Optimal Price Setting During a Currency Changeover: Theory and Evidence from French Restaurants

Nicoletta Berardi [a], Thomas A. Eife [b] and Erwan Gautier [a c]

a: Banque de France

b: University of Heidelberg

c: IEMN-IAE Université de Nantes, LEMNA

Very preliminary version

Abstract

This paper explores the optimal price setting during a currency changeover. The theoretical model suggests that both increasing and decreasing prices may be optimal and, in particular, that prices are more likely to increase when consumers have difficulties observing a firm's conversion and when the firm has few regular customers or is small. The model's predictions are tested with a difference-in-difference analysis of firm-level behavior of French restaurants, based on monthly observations at the firm level over 7 years. The empirical analysis shows that in the period the euro cash changeover prices in traditional restaurants increased by 2.2% more than in larger and more visible restaurants.

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1 Introduction

Euro banknotes and coins replaced national currencies in January 2002 in 12 European countries. The introduction of the euro triggered large and intense debates about the inflationary consequences of the cash changeover. According to household surveys, a large majority of European citizens perceived a sharp increase of prices in January 2002 and this opinion persisted during a couple of years (see for instance Ehrmann [2011]). However, the inflation rate around the euro cash changeover remained rather stable around 2% and the euro effect was estimated to be very limited and temporary by many studies. This paper argues that the introduction of a new currency may have created a confusion on new prices among buyers and this confusion led to heterogeneity in the price setting behavior of firms. We show that during a cash changeover it could be optimal for firms to increase or decrease their prices and we study the conditions under which price decreases and price increases are optimal. In particular, we show that the size of the firm may play a role in the price conversion.

We propose a model in which consumers are fully rational but at the euro cash changeover they have difficulties in realizing the new absolute price level, so that firms may take the opportunity to increase their prices. On the other hand, a firm may damage its reputation once buyers find out that prices increased, so that decreasing prices at the euro cash changeover could be optimal for firms if consumers have a high probability to realize that prices increased. Therefore, there is a trade-off between short-run gains from raising prices and long-run losses of customers' goodwill.

At the euro cash changeover, out of the many price changes (in France for instance 35% of prices changed in January 2002 versus 15% on the period 1994-2003)[1] more than one third were decreases. Existing theories explaining why firms did not convert exactly their new prices in euro don't explain this stylised fact. Beyond rounding up effects or the existence of menu costs (Gaiotti and Lippi [2004] or Hobijn et al. [2006]), two existing models suppose that information on the new price is not perfect. Dziuda and Mastrobuoni [2009] suppose that consumers receive signals about whether an observed price is high or low and assume that the changeover increases the variance of this signal, which gives incentives for firms to raise prices. Gaiotti and Lippi

[1] See Baudry et al. [2007].

[2004] assume that some customers are unable to observe the new (relative) price. This allows firms to raise prices without affecting demand.[2] One key assumption in our model is that price increases at the euro cash changeover might damage the reputation of the firm and decrease the demand addressed to the firm. We follow the advertising literature and assume that demand is a function of both price and goodwill, where goodwill comprises anything that affects demand other than the good's price. This may be interpreted as the seller's friendliness, the services offered in addition to the actual good on sale and, central for our case, the seller's reputation as a fair trader. Increasing prices at the changeover may damage goodwill, while lowering prices may have a positive effect on goodwill. That is, firms can invest in goodwill by lowering prices, which may be viewed as a substitute to an advertising campaign.

Moreover, we assume that the probability that consumers realize that prices increased at the euro changeover depends on the size of the firm. We assume that a customer realizes a firm's conversion only if she happened to be customer in the previous period or if she meets someone who was customer in the previous period.[3] Our model then predicts that large firms are less likely to increase their prices when they convert their prices.[4]

The model's main predictions is that both price increases and price decreases can be optimal depending on a firm's environment. Raising prices offers short-run profits but comes at the risk of damaging a seller's reputation in the long run. In particular, price increases are more likely when: *(i)* when consumers have difficulties observing a firm's conversion, *(ii)* when consumers are slow in observing the conversion, *(iii)* when the firm has few regular customers, and *(iv)* when the firm is small. Competition in a market (or the lack of it) does not affect the direction of the impact, only whether or not an impact is measurable.

The theoretical predictions are supported by price data. We show that firms both raised, lowered or converted exactly their prices to euros in January 2002. We provide evidence that this decision was not random and depended on the size of the firm and more broadly on the

[2]In this set-up, the price needs to be restricted above, otherwise firms would choose an infinite price.

[3]In order not to have perfect information, we have to cut off this information propagation at some point: meeting someone who met someone who was a customer does not provide information.

[4]There are other reasons why large firms may be better off lowering prices. One possibility is that the probability to appear in a news report is higher for larger companies. One may also argue that the value of a company's name relative to its revenues is higher for larger firms, so that they have more to lose from bad reputation. Another possibility is that customers' behavior introduces such a bias. Customers may, for example, be more tolerant when a small, family-owned company raises prices. In our model, the bias toward larger firms is due to the way information spreads.

probability of consumers to find out that prices increased. The empirical analysis is based on a large original data set of individual price quotes collected by the national statistical office to compute the Consumer Price Index and focuses on restaurant prices. The data set contains monthly observations at the firm level, covering the entire industry (from fast food to high-quality restaurants), over a period of 7 years, summing up to more than 600 000 price quotes. We focus on restaurant sector for at least two reasons: *(i)* the inflationary effect of the euro was shown to be larger in services and in particular in restaurants (see for instance Attal-Toubert et al. [2002] or Gallot [2002]). Ehrmann [2011], Dziuda and Mastrobuoni [2009] and Ercolani and Dutta [2007] show that the changeover's impact in other industries was significantly smaller. Moreover, in the public opinion, the perception was that restaurants particularly increased their prices at the euro cash changeover;[5] *(ii)* the restaurant sector consists of large firms like fast food restaurants and many very small firms like traditional family restaurants. The composition of the restaurant sector allows to assess the degree of heterogeneity in price changes at the euro cash changeover. Other studies have studied the impact of the introduction of the euro in restaurants. Gaiotti and Lippi [2004] and Adriani et al. [2009] used Michelin Red Guide price data, but the time dimension available is rather short, making the comparison of prices before the euro quite difficult. Hobijn et al. [2006] used aggregate data which can not allow the analysis of price setting heterogeneity.

To assess the effect of the euro cash changeover on restaurant prices, we rely on a difference-in-difference empirical strategy. We compare the price setting strategy of firms before and after the euro conversion for two types of firms. In our benchmark exercise we consider fast food and traditional restaurants. Both types of restaurants share many price determinants but the fast food restaurants, often belonging to international chains, are assumed to be more concerned with their reputation than smaller traditional restaurants. We expect that fast food restaurants do not want to compromise their reputation by taking advantage of the changeover. We find that the effect of the euro cash changeover is significantly different between fast food restaurants and traditional restaurants. In particular, around the euro cash changeover meal prices in traditional restaurants increased by 2.2% more than in fast food restaurants. Moreover, the differences are

[5] With the exception of Parsley and Wei [2008], all the papers studying restaurant prices find a significant positive impact. In line with our model's predictions, Parsely and Wei's focus on a large restaurant chain explains this difference.

significant both on the probability of price changes and on the size of price changes when prices are modified.

