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# Inflation, Price Dispersion, and Market Structure

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**Abstract.** In this paper, we use a unique micro-level data set from Istanbul to investigate the empirical relationship between inflation and price dispersion. In particular, our data set includes price observations from three distinct store types: *bakkals* (convenience stores), *pazars* (bazaars), and supermarkets. Our findings indicate that pazars exhibit the least amount of price dispersion on average, which is consistent with the fact that menu and search costs are very low in the pazar and that such sellers seem to have very little market power. Moreover, we find that several of the basic inflation-dispersion channels identified by the theoretical literature seem to be operating in our data.

**Keywords:** inflation, market structure, menu cost models, micro panel data, price dispersion.

**JEL Classification Numbers:** C23, D40, D83, E31.

Information search, thus, is the really advanced art in the bazaar, a matter upon which everything else turns.

Geertz (1978, p. 30), quoted in McMillan (2002, p. 41)

## 1. Introduction

The link between inflation and price dispersion has been the focus of an extensive theoretical and empirical literature, which contributes to our understanding of the distortionary effects of inflation on the price system, as well as the transaction costs of inflation. In this paper, we use a unique micro-level data set from Istanbul to study the empirical relationship between inflation and dispersion, as well as the systematic effects of market structure on dispersion levels.

The theoretical literature (briefly surveyed in the next section) includes static (zero inflation) equilibrium search models, menu cost models, signal extraction models, and Van Hoomissen's (1988) information investment model. The Reinganum (1979) equilibrium search model explains the existence of persistent price dispersion assuming imperfect information about prices, elastic demand, and heterogeneity in firms' production costs. In terms of comparative statics, dispersion is increasing in the cost of search and decreasing in the elasticity of demand when prices are not too low, where the latter result can be interpreted in terms of market power. For a survey of this literature, see Baye, Morgan, and Scholten (2005).

In menu cost models such as Sheshinski and Weiss (1977, 1983) and Bénabou (1988, 1992), inflation is constant and fully anticipated. Nevertheless, dispersion is increasing in *expected aggregate* or *macroeconomic* inflation, as well as menu and search costs. Signal extraction models include Bénabou and Gertner (1993) and Dana (1994), where inflation is unanticipated and cost-push, reflected in firms' production costs via input prices. In these models, the effects of unanticipated inflation are primarily *informational* so the relevant inflation rate is *unexpected product-specific* (PS) inflation, since buyers in the market for good A should not be confused by unanticipated inflation in the market for good B. In particular, the Bénabou-Gertner model explains how a burst of unexpected PS inflation can reduce the value of search, inducing greater price dispersion. As in the Reinganum model and menu cost models, dispersion is increasing in the cost of search. In the information investment model sketched in Van Hoomissen (1988), search not only lowers the current purchase price, it is also an investment which adds to the consumer's stock of information. In that model, dispersion is increasing in *expected PS* inflation (which proxies the depreciation rate of information), *unexpected PS* inflation (a negative shock to information stocks), and lagged dispersion (reflecting the pre-search stock of information).

The empirical literature includes Domberger (1987), Van Hoomissen (1988), Lach and Tsiddon (1992), Tommasi (1993), and Parsley (1996), among others.[1] With some notable exceptions, including Reinsdorf (1994), the consensus seems to be that there is a positive relationship between inflation and dispersion. However, the actual inflation measure used differs from study to study. Some authors regress dispersion against PS inflation (i.e., price dispersion for good $i$ is related to $i$'s inflation rate), while others use average inflation across all goods in the data set, or some broader measure such as CPI inflation. Although the theoretical literature is not sufficiently well-developed to subject the disparate models to full empirical testing, some researchers decompose inflation (whether PS, average, or aggregate) into its expected and unexpected components in order to test the basic implications of menu cost and signal extraction models. Again, the consensus seems to be that dispersion is positively related to its expected and unexpected components.

Motivated by the theoretical literature, in this paper we estimate an empirical model relating price dispersion to expected and unexpected PS inflation, as well as expected and unexpected aggregate inflation. We use a broad-based cost-of-living

[1] In this paper, we focus exclusively on price dispersion, or *intra-market* relative price variability. There is also a substantial literature on *inter-market* relative price variability, including Vining and Elwertowski (1976), Parks (1978), and Debelle and Lamont (1997).

(COL) index for Istanbul to proxy the "aggregate" price level (CPI inflation yielded similar results). A basic implication of menu cost and signal extraction models is that dispersion should be positively related to expected COL and unexpected PS inflation, respectively. We also include expected PS inflation and lagged dispersion in the specification, since the information investment model suggests that dispersion should be positively associated with these variables. Finally, we add unexpected COL inflation to test the hypothesis that market participants are not fooled by unanticipated aggregate inflation. Strikingly, our empirical findings support all of these hypotheses, the only exception being that there is no statistically significant relationship between dispersion and expected PS inflation. We conclude that many of the basic inflation → dispersion channels identified by the theoretical literature seem to be at work in our data set.

A unique aspect of our data set is that it includes three distinct store types — *bakkals* (small mom-and-pop convenience stores), *pazars* (bazaars), and supermarkets — which allows us to test whether there are any systematic differences in dispersion levels across these three distinct market structures. The role of search and information in the bazaar is discussed in Geertz (1978) and highlighted in McMillan's popular book "Reinventing the Bazaar: A Natural History of Markets" (2002, Chapter 4). Interestingly, we find that dispersion in pazar prices is significantly lower on average than the other two store types. This is intuitive, since menu costs are negligible in the pazar. Moreover, pazars contain a large number of sellers within a very small geographical area, resulting in very low search costs and relatively fierce competition. We also find that dispersion in bakkal prices is on average less than dispersion in supermarket prices. This finding also makes sense, since bakkals are convenience stores (low search costs) where menu costs are likely to be small.

