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Cost behavior in e-commerce firms

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Abstract
We conduct empirical research on the flexibility of operating costs of e-commerce firms. With an international sample of firms from different European countries, we find that e-commerce firms have a different cost structure than traditional retail firms, with a lower share of labor costs and cost of goods sold, but a higher share of other operating costs. While we find no significant different behavior in cost of goods sold and labor costs between the two types of firms, e-commerce firms are more flexible in adjusting other operating costs than traditional retail firms when activity decreases. Results are robust to different models, estimations methods and samples. The higher flexibility of e-commerce firms relies on other operating costs, but e-commerce creates qualified jobs with higher wages than traditional retail, with no additional exposure to labor uncertainty for employees.

Keywords Cost behavior · E-commerce · Retail firms · Operating costs · Labor costs

1 Introduction

E-commerce is the trading or facilitation of trading of products or services using computer networks, such as the internet or online social networks [1]. It has increased dramatically in recent years, usually as a consequence of strategic business decisions and its perceived advantages over traditional commerce in terms of factors such as economic and information efficiency, coordination, and market impact. According to data from eMarketer, worldwide e-commerce sales increased from US$ 1336 billion in 2014 to US$ 4280 billion in 2020, a 320% increase in 6 years, continuing to climb to a forecasted US$ 6388 billion in 2024, a much greater

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increase than for traditional commerce. This represents a rise from 7.4% share of total global retail sales in 2015 to 18% in 2020, up to a forecasted 21.8% in 2024 [2].

We analyze the effects of e-commerce on resource adjustment when activity decreases, in view of the ongoing debate on the economic effects of e-commerce versus traditional business for firms [3–7], employees [8–10] and consumers [11–13] (see Appendix 1 for detailed information about this and other literature reviewed in this study). We focus on the economic advantages of e-commerce over traditional business for firms and, more specifically, on the greater flexibility of the former from the point of view of costs. We analyze the comparative flexibility of firms to adjust resources when sales decrease, using the established business research approach of cost stickiness. Firms exhibit asymmetric cost behavior, with certain costs rising more when activity increases than the corresponding decrease when there is a drop in activity. The economic and business literature describes this behavior as cost stickiness.

Despite the increasing importance of e-commerce in the economy, to the best of the authors' knowledge, there are no empirical studies comparing the economic characteristics and cost behavior of e-commerce firms. More precisely, there is no previous empirical research on the differential asymmetric cost behavior of e-commerce with respect to traditional retail firms. This study contributes to both business and e-commerce research, with an interdisciplinary study in line with following Kauffman and Walden's claims [14] to build an integrated basis for managerial understanding of e-commerce.

We use an international sample of European e-commerce and traditional retail firms and find that e-commerce firms have a different cost structure than traditional retail firms, with a lower share of labor costs (LC) and cost of goods sold (CGS), but a higher share of other operating costs (OTHOP). While we find no significant difference in the behavior in terms of the CGS and LC between the two types of firms, e-commerce firms are more flexible in adjusting OTHOP than traditional retail firms when activity decreases. Results are robust to different models, estimations methods, and samples.

The rest of the paper is organized as follows: the next section reviews the literature and formulates hypotheses; next, we formulate a model, describe the sample, and present results, before finishing with a section on conclusions and implications.

2 Literature review and hypotheses development

There is a wealth of business research on e-commerce, usually focusing on commercial, marketing or technical issues related to the logistic efficiency or impact on clients. Kauffman and Walden [14] provide a review on economics and e-commerce from a variety of disciplines with a focus on information systems. Costs of e-commerce adoption have been studied [15, 16]. To the best of the authors' knowledge, there are almost no empirical studies of the costs and financial performance of e-commerce versus traditional retail trade firms. Koo et al. [17] compare 67 online with 55 click-and-mortar firms, analyzing the contribution of Porter's competitive strategies to firm performance. Brynjolfsson et al. [12] evaluate the consumer

surplus generated for consumers by e-commerce with respect to traditional firms. Stylianou et al. [18] examine prices and costs from pharmaceutical retailers that sell exclusively on the internet compared to retailers with both conventional and internet channels. They collected data from the firms' websites and found small but significant differences in prices and larger differences in costs. Prices were lower on the internet, but the costs to the consumer were higher. These studies use fragmentary data rather than the complete accounting data of the whole firms used in the study.

Since the seminal study by Anderson et al. [19], cost stickiness research has usually analyzed selling, general and administrative expenses (SG&A) [20–23] and total operating costs (TOP) [24, 25]. Few studies have analyzed LC [26–29]. Various industries [30], including international comparisons and settings [31] or certain specific contexts or industries, have also been analyzed, such as the air transportation industry [32], manufacturing enterprises [33], hospitals [34], therapy clinics [35], small and medium sized firms [27], and local public enterprises [36], among others. However, to the best of the authors' knowledge, no empirical research has been conducted on the comparative resource adjustment of e-commerce in comparison to traditional retail firms when activity decreases, as can be seen in the Appendix 1, which summarizes our literature review.

Previous research has identified various factors causing cost stickiness, with the most important being the managers' inability to adjust resources because they are not flexible enough to react in a timely manner, the deliberate decision to keep resources because they have some expectations or specific interests, and/or the fixity of certain costs influencing the ability to react in the short term [24, 37, 38].

The traditional cost behavior model distinguishes between variable and fixed costs [39]. Since their inception, economic theory [40, 41] and cost accounting [42, p. 222–238] have rebutted the concepts of fixed and variable costs, recognizing that they are controversial concepts. They have also assumed that most costs are conventionally considered variable in the long term and fixed in the short time. More recently, the activity-based costing approach considers that all costs, including overhead costs, are variable [43, p. 239]. Some authors argue that fixed costs are the most variable and rapidly increasing costs [44, p. 225]. According to Cooper and Kaplan [45], managers erroneously conclude that some costs are fixed because they fail to reduce them. The activity-based costing model stresses the importance of transactions as cost drivers and criticizes the use of volume drivers to allocate costs to products through the traditional cost accounting models [46]. However, the two models agree to a certain extent, considering that fixed costs increase in the long term. The differences are more based on the emphasis. The activity-based costing model emphasizes the variable nature of overhead costs and the convenience of shifting from volume to transactions as a criteria for allocating costs to products and services [47, 48]. According to these authors, the real driver of costs is the complexity that firms have acquired in the long run to fulfill their objectives They also recognize that there is no automatic adjustment of overhead costs when activity decreases. They increase easily, but there are a great deal of rigidity that makes decreasing them difficult. They argue that the variability of overhead costs should be measured in terms of transactions rather than in terms of volume. The proportionality of costs is also called into question

[34, 49]. However, despite the controversial distinction between the two types of costs, the traditional cost behavior model of and the empirical research on cost stickiness assume that variable costs are proportional to activity and that fixed costs do not change with activity in the short term and within the firms' relevant range of activity [50, p. 179]. With this approach, variable costs are assumed to display the same pattern and change in both phases of increasing and decreasing activity, and thus do not show sticky behavior, while fixed costs do exhibit sticky behavior.

Therefore, in the case of variable costs, the magnitude of the change depends only on the extent of the change, but not on its direction [51]. Similarly, the costs of goods sold are recorded automatically in the profit and loss statement, depending on revenues. In the retail trade industry, the costs of goods sold are the goods sold valued at acquisition costs. They are considered variable costs. According to this argument, such costs should not display sticky behavior, or their stickiness should be insignificant. They are related to the units of products or services sold by firms. They appear in the profit and loss statement depending on the units sold, increasing with increasing sales and decreasing similarly when sales decrease. There are no expected differences in the sticky behavior of such variable costs between e-commerce and traditional retail.

