In this paper, we examine the effect of the minimum wage on restaurant prices. We contribute both to the study of economic impact of the minimum wage and to the study of microeconomic patterns of price stickiness. For this purpose, we use a unique data set of individual price quotes collected to calculate the Consumer Price Index in France and we estimate a price rigidity model based on a flexible $(S, s)$ rule. We find a positive and significant impact of the minimum wage on prices. The effect of the minimum wage on prices is, however, very protracted. A change in the minimum wage takes more than a year to fully pass through to retail prices.

**JEL codes:** D43, E31, L11

**Keywords:** price stickiness, minimum wage, inflation, restaurant prices.

The economic effects of the minimum wage are at the heart of a long-lasting controversy. Recent and influential works by Katz and Krueger (1992) and Card and Krueger (1994) have revived this controversy. Focusing on U.S. fast-food restaurants, in which employees paid the minimum wage are a substantial part of the labor force, they find little evidence of an effect of the minimum wage on employment. Neumark and Wascher (2000) dispute their result. Using payroll

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data, they found evidence of a negative employment effect. Card and Krueger (2000) subsequently challenge this result by using the same payroll data. Although most of the controversy focuses on the impact of the minimum wage on employment (Brown 1999), changes in the minimum wage may have an impact on prices as well. However, evidence on the price effect of the minimum wage is relatively scant for the moment (Lemos 2008). In the case of fast-food restaurants, available evidence include papers by Card and Krueger (1994) and by MacDonald and Aaronson (2006).

The present paper uses individual price quotes and a microeconometric approach to assess the impact of the minimum wage on prices in restaurants in France. Like in the United States, French restaurants are well suited for assessing the effect of minimum wage increases since the proportion of employees paid at the minimum wage is high in this industry (around 40%). Moreover, wage setting is not affected by collective bargaining in restaurants, because collective agreements are very scarce in this industry composed of very small firms. Our price data set is unique and consists of thousands of monthly price quotes collected in restaurants between 1994 and 2003 by the French Statistical Institute (Insee, Paris) to compute the Consumer Price Index (see Baudry et al. 2007 for an overall analysis of price stickiness using these data).

The contribution of our paper is twofold. First, we provide new estimates of impact of minimum wage increases on prices by using microdata. This approach was introduced by Katz and Krueger (1992) and Card and Krueger (1994), who use a difference-in-differences estimation strategy. More recent studies use panel data with a larger time dimension. For instance, using BLS data, MacDonald and Aaronson (2006) find a positive and fast impact of the minimum wage on prices. Using the same type of data, our econometric strategy is, however, different since we build a microeconometric nonlinear model that accounts for both the infrequency of price adjustments and the size of price changes. This strategy allows us to better capture delayed effects of the minimum wage on prices and to analyze the aggregation of nonlinear pricing rules adopted by heterogenous agents.

Our paper also adds to the empirical literature on price rigidity. Price rigidity is a crucial issue in macroeconomics. Macroeconomic dynamics after a shock typically depend on microeconomic features, like price-setting behavior of the firms (see, e.g., Goodfriend and King 1997). A recurrent challenge for economists is to understand the mechanisms underpinning the infrequency of price adjustments. In particular,

1. Since the minimum wage in France is binding at the national level, all firms are equally concerned. Thus, there is no possibility to apply a difference-in-differences methodology requiring the existence of a valid control group.

2. Another possibility is to use aggregate sectoral data. Adopting this approach, Lee and O’Roarke (1999) find a significant effect of the minimum wage on prices. Aaronson (2001) uses time-series reduced-form equations for estimating the reaction of the price subindices of the Consumer Price Index (CPI) (in the U.S. and Canada) to an increase of the minimum wage. He obtains some evidence of a lagged and positive impact of minimum wage increases on prices.
price changes in the services sector are known to be rare. In the euro area and in
the United States, only 5.6% and 15% of service prices are, respectively, modified
each month (compared with 15% and 25% for prices composing the overall CPI).
Restaurant prices are a particularly sticky component of services, with respective
frequencies of price changes of 4.7% and 9.0% (Bils and Klenow 2004, Dhyne
et al. 2006). Restaurant prices thus appear as an ideal item for assessing price rigidity
models. In addition, industries with very sticky prices are of particular interest from
a monetary policy perspective: Aoki (2001) shows that the optimal monetary policy
should put more emphasis on stabilizing the inflation rate in the stickiest sectors.
Some recent papers have looked at restaurant prices with a sticky price perspective.
For instance, Gaiotti and Lippi (2005) and Hobijn, Ravenna, and Tambalotti (2006)
propose theoretical models to explain the pricing behavior of restaurants during the
euro cash changeover. Using microdata for European and Italian restaurants, they
build and calibrate theoretical models to test different theoretical assumptions and
provide some insights into the mechanisms underpinning the inflation peak at the
euro cash changeover date. Goette, Minsch, and Tyran (2005) report some empirical
evidence about the price adjustment of various items sold in Swiss restaurants. They
show that the size of price changes does not respond to inflation while the key
variable in the variability of inflation seems to be the frequency of price changes. Our
contribution is to estimate a microeconometric model that links restaurant prices to
costs. By contrast, many empirical studies of price adjustment approximate marginal
cost using a sectoral inflation rate (see, e.g., Cecchetti 1986, Fougère, Bihan, and
Sevestre 2007) or an unobserved synthetic factor (Dhyne et al. 2007). Here, the large
proportion of workers paid the minimum wage in French restaurants motivates our
focus on the minimum wage as a relevant measure of firms’ marginal cost. We are
then able to determine to what extent observed price stickiness in this industry may
result from cost stickiness.

Our main findings are the following. The minimum wage has a positive and
significant impact on prices in restaurants, in line with the weight of low-wage
labor in total costs. However, contrary to other studies, we exhibit a protracted
impact of the minimum wage on prices. Changes in the minimum wage can
take more than a year to pass through to retail prices. As a result, stickiness
in restaurant prices is not just the mere reflection of stickiness in its main
determinants.

The next section presents the data set used as well as the main features of restaurant
price adjustments in France. Section 2 motivates our econometric strategy, namely,
to rely on a microeconometric model rather than on time-series analysis. Section 3
presents our econometric model of price rigidity. Estimation results of the model are
shown in Section 4. In Section 5, we simulate the model to assess its overall fit and the
aggregate effect of the minimum wage on prices. We compare the response obtained
from these microsimulations with those obtained from a linear model estimated with
aggregate data.
1. DATA

1.1 Restaurant Prices

Data sources. Our data are extracted from a longitudinal data set of monthly price quotes collected by the French Statistical Institute (Insee, Paris) from July 1994 to February 2003 to compute the CPI. Each observation is the price of a specific item (here a menu or a course) in a particular outlet (here a restaurant). Prices are inclusive of all taxes. Along with the price level, an individual product code (the outlet and the product category), the year and the month of the record are also available; they allow us to follow the price of a product through time. Prior to estimation, some specific data treatments have been done. Due to holidays, “missing” prices are quite frequent. The French Statistical Institute (Insee, Paris) generally replaces them with the average price observed in other outlets in the same area. But this procedure may introduce some spurious price changes. Thus, we assume that the price does not change when the restaurant is temporarily closed. As the euro cash changeover is included in our observation period, we divide all prices recorded before 2002:1 by 6.55957, the official French franc/euro exchange rate. Details on data treatments are provided in Baudry et al. (2007) and Fougère, Bihan, and Sevestre (2007).

Our analysis is focused on restaurant prices. We distinguish between traditional and fast-food restaurants, since the pricing strategy of these two types of outlets is markedly different, as shown later. Several types of items are observed in our data set: hors d’œuvre, desserts, main course, wine, meals in traditional restaurants, and meals in fast-food restaurants. We choose to restrict our sample to full meals in traditional and fast-food restaurants since they are the most representative items, and because data on full meals are more systematically recorded in restaurants (while the other items may not be systematically reported). The meal in a traditional restaurant typically consists of a starter plus a main course or a main course plus a dessert. In fast-food restaurants, it consists of a hamburger, french fries, and a soft drink. Prices in restaurants are always inclusive of service and value-added tax (VAT). Note that the VAT rate for take-away food is lower than for traditional restaurants (5.5% versus 19.6%). Our database contains 93,816 price quotes for the item “menu in a traditional restaurant,” corresponding to 2,948 different restaurants, and 10,726 observations for the item “menu in a fast-food restaurant,” corresponding to 448 different fast-food restaurants.

Figure 1 displays examples of actual price trajectories for a full meal in traditional restaurants. Price changes do not occur continuously. This pattern is quite typical of sticky prices: long periods of price stability are interspersed with small or large price increases. In the following section, we document the main characteristics of price rigidity in traditional and fast-food restaurants.

Patterns of price rigidity. The frequency of price changes is generally considered as a good indicator of price rigidity (e.g., Bils and Klenow 2004, Dhyne et al. 2006). In our sample, traditional restaurant prices and, to a lesser extent, fast-food prices are very rigid. On average, around 4% of traditional restaurant prices and 9.4% of
fast-food prices are modified each month in France, compared to around 19% on average for all CPI price quotes (Baudry et al. 2007). As a result, the duration of a price spell is on average equal to 2 years in traditional restaurants and to less than 1 year in fast-food restaurants (see Table 1). This result is quite consistent with previous findings in the United States and in the euro area. Using U.S. data, MacDonald and Aaronson (2006) find that around 13% of restaurant prices change every 2 months, implying a monthly frequency of price changes equal to 6.5%. For the euro area, Dhyne et al. (2006) report a frequency equal to 4.7%. Owing to this apparently high degree of stickiness, restaurant prices seem to be a good candidate for the estimation of price rigidity models.