The rest of the paper is organized as follows. In section 2, we survey the relevant theoretical literature. In section 3, we describe the data, provide institutional details for the three market structures in our data set, and define the relevant independent and dependent variables. For comparison purposes, in section 4 we use our data set to estimate some commonly used specifications of the relationship between inflation and dispersion. We present our new empirical specification in section 5 and discuss our findings. Section 6 concludes.

## 2. Theoretical Literature

### Static Equilibrium Search Models

The literature on equilibrium search models with sequential search includes Reinganum (1979), Rob (1985), Bénabou (1993), and Rauh (2005), among many others. A major goal of this class of models is to explain the existence and determinants of observed persistent price dispersion for seemingly homogeneous goods.[2] In the Reinganum model, a continuum of firms produce a homogeneous good under constant returns to scale. A continuum of *ex ante* identical buyers have constant elasticity demand $q(p) = p^{\epsilon}$, where $\epsilon < -1$. Buyers have imperfect information about prices in the sense that they are assumed to know the cumulative distribution function $F$ of prices, but not the price profile that generates it (they don't know which firm is charging what price). Given search cost $c > 0$, it is well-known that buyers' optimal reservation level is given by

$$\int_0^r q(p)F(p)\,dp = c. \tag{1}$$

Baye, Morgan, and Scholten (2005) show that $d\sigma^2/dr > 0$ and $dr/dc > 0$, where $\sigma^2$ is the variance of equilibrium prices, so dispersion is increasing in the cost of search in the Reinganum model.

Since our data set contains sellers with varying degrees of market power, we are also interested in the relationship between dispersion and the constant elasticity

[2] Although inflation is assumed to be zero in this class of models, this literature is still relevant for explaining the vertical intercept terms in empirical models (dispersion when the various components of the inflation measures are zero).

of demand. As far as we know, this issue has not yet been explored in the literature. We now show that $d\sigma^2/d\epsilon < 0$ when the Reinganum model is appropriately normalized. Totally differentiating (1) with respect to $r$ and $\epsilon$,

$$\frac{dr}{d\epsilon} = -\frac{\int_0^r p^\epsilon \ln p \, F(p) \, dp}{r^\epsilon F(r)}. \tag{2}$$

Since $c > 0$, (1) ensures the denominator is positive. A sufficient condition for the derivative to be negative is that the lowest equilibrium price

$$\underline{p} = \left(\frac{\epsilon}{1+\epsilon}\right) \underline{m} \tag{3}$$

be no less than one, where $\underline{m}$ is the marginal cost of the lowest cost firm. A sufficient condition is therefore $\underline{m} \geq (1+\epsilon)/\epsilon$. Other normalizations give the same result.

**Menu Cost Models**

We focus on the Bénabou (1988, 1992) menu cost models, which extend the seminal contribution of Sheshinski and Weiss (1977) to consider search and price dispersion. In these models, inflation is assumed to be constant and fully anticipated. Given non-zero menu costs, firms find it suboptimal to increase prices in lock-step with inflation and instead follow optimal $(S, s)$ pricing strategies. An increase in expected inflation induces firms to widen their $(S, s)$ bands to conserve on menu costs, thereby increasing dispersion. During deflationary periods, the model works in reverse, so there is a V-shaped relationship between dispersion and expected inflation in menu cost models: dispersion is increasing in the absolute value of expected inflation. Moreover, dispersion is increasing in the cost of search and menu costs.

In empirical work, one is confronted by several distinct inflation rates: PS inflation (inflation rates for each individual good in the sample), average inflation over all goods in the sample, and inflation rates constructed from COL and CPI indices. To reduce the number of potential empirical relationships, it is therefore important to determine which *type* of inflation is meant by any particular theory. In the case of menu cost models, expected inflation acts to depreciate the real purchasing power of revenues.[3] Indeed, Sheshinski and Weiss (1977) explicitly consider expected aggregate or macroeconomic inflation, while the Bénabou menu cost models focus on expected inflation in input prices.[4] For example, consider an individual seller in the pazar. Even if this seller obtains his or her apples from an independent grower, that seller will be sensitive to more than just apple inflation: increases in general food expenses, dwelling expenses, and other COL categories will all induce the seller to increase price. A similar statement applies to bakkals, which are almost always family-owned and operated. Of course, a seller's ability to successfully raise price will be tempered by search and competitive pressures.

Although menu cost models are too stylized for full empirical testing, we can still test the basic hypothesis that there is a positive relationship between dispersion and the permanent component of some aggregate inflation measure. In this paper, we test this hypothesis using a broad-based COL index for Istanbul (using national CPI inflation produced qualitatively similar empirical results).

**Signal Extraction Models**

The literature on search and unanticipated inflation includes Bénabou and Gertner (1993) and Dana (1994). For concreteness, we focus on the Bénabou-Gertner model, which assumes sequential search and that inflation is cost-push and unexpected: marginal costs are subject to inflation shocks via input prices. The signal extraction aspect of the model is that a consumer who observes a high price at a particular seller must infer to what extent that high price is due to unexpected inflation, as opposed to idiosyncratic factors. If the consumer believes the former is more likely, then the expected benefit of search is lower, and less search induces greater

[3] See the first equation in the proof of theorem 2.1 in Bénabou (1988, p. 369).

[4] The Bénabou menu cost models study the long-run steady-state where PS inflation equals macroeconomic inflation, but this is unlikely to hold in real-world data sets and may not hold in more general theoretical models.

dispersion in equilibrium.[5] The Bénabou-Gertner model therefore formalizes the traditional view that unexpected inflation (or unexpected deflation) can increase dispersion by reducing the expected benefit of search. Furthermore, dispersion is increasing in the cost of search as in previous models.

