Total factor productivity and tax avoidance: An asymmetric micro-data analysis for European oil and gas companies

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ABSTRACT

This paper investigates the asymmetric relationship between corporate tax avoidance and total factor productivity (TFP) using firm-level data for 141 European oil and gas companies, covering the period 2007 to 2015. Firstly, we rely on the novel mechanism advanced by Rovigatti and Mollisi (2018) to compute firms' TFP. Secondly, we resort to Canay's (2011) panel data fixed-effect quantile approach to assess the nonlinear, asymmetric effect that tax avoidance has on a firm's productivity. As novelty, we use two proxy variables to estimate tax avoidance, namely companies' holding structures and tax haven location. We discover that the impact of tax avoidance on TFP is not straightforward. On the one hand, we report mixed empirical findings regarding the impact of firms' organization in holding structures on TFP. On the other hand, tax haven location enhances the productivity of oil and gas companies from the extractive industry. Finally, we show that the impact of tax avoidance on TFP is stronger at higher quantiles, that is, for higher levels of productivity. Our findings show that offshore profit transfers represent a quite common practice for European oil and gas firms, in particular for the large companies, which helps them to increase their productivity level. In our analysis we control for the role of ownership structure, firm size, intangibles, indebtedness and energy price dynamics. To check the robustness we use different approaches to compute the TFP.

Keywords: TFP, tax avoidance, oil and gas companies, tax haven, quantile regression

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1. INTRODUCTION

The accelerated growth in energy productivity recorded globally between 1990 and 2010, which was mainly driven by technological progress, started to fade during the last decade (Du and Lin, 2017). This changed the behaviour of energy companies, in particular the multinational ones, in their pursuit of after-tax profits. Although tax avoidance is a common practice of multinational companies (Hines and Rice, 1994), its implications for productivity are unclear (Gkikopoulos et al., 2022). Against this background, the main purpose of this paper is to investigate the impact of tax avoidance behaviour of European energy companies on their total factor productivity (TFP).

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To this end, as the first step, we compute the TFP for a set of 141 European oil and gas companies, covering the period 2007 to 2015. In the second step, we investigate the asymmetric effect of tax avoidance on TFP, within a panel quantile framework. Indeed, the existing literature fails to show how the impact of tax avoidance on firm productivity is influenced by their productivity level. If for example, tax avoidance represents a significant driver of productivity, we expect a stronger impact for highly productive firms. But if tax avoidance constitutes an instrument used to mitigate the lack of firm productivity, we expect a stronger effect for less productive firms.

From a theoretical point of view the impact of tax avoidance on firm productivity is not straightforward. On the one hand, corporate tax avoidance –an act aiming at reducing tax liabilities to the government– is expected to raise firm value (Edwards et al., 2016). This is because tax avoidance allows firms to access more capital in the context of decreasing external financing costs, and consequently, firms finance productive investments. This mechanism is explained by both the positive cash flow effect (Goh et al., 2016) and the low tax commitment effect (Jacob and Schütt, 2020). On the other hand, tax avoidance might negatively impact productivity, by reducing the marginal cost of investment. That is, in the presence of tax avoidance, firms might invest beyond their optimal scale (Hvide and Møen, 2010). In addition, tax avoidance amplifies the principal-agent bias given that managers might be determined to invest the tax savings in their own interest (Desai and Dharmapala, 2009). Further, tax avoidance might also generate a form of uncertainty regarding the tax planning strategy, with negative implications for firm performance (Hanlon, et al., 2017). These opposite points of view are, in various ways, explained by a set of papers that documents mixed findings regarding the impact of tax avoidance on firm productivity (Khuong et al., 2020). Given the two opposite views, the relationship between tax avoidance and productivity becomes an empirical question. Nevertheless, none of the previous papers investigated the asymmetric effect that tax avoidance might have on firm productivity.

Consequently, our first contribution to the existing literature is represented by the investigation of the relation between productivity and tax avoidance within a panel framework, using firm-level data and a fixed-effect quantile approach. We resort to Canay's (2011) approach, which considers firm-specific and time-varying heterogeneity and allows parameter identification even in the presence of a fixed panel dimension. In line with Gkikopoulos et al. (2022), we use a lag model to mitigate the reverse causality bias.[1]

Second, we contribute to the existing literature by addressing in a different way the tax avoidance phenomenon. Most previous papers (e.g. Cheng et al., 2012; Khuong et al., 2020; Wu et al., 2012) resort to the current effective tax rate or cash effective tax rate as a proxy for tax avoidance. These measures are based on the view of Dyreng et al. (2008), according to which tax avoidance is explained by the firm's tax burden. However, these accounting-based tax avoidance measures are heavily criticized (Frank et al., 2009). Therefore, we propose a different approach to estimate the tax avoidance phenomenon, starting from the main international tax avoidance channels identified by Beer et al. (2018), namely transfer mispricing, international debt shifting, tax deferral and locating asset sales in low-tax jurisdictions. To this end, we analyse the ownership configuration of energy companies in order to see if they have a holding structure or not.[2] Holding firms can avoid taxes by tax deferral or debt shifting. On the one

1. Indeed, the productivity level might also influence the firm's tax avoidance behaviour. For example, using firm-level data, Dabla-Norris et al. (2019) show that higher productivity causally leads to lower tax avoidance.

2. A significant portion of energy firms located in Europe are organized as holding companies, or have in their ownership struc-

hand, compared to the dividends paid to individuals, dividends paid to the holding company do not create a tax liability. Thus, taxpayers can defer personal taxes on capital income by holding assets through separate legal entities (Alstadsæter et al., 2022). On the other hand, holding companies are able to offset losses of one subsidiary against the profits of another subsidiary. If subsidiaries are entirely held by a holding company, they may not be forced to pay profit taxes. At the same time, it is worth mentioning that such complex structures means high operating costs, which might negatively impact a firm's productivity.