The infrequency of price changes is often explained by the existence of price adjustment costs. As noticed by Fisher and Konieczny (2006), these costs can be divided into three categories. First, some costs, called menu costs, are associated...
with printing new menus or labels. The second category includes the costs of the
decision-making process, for example, collecting information, analyzing changes in
the “optimal” nominal price in the absence of adjustment costs, and deciding the
amount of the price change. The last type of costs could occur in the event of an
unfavorable reaction from customers to price increases; these costs could be called
“antagonization costs.” In restaurants, these three types of costs are likely to be
at stake. Note that in traditional restaurants, managers may choose to decrease the
quantity or quality of food in their standard menu as a substitute to a price increase.
This reaction would strengthen the case for antagonization costs associated with price
changes. Such a strategy is however not possible for standardized products like fast-
food restaurant items, which may rationalize the higher degree of price stickiness in
traditional restaurants.

Figure 2 displays the frequency of price changes over time for the two types of
restaurants considered here. The frequency of price changes is quite stable over time,
except in some specific months. In the case of traditional restaurants, the frequency
of price changes has noticeable peaks in January and September, the frequency value
being around 5% in these 2 months versus around 3% in other months.3 In fast-food
restaurants, the frequency of price changes displays less regular patterns. However, in
January, February, and July, around 10% of prices are modified, against less than 7%
on average during the year.4 Such seasonal price changes may result from the costs
associated with the price-change decision. As documented by Zbaracki et al. (2004),
adjusting prices is a long process which can last a whole year because managers have
to collect information on competitors and monitor the cost developments. Moreover,
as shown by Müller et al. (2010), the opportunity cost of adjusting prices may increase
in some periods of the year in which managers face a higher store traffic (e.g., during
holidays). So, managers may prefer revising their prices according to a discrete-time
process (in specific periods of the year) rather than continuously (see Fisher and
Konieczny 2006 for some empirical evidence). In our case, January and September
correspond to the reopening of traditional restaurants after holidays. Price changes
during these months would then be less costly.

The distribution of price changes. A specific feature of price changes in services
is the low proportion of price decreases: 20% of price changes are decreases while
this proportion is around 40% for the whole CPI (Baudry et al. 2007). The degree
of downward price rigidity is even higher in traditional restaurants: more than 90%
of price changes are increases and only 10% are price decreases. Prices in fast-food
restaurants also exhibit, though to a lesser extent, some nominal downward rigidity.
In fast-food restaurants, 24% of price changes are price decreases. Two interpre-
tations for nominal downward rigidity can be invoked. First, marginal costs may
rarely decrease. Second, it could also be a consequence of customer antagonization

3. This calculation does not take account of years 2002 and 2003, which have very specific patterns
due to the impact of the euro cash changeover.
4. This calculation does not take account of years 2002 and 2003. See the previous footnote.
Fig. 2. (a) Frequency of Price Changes in Traditional Restaurants. (b) Frequency of Price Changes in Fast-Food Restaurants.

costs: Rotemberg (2005) develops a model in which consumers may react negatively to price changes and Zbaracki et al. (2004) show the empirical relevance of these antagonization costs. A restaurant manager may then be reluctant to reduce the price immediately if he/she expects that the price will rise again in the future, which implies that the adjustment cost will have to be paid again. Although it is unlikely that a price decrease would entail customer anger, one can assume that the prospect of future antagonization costs could prevent current price decreases.

The distribution of price changes is represented in Figure 3. While a simple menu-cost framework would suggest that, as price changes are rare, the size of price changes should be rather large, we observe that the proportion of small price changes is substantial. Around 25% of the price increases are smaller than 1.6% in traditional restaurants and smaller than 1.3% in fast-food restaurants (Table 2). We also note that the average size of a price decrease is larger than the size of a price increase (Table 2). The distribution of price changes is also characterized by a noticeable proportion of large price changes: in traditional restaurants, 10% of price increases are larger than 8% (while 10% of price decreases are smaller than $-13\%$). One possible interpretation is that although customers may react more strongly to a large price increases than to small repeated price increases, some firms may prefer implementing large price changes because of fixed costs associated with price changes.
Table 2
Size of Price Changes (%)

<table>
<thead>
<tr>
<th></th>
<th>Sample size</th>
<th>$\Delta P_{90}$</th>
<th>$\Delta P_{75}$</th>
<th>$\Delta P_{50}$</th>
<th>$\Delta P_{25}$</th>
<th>$\Delta P_{10}$</th>
<th>$\Delta P_{av}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional restaurants</td>
<td>$\Delta P^-$</td>
<td>340</td>
<td>-13.36</td>
<td>-8.54</td>
<td>-3.95</td>
<td>-1.30</td>
<td>-0.26</td>
</tr>
<tr>
<td></td>
<td>$\Delta P^+$</td>
<td>3,909</td>
<td>8.00</td>
<td>5.25</td>
<td>3.18</td>
<td>1.65</td>
<td>0.30</td>
</tr>
<tr>
<td>Fast-food restaurants</td>
<td>$\Delta P^-$</td>
<td>269</td>
<td>-7.55</td>
<td>-5.09</td>
<td>-2.78</td>
<td>-0.95</td>
<td>-0.55</td>
</tr>
<tr>
<td></td>
<td>$\Delta P^+$</td>
<td>844</td>
<td>5.88</td>
<td>3.66</td>
<td>2.82</td>
<td>1.29</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Note: In the calculations, price changes equal to zero are not taken into account. Price increases $\Delta P^+$ and decreases $\Delta P^-$ are considered separately. $\Delta P_{90}$ is the 90th percentile of the distribution; $\Delta P_{75}$ is the 75th percentile of the distribution; $\Delta P_{50}$ is the median of the distribution; $\Delta P_{25}$ is the 25th percentile of the distribution; $\Delta P_{10}$ is the 10th percentile of the distribution; $\Delta P_{av}$ is the average price change.

To sum up, large price changes are common and small price increases are not rare. MacDonald and Aaronson (2006) observe similar patterns for U.S. restaurant prices: the price change distribution is asymmetric, the proportion of small price changes is important, 12% of price changes are large (above 10%), and the average size of price increases is smaller, in absolute value, than the average size of price decreases.

1.2 Determinants of Price Changes

Our aim is to investigate determinants of price changes. Following Cecchetti (1986) and Ratfai (2006), we assume that the price adjusts infrequently to an unobserved optimal “frictionless” price that depends on the structure of costs and demand. This optimal price is typically defined by a markup over marginal costs. Our starting point is that, in restaurants, labor costs and input costs (food prices) are the main elements of marginal costs.

Labor costs and the minimum wage. We expect labor costs to be a major element of costs in restaurants. According to national accounts, the share of total compensation in costs is around 40% in traditional restaurants and 33% in fast-food restaurants (on average between 1997 and 2002). For fast-food restaurants, we can also use Parsley and Wei’s (2007) cost function estimation for Big Mac hamburgers (a standardized product) as another benchmark. They find that labor costs represent around 46% of total costs.

In French restaurants, most of the labor costs consist of the wages of employees paid the minimum wage. In restaurants and hotels, more than 40% of employees are paid the minimum wage (DARES 2003). This ratio is particularly high as compared to the national proportion of employees paid the minimum wage, which lies between 12% and 15% over the observation period. Moreover, minimum wage increases may spill over to wages of employees above the minimum wage. Koubi and Lhommeau (2006) find that the elasticity for restaurants and hotels is estimated at 0.7, for wage levels lower than 1.1 times the minimum wage. This implies that a minimum wage increase is expected to indirectly but rapidly affect a wider share of labor costs in restaurants.
In France, the minimum wage (SMIC, Salaire Minimum Interprofessionnel de Croissance) is set at the national level. It applies to all employees and types of firms, and minimum wage increases are binding. The minimum wage is raised each year in July according to a legal rule, which is based on the partial indexation to past inflation and to past wage growth. Besides these indexation procedures, the government may decide on a discretionary basis to amplify the raise. Over the sample period, the minimum wage was mostly changed in July, except in 1996 when it was also increased in May. We observe some variability among the minimum wage increases over the period: most of the minimum wage increases were in the interval $+1.2\%$ to $+4\%$ (see Figure 4). Over the period, the minimum wage increases were on average higher than the overall wage growth. In parallel, the successive French governments implemented policies that consisted in reducing employer social security contributions on low wages. For instance, the employer social security contribution rate at the level of the minimum wage was brought from $24.8\%$ to $12.0\%$ in September 1995 and to $4.2\%$ in January 2003.\(^5\) The index for the labor cost at the minimum wage level that we use hereafter takes into account this rate.

Measuring wages and costs in the restaurant industry raises specific issues, which could bias the estimated impact of the minimum wage on labor costs. First, it is

\(^5\) Contribution rates are taken from OFCE (2003, table 1, p. 230).
known that a fraction of restaurant employees are hired on the black market. But we can assume that the wage level on the black market is proportional to the minimum wage level. Second, tips are not reported in the available price quotes. Tips are however a limited concern since a service charge is included in restaurant prices; thus, tips may contribute to the incomes of employees, but they do not affect restaurant cost functions. They may affect restaurant decisions only indirectly, through the opportunity to offer a lower wage against the payment of tips. In addition, tips are optional and there is no standard convention or social norm in France as to their level. Our assessment is that tips are unlikely to bias our estimates.

*Other costs, demand, and specific events.* Another obvious cost consists of food inputs. For fast-food restaurants, Parsley and Wei (2007) find that food inputs represent 31.6% of costs to produce a Big Mac hamburger. In this study, we use an aggregate price index to approximate the price of inputs, namely, the producer price index of food over the sample period. We also incorporate a control variable to represent the demand level. More precisely, we use the volume of total sales in traditional and fast-food restaurants. These two monthly series are published by the French Statistical Institute (Insee, Paris).