In contrast with menu cost models, where the relationship between inflation and dispersion is essentially *technological* (driven by the existence and magnitude of menu costs), in signal extraction models the relationship is *informational*. It therefore seems clear that the relevant inflation rate for signal extraction models is unexpected PS inflation: a rational consumer searching for good A should not be fooled by unexpected inflation in the market for good B, where "fooled" means allowing her statistical inferences about the expected benefit of search for A to be clouded by idiosyncratic events in the market for B (any common component should already be reflected in A's prices). Of course, real-world consumers may not be that rational, so we include both unexpected PS and COL inflation in our empirical model to test this hypothesis. Indeed, we find that unexpected COL inflation plays no significant role in the relationship between inflation and dispersion.

### Information Investment Model

In the above models, individual consumers only purchase the good once. In contrast, Van Hoomissen (1988) poses the repeat-purchase search problem as an optimal investment decision where search not only reduces the current purchase price, but also adds to the consumer's stock of information. This stock depreciates because information can be forgotten or become obsolete. In particular, an increase in

[5] In contrast, Bénabou and Gertner show that when the search cost is sufficiently low, an increase in unexpected inflation can induce greater search and lead to higher welfare in equilibrium. This has led some researchers to conjecture that an increase in unexpected inflation might *reduce* dispersion in their model. However, there are no analytical or simulations results or claims to that effect in the Bénabou-Gertner paper, and our analysis of their Tables 1-3 on p. 85-86 shows that dispersion increases in all cases, even when search costs are low. [However, we did not consider the mixed-strategy (type 4) equilibria in the intermediate search cost case.] Hence, the notion that unexpected inflation might reduce dispersion remains a conjecture. We have benefitted from correspondence with Roland Bénabou on this point.

inflation increases the depreciation rate on information, inducing consumers to hold smaller information stocks, which should increase current and future dispersion. Here, the relevant inflation measure is expected PS inflation, since one can only discount based on anticipated inflation and because information about one good should not depreciate with inflation in other markets. The information investment model also predicts that current dispersion should be positively related to lagged dispersion, since the latter reflects consumers' pre-search stock of information.[6] Furthermore, unexpected PS inflation causes a temporary reduction in information stocks, which may increase dispersion in current and future periods while they are being replenished.

**Summary and Objectives**

Menu cost models, signal extraction models, and the information investment model focus on different aspects of the inflation-dispersion relationship: menu cost models analyze the effects of expected macroeconomic inflation from a technological point of view, while the latter consider the effects of inflation from an informational point of view. Signal extraction models consider the relationship between dispersion and unexpected PS inflation, while the information investment model incorporates both expected PS inflation (which proxies the depreciation rate on information) and unexpected PS inflation, and also suggests a role for lagged dispersion. According to static equilibrium search models, dispersion is increasing in the cost of search (as in menu cost and signal extraction models) and decreasing in the elasticity of demand (provided equilibrium prices are not too low).

Given the current state of the theoretical literature, we cannot subject the disparate models to full empirical testing. On the other hand, regressions involving the expected and unexpected components of some inflation measure, essentially arbitrarily chosen, do not adequately capture the richness of the existing theoretical

[6] Since the model is recursive (the state is lagged dispersion, the current pre-search stock of information), the model does not suggest a role for additional lags.

literature. In this paper, we estimate an empirical specification including all of these variables, as well as unexpected COL inflation to test the hypothesis that consumers are not fooled by unanticipated macroeconomic inflation. The goal is to identify which of the basic forces suggested by the theory seem to be at work in our data, which should serve as a guide in the development of a unified theory of the relationship between inflation and price dispersion.

## 3. Data and Definitions

### Data

The data consist of monthly price observations for 58 distinct products, mostly foodstuffs, listed in appendix A. These observations span the period 1992:10 to 2000:06, during which the average inflation rate was high but relatively stable at about 60% per annum.[7] The Istanbul Chamber of Commerce collects this data to construct a broad-based COL index for wage earners in Istanbul, which we also use. The 58 products listed in appendix A comprise 25% of the entire COL index.[8] Whenever possible, the data collectors visited the same seller to record price observations on the same product (same brand, quantity/weight, and other characteristics).

Each price entry $p_{ijkt}$ in our data set is indexed by the product $i$, the neighborhood (borough) $j$ in Istanbul where it was collected, the store type $k$, and the month $t$. Each entry was collected from one of three distinct store types: bakkals, pazars, and supermarkets.[9] *Bakkals* are relatively small convenience stores which are almost always family-owned and operated. They tend to be concentrated in residential areas and to be separated from one another by short walking distances

[7] The stability of inflation during the sample period may be significant, since Caglayan and Filiztekin (2003) have shown that the empirical link between inflation and dispersion can break down in the presence of large structural breaks.

[8] The COL index includes the following categories: Food; Dwelling Expenses; Household Expenses; Clothing, Health, and Personal Care; Transportation and Communication; Culture, Education, and Entertainment; and Other.

[9] Note that all of these store types are major institutions with many customers, so our results are not biased due to a lack of consumers for some store type.

(e.g., a few blocks). Bakkals are also local institutions with an important social dimension, as customers tend to drop in to buy one or two items and exchange news and gossip with the owner. *Pazars* are classic Middle-Eastern-style bazaars selling fresh produce and small consumer items. These markets approach the perfectly competitive ideal, since vendors operate small stalls selling 1-4 items each, and each product generally has several sellers within a very small geographical area (approximately two acres for a large pazar in Istanbul). There is one main pazar in each neighborhood, open one day a week. Turkish supermarkets are similar to their Western counterparts. They are relatively large, corporate-owned, and stock a wide variety of distinct products and brands. As in the US, they tend to isolate themselves geographically from similar sellers. Fischer and Harrington (1996) document this phenomenon for a major US city (Baltimore).

