\partial \log S_r^m(a^k)}{\partial \log y_{r'}} = 0$ is immediate from (E.9) and the fact that $\frac{\partial \log A_r}{\partial \log y_{r'}} = \frac{\partial \log P_r}{\partial \log y_{r'}} = 0$ since we shutting down the general equilibrium effect through P_r. $\frac{\partial \log \phi_r(a^k)}{\partial \log y_{r'}} = \frac{\partial \log p_r(a^k)}{\partial \log y_{r'}} = 0$ follows from (E.4) and (E.5) and $\frac{\partial \log S_r^m(a^k)}{\partial \log y_{r'}} = 0$. □

Appendix F Model Extensions

In this section, we extend the model by allowing firms to optimally choose whether to uniformly adjust quality of their products and replace them in all their markets (uniform quality strategy), or adjust quality and replace products market-specifically (market-specific quality strategy). We do so by combining the benchmark model with uniform quality choice with the counterfactual version of market-specific quality choice in the Appendix E. We let firms to make two-step decision: (i) each firm decides whether to choose uniform quality strategy or market-specific quality strategy with option not to operate, and then (ii) optimally set prices and quality.

F.1 Demand

For the demand side, the only part that changes is that the perceived quality $\log \zeta_{rf}$ now depends on the intrinsic quality choice $\log \phi_{(r)f}$ by firm f that could either be market-specific or uniform:

$$\log \zeta_{rf} \equiv \gamma_r \log \phi_{(r)f} \tag{F.1}$$

Here, $\phi_{(r)f} = \phi_f$ if firm f chooses uniform quality across markets, and $\phi_{(r)f} = \phi_{rf}$ if it choose market-specific quality. Firm f endogenously decides whether to choose uniform quality across all its markets or to choose market-specific quality.

F.2 CPG Production: Environments

F.2.1 Timing of Events

The timing of events is as follows. First, each firm draws productivity a from a cumulative distribution $\Psi(a)$. The draws are independent across firms and market collections they have. Second, each firm decides whether to choose uniform quality that applies to all its markets or to choose market-specific quality, with option not to operate. Third, each firm simultaneously chooses optimal quality (i.e. product attribute) and price. Finally, production occurs and markets clear subject to monopolistic competition.

We index firms (and product bundles produced by them) with $a^k \equiv (a, k)$ since all relevant firm-level decisions are uniquely determined by firm's productivity and market collection. Also, we denote quality of product bundle produced by firm a^k supplied in market r as $\phi_{(r)}(a^k)$. If firm a^k chooses uniform quality strategy, $\phi_{(r)}(a^k) = \phi(a^k)$ for all $r \in k$, and if it chooses market-specific quality strategy, $\phi_{(r)}(a^k) = \phi_r(a^k)$, where $\phi_r(a^k)$ need not equal $\phi_{r'}(a^k)$ if $r \neq r', r \in k, r' \in k$.

F.2.2 Price and Quality Choice

The optimization problem given the uniform quality strategy is identical to that in the benchmark model (i.e. Section 6). Similarly, the optimization problem given market-specific quality strategy is identical to that in the counterfactual model (i.e. Appendix E).

F.2.3 Choice between Uniform Quality vs. Market-Specific Quality

Due to monotonicity of $\pi(a^k)$ and $\pi^m(a^k)$, firms with market collection k only produce if their realized productivities are above a cutoff productivity $\overline{a_k}$ defined by

$$\min[\pi(\overline{a_k}^k), \pi^m(\overline{a_k}^k)] = 0 \tag{F.2}$$

where $\overline{a_k}^k \equiv (\overline{a_k}, k)$. The fraction of firms with $a \geq \overline{a_k}$ is $\vartheta(\overline{a_k}^k) = 1 - \Psi(\overline{a_k}) \equiv \vartheta^k$. Since the total number (measure) of firms with market collection k is given by N^k, the total number of active firms eventually serving market collection k is given by $\vartheta^k N^k$.

Conditional on operation, firm chooses uniform quality if and only if profit under such strategy is larger than that under market-specific quality:

$$\begin{aligned} \pi(a^k) &= \left[\sum_{r \in k} \frac{1}{\sigma_r} \left[1 - \beta\left(\gamma_r - \xi\right)\left(\sigma_r - 1\right)\right] S_r(a^k)\right] - f_0 \\ &> \sum_{r \in k} \left[\frac{1}{\sigma_r} \left[1 - \beta_m(\gamma_r - \xi)(\sigma_r - 1)\right] S_r^m(a^k) - f_{0r}^m\right] = \pi^m(a^k) \end{aligned} \tag{F.3}$$

Thus, the ex-ante profit for each market collection s is given by

$$\begin{aligned} \Pi^k &= \int_a \max[\pi(a^k), \pi^m(a^k)] I(a^k) d\Psi(a) \\ &= \int_{a \geq \overline{a_k}} \max[\pi(a^k), \pi^m(a^k)] d\Psi(a) \end{aligned} \tag{F.4}$$

where $I(a^k) = \begin{cases} 1 & \text{if } a \geq \overline{a_k} \\ 0 & o.w. \end{cases}$.

