

Reputation and Prices on the e-Market: Evidence from a Major French Platform*

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Abstract

We use an exhaustive data set from one of France's largest e-commerce platforms, PriceMinister.com, to estimate a statistical causal effect of a seller's reputation (and size) on transaction prices for a large range of product categories (books, CDs, video games or DVDs), product conditions (used or new) and seller types (individual or professional sellers). We go beyond the results currently available by tackling the issue of seller unobserved heterogeneity and the dynamics of reputation (and size) in price equations. Our results show large-scale empirical evidence of a significant, positive and strong effect of seller reputation on prices.

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1 Introduction

Over the past fifteen years, e-commerce has evolved from a marginal and sporadic medium of trade involving small numbers of IT enthusiasts into an economy-wide phenomenon. One of the biggest challenges e-commerce web sites are faced with is to design mechanisms that address fraud and seller misbehavior (such as poor delivery service or misrepresentation). One of the main responses to this challenge has been to develop online feedback procedures as a “technology for building trust and fostering cooperation” (Dellarocas, 2006). These procedures aim to alleviate adverse selection and moral hazard problems by providing a publicly observable measure of seller reputation. The empirical importance of these reputation indicators is the focus of a burgeoning literature in economics, that has arisen from the expansion of e-commerce and increasing data availability. The objective of this paper is to conduct an empirical analysis of the effect of seller reputation on transaction prices that contributes to this literature on at least two dimensions. First, the scale of our analysis is larger than that of previous papers as we can document the effect of reputation for a wide range of product categories, seller types and product conditions. The second contribution is methodological as we account for unobserved heterogeneity and we highlight and address issues related to the dynamics of seller reputation (and size) arising from the feedback mechanism.

We use a unique and exhaustive data set from one of France’s largest e-commerce platforms, PriceMinister (www.priceminister.com) to study the relation between a seller’s average feedback score and its prices for different categories of products, product conditions and types of sellers. Like other e-commerce web sites, PriceMinister implements a rating system where buyers grade their transactions. A seller’s reputation is defined as the (running) mean score over all transactions completed by that seller, and it is displayed at all times on the seller’s web page. Our main findings are the following:

- We estimate a statistically significant, positive and large causal effect of reputation on transaction prices.
- The effect of reputation differs across products and seller categories (professional sellers or private individuals).
- The effect of reputation increases with the number of past transactions (size) and decreases with the advertised condition of the good.
- We also find a positive effect of recent feedback scores on prices, but of a small magnitude.

Identifying and understanding the effects of feedback mechanisms on transactions is a key step in the economic analysis of online markets. Our work confirms that reputation effects are significant, and thus that due care should be taken in the design of feedback systems.

Our results also confirm the importance of information in online trading, and suggest that variation in buyers' information may partly explain why the Internet does not seem to have caused the substantial reduction in price dispersion that was initially expected (see Baye et al., 2004).

More generally, our work provides evidence of reputation effects at work. Economic theory has identified several channels through which public information about buyer satisfaction may improve trade efficiency (see MacLeod, 2007 or Bar-Isaac and Tadelis, 2008 for a review), but the empirical evidence remains scarce and often inconclusive. Rating systems whereby one or both trading parties can report to the community of traders about their level of satisfaction with any transaction they were involved in are interesting for at least two reasons: they apply to a large set of agents who can be tracked across time and transactions, and the information transmitted is directly observable. These features provide economists with new opportunities to analyze reputation effects.

While a number of contributions have already taken steps in that direction, efforts to exploit these features have been constrained by data availability (see Bajari and Hortaçsu, 2004 or Cabral, 2012 for a recent review).¹ Our rich data set allows us to overcome several of the difficulties previously encountered in this emerging domain of research.

PriceMinister has several specific features that distinguish it from eBay, which has been the focus of most of the extant literature. First, PriceMinister has a unilateral rating system in which only buyers rate sellers, which avoids the sophisticated gaming between buyers and sellers that arises on eBay's bilateral rating mechanism. Also, PriceMinister uses a pure price-posting mechanism, as opposed to auctions, and it serves as an intermediary for payment in all transactions. Importantly, PriceMinister makes the completion of any transaction conditional on the buyer acknowledging receipt of the item and rating the seller. These features arguably make the data from PriceMinister better suited to the analysis of reputation mechanisms.

Another interesting feature of our data set is that, in an effort to help sellers set their prices, PriceMinister records the list price of each product, that is the suggested retail price of the product when it was released. For books, the list price would then be the price set by the publisher. An important aspect of our analysis is that we can control for this variable, which will facilitate comparisons across products.

Most studies of feedback systems rely on data downloaded directly from a web site using a spider software (a prominent example is Cabral and Hortaçsu, 2010), which inevitably makes the resulting information limited in time and in product space. In this paper, we use an exhaustive data set obtained directly from PriceMinister. This data set allows us

¹The earlier literature includes Dewally and Ederington (2006), Dewan and Hsu (1995), Houser and Wooders (2006), Livingston (2005), Lucking-Reiley et al. (2007), McDonald and Slawson (2002), Melnick and Alm (2002), Resnick and Zeckhauser (2002).

to overcome many of the issues attached to the use of observational Internet data, from seller heterogeneity to limited product ranges.² To our knowledge, ours is the first study that estimates reputation effects for different types of product categories, advertised product conditions, and sellers. We show that the impact of reputation on prices varies across product categories, as suggested by Resnick et al. (2006).

Our data allow to track the full transaction and feedback rating history of sellers (including items sold), objective measures of the products' value (mainly, their list price) and condition (as advertised by the seller). This enables us to control for seller unobserved heterogeneity which has been identified as a major limitation in existing work (Resnick et al., 2006 or Cabral, 2012). This issue has been addressed in the literature by relying on field experiments (see Durham et al., 2004 or Resnick et al., 2006) or natural experiments (Cabral and Hortaçsu, 2010). An alternative strategy adopted by Lei (2011) is to focus on one specific product (Gmail invitations), for which there is little heterogeneity, and further including well chosen measures of seller quality. Klein et al. (2013) exploit a natural experiment and multiple feedback on eBay to provide evidence that the feedback mechanism affects seller behavior, but their data do not allow to measure effects on transaction prices.

More recent papers have been using richer data sets from e-commerce web sites. For instance Fan et al. (2013) follow a group of sellers on a large Internet platform in China for 14 months and estimate the effect of reputation measures on sellers' monthly revenue and sales. Another recent paper by Cai et al. (2013) uses a panel of online sellers from a Chinese e-commerce web site with similar features as eBay. Its focus and approach are different from ours as these authors study both theoretically and empirically how buyer protection may affect trust between buyers and sellers. In a recent contribution using a rich data set from eBay, Elfenbein et al. (2012) study how charity donations can be used as a substitute for reputation.

Due the exhaustive nature of our data, we are able to address the issue of unobserved heterogeneity using more standard panel data methods and thus draw inference for a varied set of product categories, product conditions and seller types. In so doing, we also highlight another substantive issue that was not investigated before: feedback ratings given by buyers depend on the prices set by a seller, thereby introducing a dynamic relationship between prices and reputation that needs to be taken into account in the estimation strategy.

The empirical evidence on the effect of reputation on the Internet is not solely based on data from e-commerce web sites. Two recent papers, Anderson and Magruder (2012) and Luca (2011), use data from Yelp.com, a web site providing reviews of restaurants. An interesting feature of these studies is that they exploit a discontinuity in restaurant scores to estimate the effect of a change in a restaurant's reputation on its bookings (Anderson

²A detailed discussion of these issues is conducted in Einav et al. (2013). These authors also use a rich data set from eBay to study the effect of listing characteristics on prices and other outcomes.

and Magruder, 2012) or its revenues (Luca, 2011). Our paper is different in at least two dimensions. First, our outcome variable is the transaction price and we control for the value of the item (through its suggested retail price). We thus have a direct measure of the effect of reputation on prices. Secondly, each feedback rating on PriceMinister.com is associated with one and only one transaction, while anyone can post a review on Yelp.com. We will discuss the existing literature at the end of our paper, after having presented our estimates, and compare our results with those of related papers.

The paper is organized as follows. We first describe the PriceMinister.com platform and the content of our data in Section 2. In Section 3 we lay out our statistical model, discuss the underlying theory and describe our identification and estimation strategy. Results are then presented and discussed in Section 4. Section 5 concludes.

2 The PriceMinister.com data

2.1 A short description of PriceMinister.com

Our data come from PriceMinister.com, a French company organizing on-line trading of first-hand or second-hand products between buyers and professional or non-professional sellers through their web site (www.priceminister.com).³ The PriceMinister web site opened in 2001 with a business model emphasizing the fight against fraud and counterfeit, as well as price recommendations for sellers. It is now one of France's biggest e-commerce web sites, claiming 11 million registered members in 2010.⁴ There were over 120 million products for sale in 2010, from books to television sets, shoes to motorbikes and computers to paintings.

In this paper, we focus on four categories of so-called 'cultural' goods: books, CDs, video games (games thereafter) and DVDs (videos thereafter).⁵ In 2004, these products represented more than 80% of the transactions on the web site and more than 60% of the transaction value (defined as the sum of all transaction prices). These numbers decrease over time but remain large even at the end of our observation period (still more than 60% of the transactions in 2007). We thus find it relevant to conduct our analysis on a set of goods that represent such a large share of the trade on a major e-commerce platform.⁶

The web site is a platform where sellers post adverts and buyers choose what products to purchase and which sellers to buy from. PriceMinister does not charge a sign-on fee, and posting an advert is free of charge. However for each completed transaction, sellers have to

³This company also runs a similar a web site in Spain, and had another one in the UK for a time. In this paper, we focus exclusively on the French web site.

⁴It was ranked first among e-commerce web sites in terms of ratings in a survey conducted by Mediamétrie in March 2010. The other main e-commerce web sites in France are Amazon, eBay and fnac.

⁵The 'video' category in fact also covers VHS, although the fraction of VHS in total sales in that category is likely to be negligible, as VHS were practically extinct in 2001, when PriceMinister started.

⁶In 2012, the categories 'books and magazines' and 'music and videos' accounted for 10% of US e-commerce sales (source: US Census).

pay a variable fee to PriceMinister.⁷ Sellers can be professional (registered businesses) or non professional (private individuals). Goods can be new or used. Used goods have been sold since the web site opened in 2001 whereas new goods have only been sold since 2003. Only professional sellers can sell new goods (they can also sell used goods).

Three specific features make PriceMinister different from other e-commerce web sites that are studied in the economic literature. First, PriceMinister itself does not sell any products: it is a platform (unlike, e.g., Amazon). Second, prices are posted by sellers, there are no auctions (unlike eBay). Lastly, PriceMinister also uses a specific feedback and transaction control mechanism that makes it particularly well suited to our study.

Every time a seller wants to sell an item, she must enter the product characteristics (bar code or detailed description), and then receives a price recommendation from PriceMinister based on the list price and the condition of the item (the recommendation also factors in prices charged for the same item by other sellers on the platform). She then chooses a price and creates the advert.

A buyer looking for a given product at a given date will be taken through a sequence of web pages. On the first page, he will see all live adverts for this product. Each advert conveys information on the price, the seller's name and country, the different shipping options, whether the product is new or used and, in the latter case, its advertised condition. For used products, sellers have to state whether the good's condition is 'as new', 'very good', 'good' or 'fair'. Buyers also observe the seller's size, equal to the number of completed transactions to date, and the seller's average feedback score over all completed transactions, rounded to the nearest multiple of 0.1 — what we define as the seller's reputation (more on this below). There is also a link to the seller's web page on PriceMinister (the seller's 'showcase'). The buyer may then select an advert, obtain more detailed information about the item and make a purchase.