We also run some robustness exercises: *(i)* we consider the prices of meals in traditional restaurants and prices of other products sold in the same restaurants, assuming that prices of meals are more easily observed by consumers and we find significant inflationary effect on prices of other products sold in restaurants; *(ii)* we also study restaurant prices in touristic location and find that touristic restaurants increased their prices more than other restaurants around the euro cash changeover.[6]

Section 2 presents the theoretical framework, describing the economy and discussing how a changeover affects the equilibrium. The model predicts that the euro cash changeover does not have the same impact across the different types of firms. Section 3 presents the data and investigates the effects of the euro cash changeover on prices in French restaurants, relying on a difference-in-differences empirical strategy. Finally, section 4 concludes.

2 Theoretical Model

In this section, we first describe our economy, that is, households, firms and the equilibrium. In section 2.2, we show how this equilibrium is affected by a changeover. We find the notion that an economy may temporarily be out of equilibrium useful mainly because it seems plausible that no firm enters or exits the market because of the changeover. This implies that firms may temporarily make profits (or losses). In our model, the economy returns to its pre-changeover equilibrium after two periods. Section (2.2.1) studies the possibility that firms alter prices already before the actual changeover.

2.1 The Pre-Changeover Economy

We modify a standard Dixit-Stiglitz-economy with a large number of monopolistically competitive firms in two ways. First, following the advertising literature (*e.g.* Bagwell [2007]), we assume that households have preferences over goods as well as over sellers. Sellers can invest in goodwill and sellers with high goodwill are able to sell more for a given price. Demand will

[6]In a similar exercise Adriani et al. [2009] find comparable results.

take the form:

$$c_i = c_i(p_i, G_i)$$

where p_i is firm i's price and G_i its goodwill.

Second, we allow for the possibility that the firm is uncertain about its customers' identities. In the standard Dixit-Stiglitz model, all consumers purchase all products so that this uncertainty is absent. In our model, households consume only a fraction of the existing range of products and firms have regular as well as non-regular customers. Regular customers visit every period the same shop, whereas non-regular customers are assigned randomly.

Let M be the economy's number of households, $(j = 1, 2, ..., M)$ and N the number of firms, which equals the number of varieties, $(i = 1, 2, ..., N)$.[7] Firm i's size is denoted by $m_i \leq M$ and $\rho_i \in [0, 1]$ is the fraction of a firm's regular customers. We assume that a firm knows its size and how many of its customers come regularly, but since some customers are assigned randomly, the firm does not know who exactly of the M households will enter its shop in a given period. This assumption will play an important role during the changeover. Households consume only a fraction n of all available products $(n \leq N)$ but all purchase the same amount $(n_j = n \ \ \forall j)$. Thus, the households' consumption baskets differ in their composition but not in size. Note that we assume that $M \geq N$, that is, no consumer purchases the same item more than once in one period.

2.1.1 Households

Consider an economy that admits a representative household with preferences given by:

$$U(c_1, c_2, ..., c_N, c_0) = U(C, c_0) \tag{1}$$

where $C = \left(\sum_{i=1}^{N} I_i G_i^{\frac{1}{\varepsilon}} c_i^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}}$ is a consumption index of the N differentiated varieties $c_1, ..., c_N$ of a particular good and c_0 a generic good that embodies the rest of the economy. Let c_0 be the numeraire good. G_i is goodwill of variety i and $I_i = \{0, 1\}$ is an indicator function described below. The function $u(\cdot, \cdot)$ is strictly increasing, differentiable in both of its arguments, and jointly strictly concave, which requires in particular that the elasticity of

[7]We abuse notation slightly by using the same symbol to denote the set and its cardinality.

substitution between the different goods is greater than one ($\varepsilon > 1$). The household problem is static; we therefore suppress all time indices.

In order to avoid that the supply of goods produced by the monopolistically competitive firms automatically generates its own demand, households have the choice between the produced good (C) and the non-produced good (c_0). Each household consumes only a fraction of all available goods, that is $\sum_{i=1}^{N} I_i \equiv n \leq N$. Let the price of C be defined as:

$$P \equiv \left[\sum_{i=1}^{N} I_i G_i P_i^{1-\varepsilon} \right]^{1/(1-\varepsilon)}.$$

Then, the choice between C and c_0 can be made by maximizing expression (1), subject to: $PC + c_0 \leq Y$, where Y is the household's income (that includes potential profits generated by the monopolistically competitive sector). This maximization yields the first order condition:

$$\frac{\partial u (C, c_0) / \partial c_0}{\partial u (C, c_0) / \partial C} = \frac{1}{P}$$

which assumes that the solution is interior (an assumption we maintain throughout). The strict joint concavity of u, combined with the budget constraint, implies that this first order condition can be expressed as:

$$\begin{aligned} c_0 &= h(P, Y) \\ PC &= Y - h(P, Y) \equiv y \end{aligned}$$

for some function $h(\cdot, \cdot)$. The share y of income is then devoted to the differentiated goods and the rest to the non-produced good. To derive the demand for individual varieties, denote the price of variety i by p_i. Then the budget constraint of the individual takes the form:

$$\sum_{i=1}^{N} I_i p_i c_i \leq y. \tag{2}$$

If $I_i = 0$ for some i, the good does not enter preferences and demand will be zero. If $I_i = 1$, the good provides utility and demand is positive. Maximizing (1) subject to (2) implies the following demand function for good i:

$$c_i = G_i \times Q(p_i)$$

where $Q(p_i) = \left[\frac{p_i}{P}\right]^{-\varepsilon} C$.

Two comments are in order. First, since the household's expenditure devoted to the differentiated good sector (PC) is independent of goodwill, a firm can only raise demand (by investing in goodwill) at the expense of its competitors. Second, note that demand is separable in goodwill (G_i) and in the 'primitive' demand function $Q(p_i)$. This separability implies that advertising (investing in goodwill) increases the quantity sold but not the good's price. The model, thus, represents what the literature calls the 'informative' view of advertising[8].

2.1.2 Firms

Suppose that each variety i can only be produced by a single firm, which is thus an effective monopolist for this particular commodity. Also assume that all monopolists maximize profits and are owned by the representative household. Let superscripts denote time periods. Firms maximize profits by choosing the price and by investing in goodwill. Investment in goodwill in period t is denoted by $A_i^{(t)}$ and takes effect with one period lag, so that demand in t is given by:

$$c_i^{(t)} = Q\left(p_i^{(t)}\right) G\left(A_i^{(t-1)}\right). \tag{3}$$

where $G' > 0$ and let per unit costs of advertising be denoted by w.[9] We assume that the number of firms is sufficiently large in order to ignore the effect of p_i on P and C. By assumption, the firm knows the number of buyers (m_i) assigned. The problem of the firm is to maximize a stream of profits choosing p_i and A_i optimally:

$$\max_{p_i^{(t)}, A_i^{(t)}} = m_i \sum_{t=1}^{\infty} \beta^t \left(\left(p_i^{(t)} - \phi\right) c_i^{(t)} - w A_i^{(t)} - f\right)$$

[8] See Bagwell [2007] for a discussion.