Let $\mathcal{M}^r \equiv \{k \in \mathcal{K}_{\mathcal{R}} : r \in k\}$ denote the set of market collections that contain market r. Then, the equilibrium CPG price in market r can be expressed as

$$\begin{aligned} P_r &= \left[\int_{f(a^k) \in G_r} \left(\phi_{(r)}(a^k)^{-(\gamma_r - \xi)} \frac{\mu_r}{a} \right)^{1-\sigma_r} di(a^k) \right]^{\frac{1}{1-\sigma_r}} \\ &= \left[\sum_{k \in \mathcal{M}^r} N^k \int_{a \geq \overline{a_k}} \left(\phi_{(r)}(a^k)^{-(\gamma_r - \xi)} \frac{\mu_r}{a} \right)^{1-\sigma_r} d\Psi(a) \right]^{\frac{1}{1-\sigma_r}} \end{aligned} \tag{F.5}$$

From the equation (F.3), we can easily see that if fixed costs associated with market-specific quality adjustment are sufficiently high (i.e. $f^m(\phi_r(a^k)) + f^m_{0r}$ is high), or firms sell in sufficiently many markets that they find it less profitable to pay recurring market-specific fixed costs, firms optimally choose uniform quality strategy.

Figure A.1: Local Sales Growth and the Direct Local Shock (Residualized)

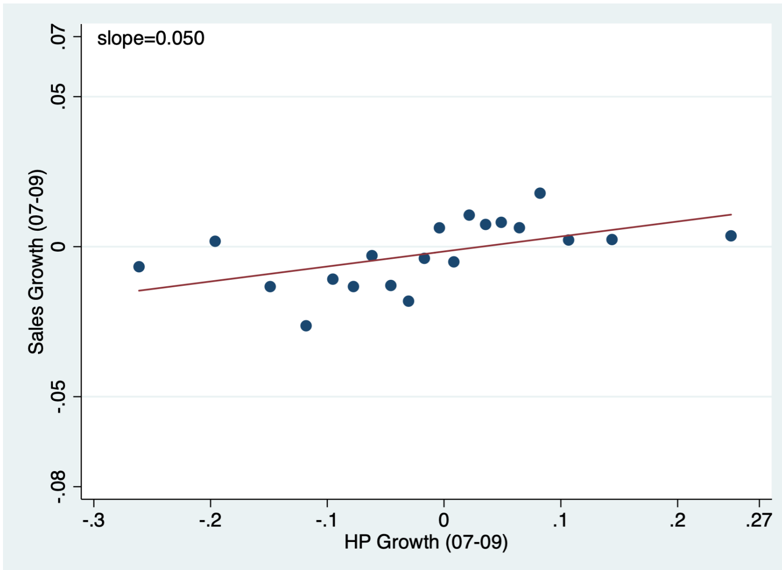
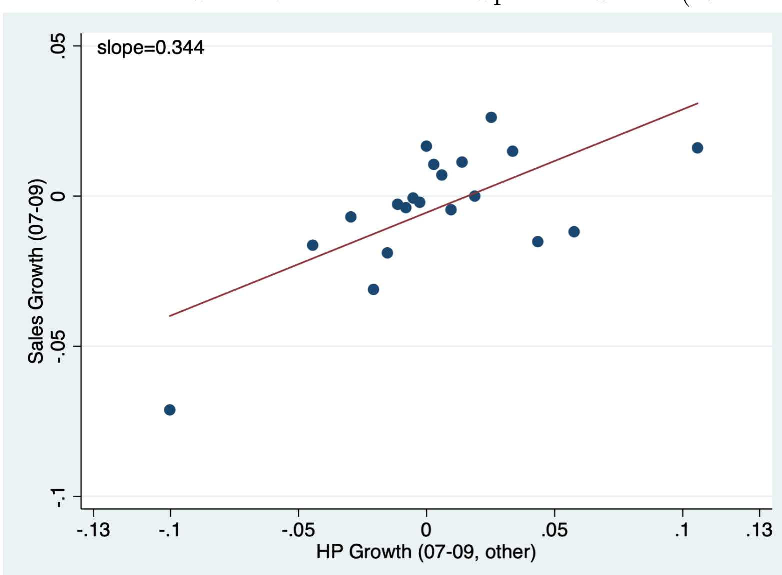