Fixed costs are more related to the maintenance of the structure required to keep the firm working. As the characteristics of e-commerce and traditional retail firms are different, the structure of fixed costs and their behavior is expected to differ between the two types of firms. Traditional retail firms rely on physical presence and the use of brick-and-mortar outlets. They offer products to their customers face-to-face in a store that the business owns or rents. Therefore, they need higher investments in fixed assets, as well as expenses related to their depreciation, rent, maintenance, and sustaining their working conditions, such as electricity and heat. They also need a higher number of employees to conduct their sales. In contrast, e-commerce conducts business with fewer employees. The OECD [52, p. 66–67] reports greater revenue per employee in internet businesses than in their traditional counterparts. Falk and Hagsten [4] find greater labor productivity growth in e-commerce firms across 14 European countries. Like traditional retail, e-commerce requires a lot of unqualified employment, but its core business is based on qualified work. However, in both cases, as its activities are less dependent on physical locations, e-commerce firms may more easily outsource certain tasks and/or use non-standard employment, or even hire employees in countries or locations with cheap wages and low social security contributions or labor protection. Firms' sales in these locations may be tiny, but the employees hired in these locations may work in other countries where sales are high but may have less favorable labor jurisdictions from the point of view of the firms' costs. The International Labor Organization [53] reports an increasing use of non-standard employment, which is particularly significant in e-commerce firms. Some authors [54, 55] stress that e-commerce exacerbates the usual monitoring problems for tax and labor authorities. Therefore, they are more flexible not only in terms of contracting employees in the most favorable labor locations and using them to work in other locations, but also for adjusting human resources needs to fluctuations in demand.

In most business dimensions, flexibility is a distinctive feature of e-commerce. Saini and Johnson [56] identify a significant relationship between firm flexibility and e-commerce performance. Speed of change, real-time pricing, customer interactions, and the low cost of distributing product information are important advantages and characteristics of e-commerce firms, among others [57]. E-commerce is knowledge-intensive and technology-based, creating new value through the increased number and variety of information, services, and products available to the customer. E-commerce relies more on intangibles and technological investments, which are more exposed to obsolescence, shorter lifetime periods and, consequently, higher depreciation rates. Their businesses probably require greater coordination of a wide range of activities conducted in different places, such as promotion, customer enquiries and delivery. It also requires constant innovation, the development of information systems and their integration into daily operations [5]. According to these authors, the important benefits of e-business include efficient information/knowledge sharing and data analysis, as well as working without any distance limitations. Organizational innovation and the automation of the company's activities are also crucial features of this type of business. Their specific business model makes e-commerce firms more flexible than traditional firms. There are abundant flexibilities that come with electronic commerce [58]. Bieńkowska and Sikorski [59] argue that flexibility for applying organizational solutions, adapting to unforeseen changes, and using and reassigning resources pragmatically to adapt to changing circumstances is a key feature of e-commerce, which is required and determined by its dynamic environment. As a consequence, e-commerce firms are more prepared to adapt flexibly to changing circumstances, including a drop in activity, as well as getting rid of unused resources, if necessary.

We therefore formulate the following hypotheses:

H1 There are no differences in variable cost behavior between e-commerce and traditional retail firms.

H2 Fixed costs are less sticky in e-commerce firms than in traditional retail firms.

3 Model development

Based on previous studies [21, 26, 28–30, 60], we formulate the following model to explain cost behavior:

$$\begin{aligned}\Delta \log OP_{i,t} =& \beta_0 + \beta_1 \cdot \Delta \log REV_{i,t} + \beta_2 \cdot D_{i,t} \cdot \Delta \log REV_{i,t} + \beta_3 \cdot D_{i,t} \cdot \Delta \log REV_{i,t} \cdot ECOM_{i,t} \\ &+ \sum_{i=1}^{N} \gamma_4 \cdot D_{i,t} \cdot \Delta \log REV_{i,t} \cdot CONTROLS_{i,t} + \delta_1 \cdot ECOM_{i,t} \\ &+ \sum_{i=2}^{N} \delta \cdot CONTROLS_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{1}$$

where each observation refers to firm i in year t, β, γ and δ are the parameters to be estimated, and ε is the error term, $\Delta\log OP$ is the log-change in operating costs (OP), $\Delta\log REV$ is the log-change in revenues, and D is a dummy indicating that revenues decrease with respect to the previous year. *ECOM* is our experimental variable, a dummy indicating with value one (and zero otherwise) that a given firm is coded as retail trade via the internet. *CONTROLS* are various control variables likely to influence LC stickiness, which have also been used in previous studies. The Appendix 2 gives a list and full description of these and all other variables.

Different OP measures are used. More precisely, we use CGS, indicating the value (at acquisition cost) of merchandise sold, with similar behavior to variable costs. We also use LC and OTHOP, with similar behavior to fixed costs, as well as considering TOP.

As mentioned, we include control variables commonly used in previous research, such as employee intensity (*EMPINT*), asset intensity (*ASSINT*), return on assets (*ROA*), indebtedness (*DEBTTA*), successive revenue decreases (*DSUC*), loss in prior year (*LOSPRY*), and dummies for firms (*FIRM*) years (*YEAR*) and countries (*COUNTRY*). The definition and calculation of these variables is shown in the Appendix 2.

4 Sample

We selected the retail trade sector because it is the only industry that distinguishes between firms selling through both traditional and e-commerce channels, in the most important and common industry statistical classifications, such as the Statistical Classification of Economic Activities in the European Union, also known as the NACE (the French title *Nomenclature générale des Activités économiques dans les Communautés Européennes*). The NACE code 47 (retail except of motor vehicles and motorcycles) distinguishes between firms classified as retail trade via internet (NACE code 4791) and traditional retail firms (the remaining codes in NACE code 47).

We downloaded all the available data for firms in the European AMADEUS database for the last ten years when we started the study (2010 to 2019), in the two-digit industry code 47. AMADEUS contains comprehensive information on around 21 million companies over ten years across both Western and Eastern Europe. Despite this huge number of firms, there are only 411,295 active firms with a known industrial activity code in our subscription to the database, which are the biggest firms in the different European countries.

The first download contained 210,888 firm-year observations. Table 1 shows sample details, including sample construction. A total of 158 observations with no firm identification were discarded. As is usual in empirical research on cost stickiness, to clean the sample from the exceptional effects of mergers, acquisitions and other extraordinary operations, we dropped 92,571 observations with revenue changes of 50%, either upward or downward. To prevent any likely bias from mistakes in the database, we additionally dropped 1695 observations with negative revenues or total operating costs. Considering the necessary lags and information in all our independent variables and total operating costs, our final sample consists of 83,266 firm-year

Table 1 Sample details

	Total	E-commerce	Traditional
Panel A. Sample construction			
Firm year observations in AMADEUS for NACE code 47 years, 2010 to 2019	210,888		
No firm identification	158		
More than 50% variation in revenues	92,571		
Negative revenues or total operating costs	1695		
Lags and missing factors in the dependent (total operating costs) and independent variables	33,198		
Firm year observations with data in all dependent (total operating costs) and independent variables	83,266		
Panel B. Observations by year			
2012	7844	259	7585
2013	8985	318	8667
2014	9821	369	9452
2015	10,491	413	10,078
2016	11,062	474	10,588
2017	11,958	534	11,424
2018	12,159	565	11,594
2019	10,946	513	10,433
Total	83,266	3445	79,821
Panel C. Firm-year observations by country			
Albania	8	0	8
Austria	902	20	882
Belgium	3059	100	2959
Bosnia and Herzegovina	754	0	754
Bulgaria	1023	16	1007
Croatia	883	14	869

Table 1 (continued)

	Total	E-commerce	Traditional
Czech Republic	1563	180	1383
Cyprus	73	0	73
Denmark	218	10	208
Estonia	541	26	515
Finland	1650	11	1639
France	12,047	434	11,613
Germany	2979	166	2813
Greece	945	11	934
Hungary	1605	66	1539
Ireland	520	4	516
Iceland	118	0	118
Italy	12,490	579	11,911
Kosovo	10	0	10
Lithuania	616	33	583
Luxembourg	76	5	71
Latvia	604	18	586
Moldova	39	0	39
Montenegro	134	0	134
North Macedonia	310	6	304
Malta	36	0	36
Netherlands	437	22	415
Norway	1581	101	1480
Poland	2344	130	2214
Portugal	3061	32	3029

Table 1 (continued)

	Total	E-commerce	Traditional
Romania	1955	62	1893
Russia	7488	103	7385
Slovenia	559	17	542
Slovakia	866	17	849
Serbia	826	16	810
Spain	6878	143	6735
Sweden	3974	374	3600
Switzerland	79	0	79
Ukraine	2003	20	1983
United Kingdom	8012	709	7303
	83,266	3445	79,821

observations (see Panel A in Table 1). However, fewer observations are available for the estimations with the different types of operating costs, as shown in the estimations displayed in Tables 4, 5, 6, 7, and 8.