[9] We assume full depreciation of this investment. This assumption may be relaxed without affecting the main predictions of the model. The difference is that the depreciation rate enters the Dorfman-Steiner condition as in Nerlove and Arrow [1962]. Calculations can be obtained from the authors.

where marginal costs (ϕ) are assumed constant, $\beta \in (0,1)$ is a discount factor and f are per-buyer fixed costs.[10] The fixed cost are expressed in terms of the firm's own output and A^0 is given. Rearranging the first order conditions, we find that:

$$p_i^{(t)} = \phi \frac{\varepsilon}{\varepsilon - 1} \tag{4}$$

$$\frac{\varepsilon_A}{\varepsilon} = \frac{1}{\beta} \frac{w A_i^{(t)}}{p_i^{(t+1)} c_i^{(t+1)}} \tag{5}$$

where $\varepsilon_A \equiv \frac{d \ln G_i}{d \ln A_i} \in (0,1)$. Equation (4) is the familiar mark-up pricing equation and equation (5) is the Dorfman and Steiner [1954] condition that states that the proportion of sales revenue that a profit-maximizing monopolist spends on investment in goodwill is determined by a simple elasticity ratio. Here, the discount factor enters because we assumed that investing in goodwill takes effect with a one-period lag.

2.1.3 Equilibrium

Equilibrium requires that the number of transactions in the differentiated good sector equals the total number of produced goods, that is:

$$(M \times n) = \sum_{i=1}^{N} m_i.$$

As long as this consistency conditions is satisfied, the model offers some freedom regarding the size-distribution of firms without disturbing the symmetry of the standard Dixit-Stiglitz model. In equilibrium, all firms set the same price (equation (4)) and invest the same amount in goodwill (equation (5)). Profits, if expressed in per-buyer terms, are the same across firms. Households purchase the same quantity (c_i) of the same number of goods (n) and thus expenditure is the same across households. For example, if all firms have the same number of customers ($m_i = m$) so that $M \times n = N \times m$ and if, in addition, we assume that households consume all existing products ($n = N$), we are back in the standard set-up where each firm serves the entire pool of customers ($m = M$).

[10] The fixed cost may be interpreted as the cost of setting up branches. A firm that serves more customers needs to open more branches.

In equilibrium, the aggregate price of the differentiated goods basket is given by:

$$P = \frac{\varepsilon}{\varepsilon - 1} \phi \left[nG \right]^{-\frac{1}{\varepsilon - 1}}$$

where G is $G(A)$ and A is given by equation (5). Equilibrium per-customer profits are given by:

$$\frac{\pi}{m} = \frac{(1 - \varepsilon_A)}{\varepsilon} \frac{PC}{n} - f. \tag{6}$$

Imposing zero profits in equilibrium, equation (6) determines the size of the consumption basket n and thus the total number of firms (N).

2.2 The Changeover

We make the following assumptions about timing: the changeover takes place in 'period 1' in which firms can raise or lower prices without consumers realizing the actual conversion. In 'period 2', consumers have realized the conversion and may react to this information. If, for example, a firm raised prices in period 1, the consumer can 'punish' the firm by reducing demand in period 2. In the third period, the economy returns to the equilibrium described in the previous section. The period immediately before the changeover is called 'period 0'.

In particular, we assume that period 1 starts with the changeover taking place, the price elasticity of demand reduces temporarily $\left(\varepsilon^{(1)} = \varepsilon - \kappa\right)$ and firms invest in goodwill and set prices. The parameter $\kappa > 0$ is a measure of consumers' 'confusion'; the higher κ, the larger firms' ability to raise prices in the first period. Then, like in all other periods, non-regular customers are randomly assigned and consumers purchase without realizing the true conversion. Consumers cannot observe whether a firm changed its price relative to the pre-changeover period. After their shopping, consumers realize a firm's conversion and share information with others. This exchange of information is discussed below.

At period 2 firms invest in goodwill and set their prices, taking into account that the price elasticity of demand is back at its normal level. If a second-period customer has some information about a firm's conversion, she will scale demand accordingly. Let $H(\eta_i)$ be the scaling function, where $H' < 0$ and $\eta_i \equiv p_i^{(1)}/p_i^{(0)}$ indicates a firm's conversion. Scaled period 2 goodwill is given by $\tilde{G}\left(A_i^{(1)}, \eta_i\right) \equiv G\left(A_i^{(1)}\right) H\left(\eta_i\right)$.[11]

The following demand functions summarize our assumptions about the changeover:

$$\text{demand in period 1} \quad : \qquad c_i^{(1)} = \tilde{Q}\left(p_i^{(1)}\right) G\left(A_i^{(0)}\right) \tag{7}$$

$$\text{demand in period 2} \quad : \qquad c_i^{(2)} = Q\left(p_i^{(2)}\right) \tilde{G}\left(A_i^{(1)}, \eta_i\right) \tag{8}$$

where in period 1, the price elasticity is reduced $\left(\varepsilon^{(1)} < \varepsilon\right)$, but goodwill is unaffected by the changeover and in period 2, goodwill is scaled by the firm's first period conversion, but the primitive demand function (Q) is unaffected by the changeover.

Let $\frac{d \ln H}{d \ln \eta_i} \equiv q_i$ be the elasticity of the scaling function. We interpret this elasticity as the probability that a second period consumer has information about a firm's first period conversion. Equivalently, q_i is the fraction of firm i's customers with information about η_i. When $q_i = 0$, no customer has information and goodwill is not scaled. The more customers have information, the larger the effect on goodwill and thus on demand.

Note that 'cheating' is only profitable if consumers have difficulties observing η_i. similarly, lowering prices is only profitable if a sufficient number of consumers become aware of the price decrease. We assume that customer j has information about η_i if either she purchased in the shop herself in the previous period or if she learns from other buyers that have purchased there in the previous period. First consider the case where j was customer herself. Recall that a firm is characterized by its size (m_i) and its fraction of regular customers (ρ_i). Let the probability that customer j is customer of firm i be given by $t_i \equiv \Pr\left(j \in m_i\right)$. With the assumptions above, we have that $t_i = \rho_i + \left(1 - \rho_i\right)^2 \frac{m_i}{M - \rho_i m_i}$.

Now consider the case where customer j learns from another buyer. Let $k \in M$, $k \neq j$ be any other buyer different from buyer j and define $E \subset M$ the set of buyers that meet buyer j to exchange information about η_i. Let $\Pr\left(k \in E\right) \equiv r$ denote the probability that buyer j meets buyer k and suppose that coming across other consumers is a pure random process, so that $r = \frac{E}{M}$. Summing up, buyer j receives information from buyer k if both happen to meet and if k happens to have purchased in the shop in period 1, that is, if the set $\left(k \in M : k \in m_i \cap k \in E\right)$

[11] In this set-up the consumer compares period 1 prices with period 0 prices. This introduces incentives to alter period 0 prices, as discussed in section 2.2.1.

is non-empty. The probability that a second-period customer has information about η_i is then given by:

$$q_i = \Pr\left((j \in m_i) \cup \left(\cup_{k=1}^{M-1} (k \in m_i \cap k \in E)\right)\right)$$

which using the definitions above can be written as:

$$q_i = t_i + (1 - t_i)\left(1 - (1 - t_i r)^{M-1}\right) \tag{9}$$

In addition to the assumptions made in section 2.1, concavity requires $\varepsilon^{(1)} - q_i > 1$ and $\varepsilon_A < 1 - \frac{q_i}{\varepsilon^{(1)}-1}$, which we assume to hold. We can now state the following proposition.