Two changes in VAT rates occurred during the observation period. They may have had an impact on the pricing policy of restaurants. In August 1995, the standard VAT rate was raised from 18.6% to 20.6%, while in April 2000 it was lowered from 20.6% to 19.6%. We construct two dummy variables for these changes. These changes may have had nontrivial impact in presence of menu costs. For instance, restaurants may cluster price changes planned otherwise at the time of the tax change. Consumers could also be more likely to accept a price rise at the time of a tax increase because the tax increase is a macroevent observable by them. Note that the VAT rate for take-away food is 5.5%, so that fast-food restaurants are expected to be much less affected by changes in VAT. The standard fast-food restaurant policy is to post the same tax-included price for a given item, either for take-away or dine-in. In the case of fast-food restaurants, the relevant VAT rate is a weighted average of the regular and low rate.

Finally, a dummy variable for the euro cash changeover that occurred in January 2002 as well as two other dummies for the period just before and just after the introduction of the euro are included. At the time of the euro cash changeover, all restaurants had to change their nominal prices due to the currency conversion. As already noticed by Hobijn, Ravenna, and Tambalotti (2006), who consider restaurants in the euro area, such an event forces firms to pay a menu cost and then implies a clustering of price changes that would have taken place at other dates in the absence of the

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6. Measuring the size of the black market is extremely difficult. A recent study by the Central Agency of Social Security Organizations (ACOSS) estimates that illegal work accounts for around 12% of employees in hotels, cafés and restaurants in 2005.

euro cash changeover. Consistent with this mechanism, many traditional restaurants chose to change their prices at this date or just before (see Figure 2).

2. IDENTIFYING THE EFFECT OF THE MINIMUM WAGE ON PRICES

A straightforward approach to assess the magnitude and the delay of the pass-through of minimum wage to prices is to rely on aggregate data and time-series models. In this section, we show that such a strategy delivers poor results in the French case and we try to rationalize this outcome. This evidence motivates the subsequent use of a microeconometric model of price rigidity (Sections 3 to 5).

2.1 Evidence from Aggregate Data

We first investigate the degree of pass-through using a linear time series model that is fitted to our aggregate data. This strategy is used by Aaronson (2001), who estimates a linear model of restaurant price indices to assess the impact of lagged, present, and future values of the minimum wage on prices. He finds a significant and rapid impact of the minimum wage on the prices set by different types of restaurants in the United States and Canada.

Tables 3 and 4 report the estimates of various autoregressive distributed lag (ARDL) models for French fast-food and traditional restaurants, respectively. The general specification is the following:

\[
\Delta p_t = c + \sum_{k=-F}^{K} \alpha_k \Delta w_{t-k} + \sum_{k=1}^{L} \theta_k \Delta p_{t-k} + \sum_{j=1}^{J} \mu_j z_{j,t} + \epsilon_t,
\]

where \( \Delta p_t \) is the inflation rate in the restaurant industry (computed as a simple average of individual price changes) and \( z_{j,t} \) is a set of covariates (seasonal dummies, dummy variables for the euro cash changeover period, the growth rates of demand and of food producer prices). We investigate various specifications, with and without seasonal dummies, and with various lags and leads of the minimum wage. Results for traditional restaurants are reported in Table 3. They show that these covariates are often significant: the dummy variables corresponding to the VAT increase and to the euro area changeover period, as well as autoregressive terms, are systematically significant. However, two important issues come out from this statistical analysis. First, these results are very sensitive to the inclusion of seasonal dummies. Second, the impact of the minimum wage is not clear-cut: only the second lag is systematically significant (see Table 3). The long-run effect of a permanent 1% increase in the

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8. Wolfson and Belman (2004) use comparable time-series analysis at the industry level and find no significant effect of the minimum wage on employment in the United States.

9. The relation between the minimum wage and the overall CPI in France is analyzed by L’Horty and Rault (2004) who estimate a VAR model.
minimum wage is estimated to be comprised between 0.015 and 0.148, that is, somewhat lower than the effects suggested by the share corresponding to wages in restaurant total costs (about 0.15).

Results for fast-food restaurants are reported in Table 4. Only a few variables appear to explain changes in the aggregate price level. When seasonal dummies are included, the contemporary effect of the minimum wage increase is statistically significant but its lag has a negative sign. The estimated long-run impact of a variation in the minimum wage is very small. It is even negative under some specifications.

### 2.2 Lumpy Adjustment and Aggregate Models

Overall, these linear model estimates suggest that there is no pass-through of the minimum wage to prices and that the dynamics are uncertain. Our claim is that these results are unreliable since a linear aggregate model may not adequately capture the adjustment process resulting from aggregation of individual lumpy behaviors. This issue is analytically examined by Caballero and Engel (2003). Their findings help to provide an understanding of our regression results. These authors examine the performance of a partial adjustment model fitted to aggregated data for measuring the speed of adjustment, when micro-level data are actually governed by a simple lumpy adjustment model, namely, a constant hazard (Calvo-type) process. They
show that the aggregate model is asymptotically able to capture the probability of adjustment embodied in the Calvo process (when the number of firms $N$ is large and the sample period $T$ is long). However, when $N$ and $T$ are small or moderate, the speed of adjustment is overestimated by a linear aggregate model. In addition, the approximation provided by the linear partial adjustment model is particularly poor when the probability of adjustment is low. All these mechanisms appear to be present here, especially in the case of traditional restaurants, for which the probability of a price change is close to 5%.

To illustrate the relationship between lumpy adjustments at the individual level and aggregate dynamics in our context, we perform a Monte Carlo experiment. We use a nonlinear model of lumpy price adjustment, close to a $(S, s)$ model, for generating the data. The main difference with the (Calvo) analytical framework considered by Caballero and Engel (2003) is that the probability of a price change depends on state variables (minimum wage, input costs, and demand). The model as well as parameter estimates correspond to those estimated in the next section.

The data-generating process (DGP) is completed by estimating simple autoregressive processes for covariates, namely, the demand variable as well as the producer price index for food. We also design a DGP for minimum wage changes in the following way: each month of July, the minimum wage increase is drawn randomly from a uniform distribution with support [2%;5%]. This mimics the actual process for changes in the minimum wage. With this complete DGP, we are able to simulate trajectories of individual and aggregate prices for an arbitrary number of economic

<table>
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<td>Constant</td>
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<td>0.088**</td>
<td>0.090**</td>
<td>0.130</td>
<td>0.046</td>
<td>0.002</td>
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<tr>
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<td>0.036**</td>
<td>0.039**</td>
<td>0.035*</td>
<td>0.040**</td>
<td>0.044*</td>
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<td>−0.037*</td>
<td>−0.041**</td>
<td>−0.062**</td>
</tr>
<tr>
<td>Min. wage, t−2</td>
<td>0.001</td>
<td>0.003</td>
<td>0.003</td>
<td>0.006</td>
<td>0.010</td>
<td>0.010</td>
</tr>
<tr>
<td>Min. wage, t−3</td>
<td>0.015</td>
<td>0.023</td>
<td>0.020</td>
<td>0.005</td>
<td>0.017</td>
<td>0.015</td>
</tr>
<tr>
<td>Inflation, t−1</td>
<td>0.164</td>
<td>0.168</td>
<td>0.189*</td>
<td>0.198*</td>
<td>0.201*</td>
<td></td>
</tr>
<tr>
<td>Inflation, t−2</td>
<td>0.018*</td>
<td>0.178*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer prices</td>
<td>0.051</td>
<td>0.045</td>
<td>0.057</td>
<td>0.079</td>
<td>0.070</td>
<td>0.069</td>
</tr>
<tr>
<td>Demand</td>
<td>0.009</td>
<td>0.008</td>
<td>0.007</td>
<td>0.013</td>
<td>0.003</td>
<td>−0.007</td>
</tr>
<tr>
<td>Euro</td>
<td>−0.091</td>
<td>−0.055</td>
<td>−0.051</td>
<td>−0.170</td>
<td>−0.157</td>
<td>−0.149</td>
</tr>
<tr>
<td>Month dummies</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.109</td>
<td>0.176</td>
<td>0.201</td>
<td>0.176</td>
<td>0.254</td>
<td>0.291</td>
</tr>
<tr>
<td>Long-term impact</td>
<td>0.015</td>
<td>0.039</td>
<td>−0.020</td>
<td>0.009</td>
<td>0.044</td>
<td>−0.023</td>
</tr>
</tbody>
</table>

Note: statistical significance levels: **: 5%, *: 10%.
### TABLE 5
**AGGREGATE LINEAR MODEL RESULTS WITH SIMULATED DATA (TRADITIONAL RESTAURANTS)**

<table>
<thead>
<tr>
<th></th>
<th>OLS—Aggregate data $T = 105$ (1)</th>
<th>OLS—Simulated data $T = 105, N = 2,948$ (2)</th>
<th>OLS—Simulated data $T = 2,000, N = 10,000$ (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. wage</td>
<td>$-0.003$ (0.005)</td>
<td>$0.006$ (0.011)</td>
<td>$0.003$ (0.011)</td>
</tr>
<tr>
<td>Min. wage$_{-1}$</td>
<td>$0.003$ (0.004)</td>
<td>$0.003$ (0.011)</td>
<td>$0.003$ (0.011)</td>
</tr>
<tr>
<td>Min. wage$_{-2}$</td>
<td>$0.019$ (0.005)</td>
<td>$0.002$ (0.010)</td>
<td>$0.001$ (0.012)</td>
</tr>
<tr>
<td>Min. wage$_{-3}$</td>
<td>$0.001$ (0.005)</td>
<td>$0.000$ (0.010)</td>
<td>$0.000$ (0.012)</td>
</tr>
<tr>
<td>Min. wage$_{-4}$</td>
<td>$0.009$ (0.005)</td>
<td>$0.000$ (0.010)</td>
<td>$0.000$ (0.012)</td>
</tr>
<tr>
<td>Min. wage$_{-5}$</td>
<td>$-0.001$ (0.005)</td>
<td>$0.000$ (0.010)</td>
<td>$0.000$ (0.010)</td>
</tr>
<tr>
<td>Min. wage$_{-6}$</td>
<td>$0.004$ (0.005)</td>
<td>$0.002$ (0.011)</td>
<td>$-0.001$ (0.011)</td>
</tr>
<tr>
<td>Inflation$_{-1}$</td>
<td>$0.174$ (0.080)</td>
<td>$0.359$ (0.115)</td>
<td>$0.557$ (0.125)</td>
</tr>
<tr>
<td>Inflation$_{-2}$</td>
<td>$0.194$ (0.088)</td>
<td>$0.201$ (0.122)</td>
<td>$0.215$ (0.125)</td>
</tr>
<tr>
<td>Inflation$_{-3}$</td>
<td>$0.298$ (0.095)</td>
<td>$0.158$ (0.117)</td>
<td>$0.100$ (0.117)</td>
</tr>
<tr>
<td>Inflation$_{-4}$</td>
<td>$0.101$ (0.075)</td>
<td>$0.108$ (0.099)</td>
<td>$0.039$ (0.099)</td>
</tr>
<tr>
<td>Month dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Long-term impact</td>
<td>$0.137$ (0.176)</td>
<td>$0.096$ (0.176)</td>
<td>$0.074$ (0.176)</td>
</tr>
</tbody>
</table>