In a typical transaction, where a buyer purchases a given product from a given seller, the buyer's payment first goes to PriceMinister.⁸ This initiates the transaction. At this point the seller is informed that a buyer has chosen her product and ships the item to the buyer. In any transaction, the choice of shipping mode (essentially, standard or registered mail) is up to the buyer, subject to a fixed shipping cost scale imposed by PriceMinister.⁹ Sellers thus cannot compete on shipping fees.¹⁰

Once the buyer has received the product, he has to go to the web site to finalize the

⁷The fee scale is posted on the PriceMinister.com web site. For example the fee for a €10 transaction would be €2.1.

⁸Buyers may use a credit card or hold a virtual account credited with other means of payment.

⁹Specifically, the buyer chooses a particular shipping option at the time of purchase and the corresponding fee on the shipping cost scale is added to the bill and transferred to the seller by PriceMinister. It is then up to the seller to minimize its costs, subject to complying with the buyer's specific choice of shipping mode.

¹⁰Some non-standard shipping options can be offered by some sellers but not by others, always at a fixed fee set by PriceMinister.

transaction and at the same time give his feedback. PriceMinister then closes the transaction and pays the seller.¹¹ The buyer's feedback consists of a grade, or rating, which by default is equal to 5. The buyer can change it to any integer between 1 (very disappointed) and 5 (very satisfied), using a pull-down menu. Buyers can also leave a textual comment in addition to the numerical rating but we do not use that information in this paper.

Issues that have been identified as problematic for online reputation mechanisms include the low propensity of buyers to provide feedback, and the possibility for a seller to change identity (see Dellarocas, 2006 or Cabral, 2012). As the payment process is secured by PriceMinister, there is little scope for buyer moral hazard. Besides, PriceMinister does not allow sellers to grade buyers. Since feedback is given at the time when the buyer validates the transaction, there is little risk of retaliation on the seller's part. Moreover, the fact that buyers must give feedback in order to validate the transaction ensures a high feedback rate (above 90% for transactions with individual sellers, 15 to 20% of feedback ratings being strictly below 5).

PriceMinister has at least three ways of identifying a seller: the seller's IP address, the seller's bank details and, for professional sellers, an identifier from the official register of French firms (SIRET). This leaves little scope for strategic changes of identity on the part of sellers. Also, since PriceMinister holds payments until the buyer confirms receipt of the item, the risk of seller fraud is reduced. However, there is still scope for inaccurate description of the product or poor service delivery. This motivates the feedback mechanism and the scoring system.

Lastly, we should emphasize that by default adverts for a given product are listed by increasing order of price. Hence the effect of reputation that we will recover cannot be attributed to a prominence effect created by a better ranking for better score (see Armstrong and Zhou, 2011). More precisely, adverts are first sorted by price but the buyer then has the option to sort them by seller score or by product condition. There may well be some prominence effect once the buyer has asked for a ranking by score but this would result from a deliberate choice of the consumer and hence could be attributed to a reputation effect.

2.2 The data

Our initial data set contains information about all the transactions that took place on PriceMinister since the web site started (in 2001) until the first week of December 2008. For each transaction, we know the seller's identifier, her status (professional or not), the product identifier, the transaction price, the advertised condition of the good, the type of shipping, the dates when the transaction was initiated (when the payment went to PriceM-

¹¹When a buyer files a complaint, PriceMinister investigates and puts the payment on hold. If the buyer does not contact PriceMinister within 6 weeks, he is sent a reminder e-mail. If he does not respond, PriceMinister closes the transaction and pays the seller.

inister, recorded to the millisecond), and completed (when PriceMinister pays the seller), and the buyer’s feedback rating. Products are precisely defined, for instance the product identifier for a book is similar to its ISBN code. Used products are heterogenous with respect to their advertised condition (as new, very good, good or fair), whereas all new products have by definition the same condition.¹²

We observe the product list price. For each product this variable is documented once when the item is first introduced for sale on the web site. The list price is the suggested retail price set by the publisher for books, by the record company for CDs, etc. It is thus fixed for each product. Notice that it differs from the price recommendation that PriceMinister gives to sellers when they post an advert. This variable will be important to account for product heterogeneity as well as for sorting on seller/product characteristics. We discuss this issue in section 3.2.

The price variable that we use throughout the analysis is the advert price net of shipping costs. This is a way of making all prices comparable, as shipping costs are rigidly set by PriceMinister.

Then, from the initial data set, we can construct the following two variables for every transaction:

- the seller’s reputation r defined as the average feedback score over all completed transactions (at the date when the transaction was initiated)
- the seller’s size s equal to the number of completed transactions.

These two pieces of information are immediately available to the buyer, together with the advert price, for each advert on the first page seen by the buyer. Intuitively size should matter because the consumer may take market performance as reflecting part of the seller’s quality. The size may also affect the weight given by the buyer to the reputation index.

Buyers further have access to any seller’s full feedback history. By browsing that history, it is relatively easy for buyers to see at least a few of the most recent feedback ratings received by a seller. We will therefore investigate the separate effect of recent feedback.

Our empirical analysis focuses on four product categories (books, CDs, games and videos) although we use all transactions to compute a seller’s size and reputation. Since we observe all transactions for all sellers, both of those variables are available at all dates for all sellers.

Finally, for each transaction we construct the “age” of the article as the length of time between the date at which the product was first sold on the web site and the transaction date.

¹²The condition variable can be strategically manipulated by sellers. Modelling the seller’s decision to advertise a genuine or misleading product’s condition is a challenging and interesting problem (see Jullien and Park, 2011) but beyond the scope of this paper. We will show estimation results for all used goods but also for each product condition. We will also present additional results on new goods which are immune from sellers’ decisions to cheat on the condition.

The main focus of this paper is on individual sellers and used goods. However, we also present results for professional sellers and new or used goods. This allows us to gauge whether reputation is more important for individual sellers, which would be the case if professional status was interpreted by customers as an indicator of quality and thus as a substitute for reputation.

The four product categories we focus on (books, CDs, video games and videos) are the products most commonly sold on PriceMinister. They account for 12,241,317 of the 15,003,376 transactions made by individual sellers (81.6%) and 4,033,490 of the 6,337,838 transactions involving professional sellers (63.6%).

2.3 Descriptive statistics

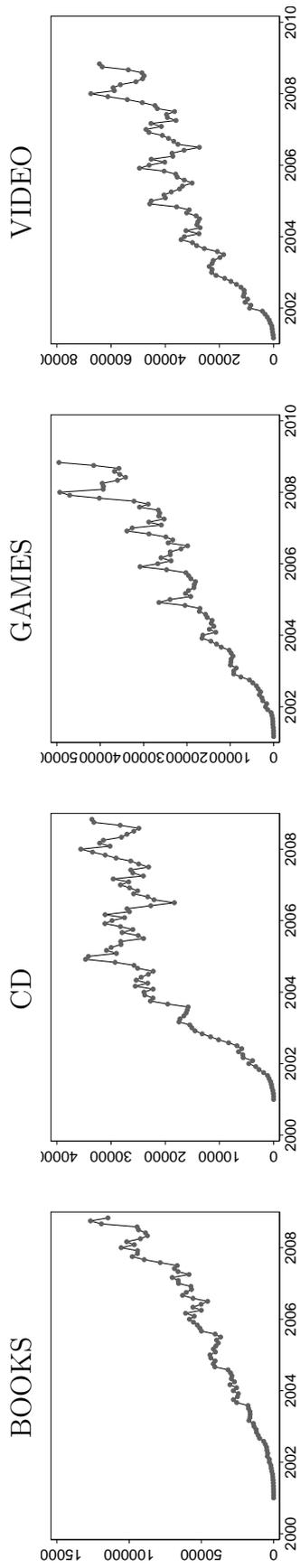
We now present some descriptive statistics for individual sellers and used goods. Descriptive statistics for professional sellers and used or new goods are in the Appendix. We start with Figure 1 which presents general trends for the four product categories we are considering. The top row shows the total number of transactions over time, at a monthly frequency. We observe a strong increasing pattern reflecting the increasing activity in e-commerce in France during the past decade, as well as the success of PriceMinister as a platform. The middle row of Figure 1 presents the evolution of average transaction prices (in €) throughout the observation period. The price fluctuations at the very beginning of each series probably reflect the small number of transactions in the few months following the opening of the platform. If we look at these series from 2002 onwards, we observe a strong increasing trend in book prices whereas transaction prices for games, videos and (after 2006) CDs decline steadily. Note that the volume and price series both exhibit strong seasonality.

Table 1 reports a series of descriptive statistics on sellers and goods. We start with the top panel. A seller is in the ‘books’ column if she sells at least one new book (the same goes for the other product categories) over the observation window. In each product category there are hundreds of thousands of individual sellers and used products, and millions of transactions. As one may expect with individual sellers, comparison of the third and fourth rows shows that very few products are sold more than once by the same seller.

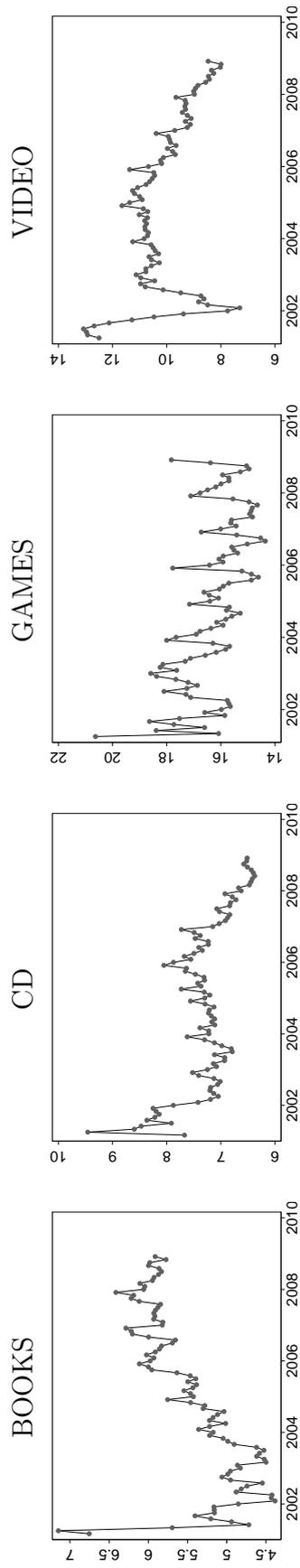
The middle panel of Table 1 shows that the distribution of product condition among transactions of used goods is non-uniform, and varies across product categories. For individual sellers, most transactions involve products in a condition advertised as ‘very good’ or ‘as new’, but there is still a large number of products sold in a ‘good’ or ‘fair’ condition.