Proposition 1. *When the firm's decision in period* 1 *affects both current and future (period* 2*) demand, the effective price elasticity of demand is given by:*

$$\tilde{\varepsilon}^{(1)} \equiv \varepsilon - \left(\kappa - q_i \beta \frac{A_i^{(1)}}{A_i^{(0)}}\right)$$

A proof can be found in the appendix. Proposition (1) is the main result of the model. Depending on the parameters, the effective elasticity may be larger or smaller than the pre-changeover elasticity, that is, $\tilde{\varepsilon}^{(1)} \gtrless \varepsilon$. The term in brackets can be both positive and negative and illustrates the firm's trade-off. A changeover can, thus, lead to higher and lower prices. Again, the price in period 1 is a mark-up over marginal costs, $p_i^{(1)} = \frac{\tilde{\varepsilon}^{(1)}}{\tilde{\varepsilon}^{(1)}-1}\phi$ and the Dorfman Steiner condition takes the same form as in equation (5) with ε replaced by $\tilde{\varepsilon}^{(1)}$. The decision about $p_i^{(1)}$ affects the decision about $A_i^{(1)}$ and $A_i^{(2)}$ and is itself affected by $A_i^{(1)}$, $A_i^{(0)}$ and $p_i^{(2)}$. The following proposition sums up the main comparative statics results.

Proposition 2. *Given the assumption about how the changeover affects demand (as summarized in equations (7) and (8)) and given the assumptions about how information is exchanged, the incentives to raise prices increase with consumers 'confusion', decrease with the probability that consumers observe a firm's conversion, with a firm's size, and with a firm's number of regular customers. That is:*

$$\frac{dp_i^{(1)}}{d\kappa} > 0, \quad \frac{dp_i^{(1)}}{dq_i} < 0, \quad \frac{dp_i^{(1)}}{dm_i} < 0, \quad \frac{dp_i^{(1)}}{d\rho_i} < 0$$

Moreover, the effect on prices disappears as the market becomes more competitive, that is:

$$\lim_{\varepsilon\to\infty} \eta_i = 1$$

A proof can be found in the appendix. The effect of competition on η_i is a possible explanation for why the changeover only affected some sectors (*e.g.* Ehrmann [2011]). Note that firms' market power does not affect the direction of the impact, but only whether or not we can expect one. The effect of ρ_i on η_i is what we called 'repeat purchases' in the introduction. Firms with only few regular customers are more likely to raise prices. Firm's size enters not because larger firms have more or less market power, but because of the way information proliferates.

2.2.1 The Effect on Period 0 Prices

In this section, we discuss the possibility that firms may have incentives to alter period 0 prices. Above we defined a firm's conversion rate as the ratio of period 1 to period 0 prices: $\eta_i = p_i^{(1)}/p_i^{(0)}$. When households take period 0 prices as their benchmark, firms have incentives to alter period 0 prices.[12] If we assume, for simplicity, that such a decision does not entail losses of goodwill, we can state the effect of the changeover on period 0 price elasticity as follows.

Proposition 3. *If we assume that period 2 goodwill can be influenced by a the firm's price decision in period 0, the effective demand elasticity in period 0 is given by:*

$$\tilde{\varepsilon}^{(0)} \equiv \varepsilon - \beta^2 q_i A_i^{(1)}/A_i^{(-1)}. \tag{10}$$

A proof is provided in the appendix. The changeover decreases period 0 elasticity, so that there are incentives to raise period 0 prices. The discount factor enters squared, which means that the effect is only of second order.

[12] Alternatively, we may assume that consumers are aware of a firm's marginal costs and its monopoly mark-up. In this case, there are no incentives to alter period 0 prices.

3 Empirical Analysis of Changeover Effects in Restaurants

A crucial prediction of the theoretical model is that the more a firm thinks that consumers (care and) notice about not being cheated in the conversion to the euro currency, the more that firm avoids exploiting their temporary confusion to increase prices. Moreover, in larger firms price increases would be less frequent than in small firms when a new currency is introduced. Empirically, one way to assess the impact of the changeover is comparing the differences in inflation between euro area countries and non-euro area countries (Dziuda and Mastrobuoni [2009]). However, as noted by Adriani et al. [2009], this strategy does not allow to reject other possible explanations for an increase in inflation differentials (*e.g.* inflation trend, menu costs). Moreover, we would like to test the presence of heterogeneity in pricing strategies at the euro cash changeover. Indeed, the theoretical model developed in section 2 suggests that some firm characteristics like size may explain this heterogeneity. To this aim, we need to analyze the euro effect conditional on individual characteristics of firms. We here focus on restaurant prices for three reasons: *(i)* the inflationary effects were significant in this sector (see for instance Attal-Toubert et al. [2002] or Gallot [2002] for the French case); *(ii)* there was a widespread perception among consumers that price increases were higher in this sector during the euro cash changeover, so consumers may have paid more attention to price changes in restaurants with respect to other sectors; *(iii)* we are able to distinguish in the restaurant sector between small family firms (traditional restaurants) and large firms (like fast food chains).

3.1 Data

To test the predictions of the theoretical model, we use a large longitudinal data set of restaurant prices. The sample is extracted from the data set of millions of monthly price quotes collected by the French National Statistical Institute (Insee) to compute the French Consumer Price Index (CPI) (see Baudry et al. [2007] for details). Each observation is the price of a specific item sold in a given firm collected by a interviewer of the Insee in a given month. Prices are always inclusive of service and value-added tax (VAT). An individual code is associated to a specific product in a given outlet, which allows us to follow a price trajectory over time.

We restrict our attention to restaurants. Our sample consists in more than 600 thousand monthly price quotes for more than 20 thousand items sold in about 4,500 different outlets. The time dimension of the data set is also quite long, covering the period from January 1996 to February 2003.[13] Compared to Gaiotti and Lippi [2004] or Adriani et al. [2009] who used restaurant guide data, our sample is representative of the restaurant sector, the number of observations is larger, the time dimension is longer, there might be less measurement issues and data provide more details on the different products sold by restaurants.

Prices for very different products sold in restaurants are available in the data set: meal, starters, main course, desserts, drinks sold in traditional restaurants and also meal sold in fast food restaurants or other self service restaurants. The meal in a traditional restaurant usually consists of a starter plus a main course, or a main course plus a dessert. In fast food restaurants it typically consists of a hamburger, French fries, and a soft drink.

In our benchmark empirical analysis, we compare traditional restaurants with fast food restaurants.[14] The two types of restaurants share many characteristics and price determinants, so that it is possible, at least to some extent, to partial out changes, for instance, in input prices. At the same time, the two types of restaurants are different in one crucial dimension. Fast food restaurants typically belong to chains that are relatively widespread and known, while traditional restaurants are often small and independent firms. This difference has important implications in the light of our theoretical model. Indeed, fast food restaurants are likely to be more concerned with compromising the reputation of a well-known chain by increasing prices in a period where consumers are especially sensitive. If consumers realize that a chain has taken advantage of the changeover, the consequences may be severe should the information spread. However, the word of mouth and media coverage about price increases of an independent restaurant is much less threatening. To compare these two types of restaurants, we will focus on prices of a meal in both kinds of restaurants. Indeed, in France restaurants display the meal price on the shop window and use specifically this price to attract consumers.[15]

[13]The original data set begins in July 1994, but in August 1995 a VAT increase occurred concerning only traditional restaurants, so we restrict our sample to January 1996-February 2003.

[14]We also consider cafeterias as part of the fast food category. Indeed, they are a type of food service location in which there is little or no waiting staff table service and they are usually located in supermarkets or malls. They often belong to chains. Moreover, the average price level of meals in fast food restaurants and main courses in cafeterias is very similar.

[15]Meal prices are also more systematically collected by the Insee than prices of other products sold in restaurants.