**Note:** Column (1) reports the OLS estimates obtained with actual aggregate data. Column (2) reports the OLS estimates obtained with aggregate simulated data and a small sample size ($T = 105, N = 2,948$). Column (3) reports the OLS estimates with aggregate simulated data and a large sample size ($T = 2,000, N = 10,000$). “Yes” indicates that monthly dummy variables are included in the regression.

Units ($N$) and time periods ($T$). We then simulate trajectories both for the size of our sample ($T = 105, N = 2,948$ for traditional restaurants and $N = 448$ for fast-food restaurants) and for “large” $T$ and $N (T = 2,000, N = 10,000$). In a further step, we use these simulated data to compute an aggregate price index. Then we use this aggregate index to estimate a linear ARDL model. Following Attanasio (2000), this exercise provides us with the asymptotic predictions of a linear approximated model when the DGP is defined by the individual lumpy adjustment process. Results are provided in Tables 5 and 6. These experiments confirm that with a small sample, it is difficult to recover the effects of a minimum wage increase when using the linear aggregate specification. In our exercise, the true pass-through parameters

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11. We repeat the simulation exercise 200 times to compute standard errors.

12. In accordance with the econometrics of misspecified models, the probability limits of the parameters can here be called “pseudo-true values.”

13. The poor performance partly reflects the restriction to one specific class of time series models, namely, ARDL models. As suggested by Caballero and Engel (2003), the performance of an aggregate model may be improved by incorporating, say, moving average terms in the model. We stick to the ARDL since it is the class of models used in the empirical studies of price pass-through.
### TABLE 6

**Aggregate Linear Model Results with Simulated Data (Fast-Food Restaurants)**

<table>
<thead>
<tr>
<th></th>
<th>OLS—Aggregate data</th>
<th>OLS—Simulated data</th>
<th>OLS—Simulated data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( T = 105 )</td>
<td>( T = 105, N = 448 )</td>
<td>( T = 2,000, N = 10,000 )</td>
</tr>
<tr>
<td>Min. wage</td>
<td>0.040</td>
<td>0.017</td>
<td>0.012</td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.035)</td>
<td></td>
</tr>
<tr>
<td>Min. wage, (-1)</td>
<td>-0.040</td>
<td>0.008</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(0.020)</td>
<td>(0.032)</td>
<td></td>
</tr>
<tr>
<td>Min. wage, (-2)</td>
<td>0.010</td>
<td>0.001</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(0.024)</td>
<td>(0.031)</td>
<td></td>
</tr>
<tr>
<td>Min. wage, (-3)</td>
<td>0.016</td>
<td>-0.001</td>
<td>-0.002</td>
</tr>
<tr>
<td></td>
<td>(0.024)</td>
<td>(0.043)</td>
<td></td>
</tr>
<tr>
<td>Inflation, (-1)</td>
<td>0.184</td>
<td>0.303</td>
<td>0.783</td>
</tr>
<tr>
<td></td>
<td>(0.112)</td>
<td>(0.097)</td>
<td></td>
</tr>
<tr>
<td>Inflation, (-2)</td>
<td>0.194</td>
<td>0.195</td>
<td>0.053</td>
</tr>
<tr>
<td></td>
<td>(0.115)</td>
<td>(0.121)</td>
<td></td>
</tr>
<tr>
<td>Inflation, (-3)</td>
<td>0.022</td>
<td>0.167</td>
<td>0.022</td>
</tr>
<tr>
<td></td>
<td>(0.110)</td>
<td>(0.092)</td>
<td></td>
</tr>
<tr>
<td>Month dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Long-term impact</td>
<td>0.043</td>
<td>0.074</td>
<td>0.102</td>
</tr>
<tr>
<td></td>
<td>(0.186)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note:* Column (1) reports the OLS estimates obtained with actual aggregate data. Column (2) reports the OLS estimates obtained with aggregate simulated data and a small sample size (\( T = 105, N = 448 \)). Columns (3) report the OLS estimates with aggregate simulated data and a large sample size (\( T = 2,000, N = 10,000 \)). “Yes” indicates that monthly dummy variables are included in the regression.

(i.e., the microeconomic DGP parameters) are 0.083 in traditional restaurants and 0.103 in fast-food restaurants. For both types of restaurants, the pseudo-true values in the linear model derived with a large sample (\( T = 2,000 \) and \( N = 10,000 \)) are close to the true elasticity. In the case of small sample also, the simulated mean impact obtained from linear models (0.10 in traditional restaurants and 0.07 in fast-food restaurants) are quite consistent with the DGP parameters. However, these estimates are associated with very high standard deviations across simulation experiments: 0.176 for traditional restaurants and 0.186 for fast-food restaurants (by contrast, as expected, the standard deviation across simulations is zero when a large sample is considered). Uncertainty resulting from small sample size thus provides an explanation for the failure of linear models to capture the effects of minimum wage increases.

### 2.3 The Seasonality of Minimum Wage and Price Changes

In the French case, another main identification problem comes from the fact that a linear model cannot disentangle seasonality effects from the impact of a change in the minimum wage. The legal minimum wage changes in July each year and the distribution of minimum wage changes have a narrow support during the period we consider (Figure 4). Unlike what happens with U.S. data (see Aaronson 2001), in France, there are no geographical or within-year variations in the timing of minimum wage changes that could help for identification. Disentangling the influence of the minimum wage on prices is also particularly intricate in the French context because of the seasonality that also affects the pricing process. Prices tend to change...
more frequently in September, suggesting a 2-month systematic lag, among other observationally equivalent explanations for such pricing patterns.

The small variability in minimum wage increases is a minor concern per se since a discrete support does not impede identifiability. The systematic increase of the minimum wage in July is more problematic for our estimation. Using OLS time-series regression, disentangling the effect of minimum wage changes from any seasonal “July” effect is extremely difficult. Indeed the identification is weak since it relies only on: (i) the fact that the size of increases (mildly) varies across years, (ii) there is only one increase in May (May 1996) rather than July, and (iii) social security contributions paid by employers were reduced several times over the period. Such a weak identification is presumably another source of the inconclusive results we obtain with aggregate linear models.

By contrast, using microeconomic data should substantially alleviate this identification problem. First, interpreting the systematic 2-month lag between the regular increase in the minimum wage (July) and the price changes occurring in September as a causal relationship can be rejected by simply looking at our individual data. Indeed, for the typical restaurant, the average price duration is larger than 1 year and close to 2 years (see Table 1 and Figure 1). This strongly suggests that firms do not mechanically adjust prices 2 months after a minimum wage increase, though they may incorporate wage developments into prices with a much larger lag.

Second, we use a microeconomic model of lumpy adjustment. This model predicts that the price change depends on the cumulative increase in the minimum wage since the last price change, at the individual level. As shown, for example, in Figure 1, there is a substantial degree of variability in the length of price spells. As a result, the distribution of the right-hand-side variable has a much wider support and a higher dispersion than the distribution of instantaneous changes in the minimum wage.\(^{14}\) This favors the identification of the minimum wage effect on prices. In addition, using the cumulative increase in the minimum wage since the last price change as a right-hand-side variable strongly reduces collinearity between seasonal dummies and the relevant labor cost variable. Indeed, the linear correlation in the time dimension between the minimum wage increases and the July dummy variable is substantial: 0.43 for traditional restaurants and 0.34 for fast-food restaurants. The correlation between spell-specific cumulative increases and the July dummy variable is much weaker: 0.15 for traditional restaurants and 0.18 for fast-food restaurants.

3. AN ECONOMETRIC MODEL OF INFREQUENT PRICE CHANGES

3.1 Theoretical Background

Menu-cost models are the most standard theoretical approach to rationalize infrequent price changes. Sheshinski and Weiss (1977) first show that, in presence of menu costs and of deterministic exogenous shocks, the optimal price-setting behavior of

\(^{14}\) This distribution is shown in an appendix available on the personal website of the corresponding author (http://www.crest.fr/ses.php?user=2944).
the firm has the form of an \((S, s)\) rule. The essence of the \((S, s)\) model is the existence of a “band of inaction”: firms tolerate some deviation from their optimal frictionless price as long as this deviation is not too large. Dixit (1991) and Hansen (1999) then extend this basic model to allow for nondeterministic shocks, and they prove that the optimal behavior may still be represented by an \((S, s)\) rule.