We code as e-commerce any firms with NACE code 4791, and we consider all remaining firms as traditional brick-and-mortar firms. Panel B in Table 1 displays observations by year, distinguishing between e-commerce and traditional retail firms, with a total of 3445 firm-year observations for the former, a total of 4.1% of all firm-year observations in our sample, compared to the corresponding number of 79,821 in the case of traditional firms.

Panel C in Table 1 shows the number of observations by country. The highest numbers belong to firms in the biggest European countries, such as Italy, France, the United Kingdom, Russia and Spain, but Germany is underrepresented in the sample, contributing with a lower number of observations than Sweden, Belgium and Portugal.

As is common in empirical research on business, in order to avoid biased results due to influential cases, we winsorize all continuous variables at 0.5% in each tail. Table 2 displays descriptive statistics for dependent and independent variables, as well as other sample characteristics. In accordance with worldwide trends, as mentioned in the introduction, the revenues of e-commerce firms grow more than traditional firms over the period studied (see Panel B). Consequently, their costs also grow more (see Panel A). They need fewer employees and less investment in assets and, therefore, their ratios of employee and asset intensity are lower, but the difference is non-significant at $p<0.1$ in the case of asset intensity. Surprisingly, e-commerce firms are more indebted, probably because they grow more and have higher financing needs. Their profitability is lower, probably because of their higher financial expenses and growth orientation. In accordance with previous data, there is a significant association between traditional commerce (versus e-commerce) and decreasing sales in the current year and in two successive years. Moreover, the share of e-commerce firms' observations with losses in the previous year is higher than the corresponding figure for traditional firms. Panel B in Table 1 shows these data.

Panel C in Table 1 shows additional interesting characteristics. E-commerce firms have bigger revenues and lower number of employees, and pay considerably higher wages per employee, probably because they rely more on qualified work and need less unqualified work to perform their operations. This is in line with Steinfield et al. [61], who found greater labor cost efficiencies in e-commerce in case studies in the Netherlands. The share of fixed assets is lower and also the share of depreciation costs over total operating costs. Their cost structure is different from the cost structure of traditional firms. The cost of goods sold is lower because they probably have lower acquisition costs and a more favorable product mix. Labor costs are almost 10% (1–11.26/12.42) lower on average, which is much less than the considerably lower average number of employees, at 41% (1–261.4/444.8) less than traditional retail firms. Finally, the share of other operating costs is higher because they require more coordination, support activities and research and development.

Table 3 shows Pearson correlations between the independent variables. Correlations between non-interaction variables are low (the highest value is −0.458 between *DSUC* and $\Delta\log REV$), but there are some high and significant correlations between

Table 2 Descriptive statistics

	E-commerce			Traditional			
	Observations	Mean	Median	Observations	Mean	Median	
Panel A: dependent variables							
Δlog*TOP*	3445	0.03	0.03	79,821	0.01	0.01	***
Δlog*CGS*	2920	0.02	0.03	72,254	0.01	0.01	***
Δlog*LC*	3166	0.03	0.03	66,662	0.02	0.02	***
Δln*OTHOP*	2735	0.03	0.03	61,373	0.02	0.01	***
Panel B: independent variables							
Δln*REV*	3445	0.030	0.031	79,821	0.014	0.013	***
EMPLINT	3445	0.004	0.003	79,821	0.010	0.004	***
ASSINT	3445	0.607	0.389	79,821	0.710	0.382	
ROA	3445	0.025	0.036	79,821	0.049	0.042	***
DEBTTA	3445	0.737	0.715	79,821	0.667	0.662	***
D	3445	0.306	0	79,821	0.364	0	***
DSUC	3445	0.138	0	79,821	0.180	0	***
LOSPRY	3445	0.477	0	79,821	0.363	0	***
Panel C: other characteristics							
Revenues (000€)	3445	97,726.01	24,270.00	79,821	91,837.86	20,164.00	***
Number of employees	3445	261.37	65.00	79,821	444.85	99.00	***
Total Assets (000€)	3445	58,941.21	9,990.00	79,821	46,944.68	8447.00	***
Percent of Fixed Assets on Total Assets	3445	19.55	13.02	79,816	34.65	31.88	***
LC per number of employees (000€)	3192	41.43	39.27	66,989	30.42	28.83	***
Percent of CGS on TOP	3337	61.53	62.96	77,879	70.56	76.29	***
Percent of LC on TOP	3196	11.26	9.71	67,078	12.42	10.50	***
Percent of OTHOP on TOP	3106	27.93	25.71	65,756	18.14	13.34	***

Table 2 (continued)

	E-commerce			Traditional			
	Observations	Mean	Median	Observations	Mean	Median	
Percent of depreciation on TOP	3169	1.76	0.91	68,707	2.16	1.38	***

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Mann–Whitney tests for continuous variables and χ^2 tests for dummy variables

Table 3 Pearson correlations between standalone independent variables

	Δlog*REV*	*ECOM*	*EMPLINT*	*ASSINT*	*ROA*	*DEBTTA*	*DSUC*	*LOSPRY*
Δlog*REV*	1							
ECOM	0.051***	1						
EMPLINT	−0.164***	−0.051***	1					
ASSINT	−0.084***	−0.01***	0.145***	1				
ROA	0.161***	−0.038***	−0.062***	−0.075***	1			
DEBTTA	−0.005	0.04***	−0.068***	−0.102***	−0.43***	1		
DSUC	−0.458***	−0.022***	0.121***	0.048***	−0.143***	0.032***	1	
LOSPRY	0.001	0.047***	0.02***	0.068***	−0.26***	0.227***	0.025***	1

***$p<0.01$, **$p<0.05$, *$p<0.1$

interaction variables (not displayed for the sake of simplicity), as is frequent in samples with such variables. The highest value is 0.804 between *D*•Δlog*REV* and *D*•Δlog*REV DEBTTA*. The highest variance inflation factors are 8.5 and 5.2 for these variables, respectively, which fall within the accepted thresholds of 5 and 10, respectively [62, p. 76, and 63, p. 409], that some authors consider indications of moderate or serious collinearity problems. As the condition index is 10.9, well below the thresholds of 15 or 30, conventionally considered to be associated with collinearity concerns or serious collinearity concerns respectively [64, 65], collinearity is not considered likely to affect estimations.

5 Results

Given the panel data structure of our data and the Hausmann tests, we run fixed-effects estimations. Dummies for firms are not displayed for the sake of simplicity. As some interesting industry effects are omitted for collinearity in fixed-effects estimations, we also run industry-year interactions with firm fixed effects and random effects controlling for dummies for industry. The Breusch-Pagan/Cook-Weisberg for heteroskedasticity and modified Wald test for groupwise heteroskedasticity indicate that our models display heteroskedasticity in most cases and, consequently, we perform estimations with robust standard errors.

