Minimum Wages and Pass-Through

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Abstract

Price inflation rose dramatically in late 2021. While there were many potential causes, some point to rising minimum wages, and wage inflation, as perhaps the most important source of food-price inflation. There is a large body of research that studies the aggregate effects of minimum wages, but none consider the precise mechanisms that link higher food prices and minimum wages in an environment of high general price inflation. In this study, we investigate the possibility that general price inflation serves as a facilitating mechanism for localized price inflation. We estimate both reduced-form and structural models of minimum-wage pass-through. Reduced-form models show that general price inflation has a positive effect on minimum wage pass-through to retail food prices. However, reduced-form models cannot account for the effects of demand curvature and imperfect competition. Our structural model shows that, after controlling for the primary determinants of wage pass-through, general price inflation has an important role in accentuating the rate of minimum-wage pass-through. Our findings have important implications for minimum wage policy, and for understanding the role of labor cost in retail price inflation.

Keywords: food price inflation, imperfect competition, minimum wages, pass-through.
JEL Codes: D43, L13, M31

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1 Introduction

Minimum wages, at least at the state and local levels, have been rising rapidly for over a decade. For most of that period, food price inflation has been relatively low, averaging some 2.5% over the 2011 - 2021 period (U.S. Bureau of Labor Statistics 2023). However, starting in late 2021 food price inflation accelerated rapidly, averaging over 9.0% in the U.S. between mid-2021 and mid-2023 (U.S. BLS 2023). Labor is an important cost-component for most food retailers, forming some 16% of total operating cost (U.S. Bureau of Census, Annual Retail Trade Survey, 2023) so higher labor costs may contribute to rising food prices. But, there are many other potential contributors to food price inflation: Massive federal stimulus following the COVID-19 pandemic, conflict in Eastern Europe and rising commodity prices, and rising concentration among food retailers, just to name a few. Several recent studies examine the pass-through of rising minimum wages to food prices, and report mixed findings of either no pass-through at all (Ganapati & Weaver 2017), relatively small pass-through elasticities (Renkin, et al. 2022), or over-shifting (pass-through greater than 1, Leung 2021). Each of these studies, however, examine data from periods in which general price inflation was relatively low and use reduced-form models that cannot take either imperfect competition or the structure of demand into account in estimating pass-through. In this paper, we re-examine the role of minimum wages in retail food price inflation, and explicitly consider the role of generalized price inflation in a structural model of retail price competition and consumer search.

Many firms are only indirectly affected by higher minimum wages, either because they use relatively little minimum-wage labor, or wages form only a relatively small part of their overall cost structure. However, pass-through in multi-echelon, differentiated-product supply chains can be substantial as firms have considerable flexibility in setting prices (Ellickson & Grieco 2013; Ellickson 2016).[1] It is well understood that the rate at which firms pass-through

[1]Further, retail grocery stores are intermediaries, so cost-of-goods-sold (COGS) is clearly their most important cost-element (83%, U.S. Census). However, labor forms most of the remaining variable cost (14%, U.S. Census; NGA 2023) and is subject to greater retailer-control than are wholesale prices. Further, some 25% of workers in the grocery industry are within 1% of the minimum wage (U.S. Bureau of Census, Current Population Survey) so changes in the minimum wage are likely to apply to a substantial share of grocery workers. Therefore, it is likely that changes in minimum wages have material impacts on retailers' operating costs.

higher costs to retail prices depends on both the curvature of demand, and the extent of competition among firms in the market (Bulow & Pfleiderer 1983; Anderson, Hansen, & Simester 2009; Weyl & Fabinger 2013; Hong & Li 2017; Miller, Osborne, & Sheu 2017; Miravete, Seim, & Thurk 2018, 2022). In the textbook case, with linear demands, perfectly competitive firms pass-through any change in cost completely. However, because demand is rarely linear, the degree of competitiveness and the curvature of demand interact to produce ambiguous results (Weyl & Fabinger 2013; Miravete, Seim, & Thurk 2018). With linear demands, constant marginal cost, and constant industry conduct (the degree of competitiveness does not change with prices), then pass-through varies continuously from 100% for firms in perfectly competitive industries to 50% for monopolies (Weyl & Fabinger 2013; Miller, Osborne, & Sheu 2017; Genakos & Pagliero 2022). In a more general empirical setting, this textbook case does not apply and the effect of market power is indeterminate, depending on the interaction between conduct and curvature.[2] We account for this interaction in our empirical analysis.

Anecdotal evidence in the media reflects a common assumption that firms with market power raise prices during inflationary periods simply because they can (DePillis 2022; Curran 2023). But, the problem with this sort of casual empiricism lies in the fact that, from the perspective of food markets in 2022, retail concentration rose relatively little over the past 10 years (McDonald, Dong & Fuglie 2023) but food price inflation only emerged in late 2021. What changed to allow food price inflation in 2021? When all prices are rising quickly, consumers face a fundamental signal-extraction problem that obscures relative price changes from changes in the overall level of prices (Lucas 1972). More generally, we argue that search-obfuscation plays an important role in an environment of general price inflation as news that prices are rising gives retailers cover to increase consumer prices without fear of retribution (Ellison & Ellison 2009; Ellison & Wolitzky 2012; Richards, et al. 2020). More specifically, our framework shows that general price inflation, which contributes to the volatility of nominal prices generates an obfuscatory effect around consumers' expectations

[2]In fact, Miller, Osborne, and Sheu (2017) show that under log-convex demands (typical with CES demands, and possible under AIDS) pass-through increases as industry conduct becomes more competitive, which is counter to the "greedflation" story that oligopolies pass-through costs at a greater rate than competitive firms.

of individual–product prices, which provides firms' latitude to raise their own prices.

Obfuscation does not mean that consumers do not search. On the contrary, consumers search more with rising prices, but their search is less effective. In fact, it is well understood that pass-through depends on the extent to which consumers search for the lowest price in the market (Yang & Ye 2008; Tappata 2009; Chandra & Tappata 2011; Lewis 2011; Byrne & De Roos 2017). While most of this literature seeks to explain the "rockets and feathers" phenomenon, or the empirical observation that retail prices tend to rise after a cost shock faster than they fall after the cost shock disappears, their insights have direct relevance for empirical analysis of minimum wage pass-through. Namely, when general prices are rising, Lewis (2011) shows that "...[F]or a given level of consumers' expectations: equilibrium prices increase more quickly with wholesale cost as costs rise relative to expectations..." (p. 423). Combining the obfuscation and search insights, we argue that inflation causes consumers to search more and have less success doing so, with the result that individual product prices rise more quickly than in low-inflation settings.

Understanding retail food price inflation is more than just a methodological or theoretical curiosity due to the importance of food-at-home in consumers' household budgets (Ganapati & Weaver 2017; Leung 2021; Renkin, et al. 2022). Among the lowest income households (lowest quintile), consumers spend over 30% of their income on food-at-home, largely purchased through grocery stores (ERS 2023) while consumers closer to the median still spend nearly 10% of their income on food. While we do not address the aggregate welfare effects of minimum-wage changes, the fact that food purchased at grocery stores represents an important use of income argues for the overall importance of studying this issue, and of getting it right.

The retail food industry represents an ideal setting to study the effects of imperfect competition and inflation on minimum-wage pass-through as the degree of competitiveness varies considerably by market (Hosken, Olson, & Smith 2018) and local competition is typically intense (Ellickson & Grieco 2013; Ellickson, Grieco & Khvastunov 2020; Arcidiacono, et al. 2020). Although large, national retailers tend to follow relatively uniform pricing strategies, which in absolute terms would mitigate their usefulness in studying pass-through (DellaVigna & Gentzkow 2019; Hitsch, Hortacsu, & Lin 2021), our data includes a substantial contribution from perishable-food categories, which are more likely to reflect elements of local competition, and regional retailers that do not follow national pricing strategies. While others who study minimum wage pass-through in the grocery industry do not account explicitly for competition among retailers (Leung 2021; Renkin, et al. 2022) we examine the role of localized imperfect competition in a structural way.

Others provide extensive empirical evidence on the extent of minimum-wage pass-through in the retailing industry (Leung 2021; Renkin, et al. 2022) but none address how minimum-wage pass-through may change with generalized price inflation.[3] In this paper, we test a structural model of minimum-wage pass-through, and offer a simple explanation for how minimum wages can have heterogeneous impacts on retail pricing in different macroeconomic environments, controlling for the degree of competitiveness and curvature of demand.

We use changes in the minimum wage as a clean, exogenous source of econometric identification (Allegretto, et al. 2017). Studies that examine retail-price pass-through tend to consider the effect of rising commodity prices on retail prices (for example, Lan, et al. 2022) but there is no guarantee that rising commodity prices are independent of the economic conditions that gave rise to rising retail prices in the first place. That is, commodity prices are endogenous in a complete model of retail-wholesale distribution. In our case, however, changes in minimum wages are clearly exogenous, and independent of conditions in wholesale markets. Therefore, rising minimum wages provides an excellent econometric setting in which to study pass-through in the retail sector.

Studying wage pass-through to retail prices is very different from studying more usual product-level cost shocks (Miravete, Seim, & Thurk 2018, 2022, 2023; Lan, et al. 2022). Whereas changes in commodity prices affect the cost of acquiring products at the wholesale level, wage changes affect the cost of selling finished goods through a retailer's fixed costs.[4]

[3]There is a deep and unsettled literature on the employment effects of minimum wages (see Card & Krueger (1994) for the seminal article on this topic, and Neumark & Washcher (2007) for an early review of the literature), but the weight of the recent empirical evidence suggests that there are very small impacts of an increase in the minimum wage on employment (Dube, Lester, and Reich 2010; Allegretto, et al. 2017; Cengiz, et al. 2019; Azar, et al. 2019; Dustmann, et al. 2022), despite orthodox reasoning that suggests the opposite – in the perfectly competitive case, a binding minimum wages must have a negative effect, and create unemployment at the new minimum wage. Considering this question, however, is related to but beyond the scope of our research.

[4]Wages affect fixed costs on the assumption that a retailer sells approximately the same amount of goods each week, and does not respond to variation in weekly volume by employing more workers.

Typical structural models of retail pass-through use matrices of cross-price effects to control for a retailer's internal incentives to change prices in response to changes in acquisition costs, and cross-price matrices among competing retailers to control for the competitive incentives to change prices (Richards, Allender, & Hamilton 2012; Hong & Li 2017). In our case, however, changing labor costs only affect a retailer's incentive to change general price levels in competition with other retailers, assuming labor forms a different percentage of operating costs among different retailers. Therefore, we examine how changes in labor cost, induced by changes in the minimum wage, are passed through to consumers at the store level, and not through the structure of individual-product demand.

We find that the pass-through rate of minimum wages is substantially higher during periods of high inflation. Specifically, we show that each percentage point in inflation is associated with a pass-through rate that is seven points higher than otherwise. Over our sample period, retailers tend to pass higher minimum wages onto consumers completely (at or near 100%), but particularly so during periods of high inflation. In fact, the average pass-through rate in our data is over 170%, meaning that retailers increase prices by 17% for each 10% increase in the minimum wage. Further, we find that demand curvature, in spite of its theoretical importance in driving pass-through (Weyl & Fabinger 2013; Miravete, Seim, & Thurk 2022, 2023), is a relatively minor contributor to pass-through empirically. Although extreme values of curvature have an important influence on pass-through, the fact that curvature varies near 1.0 in our data means that it is of little consequence in reality. We attribute our findings regarding the importance of general price inflation to a search effect: Consumers search more intensively when prices are rising, but the fact that they are rising makes search less effective. Retailers understand this fact and raise prices accordingly. Further, we examine our data during similar periods of previous empirical analyses of minimum wage pass-through (Leung 2021) and find that some of their results may be due to not accounting accurately for the joint effects of demand curvature and market power. Third, we find that retailers price significantly below what we would expect from highly-differentiated Bertrand-Nash competitors and that imperfect competition, *per se*, has little impact on the observed rate of retail price inflation.