Further, we posit that energy companies might avoid taxes if they are located in tax havens. As Cobham et al. (2017) shows, tax havens annually cost governments about $600 billion in lost corporate tax revenue. "As a general rule, the wealthier the individual and the larger the multinational corporation—some have hundreds of subsidiaries offshore—the more deeply they are embedded in the offshore system and the more vigorously they defend it" (Shaxson, 2019). As Tørsløv et al. (2020) show, around 40% of multinational profits are shifted to tax havens worldwide. Thus we posit that the legal residence of an energy company (or its affiliates or parent company) in a tax haven allows this company to avoid taxes. To summarize, we use two instruments as a proxy for tax avoidance, namely a holding organisation structure and the location of the firm in an international tax haven.[3]

Third, we use a novel method proposed by Rovigatti and Mollisi (2018) to compute firms' TFP. Rovigatti and Mollisi (2018) builds upon the single-step Generalized Method of Moments (GMM) approach by Wooldridge (2009), considering a matrix of dynamic panel instruments. Doing so, the authors increase the moment restrictions without losing information. Therefore, this approach is well designed to compute the TFP in the case of large N and small T panel data such as ours. We also use Levinsohn and Petrin (2003), Wooldridge's (2009) and Ackerberg et al. (2015) approaches for robustness purpose.

Fourth, we compute the TFP for a set of energy firms active in the extraction of crude petroleum and natural gas (NACE code 06), using firm-level data. The computation of the TFP using firm level data has several benefits. It circumvents the bias caused by productivity aggregation at the industry or national level (Van Beveren, 2012). At the same time, it allows variation in productivity across firms with similar characteristics (Syverson, 2011). As far as we know, this is the first paper which computes the TFP using firm-level data for a set of European oil and gas companies.

Investigating the asymmetric impact of tax avoidance on TFP we explain the mixed findings reported by Khuong et al. (2020) and we respond to the call of Hanlon and Heitzman (2009) for further research regarding the implications of tax avoidance on firms' performances. Our study also provide new insights for the ongoing debate on productivity slowdown in Europe (Aussilloux et al., 2021) and the United States (Duval et al., 2020).[4]

The rest of the paper is as follows. Section 2 present a short literature review on the impact of tax avoidance on TFP. Section 3 describes the empirical methodology and we present the data and summary statistics in Section 4. The next sections present the empirical results and

ture some holding companies. Several examples of complex organizational structures are presented in Appendix A.

3. In line with Shaxson (2019), we consider the main tax havens to be the British overseas territories (British Virgin Islands, Bermuda, Cayman Islands), Cyprus, Ireland, Netherlands Antilles, Switzerland, and the United States.

4. Figure B1 (Appendix B) shows that the TFP decreases in average for the European oil and gas companies active in the extractive industry, starting with 2012. Therefore, the high TFP persistence recorded at macro-level (Pancrazi and Vukotić, 2011) does not represent an issue in the case of European extractive industry.

the robustness checks while the last section concludes and underlines the policy implications of our findings.

2. LITERATURE REVIEW

The micro-level literature usually investigates three categories of TFP drivers. The first category is represented by corporate governance characteristics, such as the board size and board gender diversity (e.g. Schoar, 2002), as well as the board independence (e.g. Jiraporn et al., 2018). The second category includes the managerial strategy and managerial performance. Within this category, the human and organisational capital (Fox and Smeets, 2011; Van Ark, 2004), R&D activities (Doraszelski and Jaumandreu, 2013; Kancs and Siliverstovs, 2016; Minniti and Venturini, 2017), firm size (Yu et al., 2017), financial frictions (Gilchrist et al., 2013) and financial constraints (Chen and Guariglia, 2013; Ferrando and Ruggieri, 2018), have been advanced as the main drivers of productivity. The third category investigates the driving factors of green TFP, with a focus on the role of climate policy and environmental regulations (He et al., 2022; Tian and Feng, 2022), renewable energy (Yan et al., 2020), energy efficiency (Santos et al., 2021) and green finance (Lee and Lee, 2022). Our analysis is related to the second strand of the literature, with a particular focus on financial frictions, and more precisely, on the role of tax avoidance.

The recent literature has devoted special attention to the role of corporate tax planning in explaining the dynamics of productivity. Tax policy (Arnold et al., 2011), as well as tax avoidance (Edwards et al., 2016), impact firms' performance. For example, in the case of liquidity constrained firms, tax avoidance help them to benefit from economies of scale and higher productivity levels (Hvide and Møen, 2010). At the same time, tax avoidance allows firms to raise more capital to finance productive investments (Gkikopoulos et al., 2022). However, tax avoidance can also amplify the principal-agent bias if managers act in their own interest (Desai and Dharmapala, 2009), and might increase the uncertainty regarding tax planning strategies, with negative implications on firms' productivity (Hanlon, et al., 2017). Therefore, the relation between tax avoidance and firms' productivity is not straightforward. Indeed, the empirical investigations of the effects of tax avoidance on firms' investment provide conflicting findings (e.g. Blaylock, 2016; Khurana et al., 2018), whereas other studies (e.g., Khuong et al., 2020) show mixed evidence regarding the effect of tax avoidance on TFP.