Figure A.2: Local Sales Growth and the Spillover Shock (Residualized)



Note. These figures show bin scatter plots (20 bins based on ventiles) depicting the relationship between (residualized) county-firm level sales growth, $\tilde{\Delta}\text{Sale}_{(07-09)}$, and either (residualized) county-level house price growth, $\tilde{\Delta}\text{HP}_{(07-09)}$ (upper panel), or the (residualized) initial sales-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales, $\tilde{\Delta}\text{HP}_{07-09}$ (other) (lower panel). Residualized variables are constructed using regression corresponding to Column (2) of Table 2. The reported slop coefficients are based on simple linear regression using 20 bins.

Table A.1: Sector List (Top 30)

	SIC 4-digit	Description	Ratio	Cum. Ratio
1	5149	Groceries and related products, nec	6.5	6.5
2	2099	Food preparations, nec	4.1	10.6
3	2084	Wines, brandy, and brandy spirits	3.1	13.7
4	5199	Nondurable goods, nec	2.6	16.3
5	2033	Canned fruits and specialties	2.4	18.8
6	5122	Drugs, proprietaries, and sundries	2.3	23.4
7	2844	Toilet preparations	2.3	21.1
8	5812	Eating places	2.2	25.6
9	2051	Bread, cake, and related products	2.1	27.7
10	5141	Groceries, general line	2.1	29.7
11	5182	Wine and distilled beverages	2.0	31.7
12	2834	Pharmaceutical preparations	2.0	33.7
13	2013	Sausages and other prepared meats	1.8	35.6
14	7389	Business services, nec	1.8	39.1
15	2026	Fluid milk	1.8	37.3
16	5148	Fresh fruits and vegetables	1.5	40.6
17	3999	Manufacturing industries, nec	1.5	42.1
18	5023	Homefurnishings	1.5	43.6
19	2035	Pickles, sauces, and salad dressings	1.4	45.0
20	5145	Confectionery	1.4	46.3
21	2064	Candy and other confectionery products	1.4	47.7
22	2842	Polishes and sanitation goods	1.2	50.1
23	5146	Fish and seafoods	1.2	48.9
24	2038	Frozen specialties, nec	1.2	51.3
25	2082	Malt beverages	1.2	52.4
26	2053	Frozen bakery products, except bread	1.1	53.6
27	2022	Cheese; natural and processed	1.1	54.7
28	5099	Durable goods, nec	1.0	55.7
29	2096	Potato chips and similar snacks	1.0	56.7
30	3089	Plastics products, nec	1.0	57.7

Note. This table lists the top 30 SIC 4-digit sectors. Ranking is based on the number of firms in the sector.

Table A.2: Balancing of Covariates in the Sample

$\tilde{\Delta}\text{HP}_{rf,07-09}$ (other) $\leq$ P50

Variable	Obs.	Mean	Std. Dev.	P10	P50	P90
ΔHP (rf, 07-09) (other)	420104	-0.20	0.03	-0.24	-0.18	-0.17
Sales (rf,07) (in thousand dollar)	420104	66.98	670.77	0.12	2.86	80.86
Sales-per-UPC (rf,07) (in thousand dollar)	420104	1.43	7.12	0	0	3
Sales (f,07) (in million dollar)	420104	66.00	307.83	0.39	8.66	123.44
Num. of counties (f, 07)	420104	1448.91	681.64	447	1519	2386
Num. of product group (f, 07)	420104	4.09	4.49	1	3	9

$\tilde{\Delta}\text{HP}_{rf,07-09}$ (other) $>$ P50

Variable	Obs.	Mean	Std. Dev.	P10	P50	P90
ΔHP (rf, 07-09) (other)	420577	-0.14	0.03	-0.17	-0.15	-0.10
Sales (rf,07) (in thousand dollar)	420577	63.87	802.94	0.10	1.94	59.22
Sales-per-UPC (rf,07) (in thousand dollar)	420577	1.38	6.50	0	0	3
Sales (f,07) (in million dollar)	420577	62.85	333.13	0.24	3.89	77.00
Num. of counties (f, 07)	420577	1321.44	716.90	286	1349	2255
Num. of product group (f, 07)	420577	3.84	4.42	1	2	8

Note. We split the sample into two quantiles based on the within-county distribution of $\Delta\text{HP}_{(07-09)}$(%)(other) (i.e. below- and above-median within each county). We report the within-quantile summary statistics of each variable.