The bottom panel shows quantiles of the distribution of seller size (the number of completed transactions) in January 2008. To compute these quantiles, we consider sellers who are ‘active’ in January 2008. Since we do not observe seller exit, we assume that a seller is active at a given date t if she created her account before t and makes at least one transaction after t . Table 1 shows that there is substantial dispersion in seller size and that some sellers

Number of transactions per month



Average transaction price (in Euros) per month



Distribution of seller reputation in January 2008

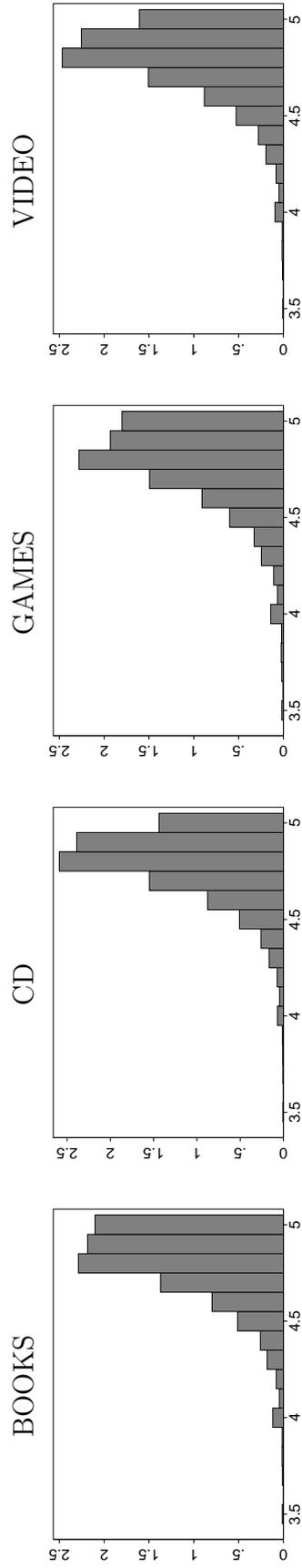


Figure 1: Descriptive statistics for individual sellers and used goods

Table 1: Descriptive statistics: individual sellers and used goods

<i>Number of...</i>	Books	CD	Games	Video sellers
sellers	152 894	88 366	164 706	131 111
products	767 209	270 189	31 500	123 789
seller/product transactions	3 820 354	1 812 987	1 586 264	2 445 400
	3 981 429	1 948 637	1 759 572	2 927 386
<i>Number of transactions per used product condition</i>				
fair	249 363	40 134	45 827	29 022
good	723 313	218 625	200 243	180 752
very good	1 712 632	1 038 310	962 373	2 054 480
as new	1 296 121	651 568	551 129	663 132
<i>Distribution of seller size in January 2008</i>				
5% quantile	2	4	2	3
50% quantile	29	48	28	38
95% quantile	328	424	321	372
99% quantile	879	1 097	877	968

Table 2: Distribution of feedback

feedback	BOOKS	CD	GAMES	VIDEO
1	23 310 (0.6%)	16 293 (0.9%)	23 886 (1.5%)	28 252 (1.1%)
2	27 267 (0.8%)	16 937 (0.9%)	18 569 (1.2%)	23 831 (0.9%)
3	85 540 (2.4%)	53 123 (2.9%)	51 912 (3.3%)	70 679 (2.6%)
4	361 208 (9.9%)	202 048 (11.1%)	211 422 (13.4%)	288 556 (10.7%)
5	3 142 420 (86.3%)	1 525 239 (84.1%)	1 269 008 (80.6%)	2 279 299 (84.7%)

are relatively big, even though they are not officially registered as businesses. Another feature of the data is that individual sellers do not seem to just occasionally sell a few products on PriceMinister: more than half of the sellers make around 30 transactions or more.

Table 2 shows the distribution of feedback ratings for each category. While it is highly concentrated on the default grade of 5, 15 to 20% of feedback ratings are below 5. Because 5 is the default, a feedback score equal to 5 only means that the buyer is satisfied enough with the transaction that he does not feel the urge to actively enter a strictly lower score.¹³

The important conclusion from Table 2 is that there is sufficient variation in feedback grades to induce variation in the reputation of sellers. In the last panel of Figure 1 we show the distribution of reputation for sellers who are ‘active’ in January 2008. As expected, very few sellers have a reputation below 4 (around 1%). In the interest of readability, we do not show these sellers on the graphs. Most reputation levels are above 4.5 and the mode of the distribution is at 4.8 for all product categories. It is important to note that while most sellers have a reputation between 4 and 5, there is substantial variation across the sample between these two bounds. Our analysis will show that a 0.1 difference in reputation will have a strong effect on the transaction price and, given the dispersion of seller reputation between 4 and 5 (4.6, 4.7, etc.) this will result in substantial variation in prices.

To end this section, we show evidence of price dispersion within product. The relevant descriptive statistics are in Table 3. Looking at the first panel of Table 3, we see that on average there are at least 3 different transaction prices for a given book and up to 25 different prices for a given video game. The distribution is very asymmetric as the median number

¹³Suppose that some consumers always grade actively while others leave the default unchanged. If the mass of the former type of consumers is small, a grade of 5 is not very informative while a grade of 4 could be interpreted as positive feedback.

Table 3: Price dispersion

	BOOKS	CD	GAMES	VIDEO
<i>No. of distinct transaction prices for a given product</i>				
- mean	3.5	5.0	25	13
- median	2	2	8	4
<i>If no. of distinct transaction prices > 1</i>				
- pmax/pmin (mean)	3.31	3.98	8.78	5.67
- pmax/pmin (median)	1.98	2.04	4.63	3.11
- p10/p50 (mean)	0.73	0.71	0.60	0.64
- p90/p50 (mean)	1.55	1.54	1.92	1.73
<i>If no. of transactions ≥ 10</i>				
- No. of prices (mean)	15	21	47	31
- No. of prices (median)	11	14	26	19
- pmax/pmin (mean)	6.62	8.40	12.24	8.70
- pmax/pmin (median)	3.98	4.43	7.47	5.56
- p10/p50 (mean)	0.65	0.60	0.55	0.58
- p90/p50 (mean)	1.77	1.73	2.03	1.85

Note: pmax (pmin) is the maximum (minimum) price observed for a given product.
p10 (p50, p90) is the 10% price quantile (50%, 90%) for a given product.

of distinct transaction prices is between 2 and 8, depending on the product category. It should be noted that these moments are taken over the whole population of products, including the very large number of products that are sold only once.

If we focus on products with at least 2 different transaction prices, and thus look at the middle panel of Table 3, we see that the maximum price is on average 3 (books) to 8 (video games) times larger than the minimum price. The median ratio of highest to lowest price is also large (2 to 4.6). Hence, transactions for a single product take place at a very wide range of prices. This range seems to be wider above the median as the 10% price quantile is 60 to 73% smaller than the median while the 90% price quantile is 154% to 192% times higher than the median.

A natural explanation for this price dispersion within product lies in changes in demand over time. The price of, say, a music album may be high just after its release but will decrease over time as the demand for this particular product falls. We will account for this feature in our analysis by controlling for the age of a product. For this section however, since we take a first descriptive pass at the data, we just look at the overall distribution of prices within product.

The bottom panel of Table 3 zooms in on the group of products that are sold at least 10 times. We see that these products have on average 15 (books) to 47 (video games) different transaction prices and, whether we look at the mean or the median ratio, the maximum price is at least 4 times higher than the minimum price.

We thus observe a large amount of within-product price dispersion in our data. The same CD can be sold at prices that differ by a factor 4 on average. These price differences could result from changes in demand over time, from seller differentiation (and thus reflect differences in reputation or size) or from market imperfections such as search frictions. We will control for the dynamics of the demand side (accounting for product age and for product category-specific trends) and study the effect of two seller characteristics, reputation and size, on transaction prices.

3 Empirical framework

A vast theoretical literature is devoted to seller reputation, a complex concept as it may encompass different phenomena depending on the information unavailable to market participants (sellers' hidden characteristics or hidden actions) and on the equilibrium concept (Markov or Bayesian Perfect).¹⁴ Another difficulty is that most theoretical models are solved under extreme assumptions about the environment, in particular about hidden characteristic and the distribution of observables. In section 3.1, we present the econometric model used for our analysis and discuss its link with existing theory. Section 3.2 shows how we address the identification issues arising from the dynamics of reputation and section 3.3 is devoted to estimation.

3.1 The econometric model

3.1.1 Prices

Let p_{ijd} be the (logarithm of the) price set by seller i for product j at time d (time is discrete). We consider the following price equation:

$$p_{ijd} = g(r_{id}, s_{id}) + \beta x_{ijd} + \alpha_i + \mu_j + \varepsilon_{ijd}, \quad (1)$$

where r_{id} denotes seller i 's reputation at date d and s_{id} denotes her size. The effect of these two variables, formally defined below, is modeled as a function g which we will specify momentarily. The vector x_{ijd} contains the seller/product characteristics observed by the econometrician at date d while α_i and μ_j respectively denote seller and product fixed characteristics that are unobserved by the econometrician. Finally, ε_{ijd} is a scalar unobserved seller/product-specific shock capturing market conditions for (i, j) at date d . It is assumed

¹⁴A tentative unifying framework is provided by Bar-Isaac and Tadelis (2008)

mean-independent of any of the other contemporaneous right-hand side variables. Apart from α_i , all the variables on the right-hand side of (1) are observed by buyers. The seller fixed effect α_i may or may not be observed by the buyer (see the discussion below).

Our main outcome of interest is the transaction price. We cannot study advert prices or purchase probabilities because, whilst we have exhaustive information on transactions, we only have limited information on adverts.¹⁵ Our analysis will thus aim at estimating a causal statistical effect of reputation on transaction prices but not at delving into consumers' preferences for reputation or sellers' pricing decisions. Still, the next section discusses the links between the reduced-form equation (1) and economic theory.

3.1.2 Discussion: Theoretical underpinnings

The price equation (1) contains the main ingredients present in most theoretical models of reputation with non-competing sellers.¹⁶ The main substantive assumption underlying our statistical model is that contemporaneous reputation and size are the only relevant endogenous state variables on which strategies are made contingent. One may describe the situation using the following basic model. Each seller has an unknown type α_i , and sells a sequence of items over time. Transaction dates d and item characteristics z_{id} follow exogenous processes. At any date, all buyers observe the characteristics z_{id} of the item (if any) as well as the same public information \mathcal{I}_{id} about past transactions and in particular the experience of past buyers. For each completed transaction, the final quality q_{id} is observed by the buyer only upon consumption. This quality is random and its distribution depends on z_{id} and the type α_i of the seller. After observing q_{id} , the buyer passes on information about his experience to the market through the feedback system.

This set-up is quite flexible as it allows z_{id} to include current characteristics of the market as well as of the item, and \mathcal{I}_{id} to vary from full information to coarse information. In our main specification, we summarize the information available to buyers by the seller's reputation (mean feedback) and size, $\mathcal{I}_{id} = \{r_{id}, s_{id}\}$, because obtaining more information, while possible on the PriceMinister web site, requires pro-active search by buyers. We will also consider alternative specifications that allow the most recent feedback ratings to have a separate impact on prices.

Our model is consistent with the assumption of a Markov equilibrium being played. Under the assumption of common prior beliefs about the types of sellers and public information, all buyers hold the same beliefs about the distribution of the type α_i of the seller, resulting from the Bayesian updating of the prior distribution based on the information $\{\mathcal{I}_{id}, z_{id}\}$ available at the time of the transaction. These beliefs summarize all the information that is relevant

¹⁵As shown by Elfenbein et al. (2012), seller quality signals may affect their probability of selling. Unfortunately, our data does not allow us to tackle the resulting selection effect.

¹⁶See Bar-Isaac and Tadelis (2008) for a review.

from a buyer perspective. The Markov assumption underlying our econometric specification is then that for any given transaction, the strategy of the seller, hence the price, depends solely on the market information \mathcal{I}_{id} , the characteristics z_{id} and the seller’s type (if it is known by the seller).¹⁷ This is a common assumption in the literature on reputation, which is particularly appealing in our context, as each seller faces many buyers and buyers see at best the history of feedback ratings, but not the full history of prices and products sold.

Most models of reputation assume that demand exceeds supply so that a seller acts as a monopoly.¹⁸ In our context sellers face competition to a variable degree: some items are offered by one seller only, others are offered by many sellers at the same time. Ideally we would want to control for the degree of competition. Unfortunately at the time of writing, we only have data on completed transactions and thus cannot accurately observe the overall supply of each product at all points in time.

Although the literature on reputation in competitive markets is comparatively small, our specification would also be consistent with a situation featuring a large number of competing sellers. For instance, in a simple model of non-strategic Bayesian learning about seller quality, our price equation (1) could be interpreted as an equilibrium hedonic price equation where reputation enters as a vertical attribute of goods (Rosen, 1974). In this case competition between multi-attribute goods equalizes the utility that consumers expect to obtain from all items for sale, where this utility depends on the price and an index of quality that is a function of the attributes. Such a model was analyzed for input goods by Atkeson et al. (2012).¹⁹ In our model the attributes are z_{id} and $E(\alpha_i|\mathcal{I}_{id})$, and the implied price equation is $p_{id} - g(\mathcal{I}_{id}) - \alpha_z z_{id} = h_d$, where h_d is constant across all items for sales at date d and reflects current aggregate supply and demand conditions.