Table 4 shows estimations for a reduced model of operating costs depending on Δlog*REV* and the interaction variable *D*·Δlog*REV*. As expected, there is sticky behavior in TOTOP, LC and OTHOP, particularly in the two latter costs. For example, focusing on Column (1) in this table, total operating costs increased 0.955% per 1% increase in revenues, but they decreased slightly less, 0.9267% (0.955–0.0283) when revenues decreased by 1%. The sticky behavior is more pronounced for LC and OTHOP, with significant β_2 coefficients of −0.099 and −0.114 at $p<0.01$, respectively. However, CGS displays anti-sticky behavior, decreasing more when revenues decrease than they increase in the increasing trajectory: a significant (but only at $p<0.1$) positive β_2 coefficient of 0.0186. This may be explained by a changing product mix and/or the application of lower acquisition costs by suppliers in

Table 4 Fixed-effects estimations of operating costs depending on revenues

Variables	(1) Δlog*TOP*	(2) Δlog*CGS*	(3) Δlog*LC*	(4) Δlog*OTHOP*
Δlog*REV*	0.955***	1.005***	0.626***	0.729***
	(0.00306)	(0.00521)	(0.0106)	(0.0148)
D·Δlog*REV*	−0.0283***	0.0186*	−0.0990***	−0.114***
	(0.00711)	(0.00954)	(0.0229)	(0.0313)
Constant	0.000551***	−0.00163***	0.0119***	0.00567***
	(0.000142)	(0.000194)	(0.000427)	(0.000559)
Observations	83,266	75,174	69,828	64,108
Number of firms	15,828	14,761	13,399	12,657
Firm fixed effects	Yes	Yes	Yes	Yes
R-sq overall	0.8896***	0.7767***	0.2962***	0.2052***

Robust standard errors in parentheses

***$p<0.01$, ** $p<0.05$, *$p<0.1$

periods of decreasing activity, although that drop in sales may produce higher damaged and obsolete goods than the increase in sales, which would require inventory write-downs and, consequently, a lower decrease in costs.

Table 5 shows the results of the estimations of the full model formulated in Eq. (1). Dummies for firms and years are not shown for the sake of simplicity. All estimations show significant goodness-of-fit with R-squared overall ranging from 0.1977 to 0.8917 for other and total operating costs, respectively. There is no significant relationship (at $p<0.1$) between our experimental variable (*D*·Δlog*REV*·*ECOM*) and TOTOP, CGS and LC, thus indicating that there are no significant differences between e-commerce and traditional retail firms in the sticky behavior of costs of goods sold and labor costs. In contrast, β_3 is positive and significant (at $p<0.01$) for OTHOP, indicating that e-commerce firms are more flexible than traditional firms in adjusting other operating costs when activity decreases. Under such circumstances, they react with higher reductions to these costs and, therefore, with less sticky behavior. Consequently, these results provide support for H1, but only limited support for H2. This hypothesis is supported for OTHOP, but not for LC.

The dummy variable *ECOM* is removed from the regressions because of collinearity, given that panel data estimations with fixed effects remove all variables that do not change their value for individual firms over the different periods. Most control variables display the expected result. All operating costs increase less in more profitable and indebted firms, as well as in periods of losses in previous years (see the standalone variables *ROA*, *DEBTTA* and *LOSPRY*). Moreover, results with the interaction variables confirm expectations about higher sticky behavior in all costs for higher asset intensity, while indebtedness and sales decrease in successive years are associated with less stickiness, also as expected, in two out of four columns. The coefficient of the interaction variable with employee intensity surprisingly displays opposite signs: negative and significant in Column (2), and positive and significant

Table 5 Fixed-effects estimations of Eq. (1). Full sample

Variables	(1) Δlog*TOP*	(2) Δlog*CGS*	(3) Δlog*LC*	(4) Δlog*OTHOP*
Δlog*REV*	0.968***	1.011***	0.638***	0.763***
	(0.00291)	(0.00532)	(0.0110)	(0.0150)
D·Δlog*REV*	−0.00742	0.0580***	−0.194***	−0.236***
	(0.0139)	(0.0225)	(0.0456)	(0.0578)
D·Δlog*REV*·*ECOM*	0.0111	0.0132	−0.0681	0.237***
	(0.0206)	(0.0561)	(0.0773)	(0.0792)
D·Δlog*REV*·*EMPLINT*	−0.0637	−0.237*	4.590***	2.574*
	(0.104)	(0.143)	(0.995)	(1.468)
D·Δlog*REV*·*ASSINT*	−0.0284***	−0.0269***	−0.0310***	−0.0261**
	(0.00355)	(0.00808)	(0.00670)	(0.0117)
D·Δlog*REV*·*ROA*	0.187***	−0.0283	0.252**	0.238
	(0.0432)	(0.0643)	(0.126)	(0.153)
D·Δlog*REV*·*DEBTTA*	0.00775	−0.0124	0.0799*	0.142**
	(0.0170)	(0.0210)	(0.0437)	(0.0631)
D·Δlog*REV*·*DSUC*	0.0436***	0.00324	0.115***	−0.00267
	(0.00971)	(0.0133)	(0.0340)	(0.0432)
D·Δlog*REV*·*LOSPRY*	−0.0161	0.0111	−0.0269	0.0747*
	(0.0100)	(0.0142)	(0.0339)	(0.0444)
EMPLINT	−0.0254	−0.00858	0.488***	−0.303*
	(0.0179)	(0.0262)	(0.146)	(0.170)
ASSINT	−0.000649	−0.00158	−0.000789	0.00166
	(0.000566)	(0.00118)	(0.000889)	(0.00203)
ROA	−0.0858***	−0.0583***	−0.0388***	−0.215***
	(0.00244)	(0.00303)	(0.00514)	(0.00911)
DEBTTA	−0.0123***	−0.00476***	−0.0125***	−0.0279***
	(0.00126)	(0.00151)	(0.00268)	(0.00435)
DSUC	−0.000214	−0.000318	−0.000374	−0.00185
	(0.000305)	(0.000452)	(0.000965)	(0.00129)
LOSPRY	−0.00653***	−0.00498***	−0.00450***	−0.0187***
	(0.000242)	(0.000437)	(0.000762)	(0.00109)
Constant	0.0208***	0.0111***	0.0230***	0.0565***
	(0.00102)	(0.00136)	(0.00241)	(0.00376)
Observations	83,266	75,174	69,828	64,108
Number of firms	15,828	14,761	13,399	12,657
Year	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
R-sq overall	0.8917***	0.7775***	0.2956***	0.1977***

Robust standard errors in parentheses

***$p<0.01$, **$p<0.05$, *$p<0.1$

in Columns (3) and (4). The moderating effect of employee intensity on the sticky behavior of labor costs (Column (3)) can be explained in terms of the more urgent need to cut labor costs in firms with higher employee intensity.

Given that our sample includes a much larger number of traditional retail firms compared to e-commerce firms, results with the full sample might be biased by this unbalanced number of observations. Accounting and business research use propensity scores as a matching procedure to remove concerns about endogeneity affecting results [66, 67]. We therefore use the propensity score method to produce a matched sample with a similar number of observations and characteristics in the two subsamples. For all countries with e-commerce observations and data on total operating costs, we run logistic regressions in which the dependent variable *ECOM* depends on size, measured as total assets, and the independent standalone variables in Eq. 1, *EMPLINT*, *ASSINT*, *ROA*, *DEBTTA*, *LOSPRY* and *DSUC*, to obtain a one-to-one sample and avoiding firms being matched more than once. Despite differences in the results with the propensity score-matched sample for control variables, they are essentially the same with respect to our variable of interest, $D{\cdot}\Delta\log REV{\cdot}ECOM$, as can be seen in Table 6. According to these results, e-commerce business does not significantly influence the asymmetric behavior of CGS and LC (see Columns (2) and (3)), but the positive significant sign of the interaction variable $D{\cdot}\Delta\log REV{\cdot}ECOM$ in Column (4) indicates that e-commerce firms are more flexible in cutting OTHOP when activity decreases. Therefore, once again, our results support H1, and H2 is again supported by our results for OTHOP, but not for LC. *ECOM* is again removed for collinearity.