As far as data treatment is concerned, prices prior to January 2002 are converted from French franc to euro and rounded to the second decimal. Our aim is to measure how prices are converted from francs to euros and the extent to which they were increased or decreased around the period of the euro cash changeover. Our variable of interest is the price change, *i.e.*, the log difference of prices before and at the euro cash changeover. One important issue is to define the relevant period during which prices were converted into euros. On average prices change less than once a year in traditional restaurants, while in fast food restaurants every six months (see Fougere et al. [2010] for details). The actual date of firm's changeover decision is unobservable and it may be too restrictive to assume that all prices are converted to the euro exactly in January 2002. Thus, we allow the conversion period to be longer: restaurants could have modified their prices for the conversion some months before or after the euro cash changeover. We consider different assumptions for this period and construct different samples associated with those conversion periods. The most conservative assumption is that price conversions occurred between three months before and three months after the euro cash changeover, the sample contains price changes between September 2001 and March 2002 and we compare those price changes with price changes occurring between September of the year $t-1$ and March of year t in the 1996-2001 period. Another sample consists of price changes occurring between six months before and after the euro cash changeover (June 2001-June 2002 and we compare those price changes with price changes occurring between June of the year $t-1$ and June of year t in the 1996-2001 period. Our baseline sample is this 12-month-window sample, consistently with the typical duration of prices in restaurants. A last sample considers a wider window for the euro conversion corresponding to 18 months, *i.e.*, 9 months before (March 2001) and 9 months after (September 2002). This last sample allows to assess the longer term impact of the euro changeover on prices in the restaurant sector.

3.2 Stylized Facts

Fast food restaurants and traditional restaurants may be affected differently by the euro cash changeover. Our theoretical model predicts that fast food restaurants are less likely to increase their prices at the changeover relative to traditional restaurants. In our empirical analysis, we investigate the existence of significant differences around the changeover in the pricing strategies of fast food restaurants (control group) and traditional restaurants (treatment group).

Figure 1 shows the monthly average changes in meal price for traditional (dashed line) and fast food[16] (solid line) restaurants. The rate of monthly inflation for meals in traditional restaurants surged around the changeover from about 0.2% on average before 2002 to more than 1.2% around January 2002 whereas in fast food restaurants the inflation rate decreased from 0.2% on average before the currency changeover to 0% around January 2002. Notice that this observation is consistent with our theoretical model: traditional restaurants, that tend to be smaller firms than fast food restaurants, appear to have increased more their prices at the changeover. Another interesting fact is that in fast food restaurants, the inflation significantly increased just before and after the changeover (around 1% in July 2001 and in May 2002). This is consistent with the theoretical prediction that large firms may have incentives to raise their prices in period 0 and reduce them at the changeover (period 1).

To further investigate price movements around the changeover, we decompose the inflation rate: the monthly inflation rate could be higher because more firms change their prices (higher frequency of price changes) or because the firms increase their prices by more (larger average size of price changes when they change). The frequency of price changes was the same in both types of restaurants: in January 2002, around two thirds of restaurants modified their prices, whereas over the period 1996-2001 the frequency of price changes in January was on average 5% in traditional restaurants and 15% in fast food restaurants. The difference in inflation rates around the changeover was actually due to the differences in the proportion of price decreases: in traditional restaurants only 7% of price changes were decreases, whereas in fast food restaurants price reductions were as frequent as price increases. Since the size of price increases and decreases is roughly the same, fast food prices at the changeover were actually stable.

We now compare the distributions of price changes for meals before and around the euro cash changeover for both types of restaurants. We compute the density functions of price changes separately for traditional restaurants and fast food restaurants and we distinguish price changes around the changeover (between June 2001 and June 2002) and price changes

[16]We restrict the sample to meal price in fast food restaurants. The heterogeneity is slightly larger if including main price in cafeterias as well, without affecting qualitatively the results.

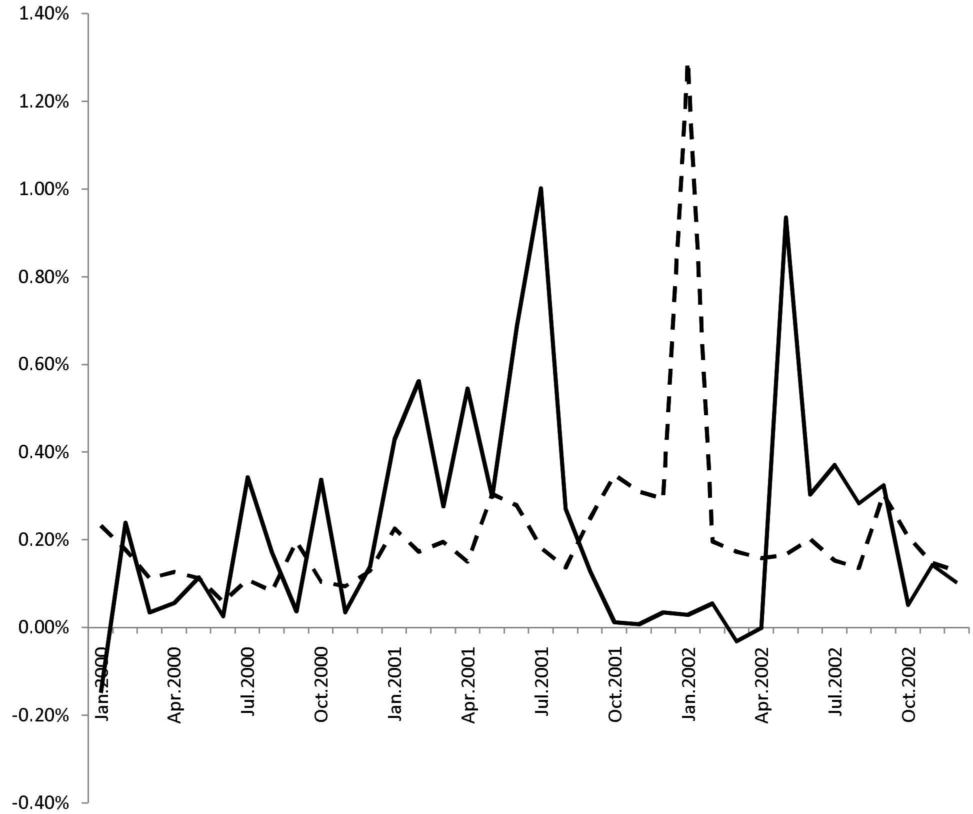

Figure 1: Monthly average price growth rate for meals in traditional (dashed line) and fast food (solid line) restaurants.

before the changeover (average price changes between June in year t and June in year $t-1$ for the period 1996-2001). We then compute the difference in density functions at the date of the changeover and before the changeover for both types of restaurants. Figure 2 shows these differences in density functions of price changes for traditional restaurants (dashed line) and fast food restaurants (solid line).

First of all, at the date of the currency changeover, we observe a drop in the proportion of no-change prices: in both types of restaurants, price changes were more frequent at the changeover than before. However, around the euro cash changeover the drop in the proportion of zero price changes was even more pronounced in traditional restaurants than in fast food restaurants. The fact that fast food restaurants avoided to some extent to change prices around the changeover can be rationalized in terms of our theoretical framework as a strategic investment in goodwill.