The theoretical literature highlights three main parameters or characteristics of market structure: menu costs, search costs, and market power. In these dimensions, pazars approach the perfectly competitive ideal. Menu costs are negligible, and the high density of sellers results in relatively fierce competition with very low search costs. Recall that the cost of search is the opportunity cost of obtaining another price quote. If one seller in the pazar quotes a high price for apples, the prospective buyer knows that there are several other sellers nearby (usually in plain sight). Despite very low search costs, price dispersion is a persistent phenomenon in the pazar.

The market structure for bakkals is roughly monopolistic competition. Their products are differentiated spatially and also in the social dimension. As a result, bakkals enjoy some market power and people tend to patronize their "favorite" bakkal. Although menu costs are low, search costs can be significant. If a particular bakkal quotes a high price, the nearest alternative seller is generally another bakkal, which may be several blocks away.

Supermarkets are very different. As Bénabou (1992, p. 303) emphasizes, menu costs incorporate *all* costs of changing prices, including decision costs. Since supermarkets stock a large array of different products and brands, menu costs are likely to be significant (recall that inflation averaged 60% over the sample). Moreover, the fact that supermarkets tend to be geographically isolated from other sellers means that search costs are generally substantial: obtaining another price quote usually entails a trip by car or public transportation. Since many Turkish consumers rely on the latter, search costs may be fairly high indeed. Finally, the geographical density of bakkals is significantly greater than that for supermarkets, so spatial product differentiation may be even more important for the latter. The fact that supermarkets advertise and employ marketing strategies such as running "loss leaders" indicates that supermarkets enjoy some market power.

Based on these characterizations, one would expect pazar prices, on average, to exhibit the least amount of dispersion due to their relatively small menu and search costs and relative absence of market power. In fact, our estimates support this hypothesis. The other two market structures are less clear-cut. What we find is that the market structures can be ranked (pazars < bakkals < supermarkets) in terms of average price dispersion. The latter result is understandable, in light of the fact that supermarkets are likely to have higher associated search and menu costs than bakkals.

### Issues

A potential problem with the pazar data is that, although pazar vendors are *legally required* to post explicit prices, the actual purchase price may be determined by haggling, whereas our data set only records the posted prices. Nevertheless, we believe the pazar data to be useful, because the issues involved in setting the *posted* prices are similar to those in menu cost and signal extraction models. In particular, consumers will make signal extraction-type inferences based on the posted prices.[10]

[10] In signal extraction models, buyers use the posted price and the firm's equilibrium strategy to make inferences about the firm's cost. The latter are then used to make inferences about other firms' costs and prices, which informs the buyer's decision concerning additional search.

Furthermore, the posted price will have to be set competitively, since if it is too high, the seller will attract little buyer interest, and if it is too low, profits will be reduced because the actual price will not exceed the posted one. Hence, the posted prices should be useful for testing the basic hypotheses of menu cost and signal extraction models, even if the actual and posted prices differ.

In fact, actual purchase prices determined by haggling are usually fairly close to the posted ones. As Geertz (1978, p. 32) notes, "most bazaar 'price negotiation' takes place to the right of the decimal point". Our own casual observation suggests that in the morning, when the Chamber inspectors reportedly collect the data, the bulk of the transactions occur at the posted price. Haggling is more important in the afternoon, when sellers are eager to get rid of their stocks. For the sceptical reader, in appendix B we report our findings following the same empirical analysis as in the text, except that only the bakkal and supermarket data are used (haggling is not a feature of these markets). *The results are essentially the same.* See tables B1, B2 in appendix B, which correspond to tables 1, 2 in the main text.

Another issue relates to the fact that consumers generally shop for *baskets* of goods at the supermarket. Presumably, supermarkets take advantage of this fact through general pricing strategies (e.g., loss leaders), as well as individual product marketing strategies. If so, then our price observations may not be completely independent. We first note that strategic linkages between price *levels* may not translate to linkages in price *dispersion*. Nevertheless, the problem may manifest itself via heteroskedasticity, which we will be careful to control for. We also note that such linkages are much less of an issue for bakkals and pazars, since most consumers only buy one or two items from these sellers (although one can purchase many items from the pazar, individual sellers in the pazar stock only a few items).

**Definitions**

We make the standard definition that the *relative price* of product $i$ in neighborhood

$j$ sold by store type $k$ in month $t$ is defined by

$$R_{ijkt} = \ln(p_{ijkt}/p_{it}) \tag{4}$$

where

$$p_{it} = \frac{1}{J}\frac{1}{K}\sum_j \sum_k p_{ijkt} \tag{5}$$

is the average price of the product at date $t$, $J = 15$ is the number of neighborhoods, and $K = 3$ is the number of distinct store types. *Price dispersion* is defined by

$$V_{ikt} = \left[\frac{1}{J-1}\sum_j (R_{ijkt} - R_{ikt})^2\right]^{1/2} \tag{6}$$

where

$$R_{ikt} = \frac{1}{J}\sum_j R_{ijkt}. \tag{7}$$

Some empirical studies use relative price *change* variability to measure dispersion as opposed to relative price *level* variability as defined in (6). However, as Reinsdorf (1994, Section IV) emphasizes, the theoretical literature refers specifically to relative price level variability. Indeed, these two dispersion measures are not equivalent and may have different relationships with inflation, so in this paper we only refer to relative price level variability as defined in (6). The *PS inflation rate* for product $i$ is defined as the average[11]

$$\text{PS}_{it} = \frac{1}{J}\frac{1}{K}\sum_j \sum_k \pi_{ijkt} \tag{8}$$

where

$$\pi_{ijkt} = \ln[p_{ijkt}/p_{ijk(t-1)}]. \tag{9}$$

[11] Alternatively, one could define separate PS inflation rates for each store type. Although regressing store-type dispersion against store-type PS inflation seems more parsimonious than using overall PS inflation, there is no theoretical basis for using such narrow inflation variables. From the perspective of signal extraction models, using store-type PS inflation would imply, for example, that a consumer who observes high apple prices at the pazar would not use this information to make inferences about bakkal apple prices.