We make three primary contributions to the labor economics and empirical industrial organization literatures. First, we complement recent research by Leung (2021) and Renkin, et al. (2022) by providing structural estimates of minimum-wage pass-through in the food retailing industry. While both of these studies discuss the importance of the curvature of demand and competition in affecting the rate of minimum-wage pass-through, neither account for these features in a way that allows pass-through to vary by the degree of curvature and the extent of competition. Our structural model allows us to directly estimate the impact of both on the rate of minimum-wage pass-through to retail prices.

Second, we provide an estimate of how pass-through varies between low- and high-general inflation environments, and explain why the difference is likely to be important. In settings with low inflation, consumers do not expect prices to rise, so any retail price increase is more likely to be viewed as a transparent attempt to increase profits. On the other hand, when retail prices rise amidst more general price inflation, consumers search more intensively, but with less success so retailers' attempts to raise prices are able to stick and are not competed away. We provide both an empirical test and theoretical explanation for why this variation on the more general theme of consumer search and obfuscation is important to the conduct of retail markets (Ellison & Ellison 2009; Lewis 2011; Allender, et al. 2021).

Finally, we contribute to the empirical industrial organization literature by providing an empirical test of the strategic obfuscation hypothesis that is both grounded in theory, and recent empirical developments in estimating retail pass-through (Miravete, Seim, & Thurk 2018, 2022; Birchall & Verboven 2022). Although others document the importance of accounting for structural attributes of demand while estimating pass-through, we are the first to apply this approach to studying the effect of minimum wages on retail prices in a high-inflation setting.

In the next section, we describe a simple model of price setting under imperfect competition, highlighting the importance of demand curvature. In section three, we explain the data used in our analysis, and provide some summary and model-free evidence on the relationship between minimum wages, retail prices, and the general rate of price inflation. In the fourth section, we explain the empirical model we bring to the data, and show how pass-through rates are likely to be affected by demand curvature and market power exercised by retailers. In section five, we present and interpret our results, both in terms of the base rate of pass-through, the effect of general price inflation on the estimated rate of pass-through. The final section concludes, and offers some insights for how policymakers should think about the relationship between minimum wages and retail price inflation, and how this relationship changes with overall price inflation.

2 Importance of Competition, Curvature and Search

Our structural model produces estimates of the minimum-wage pass-through rate that vary over time, stores and markets. In this section, we explain why this is the case using the canonical model of how pass-through varies with market power, demand-curvature and consumer search behavior (Lewis 2011; Weyl & Fabinger 2013; Byrne & De Roos 2017; Miller, Osborne, & Sheu 2017; Genakos & Pagliero 2022).

2.1 Theoretical Background

In discrete-choice models of demand, curvature derives from heterogeneity in consumers' willingness to pay, and not from functional form as is usually the case (Miller, Osborne, & Sheu 2017; Miravete, Seim, & Thurk 2018, 2022, 2023). Intuitively, consider the case of log-convex demands (demands with "high" curvature). In a discrete choice framework, greater heterogeneity in consumers' willingness to pay implies more curvature and a correspondingly higher rate of pass-through. As costs increase, firms are willing to "give up" low willingness to pay consumers by raising prices in order to exploit the much higher willingness to pay among consumers in the higher end of the market. What appears as something akin to price gouging is simply exploiting the natural curvature of demand (Miller, Osborne, & Sheu 2017). In this section, we show how this happens more formally, and derive testable hypotheses for our empirical model below.

Consider the stylized market of Weyl & Fabinger (2013) that consists of n symmetrically differentiated oligopoly firms. If they each face inverse demand curves $p(q)$ then Weyl & Fabinger (2013) show that joint profit maximization implies an equilibrium condition:

$$\theta = \left(\frac{p(q) - c(q)}{p(q)}\right) \varepsilon_D, \tag{1}$$

where $c(q)$ is the marginal cost of production, $\varepsilon_D = -p/qp'$ is the elasticity of inverse demand, and θ is a conduct parameter defined such that $\theta = 0$ implies competitive behavior, $\theta = 1$ monopoly pricing, $\theta = 1/n$ is Cournot and $\theta = 1+\sum_{i\neq j}(\partial q_j/\partial p_i)/(\partial q_i/\partial p_i)$ is Bertrand-Nash conduct in terms of Shapiro (1996) diversion ratios. Further, define the elasticity of supply as: $\varepsilon_S = c(q)'(p/q)$, the elasticity of conduct with respect to output as: $\varepsilon_\theta = (d\theta/dq)(q/\theta)$ and curvature as the elasticity of marginal surplus with respect to output as: $\rho = p_q(q)/(qp_{qq}(q))$. With these elements, Weyl & Fabinger (2013) show the rate of pass-through as a function of the degree of competition, demand curvature and the structure of cost and demand to be:

$$\phi = \frac{1}{1 + \frac{\theta}{\varepsilon_\theta} + \frac{\varepsilon_D - \theta}{\varepsilon_S} + \theta(1-\rho)}, \tag{2}$$

where ρ is the measure of demand curvature in Miravete, Seim, & Thurk (2022). In this specification, it is straightforward to recognize that under assumptions of constant marginal cost ($\varepsilon_S = 0$) and constant monopoly conduct ($\theta = 1,\ \varepsilon_\theta = 0$) then linear demands ($\rho = 0$) imply a pass-through rate of 1/2 and competitive conduct implies complete pass-through ($\phi = 1$), as the "textbook" benchmarks for pass-through. Extending this intuition further, if $\rho > 1$ then demand is log-convex, the denominator of (2) is smaller, all else constant at the monopoly values, and firms pass-through cost increases at a rate greater than 100%, or costs are over-shifted. In the concave-demands case ($\rho < 0$) then the denominator in (2) is larger, pass-through is less than 100% and firms absorb some of the cost increase as lower margins. Essentially, curvature interacts with market power to accentuate its effect on pass-through in the log-convex demands case, raising the rate of cost pass-through and creating the possibility that retailers over-shift cost increases into consumer prices, and profit as a result.

We extend the basic model of Weyl & Fabinger (2013) to include consumer search, and the role of inflation in pass-through. When consumers actively search, or choose whether to search or not search, rational retailers play mixed strategies in prices (Yang & Ye 2008; Tappata 2009; Chandra & Tappata 2011; Lewis 2011; Byrne & De Roos 2017). In a food-retailing context, mixed strategies in individual product prices manifest as "temporary price reductions" or sales (Varian 1980) in which the retailer maintains relatively high everyday prices, but attracts searching consumers by periodically reducing prices below their usual level. When the market consists of a distribution of searching and non-searching consumers, Lewis (2011) shows through numerical simulations of his mixed-strategy equilibrium that retail prices rise more quickly in wholesale prices (i.e., pass-through rises) when consumers' expectations of wholesale prices are below their current, actual level. This is precisely the situation when inflation rises unexpectedly. Consumers search more when prices are rising, so pass-through rises in inflationary periods.

Incorporating search directly into a structural expression for equilibrium pass-through is complicated by the fact that the Weyl & Fabinger (2013) result considers *pure* strategies while consumer-search arguments typically assume firms compete in *mixed* strategies. Therefore, we summarize the implications of consumer search by incorporating a price dispersion parameter, $T(q)$, in the equilibrium condition of Weyl & Fabinger (2013).[5] From Tappata (2009) and Lewis (2011) we know that $S(p)$, the distribution of searchers across prices, is strictly increasing in p: As prices rise, the payoff to search increases, incentivizing more consumers to search. Because $S(p)$ is monotonic in prices, we invert the distribution of searchers so that $S^{-1}(p) =: T(q)$, which we define to be the number of searchers in terms of *quantity* instead of prices. When we add $T(q)$ in the equilibrium condition of Weyl & Fabinger (2013) and derive an expression for pass-through, we find:

$$\phi = \frac{1}{1 + \frac{\theta}{\varepsilon_\theta} + \frac{\varepsilon_D - \theta}{\varepsilon_S} + \theta(1-\rho) - \frac{\varepsilon_D}{\varepsilon_T}\frac{T(q)}{p(q)}}, \tag{3}$$

where $\varepsilon_T = \frac{T(q)}{T'(q)\cdot q}$ is the search-elasticity.[6] The only difference between the outcome for pass-through in (2) and (3) is the negative term $-\frac{\varepsilon_D}{\varepsilon_T}\frac{T(q)}{p(q)}$ that results from incorporating search. Expression (3) implies that as search-intensity (in this case search-elasticity ε_T) increases, pass-through (ϕ) also increases due to the fact that ε_D is negative, by definition. Consequently, as inflation rises, the number of searchers rises, and we expect pass-through to increase accordingly. In the next sub-section, we derive a conceptual approach to testing each of these factors that are likely to be important to the observed rate of pass-through.

[5] In Weyl & Fabinger (2013), the equilibrium condition that generates the pass-through expression (2) is: $p(q) - \theta \cdot ms(q) = mc(q) + t$, where the LHS indicates the marginal revenue given conduct parameter θ, and the RHS indicates the marginal cost plus an exogeneous shock (e.g., per-unit tax or minimum wage hike in our case) that shifts the marginal cost curve upward.

[6] See Appendix A for full derivation of the pass-through formula involving search intensity.

2.2 Empirical Approach to Estimating Curvature

With continuous models of demand, including the elements of the theoretical model above – curvature, market power, and search – is relatively straightforward, but rarely done in the literature. In discrete-choice demand models, however, curvature is only implicit in the interaction between consumers' price sensitivity, and the distribution of unobserved heterogeneity in demands. Miravete, Seim, & Thurk (2022, 2023) show how curvature enters discrete-choice models of demand, so we only sketch their results here. Suppose the utility of consumer i choosing item j in market t is given by (dropping market subscripts for clarity):

$$u_{ij} = \mathbf{X}_j\beta_i + f_{ij}(p_j, y_i; \alpha_i) + \xi_j + \varepsilon_{ij}, \tag{4}$$

where $\mathbf{X}_j$ is a vector of attributes with parameters β_i, y_i is the income for consumer i, ξ_j are factors that affect the demand for item j but are unobserved to the econometrician, and ν_{ij} are independent, identically distributed Type I Extreme Value errors. Further, f_{ij} is a general sub-utility function that allows for a general set of relationships between price and income with parameter α_i, including the usual linear specification $f_{ij} = \alpha_i p_j$ that ignores income to the Berry, Levinsohn, & Pakes (BLP, 1995) model in which $f_{ij} = \alpha_i \log(y_i - p_j)$ which captures how consumers allocate un-committed income to high-priced items such as in their example (i.e., cars). With our Type I Extreme Value distributional assumption, the logit choice probabilities are:

$$P_{ij}(\mathbf{p}) = \frac{\exp(\mathbf{X}_j\beta_i + f_{ij}(p_j, y_i; \alpha_i) + \xi_j)}{\sum_{k=0}^{J} \exp(\mathbf{X}_k\beta_i + f_{ik}(p_k, y_i; \alpha_i) + \xi_k)}. \tag{5}$$

Market demand for item, in our case store, j is found by integrating over the distribution of consumer heterogeneity, $G(i)$, such that: $Q_j(\mathbf{p}) = \int_{i\in I} P_{ij}(\mathbf{p})dG(i)$. Define $f'_{ij} = \partial f_{ij}(p_j, y_i)/\partial p_j$ and $f''_{ij} = \partial^2 f_{ij}(p_j, y_i)/\partial p_j^2$ so that the elasticity of demand is:

$$\varepsilon_{D,j}(\mathbf{p}) = \frac{-p_j}{Q_j(\mathbf{p})} \int_{i\in I} f'_{ij} P_{ij}(\mathbf{p})(1 - P_{ij}(\mathbf{p}))dG(i), \tag{6}$$

where $f'_{ij} = \alpha_i$ in the linear sub-utility case, but more general for other non-linear sub-utility specifications. Curvature reflects how elasticity changes in the quantity demanded, which includes both the dispersion of demand over the distribution of heterogeneity in (6), and its third moment, or the skewness of $G(i)$ so that:

$$\rho_j(\mathbf{p}) = \frac{p_j^2 Q_j(\mathbf{p})}{\varepsilon_{D,j}(\mathbf{p})} \left[\int_{i \in I} f_{ij}'' P_{ij}(\mathbf{p})(1 - P_{ij}(\mathbf{p})) dG(i) + \int_{i \in I} (f_{ij}')^2 P_{ij}(\mathbf{p})(1 - P_{ij}(\mathbf{p}))(1 - 2P_{ij}(\mathbf{p})) dG(i), \right] \tag{7}$$

where $\mu_{ij3} = P_{ij}(\mathbf{p})(1 - P_{ij}(\mathbf{p}))(1 - 2P_{ij}(\mathbf{p}))$ is the skewness of $G(i)$. In the linear sub-utility case, the first term on the right side of (7) is equal to zero, but not the second term, so even in the simplest case the mixed logit model has the potential to capture a relatively wide range of curvature values.