The price equation (1) could also follow from a theoretical model of imperfect competition in the spirit of Ericson and Pakes (1995), up to some simplifying assumptions ensuring that seller i ’s optimal price for product j at date d can be expressed as a function of variables pertaining to seller i and product j at date d only (independent of other sellers’ characteristics). We thus need to impose that the set of products offered by a seller at any date is exogenous, that sellers work ‘product by product’ (i.e. treat their pricing decision on one product as independent of that on other products), and that sellers are oblivious of other sellers’ pricing decisions. The latter assumption can be related to the concept of *oblivious equilibria* which was introduced by Weintraub et al. (2008) to alleviate the computational burden of simulating Markov Perfect Equilibria with a high-dimensional state variable. These assumptions are

¹⁷Notice that the dependence on type is captured by the fixed effect α_i .

¹⁸Many reputation models, for instance Tadelis (1999) or Mailath and Samuelson (2001), assume homogeneous demand and prices set at the consumers’ reserve price, but our model would also be consistent with elastic demand accounting for the seller’s benefits of inducing learning (Bergemann and Välimäki, 1996).

¹⁹Hörner (2002) proposes a competition model where the equilibrium price is an increasing function of reputation (see equation B2, p. 659). However, in his model reputation is not public as only loyal customers observe the seller’s history.

reasonable for a large online market although there may be some limitations due to loyalty and the endogenous degree of competition. Intuitively, these assumptions are more likely to hold for individual sellers, which is the category we study in our benchmark estimation.

We do not observe seller exit. Exit (or entry) decisions depend in principle on the seller's future prospects, thus on her type, reputation and size (Bar-Isaac, 2003). As the next subsection will show, our identification strategy requires that we observe a seller's price, reputation and size at least for two different goods in a given product category. This means that the sellers who are selected out of the sample have completed at most one transaction for which their reputation was available on the web site before leaving the platform. We think that such 'one-off' sellers are irrelevant for the question investigated in this paper.

We remain agnostic about whether or not a seller's fixed effect α_i is observed by buyers. Both cases may arise: observable fixed effects may be related to the seller's presentation skills, i.e. the general look and feel of the seller's page on the PriceMinister web site.

3.1.3 Feedback, reputation and size

Our main parameter of interest is the effect of reputation on prices. We are also interested in the effect of a seller's size on prices. Before we turn to the identification and estimation of these effects in our data, it is useful to discuss the flip side of the reputation mechanism, namely the feedback process.

Consider the n^{th} transaction for seller i and product j and let $d^0(i, j, n)$ and $d^1(i, j, n)$ be the dates when this transaction is initiated (when the buyer purchases the product) and completed (when feedback is received) respectively. Seller i 's size at date d is given by:

$$s_{id} = \# \{j, n : d^1(i, j, n) \leq d\}, \quad (2)$$

where $\#\{\cdot\}$ denotes the cardinality of a set.

Let f_{ijn} denote the feedback grade set by the buyer for this transaction. The reputation index r_{it} of seller i at date d is the rounded average, to the nearest first decimal, of all past feedback (for all completed transaction). Formally:

$$r_{id} = \lfloor 10 \cdot \bar{f}_{id} + 0.5 \rfloor / 10 \quad \text{where} \quad \bar{f}_{id} = \frac{1}{s_{id}} \cdot \sum_{j,n: d^1(i,j,n) \leq d} f_{ijn}, \quad (3)$$

and where $\lfloor \cdot \rfloor$ denotes the floor (integer) function.²⁰

We assume that feedback f_{ijn} is a function of price, reputation, size, all observed or unobserved characteristics at date $d^0(i, j, n)$ (when the transaction is initiated), of the duration

²⁰Note that a seller's reputation (and size) may change between the date when an advert for a given product is posted and the transaction date. We use the seller's reputation at the latter date as it is the one seen by the consumers when they purchase the good. Using the limited information we have on adverts, we find that sellers very rarely change their advert price for a given product (most of our sellers are private individuals, not professional sellers).

$d^1(i, j, n) - d^0(i, j, n)$ between the initiation and completion dates of a transaction, and of some unobserved shock affecting buyer satisfaction. We will not derive or estimate this function. Studying the determinants of buyer feedback is an important and interesting question but it is beyond the scope of this paper. Yet, independently of the specific form of that function, this discussion suggests that reverse causality may be an issue in our estimation of the effect of reputation on prices, as the feedback rating f_{ijn} can be affected by the price $p_{ijd^0(i,j,n)}$ in any transaction. For instance, a buyer paying a higher price may have higher expectations about quality of service. Moreover high-price and low-price offers may attract consumers with different marginal willingness to pay for quality.

Since reputation is a summary measure of past feedback, it will in general depend on past prices. The reputation variable r_{id} in equation (1) may thus be correlated with past realizations of the ε shocks. The same problem may arise with the size variable. Again, rather than fully specifying the feedback function and estimating the determinants of feedback, we will take a reduced-form approach to tackling reverse causality, as discussed in the next sub-section.

3.2 Identification

The main identification problem lies in the presence of seller and product fixed effects, respectively α_i and μ_j , which are not independent of the outcomes of seller i 's past transactions, and thus of seller i 's reputation r_{id} and size s_{id} .

Sellers can change the price they post for a specific item, so that prices do vary within a seller/product pair (i, j) . However, exploiting this source of variation is problematic for several reasons. First, we observe that only a small fraction of seller/product pairs have transactions at different prices. This is especially true for non-professional sellers who, in the overwhelming majority of cases, sell only one copy of any given good. Second, in order to exploit price changes within seller/product pairs, we need to model the sellers' decision to update their prices and address the resulting selection problem.

We thus choose another route to identify our effects of interest and exploit differences within sellers.²¹ While this will take out the unobserved seller effect α_i , this approach raises two further concerns which we discuss in turn. First, we still have to deal with product unobserved heterogeneity. Second, reputation and size may depend on past ε shocks in (1).

²¹As discussed in section 2.2, our price variable is net of shipping costs, which depend on the shipping mode chosen by the buyer according to a fixed scale set by PriceMinister. If sellers try to influence buyers' choices of shipping options, our identification approach requires that the resulting strategy does not vary over time within seller in response to reputation or sales shocks.

3.2.1 First transactions

By definition, when a seller sells a product j for the first time, she has not yet received any feedback for transactions involving this product. Hence product j 's characteristics have not yet had any direct effect on the seller's reputation or size. We will use this insight to identify g .

We focus on the *first transaction for each seller/product pair* (i, j) : for all product j /seller i pair observed in our initial data set, we only keep the observation corresponding to the first time seller i sells a copy of product j . We then sort these 'first transactions' chronologically for each seller and denote the t^{th} first transaction using the index t .²² The product sold by seller i at (first) transaction t is denoted by $j(i, t)$. Considering equation (1) for first transactions only thus consists of selecting those observations for which there is a $t \geq 1$ such that $d = d^0(i, j(i, t), 1)$. This allows us to replace the triple index (i, j, d) by the double index (i, t) where $d = d^0(i, j(i, t), 1)$. Rewriting (1) in this fashion, the price equation that we take to the data reads:

$$p_{it} = g(r_{it}, s_{it}) + \beta \cdot x_{it} + \alpha_i + \mu_{j(i,t)} + \varepsilon_{it}. \quad (4)$$

We thus have a panel where sellers are individuals for which we observe a series of 'first transactions', as defined earlier, and where the time dimension is given by the chronological rank of a transaction in a seller's series of first transactions. Taking forward differences between t and $t + k$, $k \geq 1$, we get:

$$p_{it+k} - p_{it} = [g(r_{it+k}, s_{it+k}) - g(r_{it}, s_{it})] + \beta \cdot (x_{it+k} - x_{it}) + \mu_{j(i,t+k)} - \mu_{j(i,t)} + \varepsilon_{it+k} - \varepsilon_{it}, \quad (5)$$

The seller unobserved effect α_i has been differenced out but the second line of (5) shows that there are still two unobservables: $\mu_{j(i,t+k)} - \mu_{j(i,t)}$ and $\varepsilon_{it+k} - \varepsilon_{it}$. These two unobserved variables are at the source of both identification issues discussed above: unobserved product heterogeneity and the dependence of reputation and size on past shocks.

3.2.2 Product heterogeneity

At any first transaction t , the reputation and size posted on the web site for seller i are based on that seller's past transactions, none of which involves product $j(i, t)$. Hence, product $j(i, t)$'s characteristics have no direct effect on the seller i 's size and reputation at transaction t . They may still affect r_{it} and s_{it} indirectly through their correlation with the seller's characteristics. We thus need further assumptions.

²²Since individual sellers rarely sell more than one copy of any item (see Table 1), the descriptive statistics shown in 2.3 would not vary much if we computed them on first transactions only. In particular, there would be as much variation in reputation and size across sellers. Descriptive statistics on first transactions are available from the authors upon request.

Formally, the first assumption we will use to achieve identification and to write our moment conditions is the following mean-independence condition:

$$E [(\mu_{j(i,t+k)} - \mu_{j(i,t)}) | r_{it-\ell}] = E [(\mu_{j(i,t+k)} - \mu_{j(i,t)}) | s_{it-\ell}] = 0, \quad \forall i, t, k \geq 1, \ell \geq 0. \quad (6)$$

In words, condition (6) means that for each seller the change in unobserved product characteristics between two (first) transactions, t and $t + k$, is mean independent of the seller's reputation or size at t . We now discuss the validity of this assumption.

First, we observe key product characteristics, namely the product list price, age and condition, which arguably capture a large share of the heterogeneity across products. We should also note that estimation is conducted separately by product category so we do not compare, say, books with video games. If a seller specializes in, say, special collector's editions of certain books, this should be reflected in those books' list prices and will thus be captured by our observed variables.

Residual unobserved heterogeneity may then arise from features not captured by the list price such as whether the book seller specializes in, say, French literature. This could be a problem if equation (6) was written in levels. We would then need a stronger, but easier to interpret, assumption that would rule out any sorting between seller and product unobserved characteristics. Writing (5) in differences however allows for sellers to specialize in an unobserved category with the variation in μ within seller coming from iid shocks.

The latter assumption rules out cases where sellers change the (unobserved) type of products they specialize into in response to changes in their reputation. We believe this assumption to be largely uncontroversial for individual sellers (the category we mainly focus on), the majority of whom are private individuals selling whatever products they happen to have purchased at some point and now want to get rid of. It is difficult to believe that those sellers strategically adjust the types of products they sell in response to changes in their reputation. Our assumption, however, may be stronger when applied to professional sellers. It should be stressed, however, that that this assumption only applies to unobserved product characteristics. If, for example, a seller responds to a declining reputation by advertising cheaper, low-margin products, this will be captured by the observed product list price.

Lastly, an alternative approach would have consisted in focusing on a small number of products (see e.g. Cabral and Hortag̃su, 2010) and thus conduct estimation for each product separately. We do not follow this route because we want to evaluate the effects of reputation for a large and varied set of products, which we think is in itself a contribution to the existing literature.

3.2.3 The dynamics of reputation and size

The second issue with the differenced price equation (5) lies in the term $\varepsilon_{it+k} - \varepsilon_{it}$. The seller's reputation and size at transaction $t + k$ are built on past transactions and will thus

be correlated with past prices, including p_{it} and thus ε_{it} , through the feedback mechanism. Since the unobserved price shock ε_{it} is orthogonal to the current (or past) reputation and size variables, we can use (any function of) $r_{it-\ell}$ and $s_{it-\ell}$, for $\ell \geq 0$, as instruments. The corresponding conditional mean independence assumption reads:²³

$$E[(\varepsilon_{it+k} - \varepsilon_{it}) | r_{it-\ell}] = E[(\varepsilon_{it+k} - \varepsilon_{it}) | s_{it-\ell}] = 0, \quad \forall i, t, k \geq 1, \ell \geq 0. \quad (7)$$

We use conditions (6) and (7) to identify and estimate the function g . Before presenting the estimation approach in the next subsection we should point out that we have discussed identification under the assumption of iid price shocks ε . While our approach could easily be extended to accommodate some persistence in ε_{it} , we will test (and accept) after estimation the assumption of iid shocks.