Several arguments are advanced in the literature showing that tax avoidance favours a productivity increase. In line with the financial frictions theory, financial markets' volatility negatively affects the allocation of resources (Gilchrist et al., 2013; Midrigan and Xu, 2014), forcing firms to rely on internal sources to sustain their investments. As Edwards et al. (2016) argue, tax avoidance allows cash tax savings and sustains firms' productive investments. At the same time, tax avoidance means lower financing costs, with a positive impact on firm valuation (Goh et al., 2016). This mechanism is known as the positive cash flow effect of tax avoidance. A concurrent mechanism, namely the low tax commitment effect (Jacob and Schütt, 2020), shows that in the presence of tax avoidance, firm valuation increases. In this context, firms can raise more easily the capital from external markets, to finance productive investments. Further, productive investments increase the knowledge pool of firms, with positive and persistent effects on productivity (Doraszelski and Jaumandreu, 2013). Moreover, in the presence of tax avoidance, there is no limitation for risk-taking and innovative investment returns (Hall and Lerner, 2010).

Although the list of arguments according to which tax avoidance has positive effects on firms productivity is open, the literature also advances a series of counter arguments in this line. One argument against the positive effects of tax avoidance is represented by the uncertainty effect. Indeed, tax avoiding firms operates in less transparent environments, which increase the information asymmetries among managers and shareholders (Balakrishnan et al., 2019; Desai and Dharmapala, 2009). This uncertainty manifests itself in relation with both the agency problem of free cash flows (Desai et al., 2007) and future tax payments (Hanlon et al., 2017). Another argument is related to the increase in investments over the optimal scale. Actually, if the liquidity constraints diminish as a result of tax savings, this effects might push firms to overinvest, whereas the marginal productivity declines (Hvide and Møen, 2010). A different argument is put forward by the "passive learning" theory of Jovanovic (1982), according to which firms endogenously determine their productivity. Consequently, Olley and Pakes (1996) shows that firms choose their productivity levels considering the previous levels of productivity, as well as their survival probability.

These opposite views, as well as the way tax avoidance is calculated, impacts the empirical results and explains the mixed findings reported in the literature on the relation between tax avoidance and firms' productivity. For this reason, we, unlike the existing literature, test these two competing hypotheses within a panel quantile framework, arguing that the relation between tax avoidance and firms' TFP is influenced by the level of productivity. In addition, we use different approaches to proxy the tax avoidance phenomenon, relying on the identification of a holding structure and the tax haven location of firms (or of their shareholders and affiliates).

3. METHODOLOGY

3.1. TFP computation

The previous literature either uses direct measures to compute the TFP (e.g. Kendrick's and Divisia's models), or indirect approaches, relying on the Solow residual model. In line with most recent papers on this topic, we use the second approach, and the recent computation model proposed by Rovigatti and Mollisi (2018).

The computation of the TFP starts from a Cobb-Douglas function ($Y = AK^{\alpha}L^{\beta}$), which, by log-linearization, in a panel framework becomes:

$$VA_{it} = c + \alpha K_{it} + \beta L_{it} + \varepsilon_{it}, \tag{1}$$

where is the firm value added (in natural log); is the stock of capital (in natural log); is the number of employees (in natural log); i are the firms; t is the time; c is a constant that measures the average productivity of firms throughout the entire time span.

To consider different productivity shocks across firms, the error term ε_{it} can be decomposed as follows (Olley and Pakes, 1996):

$$\varepsilon_{it} = \omega_{it} + \delta_{it}, \tag{2}$$

with ω_{it} representing the productivity of firm i at time t, whereas δ_{it} are unobserved productivity shocks, not correlated with the inputs.

Given that the productivity ω_{it} is known to the firm, and the managements may decide to increase inputs in the case of a positive productivity shock, a simultaneity problem may occur. Further, a selection bias might appear because less productive firms exit the markets. To address this bias, Levinsohn and Petrin (2003) introduce the demand for intermediate goods. More specifically, they include the intermediate goods m_{it}, assuming they depend on K_{it}. The productivity function is at this point invertible:

$$\omega_{it}: m_{it} = f(\omega_{it} + K_{it}), \tag{3}$$

Thus, $\omega_{it} = h(m_{it} + K_{it})$, and Equation (1) becomes:

$$VA_{it} = c + \alpha K_{it} + \beta L_{it} + h(m_{it} + K_{it}) + \delta_{it},\ t = 1 \ldots T. \tag{4}$$

However, the choice of Levinsohn and Petrin (2003) to restrict the dynamics in the productivity process, namely $E(\omega_{it}|\omega_{it-1},\ldots, \omega_{i1}) = E(\omega_{it}|\omega_{it-1})$ and $a_{it} = \omega_{it} - E(\omega_{it}|\omega_{it-1})$, which shows that K_{it} is uncorrelated with the innovation a_{it}, is not sufficient. Indeed, δ_{it} is no longer a combination of pure errors, given that intermediate inputs are correlated with the error term (Rovigatti and Mollisi, 2018). This makes necessary the use of a GMM procedure.

Wooldridge (2009) proposes a one-step GMM procedure with consistent standard errors. A series of instruments corresponding to different equations are specified, while $\omega_{it} = f[h(m_{it-1} + K_{it-1})] + a_{it}$. Plugging into Equation (4), we obtain:

$$VA_{it} = c + \alpha K_{it} + \beta L_{it} + f[h(m_{it-1} + K_{it-1})] + a_{it} + \delta_{it}. \tag{5}$$

At this point, two equations allow the identification of α and β, namely Equation (4) and

$$VA_{it} = c + \alpha K_{it} + \beta L_{it} + f[h(m_{it-1} + K_{it-1})] + u_{it}, \tag{6}$$

where $u_{it} \equiv a_{it} + \delta_{it}$ and $t = 2 \ldots T$.