In fact, Miravete, Seim, & Thurk (2022) show how simple logit models restrict the value of $\rho < 1$, restricting pass-through to be less than complete by construction. Further, they demonstrate through Monte Carlo experiments that standard mixed logit models of the form estimated in BLP and Nevo (2001) relax this restriction only marginally. Rather, in order to remove the curvature restrictions on discrete choice models of demand, the distribution of price sensitivity should be a function of income and thereby reflect the underlying asymmetric distribution of income in the population.

In our empirical exercise below, we follow their example and estimate a discrete choice model of retail store demand in which we allow for the price sensitivity of store demand to be a flexible distribution of household income. We then estimate the value of minimum wage pass-through comparing different implied restrictions on the curvature of demand in a model of equilibrium pricing among imperfectly-competitive retailers in order to determine whether changes in minimum wages are indeed more than completely passed-through to consumers, and how the general rate of inflation affects the rate of minimum-wage pass-through.

3 Data and Identification

3.1 Data and Data Sources

We use NielsenIQ retail scanner data from the James M. Kilts Center for Marketing at the University of Chicago Booth School of Business (hereafter, NielsenIQ / Kilts data) for our primary pass-through analysis, for a time period that spans both low-inflation (2011 - early 2020) and high-inflation (late 2020 - 2021) time periods. In general, in choosing a sample time period that includes 2021 exploits a rather unique opportunity to examine retail pricing behavior during a period of high general price inflation – an opportunity that has not arisen in several decades (figure 1).

[Figure 1 in here]

The NielsenIQ / Kilts data are widely used for research in applied demand analysis, empirical industrial organization, for studying wage pass-through as we do here (Leung 2021). The NielsenIQ / Kilts data measures prices, volume, and store merchandising for every item in retail stores (at the universal product code, or UPC level), in every market in the U.S., covering some $30,000 - 35,000$ total stores. We conduct our analysis at the level of the retail chain, or banner, in each of our sample markets in order to capture competition between rival chains within the same local market. We develop store-level price and quantity indices across all grocery categories for each retail grocery store in the NielsenIQ / Kilts RMS data, which we explain in more detail below, and aggregate up to the banner level to produce a market-week data set that varies across states and local areas, as well as over time. Our empirical approach, therefore, assumes that consumers choose grocery stores on the basis of basket competitiveness, assuming that all product categories in the store contribute to the attractiveness of each store for consumers' store-choice decisions. We treat each county as a market for analytical purposes, and consider all the interaction in demand among all stores in each county, grouping stores by ownership group as competing with all other stores in all other ownership groups in each county.

The choice of county as our geographical unit of analysis is not without consequence, or alternatives. Among recent research that uses the NielsenIQ / Kilts RMS data, Dix (2022) define markets at the Designated Market Area (DMA) level to better understand retailer market power in input markets, while Dopper, et al. (2022), Triggs (2021), and Luo (2023) also use DMA-level data aggregations for different purposes.[7] On the other hand, Kroft, et al. (2022) define product markets at the county-level in order to use the state-border-county identification strategy developed by Dube, et al. (2010). Because our treatment occurs at the state and / or local levels, and we require accurate measures of market level income, we

[7]DMAs are also known as "media markets" so NielsenIQ reports scanner data by DMA in order to reflect television and radio markets that may be relevant to retailers and product suppliers.

follow Kroft, et al. (2022) and define markets at a county level.[8]

Our data measure store sales and prices on a weekly basis from the first week of January 2011 through the final week of December 2021. We do not aggregate out to the monthly level as others in this literature do (Leung 2021; Renkin, et al. 2022) in order to focus our attention on the announcement effects associated with minimum-wage legislation. Due to the exceptional nature of retail sales during the COVID-19 pandemic, we control for the onset and development of the COVID-19 pandemic using a full set of weekly controls in our empirical model. Our identification strategy, therefore, compares weekly pass-through over a long pre-inflationary period (before July 2021) with pass-through over several weeks during strong retail price inflation. Our empirical analysis with this data include both reduced-form models (similar to Leung 2021 and Renkin, et al. 2022) and structural models intended to test our search, curvature, and market-power hypotheses.

Beginning with a sampling frame of the entire U.S., we remove several markets from our analysis for various reasons. First, because we know that competitive interactions among retailers are likely to be important in determining pass-through rates (Weyl & Fabinger 2013; Miller, Osborne, & Sheu 2017; Miravete, Seim, & Thurk 2018, 2022), we choose specific markets in each state and select competing retailers from those markets. Treatments in our data are at the state and / or local areal level, so we choose the largest county, by population, in each state as representative of the largest market for groceries. While this approach ignores some important markets in each state, our intent is to sample representative markets and not necessarily to include them all. Focusing on competitive interactions, however, means that we drop some markets from our analysis that do not report at least two competing retailers that compete over the entire sample period. We realize that all the largest counties in the U.S. have at least two retailers, but not all report their data to NielsenIQ. Our set of competing retailers, therefore, is conditioned on the subset that report scanner data to NielsenIQ. Our final sample, therefore, consists of markets in seven states: Arizona, California, South Dakota, North Carolina, Washington, West Virginia, and Vermont. Second, we retain one state that does not have a minimum wage above the federal minimum (North Carolina) to serve as a

[8] There are also 12 DMAs in the U.S. that split counties, so allocating demographic variables collected at the county level is more arbitrary than we are willing to accept.

control market.[9] While there were other markets that could serve as a control market, in the sense that their minimum wage did not vary over the sample period, none also met the criteria of having at least two retailers competing consistently over the entire sample period.

We form our price indices following Beraja, Hurst, & Ospina (2019) and Leung (2021), with a similar goal of approximating the Bureau of Labor Statistics' Consumer Price Index (CPI) as closely as possible. We assume retailers make pricing decisions at the national or regional level (DellaVigna & Gentzkow 2019; Hitsch, Hortacsu & Lin 2019) so we aggregate sales over stores under the same retail banner in the same market in order to define our price indices.[10] First, we remove any store that does not appear in the data over the entire sample period in order to remove the effect of store entry and exit. Second, others aggregate the data to the monthly or quarterly level in order to minimize the effect of "chain drift," but at the expense of aggregation bias due to averaging over retailers' pricing cycles.[11] Because retailers compete on a regional basis over weekly pricing cycles, we instead use weekly prices and allow item weights to reflect week-to-week changes in item sales. Third, we construct product-group average prices by dividing the total sales in each product group, for each store, by the total number of units sold in the product group. As Leung (2021) explains, the result is a quantity-weighted weekly average price at the product group level. Fourth, we then aggregate product-group-level price indices up to the store level using store-level product-group shares as weights to construct weekly store price indices. Finally, we aggregate to the chain level by constructing weighted averages over each retail chain, where weights are defined as total store sales divided by chain sales, under the same retail chain in the same market. Designing our sample around the implicit assumption that retailers price consistently across stores in a particular region is supported by empirical evidence that there is far more variation in retail prices between chains than within over a national or regional

[9]The federal minimum wage is currently \$7.25 / hour, so retaining only North Carolina means that we drop 19 states from the analysis. Five states (Alabama, Louisiana, Mississippi, South Carolina and Tennessee) do not have state minimum wages, Georgia and Wyoming have minimum wages that are below the federal minimum, and the other 13 states have minimums equal to the federal minimum (U.S. Department of Labor).

[10]Retail banners are not synonymous with ownership groups as some owners may have several different retail brands, each of which is managed somewhat independently of the others.

[11]Chain drift is defined as the difference between a "chained" price index, or one that updates the item-weights of each item in the hypothetical consumer basket due to price-induced substitution, and one that uses fixed item-weights, such as the BLS CPI. Fixed-weight indices overstate changes in the actual cost of living as consumers substitute among items as relative prices change.

sample (DellaVigna & Gentzkow 2019; Hitsch, Hortacsu & Lin 2019).

In the structural model, which we describe in more detail below, we estimate the choice-probability for each retailer, in each market, each week. In order to estimate the relative attractiveness of each retailer, we measure retailer-week-county market shares from observed dollar-sales of each store, aggregated to the retailer level in the NielsenIQ / Kilts data. Retailer attraction also depends on marketing mix elements that vary by retailer, and over time (Bell & Lattin 1998; Briesch, Chintagunta, & Fox 2009; Briesch, Dillon, & Fox 2013)). Therefore, we also calculate the size of the assortment offered by each retailer by taking a weighted average of the assortments offered in each store, measured as the total number of UPCs sold in each week, with weights defined as store sales divided by total weekly sales of the retail chain. We introduce two marketing-mix elements by calculating the weighted-average probability that a product is on display in each store, and the average feature probability, with weights defined as above. Of course, store choice also depends on the store-level price index.

Demand curvature depends critically on observed heterogeneity, specifically household income in each market (Miravete, Seim, & Thurk 2018, 2022, 2023). Our demographic and socioeconomic data are from the NielsenIQ / Kilts HMS (Household Panel) data set for matching markets and retailers as our RMS scanner data. We use contemporaneous estimates from 2011 - 2021 for average age, education (years attained), average income, and household size for each county represented in our scanner data. Although there are many different potential measures of income, we use household income as the measure that is most relevant for household-level grocery purchases, aggregated up to the county level by taking a simple average over all households in the relevant HMS data. Table 1 summarizes all of our estimation data, including the market-level demographic data and the week-market-banner price indices that form the basis of both our reduced-form and structural models.

[Table 1 in here]

We obtain minimum wage data from Vaghul & Zipperer (2022), and define the effective date as the date of implementation rather than enactment. Table 2 below shows how minimum wages varied across our sample markets during the 2011 - 2021 time period, and Figure 2 shows how minimum wages vary more generally across all markets in the U.S. Unlike earlier sample periods used in Leung (2021) and Renkin, et al. (2022), minimum wages varied substantially both over time and across the cross-sectional markets in our data. Figure 3 provides summary evidence of the extent of covariation between minimum prices and wages across every state in the U.S.

[Table 2 in here]

[Figure 2 in here]

[Figure 3 in here]

Our inflation data are from FRED (Federal Reserve Board of St. Louis 2023) and represent monthly changes in the consumer price index (CPI) calculated by the U.S. Bureau of Labor Statistics. Although this definition of inflation invites criticisms that inflation is endogenous to minimum wage pass-through, retail food represents only 14.2% of the CPI (Statista 2024) so changes in retail food prices have a relatively small effect on our measure of inflation. Regardless, we conduct a robustness check of our main results with a measure of the CPI that excludes food and our findings remain qualitatively the same.

This is an important point because our objective is not only to study the pass-through of minimum wages to retail prices, but how the level of general price inflation affects pass-through. The popular press coined the term "greedflation" as inflation rose during 2022 and firm profits continued to rise, citing higher consumer demand a seeming unlimited willingness to pay after emerging from the COVID-19 pandemic (De Pillis 2022). In Figure 2, we examine this question visually by showing a summary relationship between quarterly gross margins of all publicly-traded food retailers, which includes the retailers in our data, again relative to the general level of price inflation. This graphic shows that there seems to be no credence to this argument, at least in summary data. In fact, there seems to be a negative correlation between inflation and gross margins. Rising profits when all costs are also increasing, however, implies a very general sort of overshifting that has yet to be documented in the empirical literature. In our empirical analysis below, we disentangle consumer and competitive responses and test whether the summary insights in Figure 4 hold up under deeper statistical analysis.