### Expected and Unexpected Inflation

The theoretical literature refers to the expected and unexpected components of inflation, so we need to decompose both COL and PS inflation into their permanent and transitory components. For purposes of comparison, we follow the same procedure used in Lach and Tsiddon (1992) and Reinsdorf (1994). According to this procedure, we regress $\mathrm{PS}_t$ against $\mathrm{PS}_{t-1}, \mathrm{PS}_{t-2}, \ldots$ up to six lags, past values of COL inflation up to three lags, and deterministic components including a constant, linear trend, and time dummies. For each product $i$, the appropriate lag length and the choice of which deterministic components to include is determined by the well-known Schwarz Information Criterion. For each estimation, the residuals are tested for serial correlation and autoregressive conditional heteroskedasticity up to six lags. If the residuals are clean with respect to these anomalies at conventional significance levels, the fitted values are used as the expected inflation series $\mathrm{EPS}_t$ and the residuals are taken to be unexpected inflation $\mathrm{UPS}_t$. If the serial correlation or ARCH tests failed, we used the second-best specification according to the Schwarz Information Criterion, and so on. The same procedure was used to decompose COL inflation into its expected $\mathrm{ECOL}_t$ and unexpected $\mathrm{UCOL}_t$ components except that only past values of COL inflation were used, along with deterministic components including a constant, linear trend, and time dummies.[12]

## 4. Common Specifications

We begin our empirical analysis with a very basic specification, common in the literature:

$$V_{it} = \alpha + \sum_i \lambda_i + \sum_{k \neq b} \theta_k + \sum_l \tau_l + \sum_n T_n + \beta \left|\mathrm{PS}_{it}\right| + u_{it} \tag{10}$$

where $V_{it}$ is dispersion as defined in (6), $\alpha$ is a constant, $|\mathrm{PS}_{it}|$ is the absolute value of PS inflation, and $u_{it}$ is the error term. We take the absolute value of $\mathrm{PS}_{it}$, since

[12] The details of the decomposition procedure are available from the authors upon request.

all the theoretical models discussed in section 2 predict a V-shaped relationship between dispersion and the relevant inflation variable. The model also includes dummy variables to control for fixed effects specific to particular products $\lambda_i$, store types $\theta_k$ (where $k = b, p, s$ for bakkal, pazar, and supermarket, respectively), months $\tau_l$, and years $T_n$.

The estimates for this fixed-effects regression model are reported in Table 1, column 1.

**Table 1 Goes Here**

The estimate for $\theta_s$ (denoted by "dmrk" in the table) is positive and significant at the 1% level, indicating that supermarkets exhibit greater dispersion on average than bakkals, *ceteris paribus*. Similarly, $\theta_p$ (denoted by "dpaz") is negative and significant, indicating that pazars exhibit less dispersion than bakkals. We therefore find the ranking (pazars < bakkals < supermarkets) with respect to average dispersion levels. The result that pazars exhibit the least amount of dispersion is consistent with their characterization in terms of relatively fierce competition (high spatial density) and very low search and menu costs. The finding that supermarkets exhibit more dispersion than bakkals may reflect casual observation that supermarkets seem to have higher menu and search costs. Given their greater numbers and relatively higher spatial density, bakkals may essentially be monopolistic competitors with less market power than supermarkets, which are corporate oligopolists. Overall, these estimates confirm the visual evidence in Figure 1 below, which plots dispersion across time for each store type.

**Figure 1 Goes Here**

The coefficient $\beta$ on $|\mathrm{PS}_t|$ characterizes the relationship between PS inflation and dispersion for this model. The estimate for $\beta$ is positive and significant at the 1% level, which agrees with the usual finding that there is a V-shaped relationship between dispersion and PS inflation.

### Asymmetric Impact of Inflation vs. Deflation

As Jaramillo (1999) demonstrates, conclusions about the empirical relationship between inflation and dispersion can hinge on the proper treatment of outliers, especially those corresponding to deflationary episodes. In order to properly account for these, we introduce a dummy variable $D_{<0}$ which equals 1 when PS inflation is negative (deflation) and zero otherwise:

$$V_{it} = \alpha + \sum_i \lambda_i + \sum_{k \neq b} \theta_k + \sum_l \tau_l + \sum_n T_n + \beta\,|\mathrm{PS}_{it}| + \gamma\, D_{<0}\,|\mathrm{PS}_{it}| + u_{it}. \quad (11)$$

This model therefore allows for an *asymmetric* V-shaped relationship between dispersion and PS inflation.

The estimates are reported in Table 1, column 2. We observe that $\beta$ and $\gamma$ are positive and significant at the 1% and 5% levels, respectively, indicating an asymmetric V-shaped relationship. Specifically, a unit increase in inflation increases dispersion by about $\beta = 0.043$, while a unit increase in deflation increases dispersion by about $\beta + \gamma = 0.06$. Similar asymmetries, involving a larger change in dispersion for increases in deflation, have been reported by Reinsdorf (1994) and Jamarillo (1999).