3.3 Estimation

In theory we could use our identifying assumptions (6) and (7) to conduct a nonparametric instrumental regression.²⁴ However we have two potentially endogenous variables, reputation and size, and many exogenous regressors (which we present in detail at the end of this section). We thus take the simpler approach of specifying a functional form for g , and using a set of instrumental variables and moment equations to estimate the parameters of interest.

All our estimations are based on the following moment equation:

$$E \{ [p_{it+k} - p_{it} - (g(r_{it+k}, s_{it+k}) - g(r_{it}, s_{it})) - \beta \cdot (x_{it+k} - x_{it})] \cdot z \} = 0, \quad (8)$$

for all instruments z in a set \mathcal{Z}_{it}^g and for a given specified function g and a given $k \geq 1$. The expectation is taken over all sellers and first transactions, that is over (i, t) within a given product category. The specification we use for our benchmark estimation results is the following:

$$g(r, s) = \gamma r + \delta s + \delta_2 s^2, \quad \mathcal{Z}_{it}^g = \{r_{it}, s_{it}, s_{it}^2\} \quad \text{and } k = 1. \quad (9)$$

The main parameter of interest will thus be γ , the effect of an increase in reputation on (log) prices. In all tables below, we will rescale γ as measuring the effect of an increase in reputation of 0.1.²⁵

We will also consider alternative specifications, essentially for two purposes. The first one is to allow for a more flexible relationship between reputation, size and prices. This will be achieved by changing the specification of g . The second purpose is to check the robustness of our results. For this we can consider longer differences in the price equation, $k > 1$, and/or

²³Note that these conditions are slightly weaker than assuming conditional independence between ε_{it} and $r_{it-\ell}$ or $s_{it-\ell}$, $\ell \geq 1$.

²⁴See e.g. Ai and Chen (2003) or Darolles et al. (2011).

²⁵Recall that reputation is rounded to the nearest multiple of 0.1 on the PriceMinister web site, so that 0.1 is the minimal variation in reputation that is observable by buyers.

a different set of instruments \mathcal{Z}_{it}^g (for instance including further lags of reputation or size). We will discuss these alternative specifications in Section 4.

For each category of sellers (individual or professional), product (books, CDs, video or games) and product quality (used or new), the sample used for estimation contains the first transaction of each seller/product pair. Sellers who only make one transaction in the product category are thus dropped from the sample. Prices are in logarithms. The strictly exogenous observed covariates x_{it} are product list price, product age,²⁶ year \times quarter dummies and, for used products, dummies indicating the product’s advertised condition (as new, very good, good, fair).²⁷

4 Results

4.1 The effect of reputation and size on prices

We now present and discuss our main estimation results. Unless mentioned otherwise, we will focus on individual sellers and used goods. Results for other types of sellers or goods will be discussed in section 4.3.

For all tables, the coefficients of reputation are divided by 10, and those of size and size² are multiplied by 10^3 and 10^6 , respectively, so one should interpret the numbers as marginal changes in (log) prices following a 0.1-increase in reputation or a increase in size by 1,000 transactions. All standard errors are robust to a within-seller correlation of the residuals (ε_{it}).²⁸

4.1.1 Benchmark specification

We first consider specification (9), with a linear effect of reputation and a quadratic effect of size. In Table 4, we show the coefficients of reputation and size estimated by three approaches. The first one simply consists in estimating the price equation (4) by OLS. Estimates thus obtained are likely to suffer from an omitted variable bias because of unobserved seller/product heterogeneity ($\alpha_i + \mu_{j(i,t)}$). We then show estimates based on an OLS regression of the first-differenced price equation (5). The resulting estimates, labeled FOLS in the tables, are also likely to be biased because reputation and size may depend on past prices, or because of changes in the unobserved product characteristics μ . Finally, our preferred results are based on the GMM estimation of the first-differenced price equation (5) using the moment conditions (8) and the specification (9), as explained in section 3.3.

²⁶Our data set contains a variable giving the release date of each product but there are many missing observations. We thus measure the age of a product as the time between the current transaction and the first observed transaction for this product on the web site.

²⁷We will also show separate results for each of the four conditions.

²⁸Recall that we are working under the assumption that ε_{it} is iid across sellers and dates, so that, as we estimate the price equation in differences, the difference $\varepsilon_{i,t+k} - \varepsilon_{it}$ will be autocorrelated within sellers.

Table 4: The effect of reputation - Estimates of γ - GMM benchmark specification (9)

	OLS		FOLS		GMM	
BOOKS	0.000612	(0.0013)	-0.00380	(0.00072)***	0.237	(0.0097)***
CD	0.0153	(0.0016)	-0.00235	(0.00091)***	0.201	(0.013)***
GAMES	0.000862	(0.00051)*	-0.00359	(0.00059)***	0.133	(0.0062)***
VIDEO	-0.000612	(0.0015)	-0.00190	(0.00083)**	0.214	(0.0097)***

Note: The coefficients are divided by 10 (effect of a 0.1 increase in reputation).
Standard errors in parenthesis, 1/2/3 stars if estimate significant at the 10%/5%/1% level.
For OLS, $N = 3051759$ (books), 1563542 (CD), 1254995 (games), 2048781 (video).
For FOLS/GMM, $N = 2949281$ (books), 1505925 (CD), 1157709 (games), 1967060 (video).
Other regressors (not shown): product age, list price, condition, year/quarter dummies.

Estimation results are in Table 4. We start with the OLS results and find little conclusive evidence of any correlation between reputation and prices in the pooled sample. The estimated coefficient of reputation is positive for books, CDs and games, and negative for videos. In all cases, the magnitude of that coefficient is very small as a 0.1 increase in reputation would change prices by less than 0.1% (except for CDs where the change would be 1.5%). The estimate is not significant (except for video games, at the 10% level).

Turning to the FOLS estimation results, we find a significant yet again very small effect of reputation for all categories, always smaller than 0.4% in absolute value. Unlike with OLS, the FOLS estimates are consistently negative across product categories.

The last column of Table 4 differs markedly from the first two. Our preferred estimates, based on GMM, show a significant, positive and strong effect of reputation on prices. This is the main result of this paper. Once unobserved heterogeneity and the dependence between reputation/size and past shocks are accounted for, we find consistent evidence that a 0.1 increase in a seller's reputation raises prices by a substantial amount (around 20% for books, CDs and videos, 13% for video games). We will show that our results are robust to changes in the instrument set, to the specification of the g function and to the way we difference out the unobserved seller effect. We will also provide evidence that the effect of reputation is also strong for professional sellers. Note that the effect of reputation varies across product categories, it is stronger for books (24%) and weaker, although still substantial, for video games (13%).

It is interesting to note that even on a platform where payments are held until buyers

confirm that they have received the good, seller reputation can have such a strong impact on prices. A higher reputation can reflect a lower probability of delays in the delivery of the good, of an inaccurate description of the product condition or of any reason why the buyer may want to file a complaint, which is costly (at least in time), especially given the relatively small amounts involved in our analysis. Indeed, the two-digit effect shown in Table 4 is relative to the price of the item which is around €10 on average (see Figure 1).

The difference between the FOLS and GMM estimates partly illustrates the bias due to the dependence of reputation (and size) on past shocks (differences in product heterogeneity may also affect the FOLS estimates). The price at transaction t can affect the reputation for subsequent transactions so that the shock ε_{it} can be correlated with r_{it+k} . Estimates in Table 4 show that this bias is negative i.e. the FOLS approach underestimates the effect of reputation. One may interpret this bias as evidence that the correlation between current prices and future reputation is positive. This conclusion is not straightforward though, as our price equation features two endogenous variables (reputation and size) which may be correlated. Although this issue would require further investigation, which we leave for a future project on the determinants of buyer feedback, our FOLS and GMM estimates still suggest that high-price transactions tend to receive higher feedback ratings. The interpretation is difficult because of the default rating set at 5 by PriceMinister. Indeed, high-price transactions could come with a better quality of service and this could be known to buyers who are then willing to pay more (the seller could have posted some additional information to that effect on her page). However, given that the default feedback score is 5, it could also be that buyers who pay high prices are less informed or proactive and then just leave the default feedback when completing the transaction.

We now comment on the estimates for the effect of seller size, shown in Table 5. Comparing the estimates across columns, we see again that unobserved heterogeneity and past ε shocks create a gap between the OLS/FOLS and the GMM estimates. The last column shows the GMM estimates and points toward a negative and convex effect of seller size on prices. The sign of the effect is constant over the support of seller size: virtually all individual sellers in the sample have fewer than 1,000 transactions by January 2008 (see Table 1) and the turning point (where the marginal effect goes from being negative to positive) is at 6,783 transactions for sellers of video games and even higher for other product categories. Hence, prices decrease with seller size.

To show the magnitude of the effect of size on prices, we consider the marginal effect $g'_s = \hat{\delta} + 2\hat{\delta}_2 s$ where $\hat{\delta}$ and $\hat{\delta}_2$ are the GMM estimates of the marginal effects of size and size² on price (from the third column of Table 5). This marginal effect is essentially constant when s varies between 1 and 1,200 transactions (remember that most individual sellers have completed less than 1,000 transactions by January 2008). If the size of a seller increases by 100 transactions, the price should decrease by around 2.6% (books), 2.8% (CDs), 5% (video

Table 5: The effect of size - GMM benchmark specification (9)

	OLS		FOLS		GMM	
BOOKS						
size	-0.0912	(0.024)***	-0.0673	(0.058)	-0.268	(0.035)***
size ²	0.0141	(0.0037)***	0.00179	(0.0021)	0.0116	(0.0038)***
CD						
size	0.0810	(0.028)***	-0.0531	(0.053)	-0.283	(0.11)***
size ²	-0.0116	(0.0054)**	0.0104	(0.0051)**	0.00927	(0.025)
GAMES						
size	0.000619	(0.019)	0.136	(0.059)**	-0.525	(0.073)***
size ²	0.00227	(0.0041)	-0.0361	(0.016)**	0.0387	(0.016)**
VIDEO						
size	0.0516	(0.021)**	0.111	(0.055)**	-0.300	(0.044)***
size ²	-0.00755	(0.0020)***	-0.00531	(0.0020)***	0.00683	(0.0059)

Note: The coefficients of size and size² are multiplied by 10³ and 10⁶.
Standard errors in parenthesis, 1/2/3 stars if estimate significant at the 10%/5%/1% level.
Other regressors (not shown): product age, list price, condition, year/quarter dummies.

games) and 3% (video).²⁹

In short, the effect of an individual seller’s size on prices is significant, small, negative, essentially linear and rather similar across product categories (albeit stronger for video games).

Before moving on to an alternative specification of the g function, we take a quick look at coefficient estimates for some variables in the x vector, still using the benchmark specification (9). These estimates are shown in Table 6. We do not show the estimates for the year \times quarter dummies.

We first note that all the variables in Table 6 have a significant effect on prices. The age of a product has a negative effect on prices, from -20% for books and CDs to -66% for video games. This is intuitive as we expect demand for a given video game to fall more quickly over time than demand for a book or a CD. The effect of list price, positive and significant, is also in line with intuition. Lastly, product condition has a strong and positive effect on prices. Moreover, we note that when the condition goes up by one level (from ‘fair’ to ‘good’ or from ‘very good’ to ‘as new’), the price increase is almost constant, around 11% for books, 13% for CDs, 12-14% for video games and 7-8% for videos.

To conclude the analysis of our benchmark estimation, we should mention that the autocorrelation of residuals from the first-differenced price equation (5) is estimated around -0.45 at the first order and drops to around 0.01 to 0.015 at higher orders for all product categories, thus indicating that our assumption of iid shocks ε_{it} (which are thus $MA(1)$ in first differences) is borne out by the data.