To avoid concerns about cross-sectional correlation, we perform Fama–MacBeth estimations. The results, shown in Table 7, provide reinforced results for our experimental variable. While there are no significant coefficients for CGS and LC for the whole and propensity-matched samples (see Columns 1, 2, 4 and 5), the coefficient is positive and significant for OTHOP in both samples (see Columns (3) and (6)). As the Fama–MacBeth procedure performs cross-section estimations by year, the dummy variable is now not removed because of collinearity.

Fixed-effects estimation does not allow us to control for country, given that the necessary dummies used are excluded for collinearity. To rule out any possibility that specific country characteristics would distort our results, we perform fixed-effects estimations, including interaction variables with dummies for year and country, and results (not tabulated) are similar for our experimental variable in the full and propensity score-matched samples: significant positive coefficient for OTHOP (at $p<0.01$ and $p<0.1$ for the full and matched sample, respectively) and non-significant coefficients for CGS and LC, with the exception of a negative and significant (at $p<0.1$) coefficient for CGS in the matched sample. We additionally run random-effects estimations, adding dummies for countries at Eq. 1 and, again, results (not tabulated for simplicity) are similar with respect to our variable of interest: non-significant (at $p<0.1$) coefficients for CGS and LC in all samples, and significant positive coefficients for OTHOP in the full and matched sample (at $p<0.01$ and $p<0.1$ respectively).

Some of the few empirical studies on LC stickiness attribute the asymmetric LC behavior to hiring and firing costs mandated by the employment protection

Table 6 Fixed-effects estimations of Eq. (1). Propensity score-matched sample by country

Variables	(1) $\Delta\log TOP$	(2) $\Delta\log CGS$	(3) $\Delta\log LC$	(4) $\Delta\log OTHOP$
$\Delta\log REV$	0.956***	1.007***	0.551***	0.806***
	(0.0127)	(0.0279)	(0.0475)	(0.0532)
$D{\cdot}\Delta\log REV$	0.172***	0.253**	− 0.138	− 0.578**
	(0.0596)	(0.112)	(0.198)	(0.235)
$D{\cdot}\Delta\log REV{\cdot}ECOM$	− 0.0371	− 0.0945	0.0292	0.434**
	(0.0432)	(0.0844)	(0.146)	(0.181)
$D{\cdot}\Delta\log REV{\cdot}EMPLINT$	− 1.111	9.361**	1.584	11.32
	(1.057)	(4.221)	(1.259)	(7.733)
$D{\cdot}\Delta\log REV{\cdot}ASSINT$	− 0.101***	− 0.0147	− 0.0696	− 0.0878*
	(0.0316)	(0.0330)	(0.0536)	(0.0456)
$D{\cdot}\Delta\log REV{\cdot}ROA$	− 0.00569	0.102	0.262	− 0.589**
	(0.0839)	(0.170)	(0.273)	(0.285)
$D{\cdot}\Delta\log REV{\cdot}DEBTTA$	0 − .0729	− 0.0949	0.0277	0.0340
	(0.0475)	(0.0838)	(0.130)	(0.135)
$D{\cdot}\Delta\log REV{\cdot}DSUC$	0.00163	− 0.0492	0.0984	0.0477
	(0.0404)	(0.103)	(0.142)	(0.136)
$D{\cdot}\Delta\log REV{\cdot}LOSPRY$	− 0.00772	− 0.0592	0.0917	0.167
	(0.0331)	(0.105)	(0.141)	(0.121)
EMPLINT	0.00592	1.730**	1.744*	− 0.729
	(0.100)	(0.732)	(0.968)	(0.629)
ASSINT	− 0.00136	− 0.00763	− 0.000352	− 0.0165*
	(0.00315)	(0.00657)	(0.00278)	(0.00889)
ROA	− 0.0821***	− 0.0412***	− 0.0542***	− 0.232***
	(0.00726)	(0.0126)	(0.0189)	(0.0202)
DEBTTA	− 0.0125***	0.000270	− 0.0297***	− 0.0437***
	(0.00320)	(0.00736)	(0.0103)	(0.0107)
DSUC	− 0.000898	0.00144	− 0.00523	− 0.00744
	(0.00175)	(0.00403)	(0.00593)	(0.00747)
LOSPRY	− 0.00888***	− 0.00897***	− 0.00351	− 0.0244***
	(0.00108)	(0.00318)	(0.00389)	(0.00499)
Constant	0.0243***	0.00554	0.0500***	0.0830***
	(0.00341)	(0.00694)	(0.0106)	(0.0125)
Observations	6558	5630	5892	5138
Number of firms	3358	2956	2962	2647
YEAR	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
R-sq overall	0.8629***	0.6864***	0.1945***	0.1753***

Robust standard errors in parentheses

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 7 Fama–MacBeth estimations for CGS, LC and OTHOP for the full and propensity score-matched samples

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample			Propensity score-matched sample		
	Δlog*CGS*	Δlog*LC*	Δlog*OTHOP*	Δlog*CGS*	Δlog*LC*	Δlog*OTHOP*
Δlog*REV*	0.997***	0.770***	0.803***	0.993***	0.720***	0.802***
	(0.00530)	(0.0154)	(0.00795)	(0.0245)	(0.0189)	(0.0430)
D·Δlog*REV*	0.0705**	−0.400***	−0.299***	0.0853	−0.385*	−0.444*
	(0.0205)	(0.0573)	(0.0390)	(0.0601)	(0.166)	(0.192)
D·Δlog*REV*·*ECOM*	0.0197	−0.0714	0.193***	0.00166	0.0966	0.194**
	(0.0287)	(0.0906)	(0.0495)	(0.0542)	(0.142)	(0.0645)
D·Δlog*REV*·*EMPLINT*	−0.288	2.334**	1.707	3.854	−1.624	28.54
	(0.203)	(0.777)	(1.385)	(3.483)	(4.522)	(16.62)
D·Δlog*REV*·*ASSINT*	−0.0288***	−0.0285***	−0.0280***	0.0101	−0.0579	0.0403*
	(0.00407)	(0.00585)	(0.00775)	(0.0279)	(0.0478)	(0.0204)
D·Δlog*REV*·*ROA*	0.176*	0.180	0.641***	0.250	0.0911	−0.137
	(0.0820)	(0.0950)	(0.101)	(0.240)	(0.224)	(0.182)
D·Δlog*REV*·*DEBTTA*	−0.0127	0.0203	0.116**	0.00365	−0.235	−0.0257
	(0.0164)	(0.0446)	(0.0456)	(0.0367)	(0.213)	(0.187)
D·Δlog*REV*·*DSUC*	0.0310*	0.177***	0.0295	−0.00626	0.309***	0.00363
	(0.0146)	(0.0426)	(0.0353)	(0.0341)	(0.0822)	(0.186)
D·Δlog*REV*·*LOSPRY*	0.0217*	0.0371**	0.149**	−0.0423	0.116	0.128
	(0.0111)	(0.0141)	(0.0486)	(0.0604)	(0.117)	(0.118)
ECOM	−2.62e-05	−0.00130	0.00460***	−0.00105	0.00324*	0.00507*
	(0.000810)	(0.00165)	(0.000939)	(0.00156)	(0.00143)	(0.00232)
EMPLINT	−0.0615**	0.278	0.0179	-0.129	0.809***	0.435*
	(0.0179)	(0.166)	(0.0886)	(0.257)	(0.159)	(0.224)
ASSINT	−0.00166***	−0.00220***	−0.00110***	0.00115	−0.00169	−0.00151
	(0.000386)	(0.000395)	(0.000262)	(0.00162)	(0.00124)	(0.00140)
ROA	−0.0241***	−0.00386	−0.0839***	−0.0236***	−0.0105	−0.0852***
	(0.00267)	(0.00218)	(0.00307)	(0.00651)	(0.0101)	(0.00899)
DEBTTA	−0.00182***	−0.00507***	−0.00871**	−0.00156	−0.0125***	−0.0176***
	(0.000242)	(0.00101)	(0.00252)	(0.00173)	(0.00285)	(0.00483)
DSUC	0.00100**	−0.00386**	−0.00225	0.000965	−0.00255	−0.0105***
	(0.000411)	(0.00141)	(0.00122)	(0.00109)	(0.00232)	(0.00287)
LOSPRY	−0.00358***	−0.00416***	−0.0140***	−0.00536**	−0.00474	−0.0160***
	(0.000663)	(0.00116)	(0.00243)	(0.00158)	(0.00307)	(0.00263)
Constant	0.00358***	0.0123***	0.0179***	0.00383	0.0139***	0.0235***
	(0.000277)	(0.00176)	(0.00180)	(0.00242)	(0.00263)	(0.00390)
Observations	75,174	69,828	64,108	5630	5892	5138
Number of groups (years)	8	8	8	8	8	8
Average R-sq	0.7750***	0.3168***	0.2274***	0.7445***	0.2695***	0.2734***