In \((S, s)\) models, the frictionless price is generally the price level that would be observed in the absence of any costs of adjustment. It can be derived in a straightforward way under the assumption of flexible prices. If we denote by \(P^*_it\) the optimal price set by a monopolistic competitive outlet \(i\) at date \(t\), a standard result is that the optimal frictionless price is given by a markup over marginal costs \(MC_{it}\), that is, \(P^*_it = k_i MC_{it}\). Assuming that the production function has two inputs, labor and food, maximizing profit under an isoelastic demand curve yields a log-linear expression for the optimal price, similar to that obtained, for instance, by Rotemberg (1982) and Cecchetti (1986):

\[
p^*_it = a_i + b w_t + c q_t + d y_t,
\]

where \(p^*_it\), \(w_t\) and \(q_t\) are the logarithms of the optimal price, and the costs of labor and food, respectively, and \(y_t\) is the demand level.

In the presence of adjustment costs, firms trade off between the opportunity cost of deviating from the optimal price (i.e., the forgone profit) and the adjustment cost. Under some conditions shown to be of the \((S, s)\) type, the optimal adjustment rule is then to adjust the price only if the difference between the optimal price \(p^*_it\) and the price \(p_{it-\tau}\) modified at period \(t - \tau\) (where \(\tau\) is the duration since the last price change), exceeds some threshold. We assume that when prices are reset they are set at the optimal frictionless price (up to a constant, like in Tsiddon 1993). If the price was changed \(\tau\) periods before, then \(p_{it-1} = p_{it-\tau} = p^*_it\). The firm’s pricing decision depends on the distance covered by \(p^*_it\) between dates \(t - \tau\) and \(t\) (the date at which the decision is taken). We denote this variable by \(\Delta_t p^*_it\). If it exceeds a certain threshold \(C\), the price is changed.\(^{15}\) Allowing for error terms in the optimal price, or in the size of the band, the probability of a price change will depend on the cumulative change in \(p^*_it\) since the last price change.

The \((S, s)\) model puts strong restrictions on the patterns of price adjustments. In particular, in a standard menu-cost model, the size of the price change will be the same for all price changes equal to \(C\). Moreover, a large adjustment cost would imply infrequent and large price changes. This prediction is at variance with the prevalence of infrequent but small price changes observed in the data (see Figure 1).

To capture this pattern, we rely on a time-varying \((S, s)\) band model. As shown by Caballero and Engel (1999) in a model of investment decision, thresholds that fluctuate over time can be obtained under the assumption of a random menu cost. In

\(^{15}\) In theoretical models (see, e.g., Sheshinski and Weiss 1977), this threshold is shown to be an increasing function of the menu cost. However, in a reduced-form approach like ours, the adjustment cost cannot be measured since this function depends on structural parameters that cannot be identified.
the context of prices, random menu costs have been popularized by Dotsey, King, and Wolman (1999). In our model, thus, the threshold is allowed to vary over time and across firms. Overall, our approach is related to the adjustment hazard model developed by Caballero and Engel (1999). In such an approach, the probability of a price change is a function of the gap between the current price and a static frictionless optimal price. That gap is the relevant state variable, so that despite the fact that an optimization problem underlies the decision rule, no expectation term is explicitly present. The adjustment hazard model is rather flexible. For instance, our model encompasses the Calvo model: when the threshold varies a lot, the model predicts a constant probability for a price change and can generate small price changes.

One additional specification issue is that, in restaurants, there could exist an alternative adjustment margin other than price. Restaurants may choose to decrease quality or quantity rather than increase their prices. The existence of such an adjustment margin is expected to lower the value of the parameter \( b \) in equation (1), compared to a standard model in which this margin does not exist. Nevertheless, in our reduced-form approach, as far as \( w_t, q_t \) and \( y_t \) are exogenous covariates, the overall impact of the minimum wage on nominal prices is consistently estimated.\(^{16}\)

### 3.2 The Econometric Model

Our econometric model, designed to encompass the \((S, s)\) specification, is related to some empirical models that have been previously set forth in the literature. For instance, Attanasio (2000) puts forward a flexible econometric specification for estimating \((S, s)\) models applied to consumption of durables. More recently, in a price-setting context, Ratfai (2006) proposes to estimate \((S, s)\) models by using a probit specification, while Dhyne et al. (2007) introduce stochastic bands.\(^{17}\) On the methodological side, our distinctive feature is, with respect to the former, to estimate a model for the size of the price change. With respect to the latter, we allow for observed proxies of the marginal cost and potential asymmetry in the decision to change the price.

Let us denote \( p_{i,t} \) the logarithm of the price posted by restaurant \( i (i = 1, \ldots, n) \) at date \( t \), \( \Delta_t p^*_{i,t} = 100 \times (p^*_{i,t} - p^*_{i,t-\tau}) \) the optimal price change, and \( \Delta_t p_{i,t} = 100 \times (p_{i,t} - p_{i,t-\tau}) \) the observed price change.

In our flexible \((S, s)\) approach, the decision rule is as follows:

\[
\Delta_t p_{i,t} = \Delta_t p^*_{i,t} \quad \text{if } \Delta_t p^*_{i,t} > C^+_{it} \text{ or } \Delta_t p^*_{i,t} < C^-_{it} \\
\Delta_t p_{i,t} = 0 \quad \text{if } C^-_{it} < \Delta_t p^*_{i,t} < C^+_{it}.
\]

\(^{16}\) For CPI data, the French statistical institute (Insee, Paris) discontinues the series whenever the nature of the product changes significantly, which limits the empirical case for such an adjustment margin.

\(^{17}\) Ratfai (2006) studies the price of meat in Hungary, and Dhyne et al. (2007) study a wide range of consumer goods in France and Belgium. See also Sheshinski, Tishler, and Yoram (1981) for an early estimation of such models.
Our econometric model is thus characterized by three processes: the optimal price change $\Delta_t p^*_i$, and the time-varying thresholds $C^-_{it}$ and $C^+_{it}$ associated with price decreases and price increases, respectively. In traditional restaurants, price decreases are very scarce. For this type of outlet, we pool the occurrences of price decreases with those of no changes.

The optimal price change is specified as:

$$\Delta_t p^*_i = \beta_0 + \Delta_t X_{1,t} \beta_1 + \epsilon^p_{i,t}, \quad (3)$$

where $\Delta_t X_{1,t} = 100 \times (X_{1,t} - X_{1,t-\tau})$ is the variation of continuous covariates $X_{1,t}$ (in logarithm) between dates $t$ and $t - \tau$ ($\tau$ being the duration since the last price change) and $(\beta_0, \beta_1)$ is a vector of parameters to be estimated. The vector of covariates $X_{1,t}$ includes variables affecting the cost structure, especially the variation of the minimum wage level (our proxy for the variation of labor costs), of the food producer price index, of the aggregate demand either in traditional or fast-food restaurants, and of the VAT. All these variations are taken between dates $t - \tau$ and $t$. The random term $\epsilon^p_{i,t}$ is a normally distributed idiosyncratic (white noise) shock with mean 0 and variance $\sigma_p^2$. By including a constant $\beta_0$ in the first-difference specification, our empirical model deviates from the baseline ($S, s$) model. This constant is here introduced because in its absence the model fails to jointly replicate three main patterns of the data: the low frequency of price changes, the existence of small price changes, and the large variance of observed price changes. The intercept of the price change equation, that is, the predicted price change for values of $\Delta_t X_{1,t}$ close to zero, is $\beta_0 + E(\epsilon^p_{i,t}|\Delta_t p^*_i \neq 0)$. The second term in this expression (the conditional expectation) is different from zero, reflecting a sample-selection mechanism associated with the process (2). As it will turn out, given the role of idiosyncratic shocks in triggering price changes, constraining $\beta_0$ to be equal to zero would predict too many and too few small price changes. In addition, we allow $\beta_0$ to be different for price increases and for price decreases for fast-food restaurants.

The time-varying thresholds are specified as

$$C^+_{it} = X_{2,t} \beta^+_2 + u_i + \epsilon^c_{i,t}$$
$$C^-_{it} = X_{2,t} \beta^-_2 - u_i + \epsilon^c_{i,t} \quad (4)$$

The time-varying threshold associated with price increases (respectively, price decreases) depends on $X_{2,t}$, a vector of time-dependent indicators, such as monthly

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18. Note the first elapsed duration $\tau$ is not observed, so that the first spell is not usable for estimation. We expect however the selection bias resulting from this omission to be small since we observe repeated spells for each restaurant.

19. In traditional restaurants, the observed proportion of price increases that are smaller than 3% is equal to 46%. The proportion predicted by the constrained model is 31% whereas it is 37% with the unconstrained model. For fast-food restaurants, we reach a similar conclusion: the observed proportion of price increases that are smaller than 3% is equal to 62%, and the predicted fraction is 46% with the constrained model and 49% with the unconstrained model. Symmetrically, the constrained models overestimate the density of large price changes.
dummies and euro cash changeover dummies.\textsuperscript{20} The monthly dummies are incorporated because we observe that restaurant managers are more likely to revise their prices in January or September. This may reflect some seasonality in adjustment costs.\textsuperscript{21} We also include in the vector $X_{2,t}$ the dummy variable indicating the euro cash changeover that occurred in January 2002. At this date, all firms had to change their prices from francs to euros, and were thus forced to pay the menu costs, which gave them an incentive to cluster price changes at that date (Hobijn, Ravenna, and Tambalotti 2006). The vectors $\beta^+_2$ and $\beta^-_2$ are slope parameters to be estimated. The term $u_i$ captures the time-invariant characteristics affecting the menu cost of restaurant $i$. We impose an opposite sign for $u_i$ in the two equations to capture the idea that some restaurants have wider “inaction band” than others, presumably due to larger menu costs, that lower both the probability of a price decrease and increase. Finally, $\xi^{c+}_{i,t}$ and $\xi^{c-}_{i,t}$ are normally distributed random terms with mean 0 and respective variances $\sigma^2_{c+}$ and $\sigma^2_{c-}$. These shocks are shocks on the price-change decision, resulting from shocks on menu costs. Consistent with the theoretical models of random menu cost (e.g., Dotsey, King, and Wolman 1999), the menu cost shock is independent from the shock $\varepsilon^{p}_{i,t}$ on the optimal price.