[Figure 4 in here]

3.2 Identification and Reduced Form Estimates

Our identification strategy for the underlying minimum wage-price index relationship is similar to that used in Leung (2021) and Renkin, et al. (2022) namely, conditional on a set of controls and fixed effects at the week and store level, stores in areas that did not experience an increase in the minimum wage serve as controls for stores in areas that did.[12] Our strategy is widely accepted in the literature that studies the impact of minimum wages on employment and, as such, is not controversial (Allegretto, et al. 2017; Cengiz, et al. 2019; Azar, et al. 2019; Dustmann, et al. 2022). Given that our main approach is structural, however, we do not rely solely on the causal nature of our findings for our main contribution, but as a means to ensure that our structural findings can indeed be interpreted as causal.

In this sub-section, therefore, we offer an econometric analysis of minimum-wage pass-through roughly equivalent to Leung (2021) and Renkin, et al. (2022) in the recent empirical literature in order to establish a baseline for our structural estimates below, and to compare our estimates to others. For this purpose, we estimate a series of reduced-form models in which we include retailer (market) and week fixed effects in order to account for factors that may affect pass-through that are either retailer or week-specific and yet not otherwise captured by our controls. We also account for the effect of inflation in a very straightforward way – simply by interacting the current rate of inflation with changes in the minimum wage.

Our estimates in Table 3 below find a pass-through rate of 8.1% (for a 100% increase in minimum wages, or a pass-through elasticity of 0.081, we use the former interpretation throughout for clarity) which is slightly larger than Renkin, et al. (2022, 3.6%) and is roughly in line with Leung (2021, 7.0%). More importantly, however, our estimates in Table 3 show that the pass-through rate in Model 5 is significantly higher in inflationary regimes than otherwise. Because these estimates are in log-values of the price and minimum wage variables, they imply that the base pass-through rate of 8.1% in the preferred model is over 10.0% when inflation-interaction is taken into account. Leung (2021) shows that a pass-through rate of about 7.0% is consistent with complete pass-through, given the share of labor in retailers' cost

[12] We refer generically to "areas" to include both states and localities. There were no changes in the federal minimum wage over our sample period, but many of the minimum wage changes took place at the sub-state or locality.

structures, so our estimate of 10.1% suggests that retailers significantly over-shift minimum-wage increases during inflationary regimes. Over-shifting implies that retailers pass through costs at a rate greater than 100% so are actually profiting from increases in cost, but whether the mechanism is greed or a competitive equilibrium remains to be seen.

[Table 3 in here]

These estimates, however, are only reduced-form in nature and do not test any underlying pass-through mechanism directly. The structural approach of Miravete, Seim, & Thurk (2022), on the other hand, allows us to test directly whether pass-through is an artefact of demand elasticity and demand curvature and, hence, the amount of market power exercised by grocery retailers. We turn to this question in the next section after explaining how we identify demand manifolds in our retailer data.

3.3 Structural Identification

As is common in structural models, however, the primary barrier to identification is the endogeneity of prices (BLP; Berry & Haile 2016). For our structural analysis, we follow Gandhi & Houde (2019) and Miravete, Seim, & Thurk (2022) and include distances between fitted prices as instruments in a IV-estimation framework. Namely, we recognize that the goal in instrumenting for prices is to remove endogeneity that derives not only from demand, but from the exercise of market power as well. Gandhi & Houde (2019) argue that if we control as nearly as possible for all of the elements that define the competitive environment of each retailer (in our case), and remove those elements from the inverse demand for the product, then we can isolate the remaining purely exogenous variation in prices. Formally, we write the inverse demand for retailer demand as:

$$\phi_{jt}^{-1}(s_t, x_t, p_t; \theta) = h(\omega_{jt}; \theta) + C_t(\theta), \tag{8}$$

where s_t is the vector of retailer market shares in market t, x_t is a vector of retailer attributes, p_t are endogenous prices, and θ is the vector of demand parameters we wish to estimate. If $C_t(\theta)$ is a market-specific constant, then ω_{jt} is a market-state vector composed of all the elements relevant to market competition, or $\omega_{jt} = \{s_{kt}, d^x_{j,kt}, d^p_{j,kt}\}$ such that $d^x_{j,kt} = x_{jt} - x_{kt}$ and $d^p_{j,kt} = p_{jt} - p_{kt}$ are the distances between firms j and k in attribute and price space, respectively. Distances cannot be used directly, however, as they are not likely to be independent of market-specific demand shocks, so we follow Miravete, Seim, & Thurk (2022) and define distances instead using fitted prices from hedonic price regressions of the form:

$$p_{jt} = \gamma_0 + \gamma_1 x_{jt} + \gamma_2 w_{jt} + \upsilon_{jt}, \tag{9}$$

where x_{jt} are exogenous store attributes and w_t are market-level cost shocks. In our application, we define the set of store attributes as the variety on offer each week (calculated as a simple sum of the number of stock-keeping-units sold that week, as in Richards & Hamilton (2015)), the percentage of items on display, the percentage of items featured that week, and the number of stores owned by each retailer in the relevant market. We calculate cost shocks as price indices for retail wages, a producer price index of manufactured food prices, and indices of electricity, marketing, and transportation costs. All of these latter variables are from the Bureau of Labor Statistics (BLS), while the retailer attributes are calculated from our NielsenIQ / Kilts RMS data. Once we estimate the model in (9) we then form fitted values, and calculate distances using:

$$z_{jt} = \sum_{r=1}^{R} (\hat{p}_{rt} - \hat{p}_{jt})^2, \tag{10}$$

for retail prices. Because these instruments reflect only exogenous variation in attributes and cost shocks, they are themselves exogenous and are not subject to the usual criticism of "Hausman Instruments" (Hausman, Leonard, & Zona 1994). Intuitively, expressing them as distances from all other prices in the market removes the part that is common to all retailers in the same market. We then use these instruments in a control-function framework in our random-parameters logit model described in the next section.

4 Empirical Model

In this section, we describe the empirical model that we use to examine the effect of general price inflation on minimum-wage pass-through. Our approach is structural in nature, so that we can control for market power and demand curvature while estimating the extent of minimum wage pass-through in different price-inflation scenarios. Therefore, our empirical approach accounts for three factors: (1) demand curvature, (2) imperfect competition among retailers, and (3) the effect of inflation on pass-through. In the description below, we explain how we account for curvature through the demand model, and address the other two through a structural model of price-competition.

4.1 Demand Model

We base our demand model on the unit-demand, discrete-choice model of Miravete, Seim, & Thurk (2022). We begin with a standard unit-demand, discrete-choice model of market-level demand in which the object of demand is a grocery-store visit (Berry & Haile 2016). Grocery stores are highly differentiated in each local market, and we assume consumers choose one store from among many alternatives for their primary store visit during each purchase cycle. Although there is a large literature that considers the role of categories that may be particularly attractive at one store or another as a driver of store choice (Bell & Lattin 1998; Briesch, Chintagunta, & Fox 2009; Briesch, Dillon, & Fox 2013), we abstract from this element of the consumer-choice process as we focus only on store choice, and the attributes of each store, and not the characteristics of each category in the store.[13]

We follow Miravete, Seim, & Thurk (2022) and consider a general discrete choice model that is capable of producing both flexible substitution patterns and flexible curvature estimates as both are important to the pass-through question. To that end, we write the utility function for consumer i in time period t for store j as:

$$u_{ijt} = \mathbf{X}_{jt}\beta + f_i(y_i, p_j) + \xi_j + \varepsilon_{ij},\ i \in I,\ j \in J, \tag{11}$$

where we assume ε is Type-I Extreme Value distributed, and the sub-utility function $f_i(y_i, p_j) = \alpha_i(y_i, \varphi_i)p_j = (\alpha_0 + \alpha_1 y_i + \varphi_i)p_j$, captures the insight from Miravete, Seim, & Thurk (2022) that the only demographic interaction factor that matters empirically, at least for demand curvature, is income. This point is particularly true in our setting, as income is a primary determinant of whether a consumer visits a high-end supermarket or a lower-priced alternative, so is likely to be also important to both the elasticity of demand, and its curvature.

[13]Zhang, et al. (2017) develop the concept of "polygamous store loyalty" that captures the notion that consumers may frequent multiple stores, depending on their needs and category-attributes of stores in their choice set. We do not deny the validity of the polygamous store loyalty concept, but maintain that consumers still have a preference for one store for the bulk of their grocery purchases.

Our specification also captures the specific type of mixing distribution that will both avoid generating positive demand-elasticities, and a general pattern of curvature with the least empirical restriction. Namely, we allow the interaction parameter φ_i to follow a normal distribution ($\varphi_i \sim N(0,1)$). With estimates from (11) we recover elasticity and curvature estimates that vary over all observations in our data set using the approach described in equations (6) and (7) above, and account for the other two features of our model (imperfect competition and inflation) using the approach in the next section.

4.2 Pricing Model

We extend the base model of Miravete, Seim, & Thurk (2018, 2022) by allowing for the possibility that pass-through changes with both curvature and the general rate of inflation. Our consumer search hypothesis implies that retailers with market power pass-through higher costs in inflationary environments because consumers are searching more actively, and yet all pass-through outcomes are conditioned by the curvature of demand. Both of these outcomes are implicit in the strategic price equilibrium, which varies over time and across retail markets.

We assume retailers maximize profit by choosing store-level prices under price (Bertrand-Nash) rivalry. We depart from the usual Bertrand-Nash pricing literature, however, by examining how retailers respond in equilibrium to a cost shock, in particular an increase in the minimum wage. In this model, the minimum wage rises, and retailers change prices in response to the cost shock in a way that restores the Bertrand-Nash price equilibrium, conditioned on how they expect consumers to respond to the change in prices. In this way, we capture the impact of imperfect competition and demand curvature on minimum-wage pass-through. We begin by assuming the profit function for retailer j is written:

$$\Pi_j = M s_j (p_j - c_j) - F_j, \tag{12}$$

where Π_j is the profit for retailer j, s_j is the market share of retailer j in its local market (county), from the expression preceding equation (6) above, M is the total size of the local market (in volume), c_j is the marginal cost of selling groceries in retailer j, and F_j reflects the retailer's fixed cost of selling items in all categories. The marginal cost of stocking items in equation (12), which reflects both the costs of producing and retailing items in all categories, is a linear function of input prices, which results in the following expression for retailing costs:

$$c_j(\mathbf{v}_j) = \sum_{l \in L} \eta_{wl} v_{jl} + \epsilon_j, \tag{13}$$

where $\mathbf{v}_j$ is a vector of L input prices, η_{wl} are estimates of the contribution of each input price to unit costs, and ϵ_j is an iid error term.

For our purposes, we assume retailing wages are separable between non-minimum wage employees and minimum-wage employees. Assuming separability is necessary to obtain a pass-through estimate that is unique to minimum-wage workers. We estimate retailing costs after substituting equation (13) into the first-order conditions derived below. Conditional on the structure of demand, store j's first order condition for optimal prices becomes:

$$\frac{\partial \Pi_j}{\partial p_j} = M s_j + M \sum_{k \in J} (p_k - c_k) \frac{\partial s_k}{\partial p_j} = 0, \ \forall j, k \in J, \tag{14}$$

where $\partial s_k / \partial p_j$ is one element of a vector of store-sales derivatives with respect to price for all retailers in each market. Stacking the first-order conditions across retailers in each market, and suppressing the market notation for clarity, we we write the Bertrand-Nash price equilibrium condition as:

$$\mathbf{p} = \mathbf{c} - (\theta \mathbf{S}_p)^{-1} \mathbf{S} + \epsilon, \tag{15}$$

where bold notation indicates a vector (or matrix), and $\mathbf{S}_p$ is the matrix of store-volume derivatives with element $\partial s_k / \partial p_j$. We include the conduct parameter θ consistent with the theoretical framework above to measure the extent of deviation from the maintained form of the pricing game, and to capture the effect of market power on pass-through. If our estimate is $\theta = 1$, then retailers compete as Bertrand-Nash rivals and any markup is due entirely to the extent of store differentiation reflected in the matrix of store-volume derivatives. If, however, we find $\theta = 0$, then margins are zero and retail prices are consistent with perfect competition. Based on the Weyl-Fabinger model in (2) above, the extent of market power interacts with curvature in determining the pass-through of minimum wages to retail prices.