Table A.3: Allowing Retailer Dimension: County-Retailer-Firm level

	(1)	(2)	(3)	(4)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	0.533***	0.520**	0.537***	-0.017
	(0.195)	(0.216)	(0.139)	(0.214)
$\tilde{\Delta}\text{HP}_{(07-09)}$ (retailer, other)		0.071	0.055	0.016
		(0.190)	(0.155)	(0.145)
Region-Firm Controls	✓	✓	✓	✓
Sector x Region x Retailer FE	✓	✓	✓	✓
R^2	0.506	0.506	0.451	0.515
Observations	1691268	1691268	1691268	1691268

Note. $\tilde{\Delta}\text{Sale}_{(07-09)}$ is the county-firm-retailer specific sales growth between 2007 and 2009, $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$ is the county-firm-retailer specific sales growth between 2007 and 2009 arising from product replacements, $\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$ is the county-firm-retailer specific sales growth between 2007 and 2009 arising from continuing products, $\tilde{\Delta}\text{HP}_{(07-09)}$ is the county-level house price growth between 2007 and 2009, $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) is the initial sales-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales, and $\tilde{\Delta}\text{HP}_{(07-09)}$ (retailer, other) is the initial "county-firm-retailer specific sales"-weighted house price growth between 2007 and 2009 in the other counties where retailer generates sales by selling the firm's products. Sectors are defined based on SIC 4-digit. Region-Firm controls include log of initial county-firm-retailer specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by county-firm-retailer specific initial sales. Standard errors (in parentheses) are three-way clustered at the state, sector, and retailer level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.4: County-Firm-Product Group level Regression:
County-Firm-Product Group level Spillover Shock

	(1)	(2)	(3)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other, firm-group)	0.439^{**}	0.654^{***}	-0.215
	(0.214)	(0.221)	(0.316)
Firm FE	✓	✓	✓
Prod.Group x Region FE	✓	✓	✓
R^2	0.602	0.652	0.628
Observations	1592568	1592568	1592568

Note. $\tilde{\Delta}\text{Sale}_{(07-09)}$ is the county-firm-product group specific sales growth between 2007 and 2009, $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$ is the county-firm-product group specific sales growth between 2007 and 2009 arising from product replacements, $\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$ is the county-firm-product group specific sales growth between 2007 and 2009 arising from continuing products, $\tilde{\Delta}\text{HP}_{(07-09)}$ (other, firm-group) is the initial "county-firm-product group specific sales"-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales by selling products in the product group. We control log of initial sales in addition to specified fixed effects. All regressions are weighted by county-firm-product group specific initial sales. Standard errors (in parentheses) are clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.5: County-Firm-Product Group level Regression:
County-Firm level Spillover Shock

	(1)	(2)	(3)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other, firm)	0.114	0.210***	-0.096
	(0.084)	(0.051)	(0.088)
Region-Firm Controls	✓	✓	✓
Sector FE	✓	✓	✓
Prod.Group x Region FE	✓	✓	✓
R^2	0.339	0.427	0.397
Observations	1592716	1592716	1592716

Note. $\tilde{\Delta}\text{Sale}_{(07-09)}$ is the county-firm-product group specific sales growth between 2007 and 2009, $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$ is the county-firm-product group specific sales growth between 2007 and 2009 arising from product replacements, $\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$ is the county-firm-product group specific sales growth between 2007 and 2009 arising from continuing products, $\tilde{\Delta}\text{HP}_{(07-09)}$ (other, firm) is the initial "county-firm specific sales"-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales (i.e. same shock as in the main county-firm level analyses). Sectors are defined based on SIC 4-digit. Region-Firm controls include log of initial county-firm-product group specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by county-firm-product group specific initial sales. Standard errors (in parentheses) are clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.6: Excluding Nearby Regions

	(1)	(2)	(3)	(4)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other, $\geq$100mi)	0.320^{***}			
	(0.101)			
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other, $\geq$300mi)		0.200^{**}		
		(0.091)		
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other, $\geq$500mi)			0.189^{**}	
			(0.078)	
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other, out-of-state)				0.238^{**}
				(0.101)
Region-Firm Controls	✓	✓	✓	✓
Sector x Region FE	✓	✓	✓	✓
R^2	0.393	0.393	0.396	0.392
Observations	839548	833893	828729	838812