### Expected and Unexpected Inflation

We now estimate a specification similar to that in Lach and Tsiddon (1992, Table 2) and Reinsdorf (1994), which relates dispersion to expected and unexpected PS inflation:

$$V_{it} = \beta_1\,|\mathrm{EPS}_{it}| + \beta_2\,|\mathrm{UPS}_{it}| + \gamma_1\, D_{<0}\,|\mathrm{EPS}_{it}| + \gamma_2\, D_{<0}\,|\mathrm{UPS}_{it}| + u_{it}. \quad (12)$$

As before, we allow for an asymmetric V-shaped relationship between dispersion and each inflation variable. We also include a constant as well as product, store-type, and time dummies, but for simplicity we do not display them.[13]

[13] From now on, we refrain from displaying these variables, although they always enter the estimation procedure.

In Table 1, column 3, the estimates for $\beta_1$, $\beta_2$, and $\gamma_1$ are all positive and significant at the 5% level or better. We therefore find a symmetric V-shaped relationship between dispersion and unexpected PS inflation and an asymmetric V-shaped relationship between dispersion and expected PS inflation, with a steeper slope for expected PS deflation. These findings are again similar to much of the existing empirical literature and have generally been interpreted as supporting the basic implications of menu cost and signal extraction models. These results are also consistent with the information investment model, where $|EPS|$ proxies the depreciation rate on information.

**Lagged Dispersion**

From a theoretical perspective, the information investment model suggests that current dispersion should be negatively related to consumers' information stocks, whose opposite (ignorance) can be proxied by lagged dispersion. Hence, current dispersion should be positively related to lagged dispersion. From an econometric point of view, visual inspection of Figure 1 indicates some persistence, so failing to include lagged dispersion may lead to biased and inconsistent estimates. We therefore add $V_{t-1}$ to the model in (12):

$$V_{it} = \beta_0\, V_{i(t-1)} + \beta_1\, |\mathrm{EPS}_{it}| + \beta_2\, |\mathrm{UPS}_{it}| + \gamma_1\, D_{<0}\, |\mathrm{EPS}_{it}| + \gamma_2\, D_{<0}\, |\mathrm{UPS}_{it}| + u_{it}. \quad (13)$$

The model now has a dynamic structure, and we use the one-step GMM estimation procedure for dynamic panels analyzed in Arellano and Bond (1991).[14]

In Table 2, column 1, we observe that $\beta_0$ is positive and significant at the 1% level, so current and lagged dispersion are indeed positively related.

[14] Arellano and Bond (1991) report that the Sargan test has asymptotic chi-squre distribution only if the error terms are homoskedastic, and that it over-rejects the null hypothesis of valid instruments in the presence of heteroskedasticity, which seems likely for our sample. Furthermore, they recommend using one-step results for inference on coefficients, as the estimated standard errors from the two-step method would be downward biased. We adopt this suggestion, and present one-step estimation results while implementing the Huber-White robust standard error estimation procedure to control for possible heteroskedasticity. All computations were performed by STATA, where lagged values of the inflation variables and the lagged dependant variable were used as instruments.

**Table 2 Goes Here**

Interestingly, $\beta_1$ and $\gamma_1$ are now insignificant, whereas before they were positive and significant. In other words, incorporating lagged dispersion removes any statistically significant relationship between dispersion and expected PS inflation. On this basis, it might be tempting to reject the basic implication of menu cost models. However, in the next section we show that there is a positive and significant relationship between dispersion and expected COL inflation, as hypothesized in our survey of the theoretical literature. In our view, these findings cast substantial doubt on previous work which neglects lagged dispersion. The results for $\beta_2$ and $\gamma_2$ are qualitatively the same as before, so there is still a symmetric V-shaped relationship between dispersion and unexpected PS inflation.

## 5. A New Specification

Despite its fragmented nature, the theoretical literature offers a richer set of inflation $\rightarrow$ dispersion channels than the previous specifications allow. We therefore propose the following:

$$\begin{aligned} V_{it} = &\beta_0 \, V_{i(t-1)} + \beta_1 \, |\mathrm{EPS}_{it}| + \beta_2 \, |\mathrm{UPS}_{it}| + \beta_3 \, |\mathrm{ECOL}_t| + \beta_4 \, |\mathrm{UCOL}_t| + \\ &\gamma_1 \, D_{<0} \, |\mathrm{EPS}_{it}| + \gamma_2 \, D_{<0} \, |\mathrm{UPS}_{it}| + \\ &\gamma_3 \, D_{<0} \, |\mathrm{ECOL}_t| + \gamma_4 \, D_{<0} \, |\mathrm{UCOL}_t| + u_{it}. \end{aligned} \tag{14}$$

This specification includes the two main explanatory variables highlighted by the information investment model: lagged dispersion and expected PS inflation. As in previous specifications, unexpected PS inflation captures the adverse informational effects of unanticipated inflation which are the central focus of signal extraction models and represents temporary shocks to information stocks in the information investment model. We use expected COL inflation to proxy anticipated aggregate inflation, the main driving force in menu cost models. In all cases, we allow for asymmetric V-shaped relationships. Finally, we include unexpected COL inflation to test the basic hypothesis that consumers are not fooled by changes in unanticipated aggregate inflation, which should be irrelevant from a signal extraction perspective.[15]

The estimates for $\beta_0$, $\beta_1$, $\beta_2$, $\gamma_1$, and $\gamma_2$ in column 2, Table 2, are qualitatively the same as in column 1, so we obtain the same results as before: dispersion is positively associated with lagged dispersion, there is a symmetric V-shaped relationship between dispersion and unexpected PS inflation, and no statistically significant relationship with expected PS inflation.