The model is estimated by maximization of the likelihood function.\textsuperscript{22} Formally our model is a bivariate sample selection model with one equation describing the decision of price change and another one describing the size of the price change. It is close to a Tobit Type 2 model. Although a theoretical result is that the parameters of this class of models are statistically identified (see Amemiya 1984), it is also known that if exactly the same regressors appear in both equations, the identification relies on specific functional form assumptions (Wooldridge 2002). Here, we use two exclusion restrictions to strengthen the identification of the model. The first one is related to the euro cash changeover. Economic theory indeed strongly points out that a change in numéraire should not influence the long run real prices or the markup ratio and relative price levels. It is thus natural to exclude this variable from the size of price change equation. On the other hand, theory tells us that to the extent that the change in numéraire entails menu costs, it is very much predicted to influence the probability of a price change (as argued in Hobijn, Ravenna, and Tambalotti 2006). We also argue that seasonality provides a relevant restriction: there exists some seasonality in menu costs (due to institutional factors like timing of holidays and accounting periods; see Müller et al. 2010, Woodford 2003, Zbaracki et al. 2004, and our Section 1.1). This seasonality affects the menu costs which play a role in the first equation only. Besides, since we control for demand, the price level should not be expected to depend \textit{per se} on seasonality (see our Section 1.1).

\textsuperscript{20} We assume that none of the determinants of the optimal price explains the band associated with the menu costs.

\textsuperscript{21} Woodford (2003) writes that “the main benefit of infrequent price changes is not lower menu costs but a reduction of the costs associated with information collection and decision making. Obtaining this benefit necessarily means that the timing of the occasions upon which prices are reconsidered is largely independent of current market conditions; for example, firms often reconsider pricing policy at a particular time of year.”

\textsuperscript{22} This likelihood function is given in an appendix available on the personal website of the corresponding author (http://www.crest.fr/ses.php?user=2944).
### Table 7

**Parameter Estimates: Traditional Restaurants**

<table>
<thead>
<tr>
<th>Notation</th>
<th>Covariate</th>
<th>Estimate</th>
<th>Notation</th>
<th>Covariate</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_0$</td>
<td>Constant</td>
<td>-10.644</td>
<td>$\beta_1^+$</td>
<td>January</td>
<td>1.657</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.317)</td>
<td></td>
<td></td>
<td>(0.135)</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>Food PPI</td>
<td>0.252</td>
<td>February</td>
<td>1.833</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.038)</td>
<td></td>
<td></td>
<td>(0.136)</td>
</tr>
<tr>
<td></td>
<td>Min. wage</td>
<td>0.083</td>
<td>March</td>
<td>1.877</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.016)</td>
<td></td>
<td></td>
<td>(0.122)</td>
</tr>
<tr>
<td></td>
<td>Demand</td>
<td>-0.124</td>
<td>April</td>
<td>1.948</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.025)</td>
<td></td>
<td></td>
<td>(0.117)</td>
</tr>
<tr>
<td></td>
<td>VAT increase</td>
<td>4.288</td>
<td>May</td>
<td>1.648</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.327)</td>
<td></td>
<td></td>
<td>(0.134)</td>
</tr>
<tr>
<td></td>
<td>VAT decrease</td>
<td>-0.966</td>
<td>June</td>
<td>1.871</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.485)</td>
<td></td>
<td></td>
<td>(0.139)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>July</td>
<td>1.774</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>August</td>
<td>1.703</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>September</td>
<td>1.135</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>October</td>
<td>1.860</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>November</td>
<td>1.966</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>December</td>
<td>2.346</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pre euro</td>
<td>-1.053</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Euro</td>
<td>-3.555</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Post euro</td>
<td>-1.761</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.186)</td>
<td>(0.135)</td>
</tr>
<tr>
<td>$\sigma_p$</td>
<td></td>
<td>6.591</td>
<td>$\sigma_u$</td>
<td></td>
<td>0.858</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.145)</td>
<td></td>
<td></td>
<td>(0.071)</td>
</tr>
<tr>
<td>$\sigma_c$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.281</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.067)</td>
</tr>
</tbody>
</table>

Value of the log-likelihood function: $-8.221$
Sample size: 93,816

---

### 4. Empirical Results

Table 7 reports estimation results for menus in traditional restaurants while Table 8 reports those for menus in fast-food restaurants. Parameter estimates associated with the estimation of $\Delta t P^*_i$ (equation (3)) are displayed in the first column of these tables, while those associated with $C^+_{it}$ and $C^-_{it}$ (equation (4)) are displayed in the second and third columns of these tables. Before turning to parameter estimates, we note the large value of $\sigma_p$, the estimated standard deviation of idiosyncratic shocks associated with $\Delta p^*$, in both tables (6.6% for traditional restaurants and 5.7% for fast food restaurants). This reflects the importance of idiosyncratic shocks in triggering
### TABLE 8
PARAMETER ESTIMATES: FAST-FOOD RESTAURANTS

<table>
<thead>
<tr>
<th>Notation</th>
<th>Covariate</th>
<th>Estimate</th>
<th>Notation</th>
<th>Covariate</th>
<th>Estimate</th>
<th>Notation</th>
<th>Covariate</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta p_{1,i}$</td>
<td>Constant</td>
<td>$-7.589$</td>
<td>January</td>
<td>$0.736$</td>
<td>February</td>
<td>$-1.238$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_0^+$</td>
<td>(0.222)</td>
<td>(0.018)</td>
<td>(0.002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_0^-$</td>
<td>$9.751$</td>
<td>$1.065$</td>
<td>$1.268$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>$0.272$</td>
<td>$0.043$</td>
<td>(0.002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>$0.454$</td>
<td>$1.469$</td>
<td>$1.253$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_3$</td>
<td>(0.049)</td>
<td>(0.070)</td>
<td>(0.002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_4$</td>
<td>$0.103$</td>
<td>$1.362$</td>
<td>$1.900$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_5$</td>
<td>(0.019)</td>
<td>(0.023)</td>
<td>(0.002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_6$</td>
<td>$0.229$</td>
<td>$0.893$</td>
<td>$1.394$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_7$</td>
<td>(0.040)</td>
<td>(0.034)</td>
<td>(0.002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_8$</td>
<td>$0.295$</td>
<td>$1.044$</td>
<td>$1.337$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_9$</td>
<td>$0.070$</td>
<td>$1.362$</td>
<td>$1.338$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{10}$</td>
<td>(0.019)</td>
<td>(0.023)</td>
<td>(0.002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{11}$</td>
<td>$0.585$</td>
<td>$0.893$</td>
<td>$1.730$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{12}$</td>
<td>(0.028)</td>
<td>(0.034)</td>
<td>(0.002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{13}$</td>
<td>$0.876$</td>
<td>$1.469$</td>
<td>$1.414$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{14}$</td>
<td>(0.051)</td>
<td>(0.070)</td>
<td>(0.002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{15}$</td>
<td>$1.631$</td>
<td>$1.469$</td>
<td>$1.730$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{16}$</td>
<td>(0.050)</td>
<td>(0.070)</td>
<td>(0.002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{17}$</td>
<td>$1.386$</td>
<td>$1.469$</td>
<td>$1.414$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{18}$</td>
<td>(0.019)</td>
<td>(0.023)</td>
<td>(0.002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{19}$</td>
<td>$0.278$</td>
<td>$1.469$</td>
<td>$1.414$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{20}$</td>
<td>(0.031)</td>
<td>(0.043)</td>
<td>(0.004)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{21}$</td>
<td>$-1.875$</td>
<td>$1.469$</td>
<td>$1.596$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{22}$</td>
<td>(0.019)</td>
<td>(0.043)</td>
<td>(0.004)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{23}$</td>
<td>$0.401$</td>
<td>$1.469$</td>
<td>$1.414$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_{24}$</td>
<td>(0.029)</td>
<td>(0.043)</td>
<td>(0.004)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_p$</td>
<td>$5.692$</td>
<td>$0.653$</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_u$</td>
<td>(0.125)</td>
<td>(0.027)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Value of the log-likelihood function: $-11.015$. Sample size: 10,726.

Price changes, a feature acknowledged by much of the recent literature (e.g., Golosov and Lucas 2007).

#### 4.1 The Effect of the Minimum Wage

The effect of the minimum wage on restaurant prices is significant for both traditional and fast-food restaurants. A minimum wage rise increases the probability of a price increase in both traditional and fast-food restaurants, and it decreases the probability of a price decrease in fast-food restaurants. This result is in line with theoretical results of state-dependent pricing models. The minimum wage thus triggers a selection effect in restaurants that change their prices, which influences the dynamics of the pass-through (see the next section). The effect of the minimum wage on the size of the price change is noticeable. In traditional restaurants, after a 1% minimum wage increase, prices that change are increased by 0.083%. In fast-food restaurants, the elasticity of price increases with respect to the minimum wage is similar, since
TABLE 9
EFFECTS OF A 1% MINIMUM WAGE INCREASE ON PRICES: BENCHMARK ESTIMATES