Note. $\tilde{\Delta}\text{Sale}_{(07-09)}$ is the county-firm-retailer specific sales growth between 2007 and 2009, $\tilde{\Delta}\text{HP}_{(07-09)}$ (other, $\geq$"N"mi) is the initial sales-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales, where we exclude "other counties" within "N" mile radius around the county (by assigning zero weights on them and re-normalizing the remaining weights to one). $\tilde{\Delta}\text{HP}_{(07-09)}$ (other, out-of-state) is similarly constructed by excluding "other counties" within the same state. Region-Firm controls include log of initial county-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by county-firm specific initial sales. Standard errors are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.7: Decomposition of Sales Growth (State level)

	(1)	(2)	(3)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	0.303**	0.376***	-0.074
	(0.113)	(0.085)	(0.058)
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
R^2	0.357	0.449	0.426
Observations	83610	83610	83610

Note. $\tilde{\Delta}\text{Sale}_{(07-09)}$ is the state-firm specific sales growth between 2007 and 2009, $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$ is the state-firm specific sales growth between 2007 and 2009 arising from product replacements (net creation), $\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$ is the state-firm specific sales growth between 2007 and 2009 arising from continuing products, $\tilde{\Delta}\text{HP}_{(07-09)}$ is the state-level house price growth between 2007 and 2009, and $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) is the initial sales-weighted house price growth between 2007 and 2009 in the other states where the firm generates sales. Sectors are defined based on SIC 4-digit. Region-Firm controls include log of initial state-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by state-firm specific initial sales. Standard errors (in parentheses) are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.8: Local Market Structure and Correlation of Shocks (State-level)

	(1st mkt,2nd mkt)	(1st mkt,3rd mkt)	(2nd mkt,3rd mkt)
(A) House Price Growth (Corr)	-0.12	-0.11	0.12
(B) Diff. Census Division (Ratio)	0.90	0.92	0.78

Note. Panel (A) calculate correlation of state-level house price growth between firms' largest and 2nd largest markets, largest and 3rd largest markets, and 2nd largest and 3rd largest markets, where markets are defined at the state-level. Panel (B) calculates ratio of firms having different Census Divisions for the largest and 2nd largest markets, largest and 3rd largest markets, and 2nd largest and 3rd largest markets, where markets are defined at the state-level. All statistics are weighted by initial firm-level sales.

Table A.9: Control Common Other-Largest-Market

	(1)	(2)	(3)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	0.674^{***}	0.578^{***}	0.097
	(0.196)	(0.112)	(0.063)
Region-Firm Controls	✓	✓	✓
Sector x Region x Other FE	✓	✓	✓
R^2	0.526	0.517	0.543
Observations	684437	684437	684437

Note. This table presents variants of the specification in Columns (4)-(6) of Table 3 with alternative fixed effects. "Other FE" indicates dummy of census divisions that contain each county-firm observation's largest other county. All regressions are weighted by county-firm specific initial sales. Standard errors (parentheses) are three-way clustered at state, sector, and "other state" level, where "other state" indicates state containing each county-firm observation's largest other county. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.10: Control Firms' Customer Types

	(1)	(2)	(3)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	0.637**	0.598***	0.039
	(0.258)	(0.150)	(0.244)
Income (other)	-0.004	0.002	-0.006*
	(0.003)	(0.002)	(0.003)
Educ (other)	-0.016***	-0.001	-0.015***
	(0.005)	(0.004)	(0.002)
White (other)	-0.003	0.003	-0.006
	(0.006)	(0.003)	(0.003)
Owner (other)	0.005	-0.007**	0.012**
	(0.004)	(0.003)	(0.005)
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
R^2	0.395	0.409	0.429
Observations	840681	840681	840681

Note. This table presents a variant of the specification in Columns (4)-(6) of Table 3 with additional demographic controls constructed in a similar way as in $\tilde{\Delta}\text{HP}_{(07-09)}$ (other). These include pre-recession median household income, percentage with high school diploma or less, percentage white, and percentage owner-occupied. All regressions are weighted by county-firm specific initial sales. Standard errors (in parentheses) are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.11: Homescan Panel (State-level): Controlling Lagged-dependent Variables

	(1)	(2)	(3)	(4)	(5)	(6)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	0.325*	0.246**	0.079	0.311*	0.238**	0.080
	(0.188)	(0.110)	(0.168)	(0.173)	(0.105)	(0.169)
$\tilde{\Delta}\text{Sale}_{(04-06)}$				0.086***		
				(0.009)		
$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(04-06)}$					0.100***	
					(0.010)	
$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(04-06)}$						-0.007
						(0.011)
Region-Firm Controls	✓	✓	✓	✓	✓	✓
Sector x Region FE	✓	✓	✓	✓	✓	✓
R^2	0.427	0.419	0.389	0.432	0.426	0.389
Observations	161537	161537	161537	161537	161537	161537