Second, the density for price increases in traditional restaurants is always above that of positive price changes in fast food restaurants. In other words, in traditional restaurants the

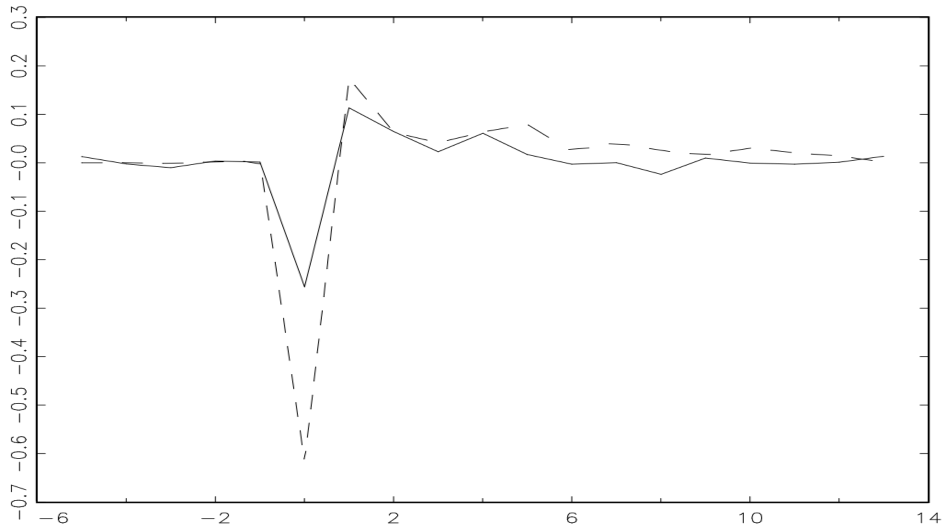

Figure 2: Density distribution of price changes for traditional (dashed line) and fast food (solid line) restaurants between a 1 year period centered around the changeover (June 2001 to June 2002) and the average of previous periods.

proportion of positive price changes around the changeover was larger than before. In traditional restaurants, the average difference in price changes at the euro cash changeover and before is large (2.52%), whereas in fast food restaurants this difference is far smaller (0.34%).

We compare the sample of price changes computed on a six-month window around the changeover (from September 2001 to March 2002) with price changes computed on a six-month window on the period 1996-2001. On average prices increased even less than usually in fast food restaurants during the changeover (-0.42%), while in traditional restaurants they increased much more than normally (+2.12%).

If we consider a larger period to compute price changes, the difference between price changes in fast food restaurants and price changes in traditional restaurants tends to disappear. Indeed, for the sample of price changes computed on a 18-month period around the changeover, in traditional restaurants, the average difference in price changes at the euro cash changeover and before is more than 3.5%, whereas in fast food restaurants this difference is now close to 3%. This last observation is consistent with our theoretical framework. Indeed, once attention to price conversion diminishes, firms go back to their normal pricing behavior and the difference-in-differences effect tends to disappear. All in all, these results suggest a positive effect of the euro cash changeover on prices in traditional restaurants.

3.3 Estimation Results

Based on the theoretical prediction of the model described in section 2, we expect the euro cash changeover to have a different impact on prices in fast food restaurants compared to traditional restaurants. Like Adriani et al. [2009] and Dziuda and Mastrobuoni [2009], we consider the introduction of the euro as the treatment. One difference is that they use data from non-euro area countries. However, Adriani et al. [2009] find small differences in inflation in restaurants between euro area and non-euro area countries.

Our baseline empirical model is the following:

$$\Delta p_{i,t} = \alpha + \beta\ EURO + \gamma\ TRAD.REST. + \delta\ EURO * TRAD.REST. + u_i + \tau\ Z_{i,t} + \epsilon_{i,t} \quad (11)$$

where $\Delta p_{i,t}$ is the log difference of prices in restaurant i between date t and $t-1$ (in our baseline model this difference is computed between September of the year $t-1$ and March t), $EURO$ is a dummy variable equal to one around the changeover (this variable captures temporal effects common to traditional and fast-food restaurants), *TRAD.REST.* is a dummy variable equal to one if the restaurant i is a traditional restaurant, 0 if it is a fast food restaurant (this variable captures systematic differences between traditional and fast food restaurants), and the dummy variable *EURO*TRAD.REST.* is the interaction between these two variables. We also add some control variables $Z_{i,t}$, like regional dummies and year dummies. The residual $\epsilon_{i,t}$ is normally distributed with zero mean and standard deviation σ_ϵ. The euro cash changeover effect is captured by the parameter δ, which measures the effect of the euro cash changeover on traditional restaurants conditional on other variables.

A first set of estimates is obtained by simple OLS technique with normal random individual effects u_i. We complement those regressions by estimating a Tobit model, which allows us to distinguish between the effect of the euro on the probability of price changes and the effect on the size of price changes. Results for the baseline model are presented in Table 1.

The effect of the euro cash changeover is significantly different between fast food restaurants and traditional restaurants. Around the euro cash changeover meal prices in traditional restaurants increased by 2.2% more than in fast food restaurants. This result is in line with the theoretical predictions: small family restaurants tend to increase their prices more than larger restaurants at the date of the euro cash changeover. Moreover, Tobit results suggest that the differences are significant both on the probability of price changes and on the size of price changes when prices are modified.

Table 1: Difference-in-differences regressions for meals in traditional and fast food restaurants (12 month-window).

	OLS	Tobit	Marg.prob.	Marg.size
Euro	-0.678***	-0.004	-0.004	-0.002
	(0.23)	(0.03)	(0.03)	(0.01)
Trad.Rest.	-0.279***	-0.158***	-0.126***	-0.075***
	(0.10)	(0.02)	(0.01)	(0.01)
Euro*Trad.Rest.	2.170***	0.360***	0.281***	0.199***
	(0.24)	(0.04)	(0.03)	(0.02)
Intercept	2.891***	0.637***		
	(0.22)	(0.04)		
σ_u	0.730	0.155***		
σ_ϵ	3.560	0.472***		
N	9768	9768		
R^2	0.063			
Log likelihood		-6258		

Note: Standard Errors in brackets. Significance levels: *: 10% **: 5% ***: 1%.
Year and regional dummies are included.

We now consider shorter and longer windows for the definition of the price changes (see Table 2). First, we find that the effect of the euro cash changeover is a little larger for the 6 month-window: prices increased by more than 2.5% in traditional restaurants than in fast food restaurants. The effect of the currency changeover instead tends to fade away when we consider longer time period for the price changes. The effect of the euro cash changeover, still positive and significant, is divided by 4 and prices increased only by 0.6% in traditional restaurants compared to fast food restaurants. This weak effect is consistent with our theoretical framework: fast food restaurants may have anticipated their price increases before the changeover, in order to keep them stable or even decrease them at the date of the changeover. On a 18-month time period, prices in fast food have increase only a little less than traditional restaurants and in the long term, inflation rates tend to be very similar, as predicted by the model.

3.4 Robustness Analysis

In this subsection we run some robustness exercises.

Table 2: Difference-in-differences regressions for meals in traditional and fast food restaurants (6 and 18 month-window).

	6 months		18 months	
	OLS	Tobit	OLS	Tobit
Euro	-0.709***	-0.040	3.630***	0.526***
	(0.19)	(0.05)	(0.24)	(0.03)
Trad.Rest.	-0.436***	-0.229***	-0.081	-0.122***
	(0.08)	(0.02)	(0.11)	(0.02)
Euro*Trad.Rest.	2.519***	0.675***	0.580**	0.158***
	(0.20)	(0.05)	(0.26)	(0.03)
Intercept	1.569***	0.220***	1.319***	0.334***
	(0.17)	(0.05)	(0.22)	(0.04)
σ_u	0.131	0.187	0.000	0.108
σ_ϵ	3.135	0.592	3.563	0.447
N	10917	10917	7923	7923
R^2	0.048		0.154	
Log likelihood		-5754		-4570

Note: Standard Errors in brackets. Significance levels: *: 10% **: 5% ***: 1%. Year and regional dummies are included.