4.1.2 Does the effect of reputation depend on size?

We now consider a different specification for g and add an interaction term between size and reputation to the piecewise-linear function in (9). Formally, the specification is the following:

$$g(r, s) = \gamma r + \phi rs + \delta s + \delta_2 s^2, \quad \mathcal{Z}_{it}^g = \{r_{it}, r_{it} \cdot s_{it}, s_{it}, s_{it}^2\} \quad \text{and } k = 1. \quad (10)$$

GMM estimates are in Table 7. They show that reputation still has a significant, positive and strong effect on prices. The coefficient capturing the linear effect of reputation is in line with the one we found with our benchmark specification (cf. Table 4). The main insight from Table 7 is that the effect of reputation on prices depends on the seller’s size, the estimated coefficient of rs is always significant and positive. This means that the positive impact of reputation on prices is stronger for larger sellers. After 10 completed transactions, the marginal effect of reputation on prices increases by 0.87% for books, 0.76% for CDs, 0.42% for video games and 0.65% for videos. This positive interaction between reputation and size is consistent with a Bayesian model of learning which predicts that the weight attached to the average performance increases over time while the weight attached to the prior decreases.

²⁹These numbers come from taking the average of the function $\hat{\delta} + 2\hat{\delta}_2 s$ in the interval $[1, 1200]$.

Table 6: The effect of strictly exogenous covariates (x) - GMM benchmark specification (9)

	BOOKS	CD	GAMES	VIDEO
Product age	-0.072 (0.0007)	-0.072 (0.0007)	-0.240 (0.001)	-0.130 (0.001)
List price	0.259 (0.001)	0.072 (0.001)	0.147 (0.002)	0.150 (0.002)
Product condition:				
- good	0.115 (0.003)	0.132 (0.006)	0.137 (0.006)	0.080 (0.008)
- very good	0.220 (0.004)	0.266 (0.007)	0.280 (0.006)	0.153 (0.009)
- as new	0.329 (0.004)	0.387 (0.007)	0.401 (0.006)	0.223 (0.009)

Note: All estimates significant at the 1% level. Standard errors in parenthesis.

Product age is measured in years.

The reference for product condition is 'fair'.

Table 7: Interaction between reputation and size, specification (10) - GMM estimates

	BOOKS		CD		GAMES		VIDEO	
r	0.248	(0.01)***	0.195	(0.01)***	0.126	(0.01)***	0.215	(0.01)***
rs	0.871	(0.29)***	0.767	(0.19)***	0.424	(0.11)***	0.650	(0.14)***
s	-42.03	(13.9)***	-37.1	(8.95)***	-20.85	(5.05)***	-31.37	(6.5)***
s^2	-0.022	(0.02)	0.0001	(0.03)	0.053	(0.026)**	-0.024	(0.013)*

Note: Standard errors in parenthesis, 1/2/3 stars if estimate significant at the 10%/5%/1% level.

The coefficient of r is divided by 10, those for rs , s and s^2 are multiplied by 10^2 , 10^3 and 10^6 .

Other regressors (not shown): product age, list price, year/quarter dummies.

We showed in Table 1 that the median size of individual sellers active in January 2008 was 29 for books, 48 for CDs, 28 for video games and 38 for videos. If we then use the estimates in Table 7 to compute the effect of reputation at these median levels of seller size, we find that a 0.1 increase in reputation raises prices by 27% for books ($27\% \approx 0.248 + 0.871 \times 0.029$), 23% for CDs, 14% for video games and 24% for videos. These numbers are qualitatively consistent with those we found with our benchmark specification (9) (see Table 4). We will thus mostly use our benchmark specification in the following sections, except when we focus on professional sellers, as the support of seller size is different for those sellers.

4.2 Results by product condition

Our benchmark analysis focuses on individual sellers, who may only sell used products. Those products can be advertised as being in one of four conditions: ‘as new’, ‘very good’, ‘good’ or ‘fair’. We already know from Table 6 that product condition has a significant effect on prices. As discussed in section 2.2, we do not tackle the challenging problem of manipulation of product condition by sellers. In this subsection, however, we check whether the estimated effect of reputation is different for different advertised product conditions. To this end, we estimate our linear specification (9) separately for each product condition. Results are in Table 8.

We first note that for any advertised product condition and category, the effect of reputation is significant, positive and large. Taking a closer look at the effect of reputation across product conditions, we see that the main pattern emerging from Table 8 is that the effect of reputation on price increases in magnitude when the advertised condition of the product

Table 8: Effect of reputation by product condition - GMM benchmark specification (9)

	<i>As new</i>		<i>Very good</i>		<i>Good</i>		<i>Fair</i>	
BOOKS	0.240	(0.012)	0.293	(0.016)	0.312	(0.022)	0.317	(0.037)
CD	0.180	(0.016)	0.214	(0.014)	0.301	(0.026)	0.514	(0.086)
GAMES	0.106	(0.007)	0.152	(0.009)	0.214	(0.018)	0.375	(0.052)
VIDEO	0.192	(0.011)	0.282	(0.018)	0.420	(0.045)	0.510	(0.13)

Note: All estimates significant at the 1% level. Standard errors in parenthesis.
 The coefficient is divided by 10.
 Other regressors (not shown): size, size², product age, list price, year/quarter dummies.

deteriorates. This is true for all four product categories.

If the information asymmetry only revolved around dimensions such as delays, care and delivery, we would expect the effect of reputation to be unaffected by the condition or to be larger for products advertised as being ‘as new’ or in a ‘very good’ condition. An alternative interpretation is that consumers are also concerned about the quality of the good itself, which seems consistent with the results. First, there is more variation of quality within the category ‘fair’ than within the category ‘as new’ (the latter is more specific). Second, seller reputation also reflects the confidence that buyers have in the description of the good (Jullien and Park, 2011) and there may be more disagreement on the accuracy of the description for poorer conditions.³⁰ Hence reputation might well convey information beyond the seller’s propensity to report product condition accurately.³¹

4.3 Results for professional sellers and new/used goods

So far, we have focused on individual sellers and used goods. In this subsection, we show how reputation and size affect prices for professional sellers (i.e. those listed in the official register of French corporations) selling used or new goods. We use specification (10), thereby allowing for an interaction term between reputation and size, and estimate the model by GMM. We think it important to allow for an interaction between reputation and size when comparing professional and individual sellers, as the support of size is very different between these two populations. Table 9 shows the estimation results for professional sellers and new

³⁰Note that the issue of misclassification of a damaged/out-of-order product as ‘fair’ may arise.

³¹The importance of an accurate description of the product’s condition is supported by the estimates in Table 6 which showed a strong positive effect of product condition on prices.

Table 9: Professional and individuals sellers - GMM estimates - Linear specification (9)

BOOKS	<i>Pro - New</i>		<i>Pro - Used</i>		<i>Individual</i>	
reputation	0.0206	(0.077)	0.229	(0.090)**	0.248	(0.012)***
reputation \times size	0.000287	(0.00028)	0.00383	(0.0058)	0.871	(0.29)***
CD	<i>Pro - New</i>		<i>Pro - Used</i>		<i>Individual</i>	
reputation	0.0478	(0.094)	0.438	(0.22)**	0.195	(0.013)***
reputation \times size	-0.0000716	(0.00014)	0.0774	(0.062)	0.767	(0.19)***
GAMES	<i>Pro - New</i>		<i>Pro - Used</i>		<i>Individual</i>	
reputation	0.202	(0.10)**	0.193	(0.070)***	0.126	(0.0066)***
reputation \times size	0.00339	(0.0035)	0.0147	(0.016)	0.424	(0.11)***
VIDEO	<i>Pro - New</i>		<i>Pro - Used</i>		<i>Individual</i>	
reputation	0.158	(0.081)*	0.256	(0.088)***	0.215	(0.011)***
reputation \times size	0.00442	(0.0049)	0.0306	(0.018)*	0.650	(0.14)***

Note: The coefficients for reputation/reputation \times size is divided by 10/multiplied by 10^2 .

Standard errors in parenthesis, 1/2/3 stars if estimate significant at the 10%/5%/1% level.

For Pro/Used, $N = 350190$ (books), 162880 (CD), 131300 (games), 161662 (video).

For Pro/New, $N = 203311$ (books), 198505 (CD), 59616 (games), 217629 (video).

Regressors not shown: size, size², product age, list price, condition (if used), year/quarter dummies.

goods, professional sellers and used goods and, for comparison, also includes the estimates for individual sellers and used goods (from Table 7).

We first consider used goods only and compare results between professional and individual sellers. Consistently with what we found for individual sellers, reputation has a significant, positive and strong impact on transaction prices for transactions involving professional sellers and used goods (although for used CDs, the standard error is large). Point estimates suggest that the prices of used games and videos respond more to reputation for professional than for individual sellers. Although these differences in point estimates should be taken with caution, given the less-than-ideal precision with which they are estimated, they may indicate that professional/individual seller status and seller reputation are not used by buyers as

complementary pieces of information to predict the quality of a transaction. If they were, and if professional status was perceived as a positive signal of quality, we would expect reputation to have a smaller effect on price for professional sellers. A more rigorous interpretation of these differences would require a structural model.

For professional sellers, the effect of reputation is not affected by size. This is different from what we find with individual sellers whose reputation had a stronger impact on prices as size increased. It is interesting to see that the ‘professional seller’ status, meaning that the seller is registered with the French ministry of commerce, seems to make the effect of reputation independent of size. Moreover, individual sellers of CDs, video games or videos need to make many transactions (respectively 317, 158 and 63)³² before the impact of their reputation on prices becomes as strong as that of professional sellers.

Next focusing on professional sellers only and comparing results for new and used goods, we first note that the effect of reputation is always significant, positive and strong except for new books and CDs. The former reflects an institutional feature of the market for new books in France. The price of a new book is fixed by the publisher, printed on the book and during the first two years after publication, no one is allowed to offer more than a 5% discount on that regulated price. This law does not apply to used books. It is therefore not surprising to find a non-significant effect of reputation on the prices of new books. The small and non-significant effect estimated for new CDs is more puzzling. It may reflect that there is less scope for inaccurate product description with new CDs than with, say, new videos, and thus seller reputation may matter less for that product category. We should also mention that the market for new CDs on PriceMinister seems to be more concentrated than for other product categories. Indeed, the seller with the highest number of transactions of new CDs accounts for almost a third (31%) of total transactions in this product category. The second largest seller only accounts for 3.5% of total transactions. If we look at other new product categories, the largest and second largest sellers make up respectively 12.7% and 6.3% of all transactions for books, 8.5% and 5.5% for video games and 6.6% and 5.8% for videos.

The effect of reputation for the other two product categories, video games and videos, is strongly positive. Point estimates indicate that it is larger than the effect found for used goods (although, here again, we should point out that precision is a concern). From a qualitative standpoint, we take these results for new goods as evidence that in the case of professional sellers, the information asymmetry does not only pertain to the condition of the good but also to the accuracy of its description on the web site (e.g. subtitles for a DVD) and/or to the quality of service (e.g. delivery time, quality of packaging, etc.).

³²These numbers come from the estimates in Table 9. For CDs: $317 \approx (0.438 - 0.195)/0.767 \times 1000$.

4.4 Prices, reputation and recent feedback history

So far we have focused on average feedback as the measure of reputation. This is motivated by the design of the PriceMinister web site, where the information immediately available to buyers about a given advert consists of the price, the product's condition and the seller's name, reputation and size. However, buyers who want to learn more about a seller can look at her feedback history, where previous feedback ratings and comments are presented in chronological order (pooling all types of product and displaying the outcomes of around 10 transactions per page). A relevant empirical question is then whether this additional information may affect prices.

This issue is also motivated by economic theory. From a Bayesian learning perspective, buyers should attach more weight on recent feedback if seller quality is subject to stochastic changes (Mailath and Samuelson, 2001, Cripps et al., 2004). In particular, with moral hazard, if sellers exert less effort, they may lose some of their reputation, which further weakens their incentives to exert effort.³³ In this case, buyers would care more about a seller's recent history than about average feedback, as a recent stream of negative feedback would be indicative of a likely drop in quality.