<table>
<thead>
<tr>
<th>Firm size</th>
<th>Wage level</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional restaurants</td>
<td>Min. wage</td>
<td>0.12</td>
<td>0.40</td>
<td>0.31</td>
<td>1</td>
<td>0.11</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>$1.1 \times \text{Min. wage}$</td>
<td>0.12</td>
<td>0.40</td>
<td>0.17</td>
<td>0.7</td>
<td>0.04</td>
<td>0.15</td>
</tr>
<tr>
<td>Fast-food restaurants (Assumption 1)</td>
<td>Min. wage</td>
<td>0.12</td>
<td>0.33</td>
<td>0.32</td>
<td>1</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>$1.1 \times \text{Min. wage}$</td>
<td>0.12</td>
<td>0.33</td>
<td>0.17</td>
<td>0.7</td>
<td>0.03</td>
<td>0.13</td>
</tr>
<tr>
<td>Fast-food restaurants (Assumption 2)</td>
<td>Min. wage</td>
<td>0.12</td>
<td>0.46</td>
<td>0.32</td>
<td>1</td>
<td>0.13</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>$1.1 \times \text{Min. wage}$</td>
<td>0.12</td>
<td>0.46</td>
<td>0.17</td>
<td>0.7</td>
<td>0.05</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Note: Column (1) reports the share of workers in the black market for hotels and restaurants (ACOSS, 2006). Column (2) reports the share of labor cost in total cost (Assumption 1: French national sectoral accounts (1997–2002); Assumption 2: Parsley and Wei 2007). Column (3) reports the share of the minimum wage compensations in the wage bill (DARES and French national sectoral accounts (1997–2002)). Column (4) gives the elasticity of wages just above the minimum wage with respect to minimum wage increases (Koubi and Lhommeau 2006). Column (5) gives the effect of the minimum wage increase on total cost, that is, $\text{col.(5)} = (1 - \text{col.(1)}) \times \text{col.(2)} \times \text{col.(3)} \times \text{col.(4)}$. Column (6) is the cumulated sum of the lines of column (5).

it is equal to 0.103. Estimates are less precise than those obtained for traditional restaurants; this may be due to the sample size, which is substantially smaller for fast-food restaurants. We therefore cannot reject the assumption that the elasticity is the same in both types of outlets.23

Using aggregate data for France, we are able to compare these results with benchmark estimates obtained from a proxy of the share of compensations of workers paid at the minimum wage in total restaurant costs (Table 9). According to available sources, the share of these labor costs in restaurant total costs lies between 33% and 46% in fast-food restaurants and is equal to 40% in traditional restaurants. The share of minimum wage compensations in the wage bill is approximately 32% in fast-food restaurants and 31% in traditional restaurants. Computing the effect of the minimum wage on costs as the product of these numbers, we find an elasticity between 0.10 and 0.15 for fast-food and equal to 0.12 for traditional restaurants. Taking into account the share of black market labor (estimated to be 12%; see earlier), the range is lowered to values comprised between 0.09 and 0.13. If we now take into account potential spillover from minimum wage increases to other wages, we obtain 0.15 for traditional restaurants and a range of estimates between 0.13 and 0.18 for fast-food restaurants. Our econometric results are lower but consistent with these benchmark estimates.

The estimated effects we obtain are somewhat higher than those found in previous studies on U.S. data by Aaronson (2001), MacDonald and Aaronson (2006), and Aaronson and French (2007). In these studies, the cumulated effect of a 1% increase in the minimum wage on restaurant prices lies between 0.04% and 0.08%.24 This gap between United States and French results is explained by the lower share of labor costs in restaurants’s total costs in the United States (31% in full-service restaurants

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23. A possible concern is that the significance of cumulated change in the minimum wage may here reflect duration dependence (stemming from a trending omitted variable). However, when added to the model, elapsed duration fails to be significant.

24. Using U.S. input–output data, Lee and O’Roarke (1999) find higher elasticities, between 0.08 and 0.12.
and 25% in limited-service restaurants, 25% in traditional restaurants and 33% in fast-food restaurants in France) and the lower share of minimum wage compensations in the wage bill in the United States (17% versus more than 30% in France; see Aaronson and French 2007).

4.2 Effects of Input Prices and Demand

As expected, food input prices have a significant and positive effect on the variations of the optimal price $\Delta_t p_{it}^*$. The elasticities of restaurant prices with respect to input prices are quite different for traditional and fast-food restaurants. They stand around 0.25 and 0.45 for traditional restaurants and fast-food restaurants, respectively. Parsley and Wei (2007) find that the share of food input costs in total costs is around 32% for Big Mac hamburgers. Using national accounts, the share of intermediate consumption (which include food inputs) in total costs is around 60% in the restaurant industry. Our estimation results appear to fall in the range of these benchmark estimates.

We find that demand has also a positive impact on $\Delta_t p_{it}^*$ in the case of fast-food restaurants and a negative effect in the case of traditional restaurants. In the latter case, this might reflect a countercyclical markup. Bils (1987) shows empirically that markups could be countercyclical. Portier (1995) and Chatterjee, Cooper, and Ravikumar (1993) propose models of procyclical entry in which the addition of new firms during booms causes markups to fall (Rotemberg and Woodford 1999).

In traditional restaurants, the effect of a change in the VAT rate on $\Delta_t p_{it}^*$ is asymmetrical. A VAT increase has a strong positive effect, but a VAT decrease has a negative but smaller (in absolute terms) effect on $\Delta_t p_{it}^*$. The 2% increase in the VAT rate in 1995 is estimated to have triggered a price increase of 4.3%, whereas after the 1% reduction in the VAT rate in 2000, prices that were modified decreased by 1%.

4.3 Seasonality and the Euro

We now discuss the effects of the variables that are assumed to affect only the decision to revise prices, but not the target price level. These variables are dummy variables indicating the specific months of the year and the euro cash changeover.

The effect of monthly dummies is quite consistent with the descriptive evidence that we have previously reported. In traditional restaurants, $C^+$ is lower in September, January and May, than in other months, all other things being equal. This means that the probability of a price change is significantly higher during


26. This is partly explained by the lower share of employees paid at the minimum wage in the United States (23% versus more than 40% in France; see Aaronson and French 2007).

27. Because the standard VAT rate is only marginally relevant in the case of fast-food restaurants, we do not include it in the model. When including dummies for VAT changes, results are unaffected and these dummies are statistically nonsignificant.
these months. In December, this probability is lower than in other months. In fast-
food restaurants, managers are more likely to increase their prices in January, July, 
August, and December, and less likely to increase them in October. They are more 
likely to decrease their prices at the end of the year. This might reflect the discrete-
time nature of the price revision process in restaurants: specific periods of the year are 
more likely to be devoted to price-change decisions, because during these periods, 
managers have more time to collect information or think about the “optimal” price 
change.

The effect of the euro cash changeover is quite different for the two different items. 
Descriptive statistics show that, in traditional restaurants, only few price decreases 
were observed during the euro cash changeover period, while many prices increased 
just before and just after January 2002. Our estimation confirms this insight. For 
fast-food restaurants, the frequency of price changes increased in January 2002, but 
neither before nor after. Hobijn, Ravenna, and Tambalotti (2006) propose a menu-cost 
interpretation for the inflationary effect of the euro cash changeover in restaurants that 
can rationalize such a pattern. With fast-food restaurants data, the estimated effect 
on the frequency of price changes is rather symmetrical. Our estimates show that the 
probabilities of price increases and decreases rose simultaneously in January 2002, 
implying no overall inflationary effect.

The variances of idiosyncratic shocks on \( C_{it}^+ \) or \( C_{it}^- \) are significantly much lower 
than those obtained for \( \Delta_t \rho_{it}^* \) (0.28% for traditional restaurants and 0.40% for fast 
food restaurants). Thus, seasonal variations appear to capture most of the variability 
in the adjustment costs as suggested by Zbaracki et al. (2004).

5. AGGREGATE IMPLICATIONS OF THE MODEL

In this section, we examine the fit of the model in terms of aggregate moments and 
statistics, and use our estimates to assess the impact of minimum wage changes on 
aggregate inflation in restaurants. Due to the nonlinearity of our model as well as the 
heterogeneity incorporated in our specification, the aggregate dynamics following a 
shock are nontrivial. We thus investigate them through simulations.

5.1 Overall Fit of the Model

We check the goodness of fit of our model by assessing its ability to match some 
aggregate moments of the data. More specifically, we compute three groups of in-
dicators from the estimated model: the frequency of price changes, the size of price 
changes, and the inflation rate. For this purpose, we run Monte Carlo simulations 
on the basis of our parameter estimates. Explanatory variables are taken at their 
sample values. More specifically, we simulate price trajectories and compare the ag-
gregate results obtained with those observed. To obtain standard errors for simulated
TABLE 10

<table>
<thead>
<tr>
<th></th>
<th>Inflation</th>
<th>Increase</th>
<th>Decrease</th>
<th>Frequency of price changes</th>
<th>Increase</th>
<th>Decrease</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional restaurants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulated</td>
<td>0.168</td>
<td>4.186</td>
<td>−0.347</td>
<td>4.061</td>
<td>0.107</td>
<td>4.168</td>
<td></td>
</tr>
<tr>
<td>Observed</td>
<td>0.134</td>
<td>4.336</td>
<td>−6.086</td>
<td>3.797</td>
<td>0.363</td>
<td>4.160</td>
<td></td>
</tr>
<tr>
<td>(0.004)</td>
<td>(0.059)</td>
<td>(0.032)</td>
<td>(0.083)</td>
<td>(0.020)</td>
<td>(0.085)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fast-food restaurants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulated</td>
<td>0.173</td>
<td>3.467</td>
<td>−3.113</td>
<td>7.528</td>
<td>2.890</td>
<td>10.418</td>
<td></td>
</tr>
<tr>
<td>Observed</td>
<td>0.135</td>
<td>3.346</td>
<td>−3.739</td>
<td>7.070</td>
<td>2.335</td>
<td>9.405</td>
<td></td>
</tr>
<tr>
<td>(0.010)</td>
<td>(0.060)</td>
<td>(0.067)</td>
<td>(0.215)</td>
<td>(0.137)</td>
<td>(0.267)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Numbers in parentheses are standard deviations.

moments, we repeat the simulation exercise a number of times by drawing several sets of parameters from their estimated asymptotic distribution.28

Results are presented in Table 10. Frequencies of price changes are slightly overestimated. For traditional restaurants, we obtain that the frequency of price increases is 4.1%, whereas it is only 3.8% in the data; for fast-food restaurants, the simulated frequency of price changes is equal to 10.4%, versus 9.4% in the sample. Standard deviations are quite small: around 0.1% for traditional restaurants and 0.3% for fast-food restaurants.