Equations (4) and (6) allow therefore the estimation of the TFP using contemporaneous state variables K_{it} and lagged inputs as instrumental variables.

Further, Ackerberg et al. (2015) show that the labour coefficient can be estimated with accuracy only if the variability of the free variables is independent of the variability of the proxy variables. More recently, Rovigatti and Mollisi (2018) make a simple innovation and modify Wooldridge's estimator, considering a matrix of dynamic panel instruments.

3.2. Panel quantiles regression

We estimate the following general equation:

$$Y_{it} = \alpha + \beta_{it} X_{it} + \gamma_{it} Z_{it} + \varepsilon_{it}, \tag{7}$$

where Y_{it} is the total factor productivity, α is the intercept, X_{it} represent the tax avoidance, Z_{it} is the vector of control variables, and ε_{it} is the error term.

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Starting from the general Equation (7), we use Canay's (2011) panel quantile regression with fixed effects, described as follows:

$$Y_{it} = X_{it}'\theta(U_{it}) + \alpha_i, \tag{8}$$

where $t = 1,\ldots, T$; $i = 1,\ldots, n$; Y_{it} and X_{it} are the observable variables whereas U_{it} is unobservable; X_{it}' contains a constant term whereas $\theta(\tau)$ represents the parameter of interest.

Now, assuming the function $\tau \rightarrow X'\theta(\tau)$ increases in $\tau \in (0,1)$, in the presence of an observable α_i, it follows that

$$P[Y_{it} \leq X_{it}'\theta(U_{it}) + \alpha_i | X_i, \alpha_i] = \tau, \tag{9}$$

Assuming that $U_{it} \sim U[0,1]$, conditional on $X_i = (X_{i1}',\ldots,X_{iT}')'$ and α_i.

We now need to correctly identify the parameter of interest $\theta(\tau)$. If $Q_Y(\tau|X)$ is the τ-quantile of Y conditional on X, and $e_{it}(\tau) \equiv X_{it}'[\theta(U_{it}) - \theta(\tau)]$, the previous equation can be written as follows:

$$Y_{it} = X_{it}'\theta(U_{it}) + \alpha_i + e_{it}(\tau), \tag{10}$$

Canay (2011) considers α_i to be a location shift, and shows that $\theta(\tau)$ is identified for $T \geq 2$. Therefore, only $\theta(\tau)$ and $e_{it}(\tau)$ are dependent on τ. In this case, Equation (8) becomes

$$Y_{it} = X_{it}'\theta\mu + \alpha_i + u_{it}, \text{ with } E(u_{it}|\, X_i, \alpha_i) = 0. \tag{11}$$

This transformation represents the key ingredient of Canay's (2011) approach and allows the computation of the two-step estimator $\hat{\theta}\mu$. In the first step, we obtain a consistent estimator of $\alpha_i(\sqrt{T})$ and $\theta\mu(\sqrt{nT})$, with $\hat{\alpha}_i \equiv E_T[Y_{it} - X_{it}'\hat{\theta}\mu]$. In the second step we introduce $\hat{Y}_i \equiv Y_{it} - \hat{\alpha}_i$ while $\hat{\theta}\mu$ becomes

$$\hat{\theta}\mu \equiv \underset{\theta \in \Theta}{argmin}\, \mathbb{E}_{nT}[\rho_\tau(\hat{Y}_{it} - X_{it}'\hat{\theta}\mu], \tag{12}$$

where $\mathbb{E}_{nT}(\cdot) \equiv (nT)^{-1}\sum_{t=1}^{T}\sum_{i=1}^{n}(\cdot)$.

4. DATA

4.1. Sample selection

Our focus is on the European companies active in the extraction of crude petroleum and natural gas. We use annual data for the period 2006 to 2015, extracted from the AMADEUS database (Bureau van Dijk – BvB).[5] Within this industry (NACE code 06), 884 companies are identified, located in Austria (12), France (60), Germany (29), Ireland (19), Italy (24), the Netherlands (103), Spain (31) and the United Kingdom (606). In our analysis, we have retained only those firms for which at least 6 consecutive observations are available for the

5. Data were extracted in December 2017 and the access to the database was allowed by a research grant. Although the update of this database is no longer possible, the time span covers several events (e.g. 2008–2009 Global financial crisis; the crisis of Crimea in 2014), where the energy prices recorded noteworthy volatility, with implications for energy firms' TFP.

value-added data (that is, 141 firms).[6] In line with the previous literature, we compute the stock of capital (K) using the Perpetual Inventory Method (PIM), and we lose one observation (for additional explanations, please refer to Albulescu et al., 2022). Therefore, the final sample covers the period 2007 to 2015.

The AMADEUS database allows the annual investigation of shareholders' structure and location. There, as a proxy for tax avoidance, we use two dummy variables. The first dummy variable (*dummyH*) takes the value 1 if the firm or its shareholders, or affiliates, have a holding structure, and 0 otherwise. The second dummy variable (*dummyTH*) takes the value 1 if this firm (or one of its shareholders) is located in a tax haven, and 0 otherwise. In line with Gumpert et al. (2016), we use the legal residence to identify the tax haven location. AMADEUS database allows to see, on an annual basis, if the legal residence of the firm, its affiliates, or parent company, changed from one country to another. Doing so, we have noticed a migration of energy companies to tax havens after 2011 (almost 10% of the selected energy companies). About 40% of companies from our sample are located in tax havens in 2015.