With respect to COL inflation, $\beta_3$ is positive and significant at the 1% level, indicating a V-shaped relationship between dispersion and expected COL inflation, as hypothesized by menu cost models. Since our data set contains only two observations of expected COL *deflation*, testing for an asymmetric relationship is equivalent to testing whether those two observations are influential outliers, as Jaramillo (1999) points out. This is indeed the case, since $\gamma_3$ is positive and significant at the 1% level. It also hints at an asymmetric relationship, with a steeper slope for expected COL deflation. Note that Jaramillo, who had more deflationary observations to work with, found just such a relationship between dispersion and aggregate inflation. As for unexpected COL inflation, $\beta_4$ and $\gamma_4$ are both insignificant, which suggests unexpected COL inflation has little or no impact on dispersion, as hypothesized. In a nutshell, our findings indicate support for all of the basic inflation $\rightarrow$ dispersion channels identified by the theoretical literature, except for the coefficient on expected PS inflation.

## 6. Conclusions

The current consensus in the empirical literature seems to be that there is a posi-

[15] We do not include lagged inflation variables in (14), since those effects should already be captured by lagged dispersion. Indeed, $V_{i(t-1)}$ is the key theoretical lagged variable, since it proxies consumers' information stocks at date $t$, and may incorporate other factors besides inflation, such as the effects of supermarket advertising.

tive association between inflation and price dispersion. Moreover, once inflation is statistically decomposed into its expected and unexpected components, there also seems to be a positive relationship between dispersion and anticipated and unanticipated inflation. Despite its disparate nature, the theoretical literature helps us to understand certain aspects of this relationship, where menu cost models focus on anticipated inflation and signal extraction models on unanticipated inflation.

In this paper, we investigate potential linkages between inflation and price dispersion using a relatively rich empirical framework, as compared with previous studies. In practice, researchers are confronted with a variety of different inflation rates, and different empirical studies have used different inflation measures with little or no discussion or justification. A central lesson of the present paper is that price dispersion can have different relationships with different inflation measures. For example, we find no statistically significant relationship between dispersion and expected PS and unexpected COL inflation, but a positive and significant relationship with the absolute values of expected COL and unexpected PS inflation. The choice of inflation measure therefore matters and should be guided by theory.

In our survey of the theoretical literature, we argued that menu cost models refer to expected aggregate inflation and signal extraction models to unexpected PS inflation. We have also drawn attention to Van Hoomissen's (1988) information investment model, which suggests a role for lagged dispersion. Strikingly, our empirical results support most of the basic implications one can identify from the existing theoretical literature. However, Reinsdorf (1994) reports a negative relationship between inflation and dispersion, which may be inconsistent with existing theory (see footnote 5). In our view, his analysis is incomplete since it does not include lagged dispersion or aggregate inflation.

Another novel feature of the present paper is our investigation of the impact of market structure on average dispersion levels. A unique aspect of our data set is that it includes price observations from three distinct market structures: bakkals, pazars, and supermarkets. These three store types should exhibit considerable variation in the main parameters and characteristics identified by the theoretical literature: menu costs, search costs, and market power. This gives us the rare opportunity to put the main insights of the equilibrium search literature to the test: by all accounts, we should expect *ex ante* that pazars should exhibit the least amount of price dispersion on average, which is indeed what we find.

In conclusion, we are encouraged by these findings, since most of the basic implications of the theoretical literature are supported by the data. On the other hand, our research highlights the need for a unified theoretical framework which incorporates the main insights of menu cost models, signal extraction models, and the information investment model. Indeed, our results suggest that all of these elements are necessary for a complete understanding of the relationship between inflation and price dispersion. In the meantime, we hope our findings on the complex linkages between inflation, price dispersion, and market structure will stimulate more empirical research along these lines.

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**Appendix A**

Table A: Products

| Product | Mean Inflation | stdev | Product | Mean Inflation | stdev |
|---|---|---|---|---|---|
| Rice | 0.0486 | 0.0485 | Roasted chick peas | 0.0523 | 0.0496 |
| Pasta | 0.0457 | 0.0544 | Walnuts | 0.0564 | 0.0930 |
| Flour | 0.0452 | 0.0361 | Raisins | 0.0473 | 0.0451 |
| Baklava | 0.0508 | 0.0317 | Apple | 0.0509 | 0.1394 |
| Cookies | 0.0508 | 0.0317 | Lemon | 0.0453 | 0.1304 |
| Flodough[a] | 0.0472 | 0.0347 | Tomato | 0.0497 | 0.2703 |
| Cracked wheat | 0.0487 | 0.0304 | Green peppers | 0.0396 | 0.3354 |
| Veal | 0.0472 | 0.0386 | Cucumbers | 0.0409 | 0.2619 |
| Chicken | 0.0446 | 0.0818 | Lettuce | 0.0420 | 0.1472 |
| Mutton | 0.0472 | 0.0411 | Zucchini | 0.0395 | 0.2209 |
| Fish | 0.0545 | 0.1898 | Scallion | 0.0456 | 0.1722 |
| Sucuk[b] | 0.0489 | 0.0343 | Olives | 0.0488 | 0.0232 |
| Offal[c] | 0.0476 | 0.0448 | Honey | 0.0496 | 0.0344 |
| Salami | 0.0479 | 0.0319 | Tomato paste | 0.0464 | 0.0610 |
| Sausage | 0.0453 | 0.0283 | Halvah[d] | 0.0472 | 0.0482 |
| Feta cheese | 0.0464 | 0.0388 | Jam | 0.0469 | 0.0360 |
| Margarine | 0.0501 | 0.0519 | Ready soup | 0.0462 | 0.0300 |
| Cooking oil | 0.0485 | 0.0572 | Broom | 0.0505 | 0.0503 |
| Eggs | 0.0400 | 0.1307 | Cleaning powder | 0.0496 | 0.0344 |
| Olive oil | 0.0504 | 0.0579 | Soap | 0.0477 | 0.0477 |
| Kasari cheese | 0.0481 | 0.0555 | Detergent | 0.0451 | 0.0367 |
| Potato | 0.0474 | 0.1125 | Bleach | 0.0497 | 0.0316 |
| Onion | 0.0530 | 0.1695 | Paper tissue | 0.0501 | 0.0431 |
| Lentils | 0.0489 | 0.0527 | Light bulbs | 0.0390 | 0.0417 |
| Chick peas | 0.0541 | 0.0569 | Plastic kitchenware | 0.0495 | 0.0388 |
| Dried beans | 0.0525 | 0.0610 | Toothpaste | 0.0489 | 0.0404 |
| Sunflower seeds | 0.0460 | 0.0420 | Toilet soap | 0.0470 | 0.0468 |
| Peanuts | 0.0493 | 0.0470 | Shampoo | 0.0436 | 0.0532 |
| Hazelnuts | 0.0599 | 0.1127 | Razor | 0.0523 | 0.0579 |