We look at two different types of additional measures of a seller's reputation. First, we consider a seller's average feedback score \bar{f}_n over the last n transactions, where $n = 5, 10, 20$.³⁴ This indicator captures the information collected by consumers who look at the seller's recent history but do not go further than the first two pages that the buyer sees. We estimate the effect of this indicator using the benchmark specification (9) where r is replaced by \bar{f}_n . We then run another estimation with the same specification except that both r and \bar{f}_n enter (linearly) the g function and the set of instruments. GMM results are reported in Table 10. For comparison, the first row replicates benchmark estimates of the effect of reputation, from Table 4.

We first consider the middle panel of Table 10, where the average of recent feedback scores is the only measure of reputation. The estimates show that recent feedback history matters and has a significant, positive and strong effect on prices. This effect is stronger as average feedback is taken over a larger number of transactions. For instance, if we look at CDs, a 0.1 rise in average recent feedback increases prices by 4.8%, 9.9% or 16.3% when the average includes the last 5, 10 or 20 transactions. This pattern is consistent across product categories.

In the third panel of Table 10, we allow for prices to depend on both the average feedback score over all completed transactions (our benchmark measure of reputation), and average

³³See Klein and Leffler (1981), Shapiro (1982) or Cabral and Hortag su (2010).

³⁴We consider feedback pertaining to the last n completed transactions at the date when transaction t is initiated. This captures the information actually shown on the web site when the consumer commits to buying the product. If at that time the seller has completed $n' < n$ transactions, we consider the average feedback over these n' transactions.

Table 10: Reputation and recent feedback - GMM estimates

<i>Benchmark specification</i>								
	BOOKS		CD		GAMES		VIDEO	
r	0.237	(0.01)	0.201	(0.01)	0.133	(0.01)	0.214	(0.01)
<i>Replacing reputation with recent feedback average</i>								
	BOOKS		CD		GAMES		VIDEO	
\bar{f}_5	0.0572	(0.0023)	0.0483	(0.0032)	0.0524	(0.0026)	0.0508	(0.0023)
\bar{f}_{10}	0.117	(0.0048)	0.0989	(0.0065)	0.0897	(0.0045)	0.106	(0.0048)
\bar{f}_{20}	0.188	(0.0080)	0.163	(0.011)	0.116	(0.0059)	0.174	(0.0082)
<i>Allowing for both reputation and recent feedback average</i>								
	BOOKS		CD		GAMES		VIDEO	
r	0.322	(0.015)	0.258	(0.018)	0.186	(0.0098)	0.282	(0.014)
\bar{f}_5	0.0035	(0.0005)	0.00242	(0.0005)	0.0018	(0.0005)	0.0022	(0.0005)
r	0.318	(0.015)	0.254	(0.018)	0.183	(0.0097)	0.278	(0.014)
\bar{f}_{10}	0.0082	(0.0009)	0.0061	(0.001)	0.0049	(0.0009)	0.0061	(0.0009)
r	0.312	(0.015)	0.251	(0.018)	0.181	(0.0096)	0.274	(0.014)
\bar{f}_{20}	0.016	(0.002)	0.012	(0.002)	0.0080	(0.0012)	0.012	(0.002)

Note: All estimates significant at the 1% level. Standard errors in parenthesis.

All coefficients are divided by 10.

\bar{f}_n is the average feedback over the last n transactions.

Other regressors (not shown): size, size², product age, list price, year/quarter dummies.

recent feedback. That is, we allow for recent feedback to have a separate effect on prices, which comes in addition to the overall effect of reputation. Before commenting on these results, a note of caution is in order: many individual sellers only have few completed transactions (recall that the median size in January 2008 is below 50), so that taking the average feedback over a large number of recent transactions may produce a variable that is strongly correlated with overall seller reputation. The following set of estimates should thus be interpreted with caution and we will only draw qualitative conclusions. The main pattern is that, while both indicators have a significant and positive effect on prices, only overall seller reputation has a strong impact: the additional effect of average recent feedback is no larger than 1.6%. This suggests that a seller's recent feedback history has a small, yet positive, impact on prices once the seller's reputation has been taken into account.

We would need a structural model to interpret this result in terms of buyer search strategy. One possible explanation is that buyers do not actually care much about recent history and only look at reputation. Another would be that buyers do care about both indicators but only those with a low search cost take the time to browse the seller's full history. In this case the estimates shown in Table 10 would capture a population average effect.

We confirm the results of Cabral and Hortaçsu (2010) in that recent feedback matters, but we find that it matters less than the average seller score (reputation) readily displayed on the web site. This, of course, does not say what would be the effect of recent feedback if average recent feedback was shown by default together with (or instead of) total average feedback.

We can also construct other indicators of a seller's recent feedback history. In line with Cabral and Hortaçsu (2010), we can for instance see whether prices are affected by extreme values of recent feedback scores. To this end, we consider two alternative types of indicators. We first construct a dummy equal to 1 if none of the last 5 (or 10) feedback scores was lower than 2 (out of 5), which indicates that none of the seller's recent transactions was rated very unsatisfactory by the buyer. We also consider a dummy equal to 1 if all of the last 5 (or 10) feedback ratings were equal to 5 (the maximum score). We then estimate specification (9) replacing reputation r by each of these new indicators in turn. Results are in Table 11.

The first two columns of Table 11 show that having recently received a low feedback score has a strong, significant and negative effect on the price (since the effect of having received no low feedback is positive). This effect weakens slightly as one looks at the last 10 feedback ratings instead of the last 5, which is consistent with negative feedback having a more aversive effect when it is more recent. Looking at the last two columns of Table 11, we note that having the maximum score in all of the last 5 or 10 transactions has a significant and positive effect on prices. However, the magnitude of the estimates, around 1-2%, is much lower than that of the effect of recent negative feedback.

Table 11: Alternative indicators - Recent feedback - GMM estimates

	$\mathbf{1}\{\min(f_{\underline{5}}) > 2\}$		$\mathbf{1}\{\min(f_{\underline{10}}) > 2\}$		$\mathbf{1}\{\min(f_{\underline{5}}) = 5\}$		$\mathbf{1}\{\min(f_{\underline{10}}) = 5\}$	
BOOKS	0.157	(0.0084)	0.112	(0.0076)	0.0189	(0.0024)	0.0159	(0.0026)
CD	0.127	(0.011)	0.089	(0.0094)	0.0132	(0.0028)	0.0131	(0.0030)
GAMES	0.136	(0.0096)	0.111	(0.0091)	0.0150	(0.0032)	0.0220	(0.0036)
VIDEO	0.130	(0.0078)	0.098	(0.0070)	0.0167	(0.0026)	0.0169	(0.0027)

Note: All estimates significant at the 1% level. Standard errors in parenthesis.

$\min(f_{\underline{n}})$ is the minimum of the last n feedback scores.

Other regressors (not shown): size, size², product age, list price, year/quarter dummies.

4.5 Robustness checks

We now report a series of robustness check. First we want to ensure that our results are not driven by a specific choice of instruments and/or by our approach to differencing out the unobserved seller effect. To this end, we consider a series of modified versions of our benchmark specification (9) and estimate the effect of reputation by GMM. The results are in Table 12 where, for comparison, the first row replicates the benchmark estimates from Table 4. As we will see, the main message from Table 12 is that the conclusions we have drawn throughout this section are qualitatively robust to changes in specification: reputation has a significant, positive and strong effect on prices (stronger for books and videos than for CDs and video games).

Alternative forward differences. The second panel of Table 12, labeled “forward differences” shows the estimates we obtain when using longer forward differences to transform the price equation and difference out the seller fixed effect. We see that except for video games, point estimates are not substantially affected. The change is more marked for video games as the estimates goes from 13% to 4-7%, still positive, significant and far from being negligible.

Using further lags as instruments. In the next two panels, labeled “instrument set”, we consider alternative instrumentation strategies. The first series of estimates (“further lags”) are exploiting the assumption that not only the current but also any past value of reputation and size qualifies as an instrument. We thus re-estimate our price equation using

Table 12: Robustness checks - Effect of reputation - GMM estimates

	BOOKS	CD	GAMES	VIDEO
Specification (9)	0.237 (0.01)	0.201 (0.01)	0.133 (0.01)	0.214 (0.01)
Alternative specifications:				
- forward differences:				
$k = 5$	0.252 (0.009)	0.179 (0.009)	0.070 (0.005)	0.206 (0.012)
$k = 10$	0.282 (0.012)	0.177 (0.010)	0.039 (0.005)	0.206 (0.021)
- instrument sets \mathcal{Z}_{it}^g :				
<i>further lags</i>				
$\{r_{it-l}, s_{it-l}, s_{it-l}^2\}_{\ell=0,3,5}$	0.176 (0.009)	0.165 (0.009)	0.122 (0.006)	0.174 (0.009)
$\{r_{it-l}, s_{it-l}, s_{it-l}^2\}_{\ell=0,5,10}$	0.123 (0.011)	0.125 (0.010)	0.111 (0.008)	0.139 (0.011)
<i>mean recent feedback</i>				
$\{r_{it}, \bar{f}_{it5}, s_{it}, s_{it}^2\}$	0.283 (0.017)	0.224 (0.021)	0.178 (0.010)	0.266 (0.014)
$\{r_{it}, \bar{f}_{it10}, s_{it}, s_{it}^2\}$	0.232 (0.027)	0.192 (0.023)	0.157 (0.012)	0.242 (0.015)
- x_{it} vector:				
<i>controlling for s_{jt}</i>	0.236 (0.010)	0.213 (0.013)	0.0860 (0.010)	0.234 (0.010)

Note: All estimates significant at the 1% level. Standard errors in parenthesis.

Coefficients divided by 10.

\bar{f}_{itn} is the average of the n feedbacks received by seller i before transaction t .

s_{jt} is the number of sales for product j realized before transaction date t .

two different augmented instrument sets that include the current values, r_{it} and s_{it} , but also the lagged values $t - 3$ and $t - 5$ (respectively $t - 5$ and $t - 10$) in \mathcal{Z}_{it}^g . We keep the current values in the instrument set in order to avoid a possible selection bias stemming from very small sellers being excluded from the estimation. We note that adding these lagged values reduces the point estimates although the effect of reputation remains significant, positive and large. This decrease in the point estimates may come from the well-known fact that adding more instruments will get the GMM estimate closer to the OLS estimate (in this case the FOLS estimate), which we found to be essentially 0 (see Table 4).

Using recent feedback scores as instruments. Moving to the next series of estimates (“mean recent feedback”), we see that adding another, potentially strong, instrument in \mathcal{Z}_{it}^g yields estimates relatively close to the benchmark ones (if anything the former are larger, pointing toward stronger effects of reputation). The motivation for using the mean of most recent feedback scores is the following. The instruments aim at explaining a change in reputation (and size) between two consecutive first transactions, $r_{it+1} - r_{it}$. In the benchmark estimation, we use r_{it} and thus instrument differences with levels. It is realistic to assume that the recent stream of feedback received by the seller contains relevant information to predict a change in reputation in the short term whereas, following from our assumptions on price shocks, it should have no direct effect on future price changes. It is thus reassuring to see in Table 12 that our conclusions are robust to changes in the instrument set that are not solely based on exploiting the panel dimension (i.e. on using further lags of reputation and size).

Product heterogeneity. The last row of Table 12 pertains to product heterogeneity. Our identification strategy requires us to control for enough product heterogeneity so that, conditionally on reputation and size, the expected difference in unobserved product characteristics between two consecutive first transactions is equal to 0, see (6). We emphasized the role of the product list price in ensuring that this assumption will hold. We now want to see whether our estimates are sensitive to adding one more product attribute in the x vector, namely the number of sales observed for this product on the web site before transaction t . Note that none of these sales are made by seller i since we are estimating the model only on first transactions for each seller/product pair. The estimation results in Table 12 show that the effect of reputation once again remains qualitatively similar to what we found with our benchmark specification.