We measure the effect of curvature and market power on pass-through by simulating pricing outcomes under equation (15) under different assumptions regarding values of ρ

that are implicit in the demand estimates from equation (11) above. We obtain empirical estimates of the pass-through rate following Miravete, Seim, and Thurk (2023), namely by shocking the level of minimum wages by 100%, changing prices by the marginal-cost estimate in (15), allowing demand to change through the matrix of cross-price elasticities implied by (11), and then re-solving for the implied Bertrand-Nash equilibrium price vector, and measuring the difference between the initial and simulated equilibrium values. Because the change in minimum wages is set at 100%, the calculated pass-through value is easily comparable to others in the literature (Leung 2021; Renkin, et al. 2022) who estimate reduced-form pass-through elasticities. By allowing our pass-through estimates to vary over all observations in the data set, over time and across retail markets, we are then able to estimate the relationship between our implied pass-through values and variation in curvature and the rate of general price inflation. We report the results of this exercise in the next section.

5 Results

In this section, we present and interpret our empirical results, beginning with estimates of the demand model, and then moving to our findings from the structural pricing and simulation exercises.

5.1 Demand Estimates

We begin by presenting and explaining our demand estimates, and then move to their implications for pricing and pass-through in the next section. Estimates from different versions of our demand model are in Table 4 below. In this table, we show estimates from successive versions of the model in which we control for different levels of fixed effects (Models 1 and 2), adding a control for endogeneity in Model 3, and allowing for a fully-flexible marginal utility of income in Model 4. Because the fully-saturated model (Model 4) provides the best fit to the data ($\chi^2 = 753.02$ relative to Model 3) we interpret our findings using this model.

[Table 4 in here]

There are several estimates of note in Table 4, but we will focus on those that are of interest to our objective of estimating pass-through, and elements of the economic environment that affect pass-through. First, note that the income effect in the random-price parameter is significant, and including income as a measure of price-response heterogeneity explains a considerable amount of demand-variation between stores and over time. Therefore, our model is likely flexible enough to capture the sort of elasticity and curvature variation noted by others in the literature (Birchall & Verboven 2022; Miravete, Seim, & Thurk 2022, 2023). Exploiting this flexibility, we estimate price-elasticity and curvature values for every observation in the data set using equations (6) and (7) above, respectively. Across the entire data set, the estimates in Table 4 imply an average own-price elasticity of -2.6038 (standard deviation = 0.7428), which is relatively elastic compared to other store-choice models (Richards & Liaukonyte 2023) but likely reflects the fact that our model accounts more completely for factors that likely cause retail prices to be endogenous.[14] Second, we find an average curvature value of 1.0239 (standard deviation = 0.3514), which is slightly log-convex. Figure 5 below shows the demand manifold implied by these curvature and elasticity estimates, and implied a significant number of elasticity and curvature pairs well into the sub-convex region of the manifold. Consequently, we expect to find an average pass-through rate that is greater than 1.0, or minimum wages that are overshifted into retail prices.

[Figure 5 in here]

Among the other parameters reported in Table 4, we note that variety and the breadth of retail distribution have strong and statistically-significant effects on retailer-level market share in each geographic market. Neither of these results are surprising (Bell & Lattin 1998; Briesch, Chintagunta & Fox 2009), but point to the fact that our specification controls for factors that are otherwise likely to explain variation in market share, and would otherwise confound our elasticity and curvature estimates if not accounted for. The negative estimate for the Display variable is somewhat surprising, but not in a model in which we already control for the demand-increasing effect of featuring a product, and price variation.

[14]It is well understood that the direction of bias in estimating demand elasticities is typically positive (Villas-Boas and Winer 1999) so removing sources of endogeneity lead to larger, or more negative, price elasticities of demand.

5.2 Retail Pricing Model Results

In this section, we discuss our pricing model estimates, and their implications for how curvature and inflation affect the rate at which changes in minimum wages are passed through to consumers. Recall that our pricing model assumes retailers compete as Bertrand-Nash oligopolists in their local market, conditioned on the structure of demand shown in Table 4. In this model, curvature is only implicit so we use the pricing model to estimate the marginal cost of retailing labor, and then use counterfactual simulation to solve for equilibrium prices that result following a shock to minimum wages. We interpret the resulting change in prices as the extent to which higher minimum wages are passed through in each market.

We show our pricing model estimates in Table 5 below. We estimate three versions of the pricing model in (15), accounting for three different fixed-effect structures in addition to two measures of labor-based retailing costs. Our preferred model is a two-way fixed effects model in which we account for fixed effects for the months of the data set and each individual retailer.[15] Because the marginal cost function is linear, each of the cost estimates is interpreted as contributing to the unit cost of producing groceries. Both the retail wage index and minimum wages are statistically significant and positive, which is to be expected. These parameters, however, cannot be used to interpret pass-through directly as equilibrium markups are likely to change following a shock to any cost item, which will change both the left-side and the right-side of the model in (15). Consequently, estimating pass-through involves re-solving for equilibrium prices conditional on the nature of competition in the market. In this regard, our conduct-parameter estimate ($\theta = 0.5766,\ p < 0.01$) implies that retailers in our sample, on average, are more competitive than the maintained Bertrand-Nash assumption ($\theta = 1$) but are not perfectly competitive ($\theta = 0$).[16] When firms are imperfectly competitive, the interaction between curvature and market conduct means that pass-through is an empirical question (Miller, Osborne & Sheu 2017) and overshifting costs is a very real

[15] Because retailer banners are generally unique to each geographic market, it was not possible to include market-level fixed effects as well.

[16] We acknowledge that estimating "conduct parameters" is controversial (Corts 1999), but follow Weyl and Fabinger (2013) in interpreting conduct as a parametric estimate of the net effect of accounting for all Shapiro (1996)-type diversion ratios across all retailers in each market. Weyl and Fabinger (2013) show that allowing for conduct is essential in modeling pass-through in imperfectly competitive industries.

possibility.

[Table 5 in here]

We summarize our findings regarding the pass-through of a shock to minimum wages in Table 6 below. We following the experiment in Miravete, Seim, & Thurk (2022) by allowing minimum wages to change by 100%, or doubling. Although a change in minimum wages of this magnitude is unrealistic, the size of the change does not affect the relative magnitude of the change in retail prices, and starting with a 100% change allows for a clean interpretation of the result. Based on our assumed change in minimum wages, the estimates in Table 6 show that we expect retail prices to rise by roughly 6.0% in equilibrium, and markups by almost 29.0%. While media reports during the inflationary period of 2021 - 2022 interpreted this outcome as "greedflation," we show that it is indeed a natural outcome of oligopoly retailers passing-through costs in market equilibrium. The fact that markups rise following a change in costs is less a matter of greed than a consequence of curvature, namely that log-convex demand means that retailers have an incentive to raise prices for high willingness-to-pay consumers, at the risk of losing low willingness-to-pay consumers, as the increase in profit from serving the former outweigh the costs of losing the latter.

[Table 6 in here]

In fact, if we allow for the fact that 25% of retail grocery workers earn the minimum wage (calculated from the U.S. Current Population Survey), and that labor accounts for some 14% of retail operating costs (National Grocers Association 2021; U.S. Census Bureau), our estimates imply a pass-through rate of some 171.6%, or well above the level of complete cost pass-through. Controlling for the structure of demand, competition in each retail market, and other labor costs, therefore, changes in the minimum wage are over-shifted into retail prices.

Our estimate is substantially higher than Renkin, et al. (2022) and even the relatively-high estimate of Leung (2021), but neither of these studies account for the equilibrium change in prices and the effect of competition on cost pass-through. Reduced-form estimates of pass-through cannot control for the impact of competition on retail pricing because conduct in imperfectly-competitive markets is endogenous in a way that cannot be addressed by simply adding fixed effects or even conventional instrumental-variables strategies (Miller, et al.

2022). Further, neither of these studies consider pass-through during inflationary periods, which may be substantially different because consumers expect higher prices when all prices are rising. In a high-inflation environment, the possibility of using a general increase in prices to pass through cost increases more effectively is a real possibility as it is a consequence of consumer search behavior (Lewis 2011; Byrne & De Roos 2017) or the ability to profit from confusion.[17] Disentangling the effect of inflation from the structure of demand, however, does not emerge from our structural model so we conduct a post-simulation regression analysis to disentangle the relative contribution of each.

As we discuss above, the effect of curvature on pass-through is implicit in the Bertrand-Nash pricing model developed in the previous section, and the effect of inflation is structurally absent. Therefore, we examine the relationship between curvature and inflation with pass-through using a set of secondary two-way fixed effects regression models in which we use variation in each to explain variation in pass-through over time, and across our sample retailers.[18] We show our estimates from these two-way fixed effects regressions in Table 7 below. In this table, the preferred-model specifications show that both inflation (Model 2) and curvature (Model 4) are positively related to pass-through rates over time and across retailers, as expected. In Model 2, we find that a one percentage point increase in inflation (for instance, from 1.0% rate of increase in prices to 2.0%) results in a roughly seven percentage point increase in pass-through (for instance, from 100% to 107%). Because inflation reached a peak of some 7.0% in our sample (2021) and over 9.0% during 2022 (see Figure 1), our findings suggest that changes to the observed pass-through rate due to inflationary pressures alone could have easily changed an under-shifting environment, in which retailers absorb cost increases and suppress food price inflation, to an over-shifted environment in which cost increases are magnified and the appearance of greedflation sets in.

[Table 7 in here]

In fact, the effect of inflation is substantially larger than the effect of curvature in our data. From Model 4 in table 7, we see that a one point increase in curvature (not measured

[17]This notion paraphrases a statement by Tony Curtis in the movie "Petticoat Junction" but refers to a more general social-psychological concept.

[18]Note that we use the national rate of inflation in these regressions, and measure pass-through at the individual store level, so any endogeneity through individual-store prices is likely to be very small.

in percentages), or roughly from the mean to the upper $95th$ percentile in our data based on the demand manifold in Figure 5, implies a 0.4 percentage point increase in pass-through (for instance, from 100% to 100.4%). Figure 6 shows this relationship in graphical form, and highlights the fact that something other than curvature seems to explain differences in the pass-through rate, particularly at low levels of curvature. Curvature does indeed have a significant effect on pass-through, but not nearly as statistically important as the effect of inflation. Based on the theoretical model of pass-through from Weyl & Fabinger (2013) in (2) above, the reason is clear: Curvature only mediates the effect of market power on pass-through, so when retailers play something near Bertrand-Nash ($\theta = 1$) and curvature itself floats around 1.0, the entire second term in the theoretical pass-through equation nearly disappears. In fact, when we restrict our sample to only high-curvature observations, the estimated effect of pass-through rises from 0.4 to 1.5, so curvature becomes much more important for pass-through in some markets.

[Figure 6 in here]

Our findings provide an important link in the policy discussion surrounding the effect of minimum wages on retail food prices, and on the causes of inflation more generally. First, we show that understanding the structure of demand is critical to understanding how changes in cost are likely to affect retail prices. Whereas traditional models of retail pricing, based on BLP-type demand models, cannot account for the effect of curvature on demand, by using a modeling approach that permits flexibility in both elasticities and curvature we are able to generate more accurate estimates of pass-through that address the effect of consumer behavior on retail pricing. Second, we provide empirical evidence that greedflation may indeed be present in retail pricing, but not through the usual mechanisms described in the media. While we cannot test our consumer search hypothesis directly, as others that use experimental data can (Allender, et al. 2021), we find evidence that pass-through rises in periods of general price inflation. This suggests that individual stores are able to use consumers' expectations of rising prices as a sort of self-fulfilling outcome – if consumers expect higher prices, and retailers profit from their expectations, then prices will indeed rise. Third, we show that there is no bright line between market structure, or even market conduct, and pass-through as the transmission of costs to retail prices results from a complex interplay of the structure of demand, the general macroeconomic environment, and the extent of imperfect competition.