Standard errors in parentheses

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

legislation (EPL). Banker et al. [68] find that costs associated with firing workers, measured through the OECD indicators of EPL, are associated with cost stickiness. Golden et al. [69] find that the share of skilled labor is associated with greater operating cost asymmetry, and assume that this is caused by the higher costs of firing, searching and selection of skilled versus non-skilled employees. Dierynck et al. [26] find differences between the LC behavior of blue- and white-collar employees, which they attribute to the differences in their dismissal costs. Prabowo et al. [29] find a positive relationship between stringent labor dismissal and LC stickiness, also using OECD country-level indicators of labor dismissal.

Addressing these previous concerns, in order to relieve endogeneity issues due to omitted variables, which may bias our results for LC, we conduct additional analyses including variables about different types of employees and country level of employment protection. We approach these through LC per employee (*LCNEMPL*) and the available *EPL* scores of the different countries and years on the OECD website,[1] variable *EPL*. Higher *EPL* values mean more stringent labor laws and, therefore, higher levels of protection and lower levels of firm flexibility. We include these standalone variables, and the corresponding interactions to assess their specific influence in LC stickiness ($D{\cdot}\Delta\log REV{\cdot}LCNEMPL$ and $D{\cdot}\Delta\log REV{\cdot}EPL$), and the influence of e-commerce in this specific stickiness ($D{\cdot}\Delta\log REV{\cdot}LCNEMPL{\cdot}ECOM$ and $D{\cdot}\Delta\log REV{\cdot}EPL{\cdot}ECOM$).

Table 8 shows the results of the corresponding estimations for the whole and propensity score-matched samples. The number of observations is slightly lower than in previous tables because of the lack of EPL scores for some countries and years. The coefficients of the standalone variables display positive and significant signs for *LCNEMPL* in all cases and negative signs for *EPL*, and significant for the full sample. The negative coefficients of the interaction variables $D{\cdot}\Delta\log REV{\cdot}LCNEMPL$ and $D{\cdot}\Delta\log REV{\cdot}EPL$ are also negative in all cases, as expected and in line with previous studies (higher stickiness for highest salaries and for more protective labor legislations), but significant only for the full sample. The important point for the purpose of our study is that e-commerce does not significantly affect the stickiness of labor costs, neither controlling for these factors nor moderating or stressing the sticky influence of these factors. Again, our results fail to provide support for H2 when the dependent variable is *LC*.

As mentioned, the descriptive statistics in Table 2 reveal that traditional retail firms bear lower labor costs per employee. These employees are exposed to higher risk of being dismissed, because the costs associated with firing are lower. Consequently, the labor cost stickiness of traditional firms should be higher. The similar pattern exhibited by e-commerce and traditional firms in our results may be indirect evidence of a different relationship influenced by e-commerce, but hindered by these biased characteristics in our sample. To rule out this possibility, we split the sample into labor costs per employee above and below the median and, once again, the

[1] See https://www.oecd.org/employment/emp/oecdindicatorsofemploymentprotection.htm for data and http://www.oecd.org/employment/emp/38940931.pdf for details on the methodology and aggregated scores.

Table 8 Fixed-effects estimations for LC including controls for *EPL* and *LCNEMPL* in Eq. 1. Year and country-year fixed effects

Variables	(1) Full sample	(2) Propensity score-matched sample	(3) Full sample	(4) Propensity score-matched sample
Δlog*REV*	0.633***	0.538***	0.633***	0.536***
	(0.0115)	(0.0470)	(0.0115)	(0.0470)
D·Δlog*REV*	0.0707	0.658	0.0687	0.659
	(0.0831)	(0.499)	(0.0831)	(0.502)
D·Δlog*REV*·*ECOM*	−0.372	−0.485	−0.371	−0.503
	(0.246)	(0.544)	(0.246)	(0.546)
D·Δlog*REV*·*EPL*	−0.121***	−0.219	−0.120***	−0.217
	(0.0294)	(0.165)	(0.0294)	(0.165)
D·Δlog*REV*·*EPL*·*ECOM*	0.148	0.219	0.149	0.223
	(0.123)	(0.198)	(0.123)	(0.198)
D·Δlog*REV*·*LCNEMPL*	−0.00269**	−0.00750	−0.00267**	−0.00773
	(0.00126)	(0.00679)	(0.00126)	(0.00686)
D·Δlog*REV*·*LCNEMPL*·*ECOM*	0.00108	0.00311	0.00102	0.00327
	(0.00397)	(0.00786)	(0.00396)	(0.00792)
D·Δlog*REV*·*EMPLINT*	11.06***	−40.86	11.10***	−40.85
	(2.972)	(27.41)	(2.976)	(27.51)
D·Δlog*REV*·*ASSINT*	−0.0165	−0.0196	−0.0165	−0.0179
	(0.0109)	(0.0520)	(0.0109)	(0.0518)
D·Δlog*REV*·*ROA*	0.244**	0.0766	0.242**	0.0711
	(0.102)	(0.303)	(0.102)	(0.307)
D·Δlog*REV*·*DEBTTA*	0.0636	0.0517	0.0615	0.0589
	(0.0389)	(0.140)	(0.0389)	(0.140)
D·Δlog*REV*·*DSUC*	0.121***	0.0754	0.121***	0.0672
	(0.0363)	(0.156)	(0.0363)	(0.155)
D·Δlog*REV*·*LOSPRY*	0.0229	0.0841	0.0226	0.0945
	(0.0348)	(0.147)	(0.0348)	(0.148)
EPL	−0.00835***	−0.00359	−0.00705***	−0.00323
	(0.00218)	(0.0119)	(0.00221)	(0.0120)
LCNEMPL	0.000948***	0.00145***	0.000949***	0.00143***
	(8.54e-05)	(0.000312)	(8.52e-05)	(0.000310)
EMPLINT	1.102***	2.419***	1.095***	2.348***
	(0.322)	(0.765)	(0.321)	(0.773)
ASSINT	−0.00123	−0.00240	−0.00128	−0.00231
	(0.00118)	(0.00294)	(0.00118)	(0.00294)
ROA	−0.0418***	−0.0505***	−0.0426***	−0.0500***
	(0.00502)	(0.0186)	(0.00503)	(0.0188)
DEBTTA	−0.0139***	−0.0229**	−0.0140***	−0.0227**
	(0.00277)	(0.00975)	(0.00277)	(0.00979)
DSUC	−0.000799	−0.00723	−0.000747	−0.00725

Table 8 (continued)

Variables	(1) Full sample	(2) Propensity score-matched sample	(3) Full sample	(4) Propensity score-matched sample
	(0.000970)	(0.00636)	(0.000970)	(0.00636)
LOSPRY	−0.00370***	−0.00177	−0.00381***	−0.00195
	(0.000777)	(0.00399)	(0.000776)	(0.00400)
Constant	0.0115*	−0.00587	0.00866	−0.00551
	(0.00675)	(0.0306)	(0.00679)	(0.0306)
Observations	60,926	5474	60,926	5474
Number of firms	11,730	2747	11,730	2747
YEAR	Yes	Yes		
Country-Year fixed effects			Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
R-sq overall	0.2192***	0.1287***	0.2229***	0.1303***

Robust standard errors in parentheses

***$p<0.01$, **$p<0.05$, *$p<0.1$

results (not tabulated for the purposes of simplicity) provide no significant signs for the coefficients of our experimental variable, reinforcing the previous results indicating no influence of e-commerce in the asymmetric behavior of labor costs.