A set of control variables are used in our model.[7] The final equation we test is[8]:

$$tfp_{it} = \alpha + \beta 1_{it} dummyH + \beta 2_{it} dummyTH + \beta 3_{it} size_{it-1} + \beta 4_{it} intangibles_{it-1} + \beta 5_{it} leverage_{it-1} + \beta 6_{it} ep_{it-1} + \beta 7_{it} dummyO + \beta 8_{it} dummyY + \varepsilon_{it}, \tag{13}$$

where tfp_{it} is the total factor productivity estimated through Levinsohn and Petrin (2003) – *lp*, Wooldridge (2009) – *wrdg*, Ackerberg et al. (2015) – *rob*, and Rovigatti and Mollisi (2018) – *mr*, α is the intercept $\beta_{k=1..8}$, represent the coefficients of the TFP's determinants, *dummyH* (holding structure) and *dummyTH* (tax haven location) are the proxy variables for tax avoidance, $size_{it-1}$ is the firm size measured in terms of total assets (natural log), $intangibles_{it-1}$ represents the intangibles to total fixed assets ratio, $leverage_{it-1}$ is loans to total liabilities ratio, ep_{it-1} is the energy price index at country level, *dummyO* is a dummy variable taking value 1 if multiple final ownership and 0 otherwise, *dummyY* is a binary variable designed to capture time-related effects, and ε_{it} is the error term.

4.2. Summary statistics

Summary statistics are presented in Table 1. We notice a high variability in terms of R&D investment, firm leverage, and firm size.

The use of a panel quantile regression with fixed effects requires that our variables be stationary. Thus, we use Choi's (2006) Fisher ADF-type tests (Pm, Z, L*), designed for unbalanced panel data as ours. Table 2 presents the panel unit root tests results and indicates that our variables are stationary in level.

6. Firms with negative added values were also excluded from the analysis. The dataset composition by country is presented in Appendix C.
7. Table D1 (Appendix D) presents in details the explanatory variables used in our empirical analysis.
8. To avoid the reverse causality effect of TFP on companies' size and performance, we have used the first lag for our control variables.

TABLE 1
Summary statistics

Variables	Mean	Std. Dev.	Min	Max
lp	0.000	0.530	–17.76	1.308
wrdg	15.23	0.605	–2.487	17.85
rob	15.15	0.596	–2.643	17.65
mr	15.24	0.607	–2.454	17.90
size	12.18	2.584	2.208	19.55
intangibles	23.03	32.07	–26.03	100.0
leverage	11.17	28.94	–3.382	559.7
ep	5.506	6.117	–5.800	18.50

Notes: (i) 1,182 observations; (ii) lp - Levinsohn and Petrin (2003), wrdg - Wooldridge (2009), rob - Ackerberg et al. (2015), mr - Rovigatti and Mollisi (2018).

TABLE 2
Results of Fisher-type ADF panel unit root tests

	Pm	Z	L*
lp	13.42***	–4.056***	–7.004***
wrdg	7.391***	–2.051**	–3.565***
rob	7.507***	–2.055**	–3.125***
mr	9.036***	–2.137**	–4.204***
size	9.888***	–0.499	–3.360***
intangibles	14.98***	–3.745***	–9.726***
leverage	17.67***	–8.942***	–12.69***
ep	6.261***	–7.913***	–7.141***

Notes: (i) the null for all tests is the presence of unit roots; (ii) Pm, Z and L* are the modified inverse chi-squared, inverse normal and inverse logit tests; (iii) ***, **, * denote statistical significance at the 1%, 5%, and 10% level (e.g. for ***, the *p*-value < 0.01).

5. EMPIRICAL RESULTS

Our main findings rely on Rovigatti and Mollisi's (2018) approach to compute the TFP. The results are presented in Table 3 and show that the organisation of a firm in a holding structure has a negative effect on productivity at all quantiles, being counterproductive. This result can be explained by the fact that such complex structure imply costly tax planning strategies in the context of an increased tax uncertainty (Hanlon et al., 2017). In addition, the "new view" of dividend taxation (Hartman, 1985) argues that dividend taxes are unavoidable costs for mature foreign subsidiaries, i.e. at some point in time they must be paid. Moreover, the EU transfer pricing legislation might negatively impact the efficiency of holding structures in terms of tax avoidance.

However, when we assess the impact of the second proxy for tax avoidance, namely the firm's location in a tax haven, the coefficient is positive at all quantiles and increases for the highest productivity levels. On the one hand, these findings show that the firm's location in a tax haven allows them to increase the use of internal funds for financing productive investments, with clear positive effects on TFP (similar results are reported by Gkikopoulos et al. (2022) for a large set of American companies). On the other hand, the relation is stronger for the upper quantiles, meaning that the relation between tax avoidance and TFP is very important for firms with a productivity above average. That is, tax avoidance help oil and gas companies from the extractive industry with a higher productivity to remain more efficient compared to their counterparts.

Further, when we analyse the control variables, we see that the firm's size negatively impacts its productivity. This means that SMEs are more productive compared to large compa-