The average sizes of price changes are well replicated. The average sizes of price increases estimated with our model are equal to 3.5% in fast-food restaurants and 4.2% in traditional restaurants versus, respectively, 3.3% and 4.3% in the sample. For price decreases in fast-food restaurants, the model slightly overestimates the size of price changes. Figure 5 displays the simulated and actual distributions of price changes for both items. First, the model captures the asymmetry of both distributions. However, our model, reflecting its similarity with a menu-cost model, fails to fully account for the share of small price changes observed in the data. One rationalization for small price changes has been put forward by Midrigan (2007) and relies on price-setting behavior by a multiproduct firm. Assuming that a restaurant faces a fixed cost of reprinting the menu, any large deviation from the optimal price for one single item gives rise to a free opportunity to reset price for all items in the menu. In such circumstances, one may observe small price changes of several items. Our model cannot capture such a rationalization for small price changes since we have sampled one item (the main menu) in each outlet. However the degree of within-outlet synchronization in price changes across items appears to be quite limited in

28. The Monte Carlo experiments are described in more detail in next subsection.
our data, which suggests that the multiproduct argument does not fully rationalize the occurrence of small price changes here.29

The estimated inflation rate, which is obtained by averaging price changes at each date, is rather well reproduced by our model. The average simulated monthly inflation rates are 0.168% and 0.173% in traditional and fast-food restaurants while the observed rates are, respectively, 0.134% and 0.135%.

5.2 The Dynamic Aggregate Impact of a Minimum Wage Increase

Finally, we assess the dynamic effect of a minimum wage increase on prices by conducting the following simulation experiment. First, we simulate individual price trajectories by inserting our estimates in the system of equations (3)–(4). Shocks $\epsilon_{i,t}^p$, $\epsilon_{i,t}^{C+}$, and $\epsilon_{i,t}^{C-}$ are drawn from three i.i.d. normal distributions with mean 0 and variances equal to the estimated variances. Paths for covariates are identical to their sample trajectories. To obtain more accurate and smoother response functions, we simulate 40 trajectories for each actual sample trajectory. We then aggregate all these individual price trajectories to compute a single path for the price level. Second, we

29. For instance, among the restaurants for which the prices of three items are collected, the monthly frequency of a single price change is 4.8%; the frequencies of two simultaneous price changes are 1.9%, and 1.0% for three simultaneous price changes.
The main results of our simulation exercise are gathered in Table 11, as well as in Figures 6 and 7. Taking as a benchmark the case of a 1% increase, we observe that the long-run impact of the shock on the minimum wage is to raise the price level by 0.122% in fast-food restaurants and by 0.097% in traditional restaurants. These results are quite consistent with the estimated value of the parameter $\beta_1$ associated with the minimum wage. There appears a mild nonlinearity, since the impact of a 5% shock is slightly lower than five times the impact of a 1% shock. The long-run impact of a minimum wage increase on restaurant prices is also in line with the one that we would recover using a simple benchmarking exercise based on national account statistics (see Section 4.1).

A striking result is that the impact of the minimum wage change on restaurant prices is very protracted. For traditional restaurants, after 14 months, only half of the long-run response has been materialized. After 2 years, only 75% of the long-run

<table>
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<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
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<tr>
<td>Traditional restaurants</td>
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</tr>
<tr>
<td>1%</td>
<td>0.097</td>
<td>(0.016)</td>
<td>14</td>
<td>26</td>
<td>34</td>
</tr>
<tr>
<td>2%</td>
<td>0.192</td>
<td>(0.031)</td>
<td>14</td>
<td>25</td>
<td>34</td>
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<tr>
<td>5%</td>
<td>0.471</td>
<td>(0.073)</td>
<td>13</td>
<td>24</td>
<td>33</td>
</tr>
<tr>
<td>Fast-food restaurants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1%</td>
<td>0.122</td>
<td>(0.021)</td>
<td>6</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>2%</td>
<td>0.242</td>
<td>(0.042)</td>
<td>6</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>5%</td>
<td>0.589</td>
<td>(0.098)</td>
<td>6</td>
<td>12</td>
<td>18</td>
</tr>
</tbody>
</table>

Note: Numbers in parentheses are standard deviations. Column (1) is the size of the shock on the minimum wage at t. Column (2) reports the cumulated impact after 57 months. Column (3) reports the duration (in months) corresponding to half of the total cumulated impact. Column (4) reports the duration (in months) corresponding to 75% of the total cumulated impact. Column (5) reports the duration (in months) corresponding to 90% of the total cumulated impact.

reiterate the experiment with the same set of random shocks but now assume that the minimum wage is permanently above its baseline trajectory as from July 1998. Three different scenarios are considered, corresponding to increases of 1%, 2%, and 5%, respectively. Finally, we compare the alternative scenarios by computing differences in aggregate price levels between the benchmark and each alternative scenario. This exercise provides only partial equilibrium results, since we assume the exogeneity of the minimum wage with respect to restaurant prices, and we assume other covariates (producer prices, demand) to be unaffected by the shock on the minimum wage. We view these assumptions as reasonable approximations.30

As a crude test, we run Granger causality tests and we reject that monthly inflation in restaurants causes overall monthly inflation and minimum wage changes. We also reject that minimum wage causes food input inflation. Noncausality between demand and restaurant prices cannot be fully rejected.
Fig. 6. (a) Impact of a Minimum Wage Increase on the Frequency of Price Changes in Traditional Restaurants. (b) Impact of a Minimum Wage Increase on the Frequency of Price Changes in Fast-Food Restaurants.

Note: Solid line: 1% increase. Dotted line: 2% increase. Dashed line: 5% increase.
Fig. 7. (a) Aggregate Response to a Minimum Wage Increase (Traditional Restaurants). (b) Aggregate Response to a Minimum Wage Increase (Fast-Food Restaurants).

Note: Solid line: simulated average aggregate response. Dotted line: bounds of the 95% confidence interval. Dashed line: response derived from the linear model estimated with aggregate data.
effect is completed. In the case of fast-food restaurants, adjustment is faster but still very slow: the half-life of the shock is 6 months, and after 12 months, 75% of the effect has been materialized. This protracted adjustment means that, each month, only a small fraction of restaurants decides to revise their prices. Part of the adjustment operates at the extensive margin, a point illustrated by Figure 6. After a shock, the fraction of restaurants revising their price rises. By contrast, in Calvo’s model, this fraction is constant. Since, here, the fraction of restaurants revising their price depends on covariates, the speed of adjustment varies with the size of the shock. Indeed, with a 1% shock on the minimum wage, the share of traditional restaurants adjusting their prices rises by 0.10 percentage point in the first month. These effects are larger in fast-food restaurants; the effect is 0.25 percentage point in the first month after a 1% minimum wage shock (Figures 6).

Figure 7 also report the impulse responses of a shock on the minimum wage performed using the aggregate linear models of Section 2. For fast-food restaurants, the linear model predicts an immediate adjustment (to a long-run target close to zero). In the case of traditional restaurants, the aggregate linear model indicates that full adjustment is almost complete (90%) after 20 months, while reaching the same relative adjustment requires 35 months according to the aggregate micro process (see Table 11). Micro estimates tend to point to slower adjustment than what macroestimates do, consistently with the analysis of Caballero and Engel (2003). The aggregate model seems to dramatically overestimate the adjustment speed, as can be inferred for example from the sum of the autoregressive parameters. Indeed the analytical results of Caballero and Engel predict the persistence parameter to be close to $1 - \lambda$, where $\lambda$ is the frequency of price changes. In restaurants, the frequency ranges between 5% and 10% (Table 10) so we expect persistence parameters to lie in the range 0.90–0.95. By contrast in, respectively, fast-food restaurants and traditional restaurants, the sum of the estimated AR parameters is equal to 0.40 and 0.77 in the linear model fitted to actual data (see Tables 5 and 6). Similar figures (0.67 and 0.82) are obtained from the Monte Carlo exercise in the “small-sample” case. Note that the bias partly vanishes in the asymptotic (large-sample) simulations, where the sum of the autoregressive parameters is equal to 0.86 for fast-food restaurants and 0.91 for traditional restaurants. These results again suggest that a linear aggregate model may not adequately capture the protracted adjustment resulting from individual lumpy behaviors, at least with a moderate sample size.

6. CONCLUSION

In this paper, we have used a unique data set of individual price quotes to assess the impact of the minimum wage on prices both in traditional and fast-food restaurants.

31. As already mentioned, the model we consider is more complex than the model analyzed by these authors, so their analytical results are not expected to exactly hold.
32. See Section 2.2.
Given that in this sector price changes are scarce, we have adopted an empirical model that features lumpy adjustment. Using this framework, we provide arguably better identified estimates of the impact of the minimum wage on prices.

Although idiosyncratic shocks play a large role in triggering price changes, we find that the minimum wage has a positive and significant impact on prices in traditional and fast-food restaurants. The estimated elasticity of prices with respect to the minimum wage is around 0.10 for both types of outlets. This impact is consistent with the share of minimum-wage compensations in total costs that can be estimated with macroeconomic data. This elasticity is higher than that found by MacDonald and Aaronson (2006) for the United States. This presumably reflects the lower fraction of workers paid at the minimum wage in U.S. restaurants (25% in the United States versus more than 40% in France).

Taking into account lumpsiness in the microeconomic adjustment of prices, we exhibit a protracted impact of the minimum wage on aggregate prices. The aggregate impact estimated with our model typically takes more than a year to pass through to retail prices. We show that such protracted impact is difficult to capture using aggregate data. In terms of price rigidity, our results indicate that although one main reason for restaurant price stickiness is that one important determinant of the cost (namely, the minimum wage) changes infrequently, there is also a substantial degree of “intrinsic” stickiness. Price stickiness is not a mere reflection of cost stickiness. In addition, our results point to the crucial role of nonlinearity and individual heterogeneity in inflation dynamics.

LITERATURE CITED