6 Discussion and conclusions

This study analyzes the relationship between e-commerce and asymmetric cost behavior, using an international sample of European retail firms. We find no specific influence of e-commerce on CGS, as hypothesized in H1, given that they are automatically recorded in the profit and loss statement, independently of the type of business. They display slightly anti-sticky behavior, probably caused by a different product mix or lower acquisition costs in periods of decreasing sales. However, we find no differences in the asymmetric cost behavior between e-commerce and traditional retail firms.

Our results show empirical evidence of more flexible OTHOP behavior in e-commerce firms than in traditional retail firms. The former apply greater cuts in OTHOP than traditional firms do when activity decreases. Along the same lines, e-commerce firms seem to be more capable of adjusting resources in unfavorable conditions, which is probably part of a wider ability to adapt to new circumstances. E-commerce is a recent form of business that, in its inception, is knowledge based. The internet environment in which e-commerce is conducted is fully involved in recording and generating information. It is agile in producing information on business development and requiring urgent feedback and responses. It is also technology based. The obsolescence risks involved in terms of technology requirements and business

setting are more demanding in e-commerce than in traditional business. Altogether, this generates a more dynamic pace to adapt to new circumstances, which, in turn, accelerates the speed of pragmatic resource adjustment. Our empirical evidence suggests more flexible use of other operational resources in e-commerce than in traditional firms. E-commerce is not only a different business model, but also a more flexible way of doing business, that adds greater economic efficiency.

We find no empirical evidence of differences in the asymmetric behavior of LC. Contrary to expectations, e-commerce firms do not exhibit higher cuts in labor costs when activity decreases than traditional retail firms.

These results are robust to different estimation methods and additional analyses. They persistently show that e-commerce is a more flexible and efficient model of doing business that creates higher quality and better paid employment, which are well-known advantages of e-commerce. However, e-commerce does not affect employment stability. There is no difference in the flexibility of LC adjustment when activity decreases. There is no disadvantage of e-commerce on the side of employment precariousness. Our results do not provide evidence that e-commerce produces more negative effects for workers and employees than traditional business. The higher flexibility of e-commerce firms is based on the pool of other operating costs, which account for a substantially higher share of total operating costs in e-commerce firms in comparison to traditional retail firms. In this respect, e-commerce provides overall positive synergies to the economy and society. It creates qualified jobs with higher wages than traditional retail, and with no additional exposure to uncertainty for employees.

Previous research has distinguished advantages of brick and mortar with respect to e-commerce in many fundamental business aspects, which we have not analyzed in this study. Some authors find that e-commerce heightens the trend of precarious work, placing stress on labor control and triggering the loss of labor rights [9, 70–72] (see Panel B in the Appendix 1). Other studies find higher tax avoidance behavior of e-commerce than traditional retail firms [7, 73]. The environmental implications of e-commerce and traditional retail is controversial and the optimal balance of advantages and drawbacks of both retail channels depends on some contextual factors and cost conditions [74–76]. Moreover, Zhang et al. [77] report the following advantages of traditional retail for consumers: quality guarantee of goods, real shopping experiences such as the fitting service, exchange and return services, buy and get instantly, and problem avoidance during delivery. Therefore, despite the more flexible behavior of some operating costs in e-commerce firms, the brick-and-mortar stores have their own advantages and cannot be completely displaced. The traditional retail is viable and advantageous under certain conditions, and dual channel is a plausible and optimal alternative in many cases.

The technological characteristics of e-commerce and the fact that it does not depend on physical presence generate a favorable opportunity for the use of non-standard forms of employment, and for applying more LC cuts and discretionary

dismissals. However, our empirical evidence suggests that e-commerce does not apply these adverse labor practices for employees. Other possible detrimental effects of e-commerce, such as for example for consumers and the environment have not been analyzed in this study, and they may deserve future analyses.

Our results have implications for scholars studying cost behavior and resource management of electronic commerce, as to the authors' knowledge it is the first to analyze the comparative resource adjustment behavior of electronic commerce versus traditional businesses. It is also of interest for practitioners, to whom it offers an assessment, grounded in empirical evidence from a big and wide sample, on the potential advantages of converting their business form traditional to e-commerce. It is also of interest for employees assessing the potential drawbacks and advantages of working in the digital versus traditional economy.

We have analyzed costs as they are registered by e-commerce firms in their accounting records, but there might be more non-standard employment recorded as non-labor costs in e-commerce than in traditional firms, which may bias our results. The topic requires future in-depth analysis of labor cost behavior and the different constituents of other operating costs in e-commerce businesses. Moreover, there is no available information on the percentage of sales performed via internet in retail firms. Most traditional retail firms also sell via the internet, but we assess the flexibility of e-commerce through a rough distinction between firms selling exclusively via the internet and other firms, which usually sell both, via internet and brick-and-mortar stores. This is an additional limitation of our research. It would be useful to perform further research using the more refined measure of the percentage of retail sales via the internet, a data that to our knowledge it is not available at firm level for a sample big enough to perform the analysis.

Appendix 1

See Table 9.

Table 9 Details of studies reviewed on economic issues and effects of e-commerce, and on research on cost behavior

Author	Year	Reference	Finding	Method	Data/Evidences
Panel A. Economic, organization and cost issues of e-commerce					
Nurmilaakso	2009	3	Information and communication technology increases labor productivity in e-commerce	Empirical	Archival
Falk & Hagsten	2015	4	E-commerce raises firms' productivity	Empirical	Archival
Soto-Acosta et al.	2015	5	E-business use contributes positively to firm performance and organizational innovation	Empirical	Archival
Relich	2017	6	Information and communication technology, such as e-commerce improves labor productivity	Empirical	Archival
Argilés et al.	2021	7	E-commerce is associated with tax avoidance	Empirical	Archival
Kauffman & Walden	2001	14	Literature review of e-commerce from the perspective of economic analysis	Literature review	
Mkanski	2021	16	Identifies adoption costs and strategies for retail micro businesses	Multi-case qualitative	Interviews
Koo et al.	2004	17	Compares competitive strategies of firms operating solely on-line and firms operating in the traditional and on-line	Empirical	Questionnaire
Stylianou et al.	2005	18	Prices, but not costs, are lower in e-commerce than in traditional retailers, whereas cost and price dispersion are greater	Empirical	Data collection of prices over the counter and assumptions about costs
OECD	2015	52	Greater revenue per employee in internet than in traditional businesses	Descriptive	Report

Table 9 (continued)