*a* A very thin sheet of dough. *b* A type of sausage. *c* Sheep viscera. *d* A type of sweet.

**Appendix B: regressions without pazar data.**

Table B1: Panel data fixed effects estimation results

| | Eq.(10) | Eq.(11) | Eq.(12) |
|---|---|---|---|
| dmrk | 0.015 | 0.015 | 0.015 |
| | [0.001]*** | [0.001]*** | [0.001]*** |
| $\|PS\|$ | 0.058 | 0.051 | |
| | [0.006]*** | [0.006]*** | |
| $D * \|PS\|$ | | 0.031 | |
| | | [0.009]*** | |
| $\|EPS\|$ | | | 0.047 |
| | | | [0.010]*** |
| $\|UPS\|$ | | | 0.047 |
| | | | [0.009]*** |
| $D * \|EPS\|$ | | | 0.053 |
| | | | [0.018]*** |
| $D * \|UPS\|$ | | | 0.000 |
| | | | [0.011] |
| Constant | 0.078 | 0.078 | 0.070 |
| | [0.004]*** | [0.004]*** | [0.006]*** |
| Observations | 8464 | 8464 | 8207 |
| $R^2$ | 0.37 | 0.37 | 0.37 |

Standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Variable definitions are given in the text.

**Appendix B: regressions without pazar data.**

Table B2: Panel data dynamic GMM estimation results

| | Eq.(13) | Eq.(14) |
|---|---|---|
| LD. | 0.638 | 0.637 |
| | [0.028]*** | [0.028]*** |
| $\|EPS\|$ | -0.003 | -0.007 |
| | [0.017] | [0.018] |
| $\|UPS\|$ | 0.060 | 0.057 |
| | [0.020]*** | [0.019]*** |
| $D * \|EPS\|$ | 0.020 | 0.024 |
| | [0.036] | [0.035] |
| $D * \|UPS\|$ | 0.004 | 0.010 |
| | [0.032] | [0.032] |
| $\|ECOL\|$ | | 0.135 |
| | | [0.033]*** |
| $\|UCOL\|$ | | 0.009 |
| | | [0.018] |
| $D * \|ECOL\|$ | | 0.463 |
| | | [0.309] |
| $D * \|UCOL\|$ | | -0.025 |
| | | [0.034] |
| Observations | 8115 | 7952 |

Standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Variable definitions are given in the text.

The numbers in parentheses are robust standard errors from Arellano-Bond one-step GMM estimation.

Table 1: Panel data fixed effects estimation results.

| | Eq.(10) | Eq.(11) | Eq.(12) |
|---|---|---|---|
| dmrk | 0.014 | 0.014 | 0.014 |
| | [0.001]*** | [0.001]*** | [0.001]*** |
| dpaz | -0.015 | -0.015 | -0.015 |
| | [0.001]*** | [0.001]*** | [0.001]*** |
| $\|PS\|$ | 0.047 | 0.043 | |
| | [0.004]*** | [0.005]*** | |
| $D * \|PS\|$ | | 0.017 | |
| | | [0.007]** | |
| $\|EPS\|$ | | | 0.036 |
| | | | [0.008]*** |
| $\|UPS\|$ | | | 0.043 |
| | | | [0.007]*** |
| $D * \|EPS\|$ | | | 0.026 |
| | | | [0.012]** |
| $D * \|UPS\|$ | | | -0.001 |
| | | | [0.009] |
| Constant | 0.089 | 0.089 | 0.088 |
| | [0.002]*** | [0.002]*** | [0.002]*** |
| Observations | 10672 | 10672 | 10341 |
| $R^2$ | 0.10 | 0.10 | 0.10 |

Standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Time and market type product dummies are included in all regressions.

Table 2: Panel data dynamic GMM estimation results.

| | Eq.(13) | Eq.(14) |
|---|---|---|
| Lagged V | 0.576 | 0.578 |
| | [0.030]*** | [0.031]*** |
| $\|EPS\|$ | 0.009 | 0.010 |
| | [0.013] | [0.013] |
| $\|UPS\|$ | 0.051 | 0.052 |
| | [0.012]*** | [0.012]*** |
| $D * \|EPS\|$ | 0.017 | 0.014 |
| | [0.024] | [0.024] |
| $D * \|UPS\|$ | 0.003 | 0.004 |
| | [0.022] | [0.022] |
| $\|ECOL\|$ | | 0.103 |
| | | [0.032]*** |
| $\|UCOL\|$ | | -0.024 |
| | | [0.017] |
| $D * \|ECOL\|$ | | 1.195 |
| | | [0.342]*** |
| $D * \|UCOL\|$ | | -0.004 |
| | | [0.028] |
| Observations | 10,225 | 10,022 |

Standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

The numbers in parentheses are robust standard errors from Arellano-Bond one-step GMM estimation.