Note. We constructed state-firm level observations using ACNielsen Homescan Panel database. $\tilde{\Delta}\text{Sale}_{(07-09)}$ is the state-firm specific sales growth between 2007 and 2009, $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$ is the state-firm specific sales growth between 2007 and 2009 arising from product replacements (net creation), $\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$ is the state-firm specific sales growth between 2007 and 2009 arising from continuing products. $\tilde{\Delta}\text{Sale}_{04-06}$, $\tilde{\Delta}\text{Sale}^{\text{replace}}_{04-06}$, and $\tilde{\Delta}\text{Sale}^{\text{continue}}_{04-06}$ are corresponding growth rates between 2004 and 2006. $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) is the lagged-initial sales-weighted house price growth between 2007 and 2009 in the other states where the firm generates sales. The weights are constructed using 2004 state-firm specific sales. Sector of each company is defined as a combination of three largest product groups with based on year 2004. Region-Firm controls include log of 2004 state-firm specific sales, log of 2004 firm-level sales, log of the 2004 number of local markets a firm has, and log of the 2004 number of product groups a firm has. All regressions are weighted by state-firm specific initial sales. Standard errors (in parentheses) are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.12: Using Shift-Share Robust Standard Error

	County-level		
	(1)	(2)	(3)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	0.398**	0.419***	-0.021
	(0.169)	(0.087)	(0.129)
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
R^2	0.392	0.408	0.427
Observations	840681	840681	840681
	State-level		
	(4)	(5)	(6)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	0.303***	0.376***	-0.074
	(0.112)	(0.081)	(0.069)
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
R^2	0.357	0.449	0.426
Observations	83610	83610	83610

Note. This table repeats Columns (4)-(6) of Table 3 under alternative definitions of markets (county and state) using shift-share robust standard error proposed by Adao et al. (2018b). *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.13: Using Binary Shock

	(1)	(2)	(3)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
Shock (Binary)	0.026***	0.030**	-0.005
	(0.005)	(0.014)	(0.014)
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
R^2	0.392	0.409	0.427
Observations	840681	840681	840681

Note. This table repeats Columns (4)-(6) of Table 3, where we replace $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) with the binary shock (i.e. Shock (Binary)). Shock (Binary) is an indicator variable that has value 0 if $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) is lower than median of the within-county distribution of $\tilde{\Delta}\text{HP}_{(07-09)}$ (other), and has value 1 if $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) is greater than or equal to median of the within-county distribution of $\tilde{\Delta}\text{HP}_{(07-09)}$ (other). All regressions are weighted by county-firm specific initial sales. Standard errors (in parentheses) are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.14: Accommodating Firms' Local Market Entry/Exit

	(1)	(2)	(3)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	0.446***	0.486***	-0.040
	(0.113)	(0.124)	(0.070)
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
R^2	0.434	0.434	0.442
Observations	1455914	1455914	1455914

Note. $\tilde{\Delta}\text{Sale}_{(07-09)}$ is the county-firm specific sales growth between 2007 and 2009, $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$ is the county-firm specific sales growth between 2007 and 2009 arising from product replacements (net creation), $\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$ is the county-firm specific sales growth between 2007 and 2009 arising from continuing products, and $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) is the initial sales-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales. While constructing each growth rate, we accommodate firms' local market entry and exit by assigning 2 (entry) and -2 (exit), respectively. Sectors are defined based on SIC 4-digit. Region-Firm controls include log of initial county-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by county-firm specific average sales (across 2007 and 2009) to avoid assigning zero weight on newly entered local market in 2009. Standard errors (in parentheses) are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.15: Creation and Destruction

	(1)	(2)
	$\text{Creation}_{(07-09)}$	$\text{Destruction}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	0.145***	-0.273***
	(0.044)	(0.079)
Region-Firm Controls	✓	✓
Sector x Region FE	✓	✓
R^2	0.572	0.437
Observations	840681	840681

Note. $\text{Creation}_{(07-09)}$ is the county-firm specific sales generated by products that didn't exist in region r in 2007 but existed in 2009 (i.e. $\frac{\text{Sales}^{\text{enter}}_{rf,09}}{\overline{\text{Sales}}_{rf,07-09}}$), and $\text{Destruction}_{(07-09)}$ is the county-firm specific sales generated by products that existed in region r in 2007 but no longer exist in 2009 (i.e. $\frac{\text{Sale}^{\text{exit}}_{rf,07}}{\overline{\text{Sale}}_{rf,07-09}}$). $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$ in Column (5) of Table 3 is identical to $\text{Creation}_{(07-09)}$-$\text{Destruction}_{(07-09)}$. $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) is the initial sales-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales. Sectors are defined based on SIC 4-digit. Region-Firm controls include log of initial county-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by county-firm specific initial sales. Standard errors (in parentheses) are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.16: Price Response at the Replacement Margin