Author	Year	Reference	Finding	Method	Data/Evidences
Frecknall & Glaister	2001	54	E-commerce increases monitoring problems by tax authorities	Analytical	Theoretical
Li	2003	55	E-commerce increases monitoring problems by tax authorities	Analytical	Theoretical
Saini & Johnson	2005	56	Strategic flexibility enhances e-commerce performance	Empirical	Interviews
Lee	2001	57	The authors analyze critical success factors of e-commerce	Analytical	Theoretical
Zeng	2001	58	There are abundant choices and flexibility with interorganizational e-commerce	Mathematical Analytical	Simulations
Bienkowska & Sikorski	2016	59	Organizations on e-commerce business must be hyper-flexible	Analytical	Theoretical
Steinfield et al.	2002	61	Click-and-mortar enterprises provide greater delivery, marketing and LC efficiencies with respect to brick-and-mortar	Case studies	Interviews
Panel B. Effects of e-commerce on employees					
Rodgers	2016	8	The knowledge economy promotes flexible workers strategies that makes work precarious	Analytical	Theoretical
Staab & Nachtwey	2016	9	E-commerce creates a new model of labor control and a dual workforce	Analytical	Theoretical
Konkolewsky	2017	10	Traditional jobs are being replaced by non-standard employment in the digital economies and e-commerce	Analytical	Theoretical

Table 9 (continued)

Author	Year	Reference	Finding	Method	Data/Evidences
International Labor Organization	2016	53	It reports an increasing use of non-standard employment, mainly in e-commerce	Descriptive	Report
Van den Broek	2010	70	The digital economy does not entail more autonomous working conditions, but an intensification of workers commodity status	Analytical	Theoretical
Friedman	2014	71	Gig employments can create a class of isolated individuals	Analytical	Theoretical
Greenwood et al.	2017	72	The gig economy can have important drawbacks for employees	Analytical	Theoretical
Argilés et al.	2020	73	Labor tax avoidance is higher in e-commerce than in traditional retail firms	Empirical	Archival
Panel C. Effects of e-commerce on consumers and the environment					
Otto & Chung	2000	11	The authors compare advantages and disadvantages of both e-commerce and traditional retailing	Analytical	Theoretical
Brynjolfsson et al.	2020	12	The increased product variety of online bookstores enhances consumer welfare	Mathematical Analytical	Simulations
He et al.	2020	13	He calculates the price premium that online retailers might obtain by increasing online ratings of their products	Empirical	Experiment
Tokar et al.	2021	74	There are unseen environmental benefits of e-commerce that should be balanced with its seen costs	Analytical	Theoretical

Table 9 (continued)

Author	Year	Reference	Finding	Method	Data/Evidences
Zhao et al.	2017	75	The environmental implications of e-commerce depend on certain cost conditions	Mathematical Analytical	Simulations
Carrillo et al.	2014	76	The authors analyze environmental implications of retail, online and dual channels	Mathematical Analytical	Simulations
Zhang et al.	2016	77	The authors report advantages and disadvantages of e-commerce and traditional retail	Descriptive	Report
Panel D. Cost stickiness					
Anderson et al.	2003	19	Seminal study on cost stickiness: SG&A of firms from different industries are sticky	Empirical	Archival
Baumgarten et al.	2010	20	SG&A stickiness signals future operating efficiency	Empirical	Archival
Chen et al.	2012	21	SG&A stickiness is more pronounced under weak corporate governance. We follow this model formulation	Empirical	Archival
Kim et al.	2019	22	SG&A are stickier for firms with internal control weakness	Empirical	Archival
Ballas et al.	2020	23	SG&A are stickier in firms classified as prospectors than in defenders	Empirical	Archival
Kama & Weiss	2013	24	TOP stickiness depends on deliberate decisions of managers, more precisely on managerial incentives	Empirical	Archival
Li & Zheng	2013	25	TOP stickiness depends on firms' financial constraints	Empirical	Archival

Table 9 (continued)

Author	Year	Reference	Finding	Method	Data/Evidences
Dierynck et al.	2012	26	LC stickiness depends on managerial incentives. We follow this model formulation	Empirical	Archival
Dalla & Perego	2013	27	Comparison of LC and OTHOP stickiness between big and small and medium sized firms	Empirical	Archival
Hall	2016	28	Listed banks have more elastic LC structures than non-listed banks. We follow this model formulation	Empirical	Archival
Prawobo et al.	2018	29	State-owned enterprises exhibit greater LC stickiness. We follow this model formulation	Empirical	Archival
Costa & Habib	2020	30	Analysis of cost stickiness in various industries. We follow this model formulation	Empirical	Archival
Calleja et al.	2006	31	International comparisons of cost stickiness	Empirical	Archival
Cannon	2014	32	Cost stickiness in the air transportation industry	Empirical	Archival
Novák & Popesko	2014	33	Cost stickiness in manufacturing enterprises	Empirical	Archival
Noreen & Soderstrom	1997	34	Cost stickiness in hospitals	Empirical	Archival
Balakrisnan et al.	2004	35	The influence of capacity on cost stickiness in therapy clinics	Empirical	Archival
Nagasawa	2018	36	Cost stickiness in local public enterprises	Empirical	Archival

Table 9 (continued)

Author	Year	Reference	Finding	Method	Data/Evidences
Anderson et al.	2007	37	Debate about cost stickiness caused by resource flexibility versus deliberate decisions of managers	Empirical	Archival
Yasukata & Kajiwara	2011	38	Deliberate decisions of managers influence cost stickiness	Empirical	Archival
Holzhacker et al.	2015	60	Cost stickiness in hospitals and price regulation. We follow this model formulation	Empirical	Archival
Banker et al.	2013	68	Employment protection legislation influences LC stickiness	Empirical	Archival
Golden et al.	2020	69	Skilled labor is associated with greater OP stickiness	Empirical	Archival
Panel E. Fixity of costs					
Various authors, sources and dates		39–51	Discussions about fixed and variable costs, and their proportionality. Between the most important conclusions is that variable costs are not expected to behave sticky	Most of them analytical methods evidenced with theoretical discussions	

Appendix 2

See Table 10.

Table 10 Definition of variables

Variable	Definition
Dependent variables	
$\Delta\log OP$	Generic variable for log-change in different types of operating costs
$\Delta\log TOP$	Log-change in total operating costs: logarithm of total operating costs in current year divided by total operating costs in previous year
$\Delta\log CGS$	Log-change in costs of goods sold: logarithm of costs of goods sold in current year divided by costs of goods sold in previous year
$\Delta\log LC$	Log-change in labor costs: logarithm of labor costs in current year divided by labor costs in previous year
$\Delta\log OTHOP$	Log-change in other operating costs (the difference between total operating costs minus costs of goods sold and labor costs): logarithm of other operating costs in current year divided by other operating costs in previous year
Independent variables	
$\Delta\log REV$	log-change in revenues: logarithm of revenues in current year divided by revenues in previous year
D	Dummy variable equaling 1 if revenues in current year are lower than revenues in previous year, and 0 otherwise
ECOM	Dummy variable equaling 1 if a firm is classified as performing exclusively as retail trade via internet (NACE code 4791), and 0 otherwise (the remaining NACE codes 47)
CONTROLS	Control variables
EPL	Aggregated OECD employment protection legislation score
LCNEMPL	Labor costs divided by number of employees
EMPLINT	Employee intensity: number of employees divided by revenues
ASSINT	Asset intensity: total assets divided by revenues
ROA	Return on assets: operating profits divided by total assets
DEBTTA	Indebtedness: short- and long-term debt divided by total assets
DSUC	Dummy variable equaling 1 for observations with two consecutive years with revenues decreases, and 0 otherwise
LOSPRY	Dummy variable equaling 1 for firms with loss in previous year, and 0 otherwise
FIRM	Dummy variables equaling 1 for observations of a given firm, and 0 otherwise
YEAR	Dummy variables equaling 1 for observations of a given year, and 0 otherwise
COUNTRY	Dummy variables equaling 1 for observations of a given country, and 0 otherwise

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