6 Conclusion

In this paper, we provide an empirical analysis of minimum wage pass-through among a sample of food retailing data using a structural approach in which we are able to account for the exercise of market power and demand curvature. We also estimate our model in a setting of general price inflation and argue why pass-through is likely to differ in high-inflation settings. While there has been a considerable amount of recent research on this topic using data from previous periods of low price-inflation (Leung 2021; Renkin, et al. 2022) we are the first to consider how pass-through differs across different regimes of fundamentally different experiences with general price inflation. Our hypothesis is that pass-through is higher when all prices are rising, and base our expectations on a theoretical model of consumer search, and consumer expectations.

We find that accounting for demand curvature and market power is important when estimating cost pass-through rates. However, our empirical findings suggest that accounting for the likely "feedback effect" through a high general rate of price inflation is more important. In fact, our empirical estimates point to an inflation effect that is an order-of-magnitude more important than demand curvature alone. We explain the importance of price inflation on minimum-wage pass-through as an example of the importance of accounting for consumer search behavior – when consumers are unsure as to what the true price of an item is supposed to be, sellers can exploit this informational uncertainty to their advantage. In this case, that means passing through cost increases that they would otherwise not be able to. There is a strong theoretical (Ellison & Ellison 2009; Ellison & Wolitzky 2012) and empirical (Allender, et al. 2021) basis for our findings, but our application in this case is arguably more important for policy purposes as minimum wages are one of the primary pillars through which governments attempt to redress issues of fundamental inequality in the economy.

Our findings are important because our experience with pass-through prior to 2021 simply cannot be used as a guide for more general expectations in a different world in which price inflation is neither low nor stable. We use minimum wages as one example of a plausibly exogenous rise in costs that may contribute to price inflation, but it is likely the case that higher rates of pass-through in high-inflation settings holds for other costs as well, from wholesale purchases to operating inputs like energy, materials, real estate, and the cost of capital. Indeed, the mechanism we describe here suggests that cost increases during inflationary times can lead to a sort of self-fulfilling prophecy wherein rising prices beget more rising prices in a destructive upward cycle of inflation.

Future research in this area would benefit from more data during high-inflation periods. Because our retail data only captures the beginning of the inflationary period in 2021, subsequent empirical analyses may find something different when inflation appeared to peak in 2022, and declined thereafter. Further, we are confident that our demand model captures a wide range of possible curvature scenarios, but other research in this area (Birchall & Verboven 2022; Miravete, Seim, & Thurk 2022, 2023) points to a much larger set of tools that are able to account for demand curvature in applications like this. Third, we consider minimum-wage pass-through as an important example of why pass-through matters in an economically-critical industry, but there are other settings in which pass-through is also important and worthy of investigation over the inflationary period of 2021-22. Horizontal mergers, new-product introductions, or changes in distribution technologies are all examples of cases in which pass-through during inflationary periods is likely to differ from non-inflationary periods.

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Table 1. Summary of Variables used in Estimation

Variable	Units	Mean	Std. Dev.	N
Store Volume	Units / Wk	5,627,097	6,717,335	17,343
Feature	%	6.4802	8.5233	17,343
Display	%	4.4530	10.3887	17,343
Variety	#	11,402	7,982	17,343
Store Price	$ / Unit	$3.5575	$1.0113	17,343
Number of Stores	#	129.0616	249.7131	17,343
Education	Years	11.6379	0.4350	17,343
Income	$ 000/ Yr	$66.5033	$7.5478	17,343
Age	Years	50.8081	1.4483	17,343
Household Size	#	2.2116	0.1183	17,343
Minimum Wage	$ / Hr	$9.2339	$1.8642	17,343
Retail Wage	Index	382.5384	23.8377	17,343
Electricity	Index	145.8650	19.2558	17,343
Marketing Cost	Index	136.3880	3.9734	17,343
Transportation	Index	139.5035	11.2508	17,343
Food Mfg. Wage	Index	202.3916	9.1223	17,343
US Inflation	%	2.0626	1.3609	17,343

Note: Retail sales and pricing data from NielsenIQ / Kilts RMS data on an individual-store level. Demographic data are from NielsenIQ / Kilts HMS data for matching stores and markets. Instrumental variables and cost indices are from U.S. Bureau of Labor Statistics.

Table 2. Minimum Wages by Year and Sample Market

Year	Phoenix, AZ	Los Angeles, CA	Charlotte, NC	Sioux Falls, SD	Burlington, VT	Seattle, WA	Charleston, WV
2011	7.35	8.00	7.25	7.25	8.15	8.67	7.25
2012	7.65	8.00	7.25	7.25	8.46	9.04	7.25
2013	7.80	8.00	7.25	7.25	8.60	9.19	7.25
2014	7.90	9.00	7.25	7.25	8.73	9.32	7.25
2015	8.05	9.00	7.25	8.50	9.15	9.47	8.00
2016	8.05	10.00	7.25	8.55	9.60	9.47	8.75
2017	10.00	10.50	7.25	8.65	10.00	11.00	8.75
2018	10.50	11.00	7.25	8.85	10.50	11.50	8.75
2019	11.00	12.00	7.25	9.10	10.78	12.00	8.75
2020	12.00	13.00	7.25	9.30	10.96	13.50	8.75
2021	12.15	14.00	7.25	9.45	11.75	13.96	8.75

Note: Minimum wage data from Vaghul and Zipperer (2016), and we extend their data set through 2021 for all markets / states. All wages are in $ / hour and do not include tipped minimums. Charlotte, NC is included as a control market as its minimum wage is the federal minimum.

Table 3. Reduced-Form Estimates of Minimum Wage Impact: Complete Data Set

	Model 1: OLS		Model 2: OLS		Model 3: OLS		Model 4: OLS		Model 5: OLS	
	Estimate	Std. Err.	Estimate	Std. Err.	Estimate	Std. Err.	Estimate	Std. Err.	Estimate	Std. Err.
ln(Min Wage)	0.2992***	0.0836	0.3034*	0.1764	0.2847	0.1767	0.3237***	0.0618	0.0814	0.0542
Inflation			-0.0615	0.0989	-0.0516	0.0990	-0.0750***	0.0285	-0.0473**	0.0224
Inflation*Min Wage			0.0232	0.0455	0.0179	0.0456	0.0324**	0.0128	0.0206**	0.0103
ln(Age)			-0.6405	0.6547	-0.6421	0.6549	-0.4782***	0.1495	-0.1340	0.1119
ln(Income)			0.0249	0.3463	0.0243	0.3464	0.3892***	0.1026	0.0115	0.0521
ln(Education)			-0.5358	0.8774	-0.5365	0.8779	0.0145	0.2410	0.0997	0.1416
ln(HH Size)			-0.0313	0.4401	-0.0298	0.4403	0.0770	0.0674	0.0458	0.0469
No. Competitors			0.0184	0.0154	0.0185	0.0154	0.0023	0.0038	-0.0021	0.0027
Constant	0.5628	0.1860	4.0217	3.8229	4.0633	3.8248	-0.1067	1.0868	0.8862	0.5465
R^2	0.0253		0.0448		0.0470		0.9664		0.9826	
RSS	4140.09		4057.41		4047.99		142.71		74.06	
Controls	No		Yes		Yes		Yes		Yes	
Week FE	No		No		Yes		Yes		Yes	
Retailer FE	No		No		No		Yes		Yes	
Retailer Trends	No		No		No		No		Yes	

Note: All models estimated with NielsenIQ / Kilts RMS data, 2011 - 2021, all states with effective minimum wages. Inflation is defined as the year-over year change in Bureau of Labor Statistics CPI value. Income, Education, Household Size, and Age from NielsenIQ / Kilts Consumer Panel (HMS) data. Coefficient on ln(Minimum Wage) is interpreted as the "pass-through elasticity" or the percentage change in average retail price for a percentage change in the wage. Unit of observation is the retailer-county-week. Standard errors are clustered at the retailer level, *** (p<0.01), ** (p<0.05), * (p<0.10). Data set consists of all retailers, in all states (counties), regardless of the number of competitors. Model 1 is base model with only minimum wage, Model 2 is Model 1 with controls, Model 3 is Model 2 with week fixed effects, Model 4 is Model 3 with retailer fixed effects, and Model 5 adds retailer-level trends.

Table 4. Mixed Logit Store Demand Model Estimates

	Model 1		Model 2		Model 3		Model 4	
	Estimate	Std. Err.	Estimate	Std. Err.	Estimate	Std. Err.	Estimate	Std. Err.
Constant	-7.6404***	0.0545	-8.6963***	0.0474	-7.0826***	0.0553	-4.1905***	0.1112
Feature	2.2292***	0.1506	0.4001***	0.0263	0.3097***	0.0198	0.2764***	0.0179
Display	0.5602***	0.1183	-0.2661***	0.0164	-0.2377***	0.0150	-0.2796***	0.0108
Variety	0.1282***	0.0016	0.1433***	0.0020	0.1370***	0.0015	0.1536***	0.0011
Num. Stores	0.5331***	0.0053	0.7755***	0.0088	0.7570***	0.0049	0.4577***	0.0061
CF*Price					0.0637***	0.0012	0.0764***	0.0012
Price	-0.0046	0.0125	-0.1621***	0.0063	-0.4746***	0.0087	-0.2114***	0.0178
Price(Inc)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	-0.0043***	0.0008
Weeks?	No		Yes		Yes		Yes	
Years?	No		Yes		Yes		Yes	
Retailers?	No		Yes		Yes		Yes	
N	17,343		17,343		17,343		17,343	
LLF	-32,648.13		4,509.52		5,077.00		5,453.51	
AIC	3.7657		-0.5139		-0.5793		-0.6227	

Note: All models estimated with NielsenIQ / Kilts RMS store-level scanner data for seven-state sample of minimum-wage states. Retailers and geographic markets are not separately identified so we estimate using retailer-level fixed effects. Model 1 is a simple logit model with only attributes and store-price indices, Model 2 adds fixed retailer, week, and year fixed effects, Model 3 adds a control function, Model 4 adds random parameters and interaction of marginal utility of income with household-income draw, *** (p<0.01), ** (p<0.05), and * (p<0.10).

Table 5. Bertrand-Nash Pricing Model Estimates

	Model 1		Model 2		Model 3	
	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.
Retail Wage	0.0105	0.0081	0.0060	0.0019	0.0067***	0.0001
Minimum Wage	0.0798	0.0843	0.0325	0.0194	0.0232***	0.0024
Conduct	-2.3022***	0.7776	0.5693***	0.2414	0.5766***	0.0375
Month Fixed Effects	No		No		Yes	
Retailer Fixed Effects	No		Yes		Yes	
R^2	0.1042		0.9426		0.9464	
F	673.61		6,194.53		5,372.60	

Note: All pricing models estimated using markups implied by estimates in Table 4. Retail wages are from the Bureau of Labor Statistics, and minimum wages from sources reported in table 3. Model 1 is the base model with only retail wages, minimum wages and markup term. Model 2 adds retailer fixed effects, and Model 3 adds monthly fixed effects. All models estimated with standard errors clustered at the market level. ***(p<0.01),** (p<0.05), * (p<0.10).