TABLE 3
Tax avoidance and TFP (*mr*) – main findings

quantiles	lower quantiles			middle quantiles				upper quantiles		
	0.05	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95
dummyH	–0.025*	–0.023***	–0.021***	–0.019***	–0.019***	–0.017***	–0.016***	–0.016***	–0.018***	–0.026*
	(0.013)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.014)
dummyTH	–0.024*	0.022***	0.023***	0.025***	0.023***	0.023***	0.024***	0.023***	0.031***	0.054***
	(0.014)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.005)	(0.014)
size	–0.011***	–0.009***	–0.007***	–0.006***	–0.005***	–0.005***	–0.004***	–0.003***	–0.001	0.004
	(0.003)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.003)
intangibles	–0.000	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
leverage	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ep	–0.001	0.000	–0.000	–0.000	0.000	0.000	0.000	–0.000	–0.000	–0.000
	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.002)
dummyO	0.008	0.009**	0.009***	0.008***	0.009***	0.009***	0.009***	0.008***	0.004	0.001
	(0.014)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.005)	(0.015)
intercept	15.33***	15.33***	15.32***	15.32***	15.32***	15.32***	15.32***	15.31***	15.29***	15.27***
	(0.040)	(0.011)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.008)	(0.013)	(0.041)
dummyY	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: (i) Standard errors in parentheses; (ii) *** $p<0.01$, ** $p<0.05$, * $p<0.1$; (iii) 1,132 observations; (iv) dummyH – takes value 1 if the firm is organized as a holding company or has a holding company in its ownership structure (the first proxy for tax avoidance); dummyTH – takes value 1 if the firm is located in a tax haven or one of the entities from its ownership structure is located in a tax haven (the second proxy for tax avoidance); size – total assets expressed in natural log; intangibles – ratio of intangible to total fixed assets (a proxy for R&D investment), leverage – ratio of loans to total liabilities; ep – energy sector inflation rate; dummyO – takes value 1 if multiple final ownership and 0 otherwise; dummy – the year dummy.

TABLE 4

Tax avoidance and TFP (*lp*) – robustness

quantiles	lower quantiles			middle quantiles				upper quantiles		
	0.05	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95
dummyH	–0.018	–0.011*	–0.008***	–0.008***	–0.008***	–0.007***	–0.006**	–0.005	–0.011***	–0.015
	(0.017)	(0.006)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.026)
dummyTH	–0.023	0.013**	0.018***	0.018***	0.019***	0.021***	0.020***	0.019***	0.026***	0.058**
	(0.017)	(0.006)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.004)	(0.027)
size	–0.023***	–0.020***	–0.018***	–0.017***	–0.016***	–0.015***	–0.014***	–0.012***	–0.010***	–0.008
	(0.003)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.005)
intangibles	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
leverage	0.000	–0.000	–0.000	–0.000	–0.000	–0.000*	–0.000**	–0.000	–0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ep	–0.001	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	–0.001
	(0.003)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.004)
dummyO	0.050***	0.048***	0.046***	0.048***	0.050***	0.049***	0.051***	0.050***	0.046***	0.041
	(0.018)	(0.007)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.004)	(0.028)
intercept	0.195***	0.196***	0.193***	0.190***	0.188***	0.197***	0.200***	0.195***	0.176***	0.192**
	(0.050)	(0.018)	(0.009)	(0.008)	(0.007)	(0.006)	(0.007)	(0.009)	(0.012)	(0.078)
dummyY	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: (i) Standard errors in parentheses; (ii) *** $p<0.01$, ** $p<0.05$, * $p<0.1$; (iii) 1,132 observations; (iv) dummyH – takes value 1 if the firm is organized as a holding company or has a holding company in its ownership structure (the first proxy for tax avoidance); dummyTH – takes value 1 if the firm is located in a tax haven or one of the entities from its ownership structure is located in a tax haven (the second proxy for tax avoidance); size – total assets expressed in natural log; intangibles – ratio of intangible to total fixed assets (a proxy for R&D investment), leverage – ratio of loans to total liabilities; ep – energy sector inflation rate; dummyO – takes value 1 if multiple final ownership and 0 otherwise; dummy – the year dummy.

nies, in accordance with the "passive learning" theory of Jovanovic (1982). The coefficient of intangible assets is also negative, showing that the investment in long-term assets does not contribute to an increased TFP, on the contrary. However, this effect is marginal in the case of European energy firms. Whereas the firm leverage and the energy prices have no significant influence on TFP, we see that the existence of a multiple final ownership positively impacts the productivity level (again, the effect is marginal).

These results can be influenced by the way the TFP is computed, but also by the heterogeneity of our sample in terms of firm size. To check the robustness of our findings we thus perform a series of robustness checks.

6. ROBUSTNESS CHECKS

6.1. Alternative approaches for computing the TFP

In the first robustness check we use alternatives approaches to compute the TFP. Table 4 shows the results relying on Levinsohn and Petrin's (2003) approach. As in the previous case, the reduction of tax liabilities supposed to be provided by a holding structure have a negative effect on productivity, while being located in a tax haven positively impacts firm's TFP. Similar to the main findings, the size is negatively correlated with firms' productivity, whereas a multiple final ownership structure has a positive impact.

In Tables 5 and 6 we present the results relying on the Wooldridge (2009), and respectively Ackerberg et al. (2015) approaches. We note that the results are quite similar to the main findings, a result explained by the fact that Rovigatti and Mollisi's (2018) method is much closer to Wooldridge (2009) and Ackerberg et al. (2015). This evidence can also be seen in Figure B1.

6.2. Comparison among SMEs and large companies

A series of studies (e.g. Desai and Dharmapala, 2009; Hanlon and Heitzman, 2010) affirm that tax avoidance plays a significant role only in the strategy of large firms. Therefore, we divide our sample into SMEs (up to 250 employees) and large companies (over 250 employees). This delimitation is made based on the number of employees recorded in 2015 (or the last observations, if data for 2015 are unavailable). Consequently, we obtain a sub-sample of 103 SMEs and 38 large companies.

Table 7 presents the findings for the sub-sample of SMEs (Rovigatti and Mollisi's (2018) approaches). In this case, the holding structure positively influences TFP but only for the middle quantiles. This result indicates that holding structures helps small firms to optimize their tax planning, with a positive impact on TFP. Similar to the main results, being located in a tax haven increase a firm's TFP. In the case of SMEs, a higher independence in making decisions associated with a single final owner negatively impacts the TFP (recall that this variable takes the value 1 if we have multiple final ownership).