Using both longitudinal and cross-sectional variation. Our estimation is based on differencing the price equation (4) within sellers and then instrumenting changes in reputation and size to account for the dynamics of these seller characteristics. We are thus essen-

tially using within-seller variation in reputation and size. One may then question whether a seller’s reputation still varies after a large number of transactions. Indeed, if the reputation mechanism aims to reveal the seller’s type, it should converge to a value reflecting the average quality of the seller’s transactions. In that case, reputation should not vary much anymore past a certain number of transactions. Our estimates would then essentially be exploiting variations in reputation for transactions with a small seller size while future transactions may not bring much information for the identification of the effects of interest.

To check that our results are not solely driven by transactions with a small seller size, we need to exploit the cross-sectional variation for large sellers. The problem is that part of this variation is due to the unobserved seller effect α_i . Our approach consists of first estimating this seller fixed effect by running our GMM estimation on the differenced price equation (5) using only on the first transactions for each seller, for instance when $t \leq T$ where $T = 5$ or 10 , from which we then obtain an estimate $\hat{\alpha}_i$ of each seller fixed effect. We can then take this effect out of the price equation (4) and estimate the parameters by OLS. Indeed, the seller fixed effect is controlled for and, if we assume away sorting between unobserved seller and product characteristics,³⁵ the unobserved product effect μ_j is not correlated with reputation and size when the first transaction for this seller/product pair takes place. We can run OLS for $t \leq T$, which should yield the same estimates as the GMM estimates obtained on $t \leq T$, and for $t > T$. This will show whether the cross-sectional variation for large size transactions is consistent with the longitudinal variation within sellers. Results are in Table 13.

Note that the standard errors for our OLS estimates would need to be corrected for the variability in the first-stage estimate of the seller fixed effect. We only show the uncorrected standard errors, which as one expects are very small, and we will draw comparisons only based on the point estimates.

First, we note that all estimates in Table 13, whether obtained by GMM or by “OLS”, are in line with our benchmark GMM estimates (see Table 4). Although all estimates are significant, positive and large, there is a small discrepancy with Table 4 as the point estimates in Table 13 are 15-20% lower (except for videos where the difference is larger). Still, the qualitative conclusions stand.

If we are to compare estimates across the columns of Table 13, we find that the longitudinal variation (used to produce the GMM estimates) is consistent with the cross-sectional variation (used in the last two columns). Moreover, we find that the estimates in the last column, for $t > T$, are systematically slightly larger than the ones in the second column, for $t \leq T$. This may indicate that seller size positively but weakly influences the effect of reputation on prices. This is consistent with the results we found in Table 7, where we allowed for an interaction between reputation and size and estimated this interaction to be significant,

³⁵Note that this is a stronger assumption than the one we used, assumption (6), for our benchmark GMM estimation.

Table 13: Comparing cross-sectional and longitudinal variation

	GMM, $t \leq 5$	OLS($\hat{\alpha}$), $t \leq 5$	OLS($\hat{\alpha}$), $t > 5$
BOOKS	0.209 (0.011)	0.200 (0.0002)	0.199 (0.001)
CD	0.178 (0.011)	0.170 (0.0002)	0.172 (0.001)
GAMES	0.120 (0.0064)	0.110 (0.0002)	0.111 (0.001)
VIDEO	0.147 (0.012)	0.136 (0.0002)	0.142 (0.003)
	GMM, $t \leq 10$	OLS($\hat{\alpha}$), $t \leq 10$	OLS($\hat{\alpha}$), $t > 10$
BOOKS	0.203 (0.0091)	0.193 (0.0002)	0.193 (0.001)
CD	0.180 (0.0098)	0.171 (0.0002)	0.173 (0.001)
GAMES	0.112 (0.0057)	0.101 (0.0002)	0.103 (0.001)
VIDEO	0.164 (0.0091)	0.149 (0.0003)	0.155 (0.002)

Note: All GMM estimates significant at the 1% level.

Standard errors in parenthesis (uncorrected for OLS estimates).

GMM based on (8)-(9).

OLS($\hat{\alpha}$) based on (4) where α_i is taken out of the left- and right-hand sides.

Other regressors (not shown): size, size², product age, list price, year/quarter dummies.

positive but small (below 0.1%) when the number of transactions was low (around 10).

4.6 Comparison with the existing literature

Our results show large-scale evidence of a strong and positive effect of seller reputation on transaction prices. Our analysis contributes to the existing literature on online seller reputation along at least two dimensions. First, we explicitly account for unobserved seller heterogeneity and for the dynamics of reputation and prices. Second, we estimate the effect of reputation on prices for a large and varied set of products, product conditions, and types of sellers.

The existing empirical evidence of a causal effect between reputation and price has been based on controlled field experiments (Resnick et al., 2006), on structural models (Bajari and Hortacısu, 2003), or on reduced-form regressions. Due to data limitations, the latter category (which includes Bajari and Hortacısu, 2004 and Cabral and Hortacısu, 2010) cannot fully account for unobserved seller heterogeneity and/or for dynamics of reputation and size. More recently, the contribution by Lei (2011), based on eBay data, tackles the issue of product heterogeneity by looking at one very specific product (Gmail invitations) and indirectly controls for sellers' skills by using the auction title as a regressor.

As we mention in the Introduction, two recent papers by Anderson and Magruder (2012) and Luca (2011) have also made significant contributions, albeit in a very different setting from ours. Indeed we use price as the outcome (they look at restaurant bookings or revenues) and our data come from a web site where feedback is systematic and unilateral. One interesting feature of those two papers is that they exploit a discontinuity in the feedback mechanism, namely the fact that the score posted on-line is a rounded average of past feedback ratings. Seller reputation on PriceMinister is constructed in the same way, so that in principle, the PriceMinister data could lend itself to such a regression discontinuity design approach (RDD hereafter). However the distance to the cutoff point (the cutoff point between, e.g., a posted reputation of 4.5 and one of 4.6 being 4.55) depends on seller size which is also an endogenous variable. Indeed, it will take more additional feedback to take a seller's average score from, say, 4.54 to 4.56 (thus changing that seller's reputation from 4.5 to 4.6) if this seller's size is large than if it is small. Directly importing the RDD idea of Anderson and Magruder (2012) and Luca (2011) into our context thus seems problematic, and we therefore resort to panel-data techniques to provide large-scale evidence of the effect of both reputation and size on prices (the latter effect could not be estimated with an RDD approach).

The recent paper by Fan et al. (2013) uses a 14-month panel with information about a group of sellers on a large e-commerce platform in China (Taobao). These authors estimate the effects of last month's reputation indicators on some seller outcomes such as revenue and sales. Their approach revolves around linear regressions with a seller fixed effect and

instrumental variables. The endogeneity that they consider arises from a potential correlation between last month's reputation and an unobserved and persistent quality shock. Their instrumentation strategy exploits the fact that sellers can also be buyers and thus uses variables pertaining to sellers' history as buyers. Our paper differs from theirs in several ways. First, we observe the sellers' entire histories and focus on transaction prices (which are not directly observed in Fan et al., 2013). We look at the effect of those seller characteristics (reputation and size) that were displayed on the web site at the exact time each transaction took place, not at a monthly frequency. This allows us to study the effect of reputation for a wider set of products and product conditions. Lastly, the source of endogeneity we consider is different as it arises from a dynamic effect of transaction prices on future reputation through the feedback mechanism. We can thus exploit structural assumptions on the dynamics of shocks to instrument for reputation and size.

We now turn to the article by Cabral and Hortaçsu (2010) on eBay data. We use a richer data set, which helps us tackle important identification issues. Moreover, the web site we use for our analysis has a different design than eBay: price-posting (no auctions), and a unilateral feedback mechanism (little scope for retaliation), make the relationship between reputation and prices more straightforward to interpret. Cabral and Hortaçsu (2010) have transaction data for three specific products sold on eBay. They find that the proportion of negative feedback affects prices negatively. OLS estimates show an effect of around 9% in magnitude, which becomes non significant when one accounts for within-seller correlation. Moreover, this effect disappears when the authors control for a large-seller dummy, in an effort to account for seller heterogeneity. An interesting feature of the Cabral and Hortaçsu (2010) analysis is that they can also exploit a change in the design of the eBay web site which affected the feedback information passed on to bidders. Using this change as a natural experiment, they show that negative feedbacks can influence prices. Unfortunately their data did not allow them to exploit any longitudinal variation for the estimation of their price equation.

Our results bring about additional evidence of a significant effect of seller reputation on transaction prices. We consider a wide range of products (at the cost of some assumptions on sorting), and our very rich longitudinal data set allows us to address explicitly unobserved heterogeneity and the dynamic relationship between reputation and past prices. Our OLS results shown in Table 4 are consistent with Cabral and Hortaçsu (2010) and previous work finding a weak, slightly positive and significant relationship between reputation and prices in cross-sections. The effect vanishes once the unobserved seller effect is differenced out. By contrast, our preferred GMM estimates, shown in Table 4 point toward a significant, positive and strong effect of reputation on prices, in accordance with Cabral and Hortaçsu (2010)'s natural experiment results.

In our data, the main effect goes through the seller's average score, although recent feedback may also matter (see Table 10). Comparing this with the result from Cabral and

Hortaçsu (2010) that the first negative feedback on eBay has a strong effect on sales suggests that framing matters, an issue that should be further investigated (see Nosko and Tadelis, 2014 for work in this direction). Finally we confirm that the effect of reputation interact with the seller’s size (see Table 7).

5 Conclusion

In this paper, we have used a unique exhaustive data set from a large e-commerce web site to study the effect of on-line seller reputation and size on transaction prices. Our first contribution is methodological as our data allow us to explicitly account for seller unobserved heterogeneity. There, we highlight, and overcome, the bias arising from the dependence of reputation on past prices. Our second contribution is descriptive as we provide empirical evidence of a significant, positive and strong effect of seller reputation on transaction prices for a large and varied group of product categories (books to video games), product conditions (used or new) and types of seller (individual or professional). We thus provide new results on the determinants of the reputation effect induced by feedback scores. As far as we know, such large-scale evidence of an empirical relationship between prices and reputation was not available prior to this study.

The next step would now be to delve into the causal statistical link between reputation and prices that we uncovered in this paper. This requires a structural model of price formation on an on-line platform. There are many issues to be tackled with a more structural approach, each of which motivating an interesting project for which the PriceMinister data would be useful. First, we can study the dynamic strategies of sellers who may want to manipulate prices over time in order to build up or milk their reputation. Secondly, one may be interested in the reverse causality mechanism and study how consumers’ feedbacks are formed. Another interesting research question is how the vast degree of price dispersion observed on the web site results from seller differentiation (through e.g. reputation) and/or through search frictions. In particular, this latter project will shed light on whether the strong positive effect of reputation on prices we found in this paper reflects consumers’ preferences and/or of other features of on-line markets.

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APPENDIX

A Descriptive statistics for professional sellers

Table A1: Descriptive statistics: Professional sellers - Used goods

	Books	CD	Games	Video sellers
<i>Number of...</i>				
sellers	1 917	1 012	1 348	1 549
products	395 084	105 532	19 511	52 589
seller/product	568 382	194 170	151 265	191 607
transactions	642 227	228 923	286 455	304 858
<i>Number of transactions per used condition</i>				
fair	76 702	3 298	11 492	4 381
good	217 831	24 621	51 269	27 227
very good	181 392	102 033	108 994	189 773
as new	166 302	98 971	114 700	83 477
<i>Distribution of seller size in January 2008</i>				
5% quantile	28	18	14	18
50% quantile	631	444	454	448
95% quantile	13 327	9 531	10 163	8 566
99% quantile	48 685	22 793	42 166	28 023

Table A2: Descriptive statistics: Professional sellers - New goods

	Books	CD	Games	Video sellers
<i>Number of...</i>				
sellers	751	855	1 048	1 442
products	157 858	150 164	15 505	75 239
seller/product	222 366	222 599	64 386	242 375
transactions	339 374	474 274	323 327	939 882
<i>Distribution of seller size in January 2008</i>				
5% quantile	3	7	9	12
50% quantile	406	302	606	542
95% quantile	9 769	6 406	12 428	8 651
99% quantile	44 503	22 793	43 530	22 793