Table 6. Summary of Pricing and Passthrough Estimates

	Base Value		New Equilibrium	
Variable	Est.	Std. Err.	Est.	Std. Err.
Minimum Wage	9.2339***	1.8642	18.4678***	3.7284
Retail Price	3.5575***	1.0113	3.7712***	1.0176
Markup	1.3749***	0.1137	1.7714***	0.8806
Market Share	0.0616***	0.0101	0.0232	0.0465
Passthrough (%)	0.0597***	0.0010		
Curvature	1.0239***	0.3514		
Elasticity	-2.6038***	0.7428		

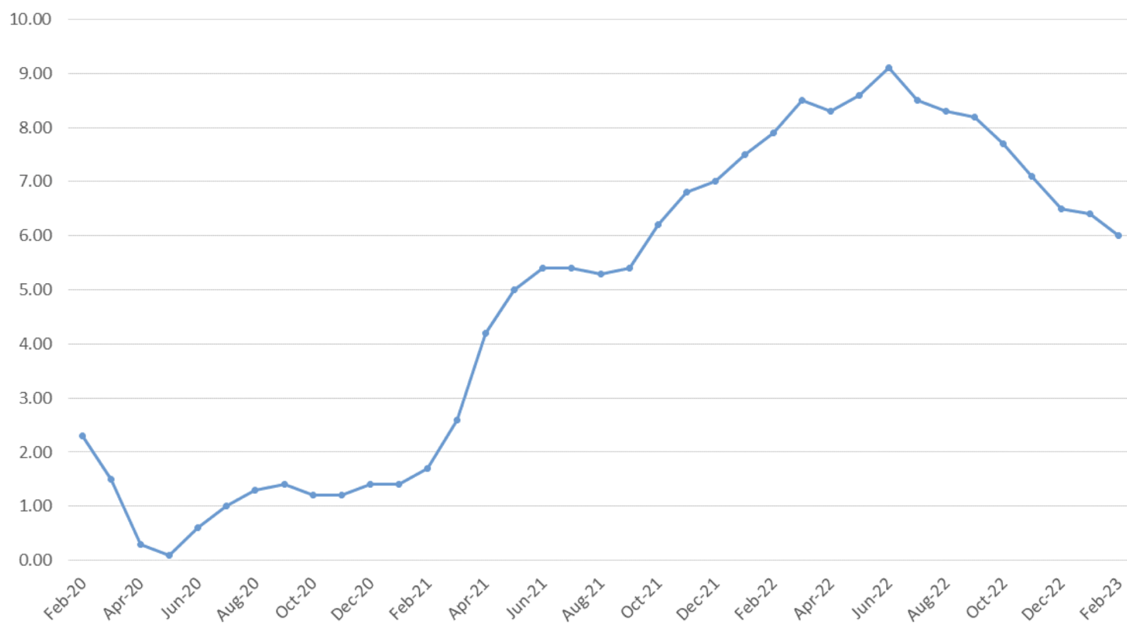
Note: All estimates based on flexible demand-model estimates in table 4. All estimates at sample-average values. Minimum wage simulation shocks wage by 100% as in Miravete, Seim, and Thurk (2023b) so the pass-through value is interpreted as an elasticity.

Table 7. Pass-through Relationship with Curvature and Inflation

	Model 1		Model 2		Model 3		Model 4	
	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.
Constant	-0.0055	0.0050	0.0045	0.0050	-0.0099	0.0053	0.0021	0.0053
Inflation	0.0711***	0.0203	0.0786***	0.0203	N.A.	N.A.	N.A.	N.A.
Curvature	N.A.	N.A.	N.A.	N.A.	0.0054***	0.0013	0.0043***	0.0013
Month Fixed Effects	No		Yes		No		Yes	
Retailer Fixed Effects	Yes		Yes		Yes		Yes	
R^2	0.9265		0.9283		0.9265		0.9284	
F	4,969.06		4,088.58		4,970.34		4,087.46	

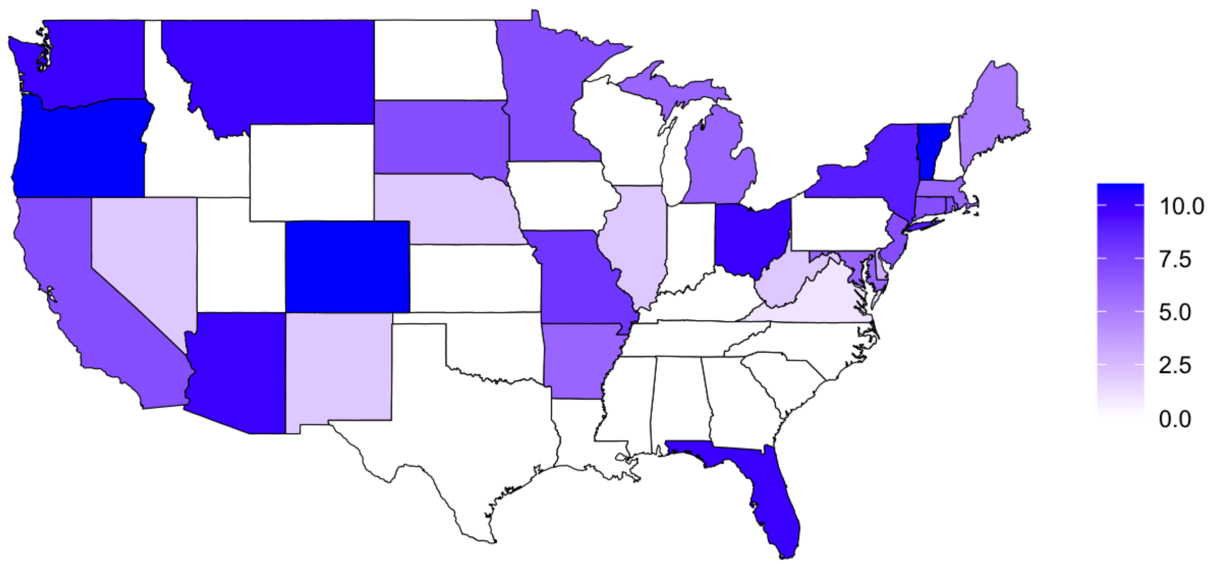
Note: All models estimated using pass-through estimates from Bertrand-Nash pricing model in Table 5. Curvature estimated from demand model using expressions from Miravete, Seim, and Thurk (2023). All models estimated with standard errors clustered at the market level. Models 1 and 2 examine inflation effect while Models 3 and 4 examine curvature. Models 1 and 3 are estimated without month fixed effects. *** (p<0.01), ** (p<0.05), * (p<0.10).

Figure 1: Rate of Inflation in U.S., by Month, 2020 - 2023



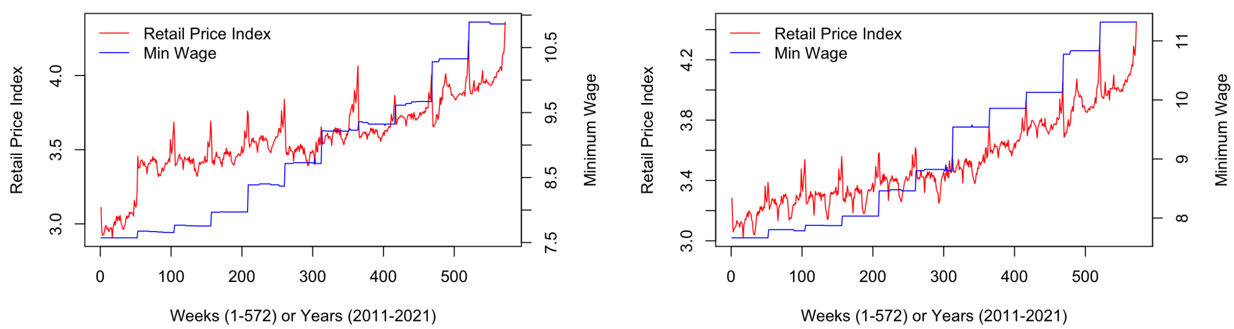
Note: Data from FRED, St. Louis Federal Reserve Board, and represents the annual percentage change in the Bureau of Labor Statistics Consumer Price Index, each month of the period represented in the figure.

Figure 2: Number of state level minimum wage changes, 2011-2021



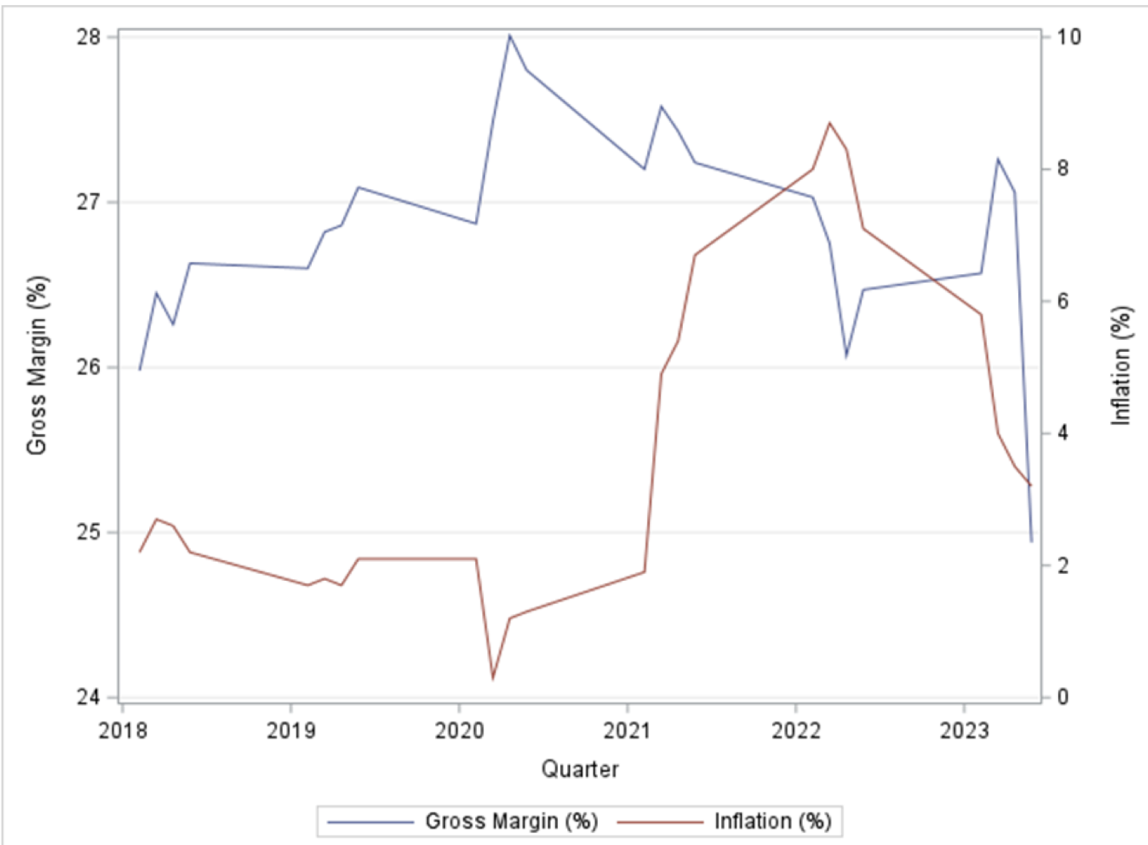
Note: A map of US states with number of new minimum wage implementations from 2011-2021. The graph shows substantial variation in frequency of minimum wage changes in several states, while about half of the states do not have minimum wage changes in our sample period. Minimum wage data are from Vaghul and Zipperer (2022).