Table 8 shows the results for the sub-sample of large companies, which are quite similar with those reported for the SMEs. While the positive impact of being located in a tax haven on TFP is seen in all quantiles, holding structures have enhanced large companies' TFP at middle quantiles only. We notice therefore that the results based on the use of holding structure as proxy for tax avoidance are sensitive to the sample composition. In the case of large companies the size is negatively correlated with the productivity, as in our main findings.

TABLE 5
Tax avoidance and TFP (*wdrg*) – robustness

quantiles	lower quantiles			middle quantiles				upper quantiles		
	0.05	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95
dummyH	–0.022*	–0.023***	–0.021***	–0.019***	–0.019***	–0.018***	–0.017***	–0.017***	–0.020***	–0.029**
	(0.013)	(0.004)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.003)	(0.004)	(0.014)
dummyTH	–0.027**	0.024***	0.024***	0.025***	0.024***	0.024***	0.024***	0.024***	0.031***	0.054***
	(0.013)	(0.004)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.003)	(0.004)	(0.014)
size	–0.012***	–0.009***	–0.007***	–0.007***	–0.006***	–0.005***	–0.004***	–0.003***	–0.001	0.004
	(0.003)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.003)
intangibles	–0.000	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
leverage	–0.000	0.000	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ep	–0.001	0.000	–0.000	–0.000	0.000	0.000	0.000	0.000	–0.000	–0.000
	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.002)
dummyO	0.009	0.011***	0.010***	0.009***	0.009***	0.010***	0.009***	0.009***	0.005	0.004
	(0.014)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.015)
intercept	15.32***	15.32***	15.31***	15.31***	15.31***	15.31***	15.31***	15.30***	15.28***	15.25***
	(0.038)	(0.010)	(0.006)	(0.005)	(0.005)	(0.004)	(0.004)	(0.008)	(0.012)	(0.041)
dummyY	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: (i) Standard errors in parentheses; (ii) *** p<0.01, ** p<0.05, * p<0.1; (iii) 1,132 observations; (iv) dummyH – takes value 1 if the firm is organized as a holding company or has a holding company in its ownership structure (the first proxy for tax avoidance); dummyTH – takes value 1 if the firm is located in a tax haven or one of the entities from its ownership structure is located in a tax haven (the second proxy for tax avoidance); size – total assets expressed in natural log; intangibles – ratio of intangible to total fixed assets (a proxy for R&D investment), leverage – ratio of loans to total liabilities; ep – energy sector inflation rate; dummyO – takes value 1 if multiple final ownership and 0 otherwise; dummy – the year dummy.

TABLE 6
Tax avoidance and TFP (*rob*) – robustness

quantiles	lower quantiles			middle quantiles				upper quantiles		
	0.05	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95
dummyH	–0.022*	–0.022***	–0.021***	–0.022***	–0.022***	–0.021***	–0.020***	–0.018***	–0.020***	–0.027**
	(0.012)	(0.004)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.005)	(0.010)
dummyTH	–0.020*	0.024***	0.026***	0.028***	0.028***	0.029***	0.027***	0.028***	0.037***	0.063***
	(0.012)	(0.004)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.005)	(0.011)
size	–0.013***	–0.011***	–0.009***	–0.008***	–0.008***	–0.007***	–0.006***	–0.005***	–0.003***	0.001
	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.002)
intangibles	–0.000	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
leverage	–0.000	0.000	0.000	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ep	0.000	–0.000	–0.000	–0.000	0.000	–0.000	–0.000	0.000	–0.000	–0.001
	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.002)
dummyO	0.011	0.012***	0.012***	0.011***	0.012***	0.013***	0.013***	0.012***	0.008*	0.002
	(0.013)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.011)
intercept	15.26***	15.25***	15.25***	15.25***	15.26***	15.26***	15.24***	15.24***	15.22***	15.18***
	(0.035)	(0.011)	(0.006)	(0.005)	(0.004)	(0.004)	(0.005)	(0.006)	(0.013)	(0.031)
dummyY	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: (i) Standard errors in parentheses; (ii) *** $p<0.01$, ** $p<0.05$, * $p<0.1$; (iii) 1,132 observations; (iv) dummyH – takes value 1 if the firm is organized as a holding company or has a holding company in its ownership structure (the first proxy for tax avoidance); dummyTH – takes value 1 if the firm is located in a tax haven or one of the entities from its ownership structure is located in a tax haven (the second proxy for tax avoidance); size – total assets expressed in natural log; intangibles – ratio of intangible to total fixed assets (a proxy for R&D investment), leverage – ratio of loans to total liabilities; ep – energy sector inflation rate; dummyO – takes value 1 if multiple final ownership and 0 otherwise; dummy – the year dummy.