	(1)	(2)	(3)
	$\tilde{\Delta}\text{Price}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Price}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Price}^{\text{replace}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	0.310^{***}	0.456^{***}	0.165^{***}
	(0.065)	(0.142)	(0.048)
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
Index	Equal Weight	Sales Weight	Size Adj.
R^2	0.417	0.397	0.420
Observations	461672	461672	461672

Note. $\tilde{\Delta}\text{Price}^{\text{replace}}_{(07-09)}$ is the county-firm specific price growth at the replacement margin between 2007 and 2009 defined in the Appendix C, and $\Delta\text{HP}_{(07-09)}$ (other) is the initial sales-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales. Sectors are defined based on SIC 4-digit. Region-Firm controls include log of initial county-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by state-firm specific initial sales. Standard errors are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.17: Quality Downgrading at the Replacement Margin

	(1)	(2)	(3)	(4)
	$\tilde{\Delta}\text{Quality}^{\text{replace}}_{(07-09)}$ (%)			
quality	relative unit price			organic
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	0.344**	0.481***	0.209**	17.973**
	(0.128)	(0.144)	(0.102)	(8.893)
Region-Firm Controls	✓	✓	✓	✓
Sector x Region FE	✓	✓	✓	✓
Market	County	County	County	State
Index	Equal Weight	Sales Weight	Size Adj.	-
R^2	0.428	0.419	0.403	0.622
Observations	461672	461672	461672	2603

Note. $\tilde{\Delta}\text{Quality}^{\text{replace}}_{(07-09)}$ is the county-firm specific quality growth at the replacement margin between 2007 and 2009 defined in the Appendix C, and $\Delta\text{HP}_{(07-09)}$ (other) is the initial sales-weighted house price growth between 2007 and 2009 in the other counties where the firm generates sales. Sectors are defined based on SIC 4-digit. Region-Firm controls include log of initial county-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by state-firm specific initial sales. Standard errors are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.18: Destruction Patterns by Number of Markets

Num. Markets (by UPC, 2007)	Exits (>50%) of Mkt	Exits (>90%) of Mkt
≤200	0.89	0.69
201-400	0.85	0.61
401-600	0.91	0.72
601-800	0.87	0.62
801≤	0.94	0.58

Note. Among the total value lost by destruction of products in local markets, we calculate the share of products (in value) that exited more than 50% (90%) of their initially sold markets. Products are partitioned into 5 bins based on the number of UPC-level markets in 2007, and the calculation was carried out separately for each bin.

Table A.19: Creation Patterns by Number of Markets

Num. Markets (by Firm, 2009)	Enters (>50%) of Mkt	Enters (>90%) of Mkt
≤200	0.53	0.22
201-400	0.50	0.17
401-600	0.55	0.36
601-800	0.63	0.15
801≤	0.80	0.28

Note. Among the total value generated by creation of products in local markets, we calculate the share of products (in value) that entered more than 50% (90%) of the firm's overall market in 2009. Products are partitioned into 5 bins based on the number of firm-level markets in 2009, and the calculation was carried out separately for each bin.

Table A.20: Creation Patterns: Entry at the National-level

Enters (>50%) of Mkt	Enters (>90%) of Mkt	Share (among Tot. Entry Values in 2009)
0.80	0.31	0.84

Note. Among the total value generated by creation of products in local markets, we calculate the share of products (in value) that entered more than 50% (90%) of the firm's overall market in 2009, conditioning on products not being sold at the firm-level in 2007. The last column shows the share of total value generated by creation at the national-level relative to total value generated by overall creation of products.

Table A.21: Creation Patterns by Number of Markets: Entry at the National-level

Num. Markets (by Firm, 2009)	Enters (>50%) of Mkt	Enters (>90%) of Mkt
≤200	0.68	0.30
201-400	0.60	0.22
401-600	0.69	0.48
601-800	0.74	0.21
801≤	0.82	0.31

Note. Among the total value generated by creation of products in local markets, we calculate the share of products (in value) that entered more than 50% (90%) of the firm's overall market in 2009, conditioning on products not being sold at the firm-level in 2007. Products are partitioned into 5 bins based on the number of firm-level markets in 2009, and the calculation was carried out separately for each bin.