3.4.1 Meal Versus Other Products

First, we should note that the comparison of traditional versus fast food restaurants does not completely overcome the difficulty of controlling for all the factors, beyond the changeover, which may have played a role in the observed price dynamics. Indeed, although traditional and fast food restaurants are likely to share many price determinants, it is impossible to rule out the eventuality that for instance some determinants have a stronger incidence in one type of restaurant than in the other.

Therefore, we also test the theoretical predictions with a complementary analysis that focuses on prices in traditional restaurants only. Within traditional restaurants, it compares price dynamics of meals and of a number of other items often sold there (main course, dessert, starter, wine). The idea underlying this empirical analysis is that not all the items sold in restaurants have the same visibility as far as their price is concerned. Indeed, the price of meals is often displayed outside restaurants, while the price of other items is much less likely to attract the attention of customers. Therefore, a further test of our main prediction consists in comparing the price evolution of meals with that of other less visible items sold by the same type of restaurants.

Price changes of products sold in traditional restaurants other than meals normally are less frequent than during the changeover and their distribution almost coincides across items. However, in the period going from six months before to six months after the changeover, the price of these products on average increased more than that of meals.

The estimated model distinguishing between prices of meals and prices of other products is very similar to the previous one; the only difference is that the dummy variable *TRAD.REST.* is substituted by the dummy variable *MEAL*. Results are presented in Table 3. We find that prices of other products increased significantly more around the euro cash changeover than prices of meals. The difference is estimated to be closed to 0.7%.

Table 3: Difference-in-differences regressions for meals and other products sold in traditional restaurants (12 month-window).

	OLS	Tobit	Marg.prob.	Marg.size
Euro	1.857***	0.433***	0.317***	0.208***
	(0.15)	(0.02)	(0.01)	(0.01)
Other Prod.	0.063	-0.124***	-0.088***	-0.046***
	(0.07)	(0.01)	(0.01)	(0.00)
Euro*Other Prod.	0.686***	0.070***	0.051***	0.027***
	(0.18)	(0.02)	(0.02)	(0.01)
Intercept	2.220***	0.367***		
	(0.18)	(0.03)		
σ_u	0.922	0.184***		
σ_ϵ	4.013	0.497***		
N	16087	16087		
R^2	0.067			
Log likelihood		-9724		

Note: Standard Errors in brackets. Significance levels: *: 10% **: 5% ***: 1%.
Year and regional dummies are included.

3.4.2 Touristic Versus Other Restaurants

In our theoretical framework, a consumer in the days after a currency changeover faces new absolute prices and fears being fooled by sellers, just like a tourist in a foreign country with an unfamiliar currency. Like a tourist, the buyer may have to pay higher prices until some familiarity toward the new absolute price level sets in. Unlike a tourist, however, the typical consumer is likely to have a regular relationship with sellers. This makes fooling risky, as the seller may damage his reputation as a fair trader. Therefore, we expect that at the euro

Table 4: Difference-in-differences regressions for meals and other products sold in traditional restaurants (6 and 18 month-window).

	6 months		18 months	
	OLS	Tobit	OLS	Tobit
Euro	1.874***	0.646***	4.323***	0.720***
	(0.13)	(0.03)	(0.15)	(0.02)
Other Prod.	0.124*	-0.114***	0.051	-0.121***
	(0.07)	(0.02)	(0.08)	(0.01)
Euro*Other Prod.	0.673***	0.064**	0.398**	0.061**
	(0.15)	(0.03)	(0.19)	(0.02)
Intercept	1.180***	-0.030	1.085***	0.149***
	(0.16)	(0.04)	(0.19)	(0.03)
σ_u	1.044	0.200	0.000	0.146
σ_ϵ	3.642	0.591	4.007	0.465
N	18086	18086	12881	12881
R^2	0.06		0.149	
Log likelihood		-8528		-6972

Note: Standard Errors in brackets. Significance levels: *: 10% **: 5% ***: 1%.
Year and regional dummies are included.

cash changeover prices in restaurants in touristic locations behave differently from prices in restaurants where customers eat on a regular basis. Indeed, in the former onces restaurant owners have incentives to benefit from confusion at the date of the changeover.

Following Adriani et al. [2009], we run another exercise focusing on restaurants in tourist locations. Contrary to Adriani et al. [2009], our data set does not contain any indication of whether a given restaurant is located in a touristic region. To identify restaurants in touristic areas, we choose the following strategy: first we restrict our sample to prices of meals in traditional restaurants and to restaurants located in départements[17] which are on the coast (*i.e.*, one quarter of the total number of départements). We consider that in this whole area the touristic period is the summer, between June and September. We define non-touristic restaurants the restaurants that are usually closed during the summer period[18] in coast départements. We can then compare restaurants that are in touristic areas and do not close in summer with restaurants in touristic locations but closed in summer, which are more likely to have regular customers. Based on a specification similar to (11), we find that there is a significant impact of the location

[17]A département is an administrative zone. There are 96 départements in France. Each has approximately the same geographical size (6,000 km^2, *i.e.*, four times an American county and three times an English county), but population differs.

[18]We exploit a variable recorded by the Insee indicating whether the restaurant is open or not.

of the restaurant on price change at the date of the euro cash changeover for price changes computed on 6-month and 18-month window (close to 1%); however, the effect is smaller on the 12-month period and non significant (see Table 5). These results seem to confirm than in restaurants where consumers pay less attention to prices, price setters may have incentives to raise their prices more than in restaurants with regular customers.

Table 5: Difference-in-differences regressions for touristic and non-touristic restaurants (6, 12, and 18 month-window).

	6 months OLS	12 months OLS	18 months OLS
Euro	1.414***	1.302***	3.361***
	(0.29)	(0.34)	(0.35)
Touristic	0.036	0.031	0.058
	(0.13)	(0.17)	(0.18)
Euro*Touristic	0.923***	0.592	1.044**
	(0.33)	(0.39)	(0.42)
Intercept	1.262***	2.447***	0.930***
	(0.22)	(0.28)	(0.28)
σ_u	0.248	0.846	0.504
σ_ϵ	3.160	3.500	3.616
N	3003	2685	2188
R^2	0.073	0.070	0.148

Note: Standard Errors in brackets. Significance levels: *: 10% **: 5% ***: 1%. Year and regional dummies are included.

4 Conclusions

In this paper, we propose a model which is able to rationalize heterogeneity in price conversion at the euro cash changeover. The key ingredients of the model are the following: *(i)* buyers have difficulties in observing the new absolute price and we assume that the demand elasticity is temporarily lower at the changeover; *(ii)* information is not perfect, customers realize that a price has increased only if he was a customer in the previous period or if he knows someone that was a customer; *(iii)* a firm may damage its reputation by increasing prices at the euro cash changeover and it may have some incentives to lower its prices to attract customers. Our model predicts that both increasing and decreasing prices may be optimal depending on the firm's environment. Firms with a large share of regular customers are more likely to lower their prices. The firm's size plays a role because of the way information proliferates: a random exchange of information generates a bias toward larger firms.