Figure 3: Evolution of retail price index and minimum wages, 2011-2021



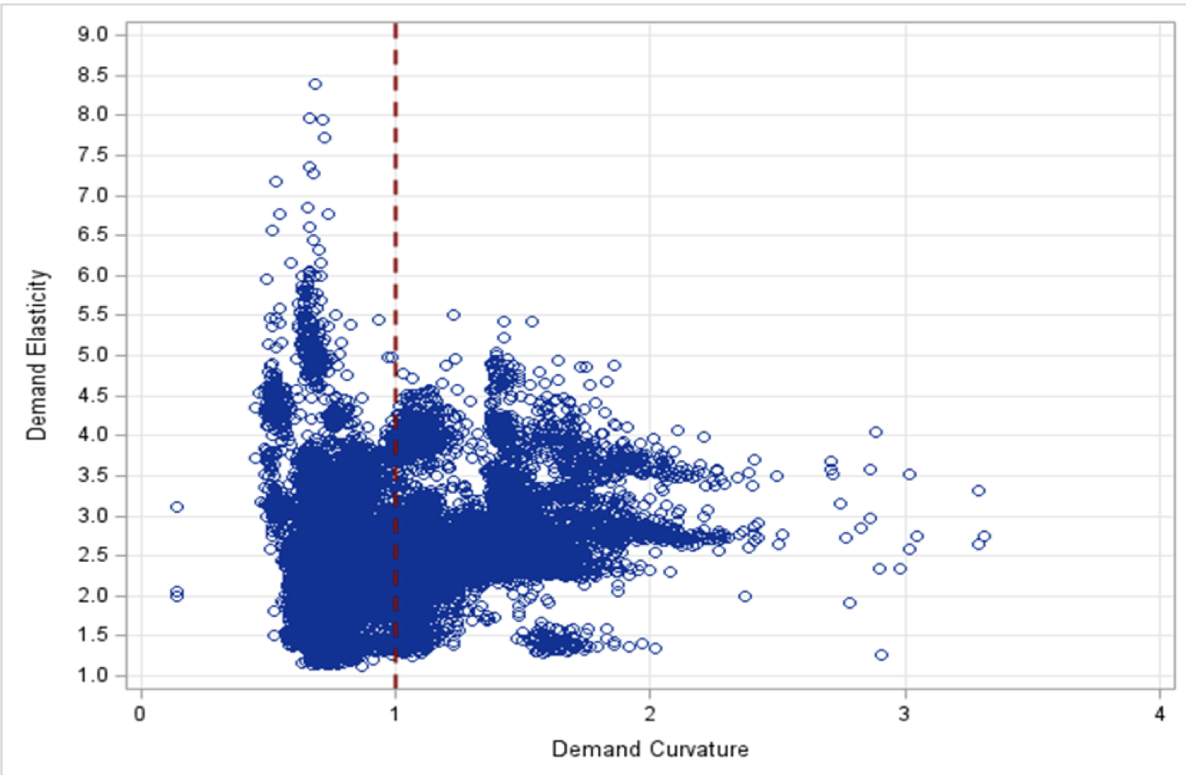
Note: The first panel shows evolution of averages of retail price index and minimum wages across our sample period 2011-2021 or weeks 1-572 in all the 25 states, which is our entire dataset in reduced-form analysis. The second panel shows the evolution within 7-states dataset, which is the data used in structural analysis and consisting of a consistent set of at least two competing retailers in each state or FIPS. Both panels show positive relationship between minimum wages and retail price index. Minimum wage data are from Vaghul and Zipperer (2022), and we compute retail price indices from NielsenIQ / Kilts data.

Figure 4: Inflation and Gross Margin, U.S. Grocery Retailers, 2018 - 2023



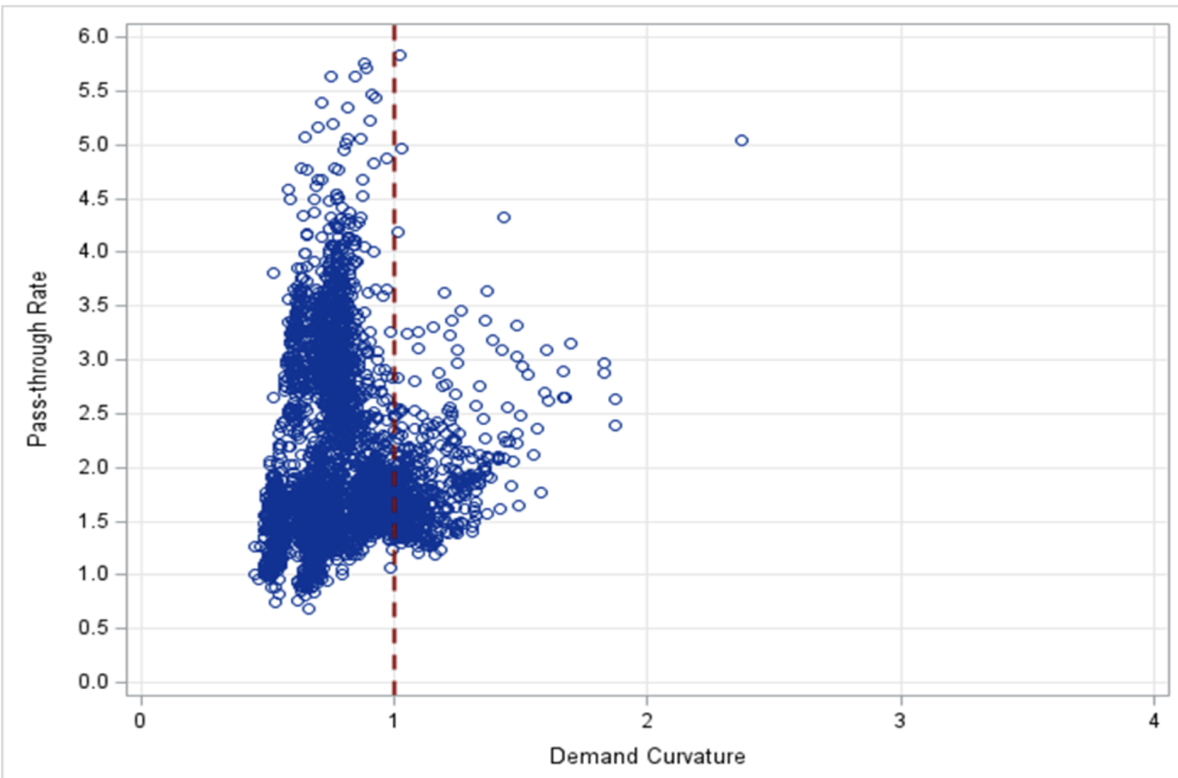
Note: Inflation data from FRED, St. Louis Federal Reserve Board, and Gross Margin data calculated as average over top 10 publicly-traded grocery retailers in the U.S., from Yahoo Finance, on a quarterly basis.

Figure 5: Demand Manifold, Mixed Logit Model of Store Choice, Various U.S. Retail Markets, 2011 - 2021



Note: Estimated with 2011 - 2021 NielsenIQ / Kilts store choice data over seven sample U.S. markets, on a FIPS (county), and weekly level. Store choice elasticities and curvature estimated using expressions in Miravete, Seim, and Thurk (2022). Elasticities and curvature values are estimated for each point in the data, and are not averages.

Figure 6: Demand Curvature and Pass-Through Rates, Various U.S. Retail Markets, 2011 - 2021



Note: Estimated with 2011 - 2021 NielsenIQ / Kilts store choice data over seven sample U.S. markets, on a FIPS (county), and weekly level. Pass-through values simulated on the assumption stores compete as Bertrand-Nash oligopolists in each local market, and prices re-equilibrate after 100 percent shock to minimum wages. Pass-through values assume wages represent 14 percent of retail operating costs (NGA 2023; Bureau of Census 2023). Curvature values estimating from demand model estimates shown in table 5 in the text.

Appendix

A Pass-through with search

In this section, we derive the pass-through formula in Equation (3). The goal is to extend the formula in Equation (2) to incorporate consumer-search. Let $p(q)$ denote the price function in terms of quantity q, $mc(q)$ marginal cost, $ms(q) = -q \cdot p_q(q)$ marginal surplus, ε_D elasticity of inverse demand, $\theta = \frac{p(q)-mc(q)}{p(q)} \cdot \varepsilon_D$ the conduct parameter, $\varepsilon_S = mc'(q)(p/q)$ supply elasticity, $\varepsilon_\theta = (d\theta/dq)(q/\theta)$ the elasticity of conduct with respect to output, and $\rho = p_q(q)/(qp_{qq}(q))$ curvature as the elasticity of marginal surplus with respect to output. Using a result in Tappata (2009) and Lewis (2011) that $S(p)$, the distribution of searchers in prices, is strictly monotone increasing, we take its inverse $S^{-1}(p) =: T(q)$ to define number of searchers in *quantities* instead of prices.[19] The starting point for a pass-through expression is the equilibrium condition

$$p(q) + T(q) - \theta \cdot ms(q) = mc(q) + t \tag{16}$$

where t indicates per unit tax or in our case, minimum wage hike. In Equation (16), the LHS indicates marginal revenue adjusted by the conduct parameter, and the RHS indicates marginal cost plus per unit exogenous cost shock. The equilibrium condition in (16) is same as that in Weyl & Fabinger (2013) but with an additional contribution of $T(q)$ in the marginal revenue part. Differentiating (16) with respect to t:

$$\frac{d}{dt}\left[p(q) + T(q) - \theta \cdot ms(q)\right] = \frac{d}{dt}\left[mc(q) + t\right]$$

Using the chain rule, we get:

$$\frac{dp(q)}{dq} \cdot \frac{dq}{dt} + \frac{dT(q)}{dq} \cdot \frac{dq}{dt} - \theta \frac{d\, ms(q)}{dq} \cdot \frac{dq}{dt} - ms(q) \cdot \frac{d\theta}{dq} \cdot \frac{dq}{dt} = \frac{d\, mc(q)}{dq} \cdot \frac{dq}{dt} + 1$$

The expression then simplies to:

$$\frac{dq}{dt}\left[p'(q) + T'(q) - \theta \cdot ms'(q) - mc'(q) - ms(q)\frac{d\theta}{dq}\right] = 1$$

$$\Rightarrow \frac{dq}{dt} = \frac{1}{p'(q) + T'(q) - \theta \cdot ms'(q) - mc'(q) - ms(q)\frac{d\theta}{dq}} \tag{17}$$

[19] It is a general mathematical result that one can always invert *strictly* monotone functions.

Pass-Through Definition and Calculation. Pass-through is defined as:

$$\phi = \frac{dp}{dt} = \frac{dp}{dq} \cdot \frac{dq}{dt}$$
$$\Leftrightarrow \phi = p'(q) \cdot \frac{dq}{dt} \tag{18}$$

Substituting Equation (17) in Equation (18),

$$\phi = \frac{p'(q)}{p'(q) + T'(q) - \theta \cdot ms'(q) - mc'(q) - ms(q)\frac{d\theta}{dq}}$$
$$\Rightarrow \phi = \frac{1}{1 + \frac{T'(q)}{p'(q)} - \frac{\theta \cdot ms'(q)}{p'(q)} - \frac{mc'(q)}{p'(q)} - \frac{ms(q)\frac{d\theta}{dq}}{p'(q)}} \tag{19}$$

We next simplify some terms in Equation (19):

$$\frac{ms'(q)}{p'(q)} = \frac{ms'(q) \cdot q \cdot p}{p'(q) \cdot q \cdot ms(q)} \cdot \frac{qms(q)}{q \cdot p} = -\frac{\varepsilon_D}{\varepsilon_{ms}} \cdot \frac{ms}{p} = -\frac{\varepsilon_D}{\varepsilon_{ms}} \cdot \frac{1}{\varepsilon_D} = -\frac{1}{\varepsilon_{ms}} = \rho - 1 \tag{20}$$
$$\frac{T'(q)}{p'(q)} = T'(q) \cdot \frac{q \cdot p}{p'(q) \cdot q \cdot T(q)} \cdot \frac{qT(q)}{q \cdot p} = -\frac{\varepsilon_D \cdot T(q)}{\varepsilon_T \cdot p(q)} \tag{21}$$

where $\varepsilon_T = \frac{T(q)}{T'(q) \cdot q}$ is the elasticity of search. Similarly,

$$\frac{mc'(q)}{p'(q)} = mc'(q) \cdot \frac{q \cdot p}{p'(q) \cdot q \cdot mc} \cdot \frac{q \cdot mc}{q \cdot p} = -\frac{\varepsilon_D}{\varepsilon_S} \cdot \frac{\varepsilon_D - \theta}{\varepsilon_D} = -\frac{\varepsilon_D - \theta}{\varepsilon_S} \tag{22}$$
$$\varepsilon_\theta = \frac{\theta}{q \cdot \frac{d\theta}{dq}} \Rightarrow \frac{d\theta}{dq} = \frac{\theta}{q\varepsilon_\theta} \tag{23}$$
$$ms(q) = -p'(q) \cdot q \Rightarrow \frac{ms(q)}{p'(q)} = -q. \tag{24}$$

We substitute Equations (20) to (22) in Equation (19) and simplify to get a final expression for passthrough:

$$\phi = \frac{1}{1 + \frac{\theta}{\varepsilon_\theta} + \frac{\varepsilon_D - \theta}{\varepsilon_S} + \theta(1-\rho) - \frac{\varepsilon_D T(q)}{\varepsilon_T p(q)}}. \tag{25}$$