Table A.22: Net Creation Decomposition (State-level)

	(1) $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	(2) $\tilde{\Delta}\text{Sale}^{\text{replace, national}}_{(07-09)}$	(3) $\tilde{\Delta}\text{Sale}^{\text{replace, local}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	0.376***	0.389***	-0.013
	(0.085)	(0.078)	(0.009)
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
R^2	0.449	0.450	0.144
Observations	83610	83610	83610

Note. $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$ is the state-firm specific sales growth between 2007 and 2009 arising from product replacements (net creation), $\tilde{\Delta}\text{Sale}^{\text{replace, national}}_{(07-09)}$ is the state-firm specific sales growth between 2007 and 2009 arising from products replaced in multiple states, and $\tilde{\Delta}\text{Sale}^{\text{replace, local}}_{(07-09)}$ is the state-firm specific sales growth between 2007 and 2009 arising from products only replaced in the state. $\tilde{\Delta}\text{HP}_{(07-09)}$ (other) is the initial sales-weighted house price growth between 2007 and 2009 in the other states where the firm generates sales. Sectors are defined based on SIC 4-digit. Region-Firm controls include log of initial state-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by state-firm specific initial sales. Standard errors are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.23: Regression of the Structural Equation: Decomposition

	(1) $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	(2) $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	(3) $\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$	(4) $\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
$\tilde{\Delta}\text{Sale}_{(07-09)}$ (other)	0.485***	0.691***	0.505***	0.033
	(0.037)	(0.245)	(0.038)	(0.229)
IV	-	✓	-	✓
First-stage F stat	-	11.5	-	11.5
Region-Firm Controls	✓	✓	✓	✓
Sector + Region FE	✓	✓	✓	✓
R^2	0.467	0.231	0.413	0.035
Observations	840681	840681	840681	840681

Note. $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$ is the county-firm specific sales growth between 2007 and 2009 arising from product replacements, $\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$ is the county-firm specific sales growth between 2007 and 2009 arising from continuing products, and $\tilde{\Delta}\text{Sale}_{(07-09)}$ (other) is the initial sales-weighted average local sales growth between 2007 and 2009 in the other counties where the firm generates sales. In Column (2) and Column (4), we instrument $\tilde{\Delta}\text{Sale}_{(07-09)}$ (other) using $\tilde{\Delta}\text{HP}_{(07-09)}$ (other), which is the initial sales-weighted house price growth between 2007 and 2009 in the other states where the firm generates sales. Sectors are defined based on SIC 4-digit. Region-Firm controls include log of initial state-firm specific sales, log of initial firm-level sales, log of the initial number of local markets a firm has, and log of the initial number of product groups a firm has. All regressions are weighted by county-firm specific initial sales. Standard errors are double clustered at the state and sector level. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table A.24: Interaction with Financial Constraint (100-paydex)

	(1)	(2)	(3)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other) x (100-paydex)	0.069***	0.088***	-0.019
	(0.021)	(0.028)	(0.047)
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	-1.425***	-1.899**	0.474
	(0.325)	(0.924)	(1.317)
(100-paydex)	0.008	0.016***	-0.008
	(0.005)	(0.004)	(0.008)
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
Market	County	County	County
R^2	0.376	0.410	0.402
Observations	763345	763345	763345

Table A.25: Interaction with Financial Constraint (Rajan and Zingales (1998))

	(1)	(2)	(3)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other) x RZ	5.325	4.503**	0.821
	(3.449)	(2.015)	(2.932)
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	-0.422	-0.237	-0.185
	(0.543)	(0.288)	(0.456)
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
Market	State	State	State
R^2	0.326	0.458	0.404
Observations	51856	51856	51856

Table A.26: Interaction with Financial Constraint (100-paydex, With Other Interaction Terms)

	(1)	(2)	(3)
	$\tilde{\Delta}\text{Sale}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{replace}}_{(07-09)}$	$\tilde{\Delta}\text{Sale}^{\text{continue}}_{(07-09)}$
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other) x (100-paydex)	0.062***	0.081**	-0.018
	(0.018)	(0.038)	(0.051)
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other) x ln(dist)	0.024	0.050	-0.026
	(0.128)	(0.141)	(0.110)
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other) x ln(Num Mkt)	0.158**	0.156**	0.003
	(0.078)	(0.061)	(0.158)
$\tilde{\Delta}\text{HP}_{(07-09)}$ (other)	-2.369***	-2.958***	0.590
	(0.584)	(0.489)	(0.809)
(100-paydex)	0.007	0.015**	-0.008
	(0.004)	(0.006)	(0.008)
ln(dist)	-0.049*	-0.032	-0.017
	(0.028)	(0.021)	(0.026)
Region-Firm Controls	✓	✓	✓
Sector x Region FE	✓	✓	✓
R^2	0.377	0.411	0.402
Observations	763345	763345	763345