We use a large data set of individual price quotes from French restaurants to test the predictions of the model. We provide some evidence supporting our model. During the euro changeover in 2002, small traditional restaurants were more likely to increase their prices than fast food restaurants. Price decreases were more frequent in fast food restaurants at the euro cash changeover than before whereas we do not observe more price decreases in small traditional restaurants. We also find that the inflationary effect of the euro tends to fade away over time. We also run some robustness exercises. We find that in traditional restaurants, the price increases were less frequent for prices of menus than for other products sold by the restaurants. This can be explained by our model, prices of meals might more carefully observed by customers than other goods. Finally, we find that in touristic restaurants which have fewer regular customers, price increases were more common than other restaurants in the same region. We focus on the restaurant sector in the empirical part mainly because the impact there was especially pronounced. The model's predictions are, however, more general. The prediction that a firm's clientele or its size influences its pricing behavior seems plausible for other sectors as well.

Appendix

Concavity of the firm's pre-changeover problem: Given that we assumed full depreciation of goodwill, sufficient conditions for concavity in the pre-changeover problem are that $\varepsilon > 1$ and $\varepsilon_A \in (0,1)$. The mixed partial derivative equals zero: $\frac{\partial^2 \pi}{\partial A_i^{(0)} \partial p_i^{(0)}} = 0$.

The Firm's Problem at the Changeover: In period 1 the firm maximizes profits taking into account that its price-decision affects goodwill in the following period. The problem is:

$$\max_{p_i^{(1)}, A_i^{(1)}} \quad \left(p_i^{(1)} - \phi\right) c_i^{(1)}(\cdot) - wA_i^{(1)} - f + \beta\left(\left(p_i^{(2)} - \phi\right) c_i^{(2)}(\cdot) - wA_i^{(2)} - f\right).$$

Rearranging the first order conditions gives equations (A-1) and (A-2).

$$p_i^{(1)} = \frac{\tilde{\varepsilon}^{(1)}}{\tilde{\varepsilon}^{(1)} - 1}\phi. \tag{A-1}$$

$$\frac{\beta \varepsilon_A}{\varepsilon^{(2)}} = \frac{w A_i^{(1)}}{p_i^{(2)} c_i^{(2)}}. \tag{A-2}$$

Concavity requires that:

$$\begin{aligned}
\varepsilon^{(1)} - 1 &> q_i, \\
1 - \frac{q_i}{\varepsilon^{(1)} - 1} &> \varepsilon_A \in (0, 1), \\
\tilde{\varepsilon}^{(1)} &> 1.
\end{aligned}$$

The second partial derivative with respect to $p_i^{(1)}$, simplifies to:

$$\left(\frac{\varepsilon^{(1)} - q_i}{\varepsilon^{(1)} - q_i - 1} \right) \left(\frac{\varepsilon^{(1)}}{\varepsilon^{(1)} - 1} \right) > \left(\frac{\tilde{\varepsilon}^{(1)}}{\tilde{\varepsilon}^{(1)} - 1} \right)$$

where $\frac{\varepsilon^{(1)}}{\varepsilon^{(1)}-1}$ is the maximal mark-up in period 1, $\frac{\tilde{\varepsilon}^{(1)}}{\tilde{\varepsilon}^{(1)}-1}$ is the effective mark-up and $\frac{\varepsilon^{(1)}-q_i}{\varepsilon^{(1)}-q_i-1}$ defines a lower bound on $\varepsilon^{(1)}$. Concavity thus requires that $\varepsilon^{(1)}$ is not too low. With this condition satisfied, $\frac{\partial^2 \Pi}{\partial p_i^{(1)} \partial p_i^{(1)}} < 0$ as needed. The second partial derivatives with respect to $A_i^{(1)}$ and the cross derivatives are given by:

$$\begin{aligned}
\frac{\partial^2 \Pi}{\partial A_i^{(1)} \partial A_i^{(1)}} &= (\varepsilon_A - 1) \frac{w}{A_i^{(1)}} \\
\frac{\partial^2 \Pi}{\partial p_i^{(1)} \partial A_i^{(1)}} &= -q_i \frac{w}{p_i^{(1)}}.
\end{aligned}$$

Given the restrictions on $\varepsilon^{(1)}, \varepsilon_A, q_i$ and β, the Hessian matrix, given by:

$$\begin{pmatrix}
\frac{\partial^2 \pi}{\partial p_i^{(1)} \partial p_i^{(1)}} & \frac{\partial^2 \Pi}{\partial p_i^{(1)} \partial A_i^{(1)}} \\
\frac{\partial^2 \Pi}{\partial p_i^{(1)} \partial A_i^{(1)}} & \frac{\partial^2 \Pi}{\partial A_i^{(1)} \partial A_i^{(1)}}
\end{pmatrix}$$

is negative definite.

Comparative Statics: First note that $p_i^{(2)}$ is independent of the other endogenous variables reducing our system of endogenous variables to 3 equations given by (A-3), (A-4) and (A-5) below:

$$c_i^{(1)} = \frac{wA_i^{(0)}}{\beta\varepsilon_A\left(p_i^{(1)}-\phi\right)} \tag{A-3}$$

$$p_i^{(1)} = \frac{\left(\varepsilon^{(1)}+q_i\beta\frac{A_i^{(1)}}{A_i^{(0)}}\right)}{\left(\varepsilon^{(1)}+q_i\beta\frac{A_i^{(1)}}{A_i^{(0)}}\right)-1}\phi \tag{A-4}$$

$$c_i^{(2)} = \frac{\left(\varepsilon^{(2)}-1\right)wA_i^{(1)}}{\beta\varepsilon_A\phi} \tag{A-5}$$

We solve the system by Cramer's rule after linearizing it by total differentiation. Let the vector of endogenous variables be $v=\left(dp_i^{(1)}, dA_i^{(0)}, dA_i^{(1)}\right)$. The system to solve is then given by $\Omega v' = E$, where Ω is a 3×3 matrix of first partials and E is a vector of exogenous variables. Showing that the determinant Ω is positive, reduces to showing that

$$\left(\tilde{\varepsilon}^{(1)}-\varepsilon^{(1)}-q_i\right)\frac{\left(\tilde{\varepsilon}^{(1)}-\varepsilon^{(1)}\right)}{\tilde{\varepsilon}^{(1)}} > -\left(\tilde{\varepsilon}^{(1)}-1\right)\left(1-\varepsilon_A\right).$$

Recall that concavity requires $q_i < \left(\tilde{\varepsilon}^{(1)}-1\right)(1-\varepsilon_A)$. Combining both and rearranging gives:

$$-\varepsilon^{(1)}q_i < \left(\tilde{\varepsilon}^{(1)}-\varepsilon^{(1)}\right)^2$$

which holds since all parameters are assumed positive.

It is straightforward to show that $\frac{dq_i}{dm_i}>0$ and $\frac{dq_i}{d\omega_i}>0$.

The Effect of the Changeover on $p_i^{(0)}$: The firm's period 0 problem is:

$$\max_{p_i^{(0)},A_i^{(0)}} \left(\left(p_i^{(0)}-\phi\right)c_i^{(0)}(\cdot)-wA_i^{(0)}-f\right)+\beta^2\left(\left(p_i^{(1)}-\phi\right)c_i^{(2)}(\cdot)-wA_i^{(1)}-f\right).$$

Rearranging the first order conditions gives equation (10) in the main text.

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