TABLE 7
Tax avoidance and TFP: Sub-sample of SMEs

quantiles	lower quantiles			middle quantiles				upper quantiles		
	0.05	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95
dummyH	–0.000	–0.001	0.001	0.001*	0.002***	0.003***	0.003***	0.004***	0.003	0.005
	(0.007)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.007)
dummyTH	0.003	0.002	0.002*	0.003***	0.002***	0.002***	0.002***	0.002*	0.002	0.000
	(0.008)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.007)
size	–0.002	0.000	0.001**	0.001***	0.001***	0.002***	0.002***	0.003***	0.004***	0.006***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
intangibles	–0.000	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
leverage	0.000	0.000	–0.000	–0.000	–0.000	0.000	0.000	0.000	0.000	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ep	0.000	0.000	0.000	0.000	–0.000	–0.000	–0.000	0.000	–0.000	–0.001
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
dummyO	–0.000	–0.007***	–0.007***	–0.007***	–0.007***	–0.007***	–0.007***	–0.007***	–0.008***	–0.013*
	(0.008)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.007)
intercept	15.18***	15.17***	15.16***	15.16***	15.16***	15.16***	15.16***	15.15***	15.15***	15.13***
	(0.024)	(0.006)	(0.004)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.007)	(0.021)
dummyY	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: (i) Standard errors in parentheses; (ii) *** $p<0.01$, ** $p<0.05$, * $p<0.1$; (iii) 820 observations; (iv) dummyH – takes value 1 if the firm is organized as a holding company or has a holding company in its ownership structure (the first proxy for tax avoidance); dummyTH – takes value 1 if the firm is located in a tax haven or one of the entities from its ownership structure is located in a tax haven (the second proxy for tax avoidance); size – total assets expressed in natural log; intangibles – ratio of intangible to total fixed assets (a proxy for R&D investment), leverage – ratio of loans to total liabilities; ep – energy sector inflation rate; dummyO – takes value 1 if multiple final ownership and 0 otherwise; dummy – the year dummy.

TABLE 8
Tax avoidance and TFP: Sub-sample of large companies

quantiles	lower quantiles			middle quantiles				upper quantiles		
	0.05	0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95
dummyH	0.031	0.024	0.035**	0.040***	0.038***	0.039***	0.040***	0.037***	0.049	0.108
	(1.019)	(0.032)	(0.016)	(0.012)	(0.011)	(0.012)	(0.012)	(0.013)	(0.042)	(0.418)
dummyTH	0.086	0.117***	0.105***	0.102***	0.107***	0.118***	0.117***	0.123***	0.123***	0.055
	(1.049)	(0.033)	(0.016)	(0.013)	(0.011)	(0.012)	(0.012)	(0.014)	(0.043)	(0.431)
size	–0.061	–0.040***	–0.035***	–0.030***	–0.028***	–0.025***	–0.018***	–0.017***	–0.015	–0.010
	(0.246)	(0.008)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.010)	(0.101)
intangibles	–0.002	–0.000	–0.000	–0.000	–0.000	–0.000	–0.000	0.000	0.001	0.001
	(0.021)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.009)
leverage	–0.003	–0.001	0.000	0.000	–0.000	–0.000	–0.000	–0.000	0.000	0.043***
	(0.025)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.010)
ep	–0.000	0.000	–0.001	–0.001	–0.001	–0.001	–0.000	–0.001	0.000	–0.004
	(0.185)	(0.006)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.008)	(0.076)
dummyO	–0.010	–0.024	–0.021	–0.017	–0.013	–0.013	–0.024**	–0.014	–0.010	–0.041
	(0.966)	(0.030)	(0.015)	(0.012)	(0.010)	(0.011)	(0.011)	(0.012)	(0.039)	(0.397)
intercept	16.00***	15.91***	15.84***	15.78***	15.76***	15.74***	15.67***	15.66***	15.62***	15.60***
	(4.017)	(0.125)	(0.061)	(0.049)	(0.043)	(0.046)	(0.046)	(0.052)	(0.164)	(1.650)
dummyY	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: (i) Standard errors in parentheses; (ii) *** p<0.01, ** p<0.05, * p<0.1; (iii) 311 observations; (iv) dummyH – takes value 1 if the firm is organized as a holding company or has a holding company in its ownership structure (the first proxy for tax avoidance); dummyTH – takes value 1 if the firm is located in a tax haven or one of the entities from its ownership structure is located in a tax haven (the second proxy for tax avoidance); size – total assets expressed in natural log; intangibles – ratio of intangible to total fixed assets (a proxy for R&D investment), leverage – ratio of loans to total liabilities; ep – energy sector inflation rate; dummyO – takes value 1 if multiple final ownership and 0 otherwise; dummy – the year dummy.

7. CONCLUSIONS AND POLICY IMPLICATIONS

Tax avoidance represents a common practice, especially for multinational companies, in their pursuit of after-tax profits. However, the impact of tax avoidance on TFP is not clear, with opposite arguments advanced in the existing literature. To shed light on this question, we posit that the TFP – tax avoidance nexus is influenced by the firm level of productivity. More precisely, this relation is asymmetric and might be stronger for highly productivity firms if tax avoidance is considered as a main driver of productivity. If, however, tax avoidance compensates for a lack of productivity, we may discover a stronger relation at lower quantiles.

Relying on a panel data fixed-effect quantile approach and using different methods to compute the TFP for a set of European oil and gas companies active in the extractive industry, we find the reduction of tax liabilities provided by holding structures have a mixed effect on TFP, being influenced by the sample composition. However, being located in a tax haven enhances the productivity for all categories of companies. At the same time, we discover that the impact of tax avoidance on TFP is stronger at higher quantiles, that is, for higher levels of productivity. This means that energy firms migrate to tax havens not to compensate a lack of productivity, but to increase their productivity level through tax avoidance.

Our findings are robust to different TFP specifications and have several policy implications. First, our results enrich the microeconomic understanding of the consequences of tax avoidance. We discover that the implications of tax avoidance for productivity are influenced by the way the tax avoidance is calculated. Second, as in Gkikopoulos et al. (2022), our evidence could potentially provide lessons to energy firms decision makers to deal with aggregate productivity shortfalls. Third, we document that tax avoidance helps the energy firms to record and maintain a productivity above the average.

The fact that our results are partially sensitive to the sample composition and we obtain mixed findings regarding the impact of holding structures on TFP, represent a limit of our empirical research

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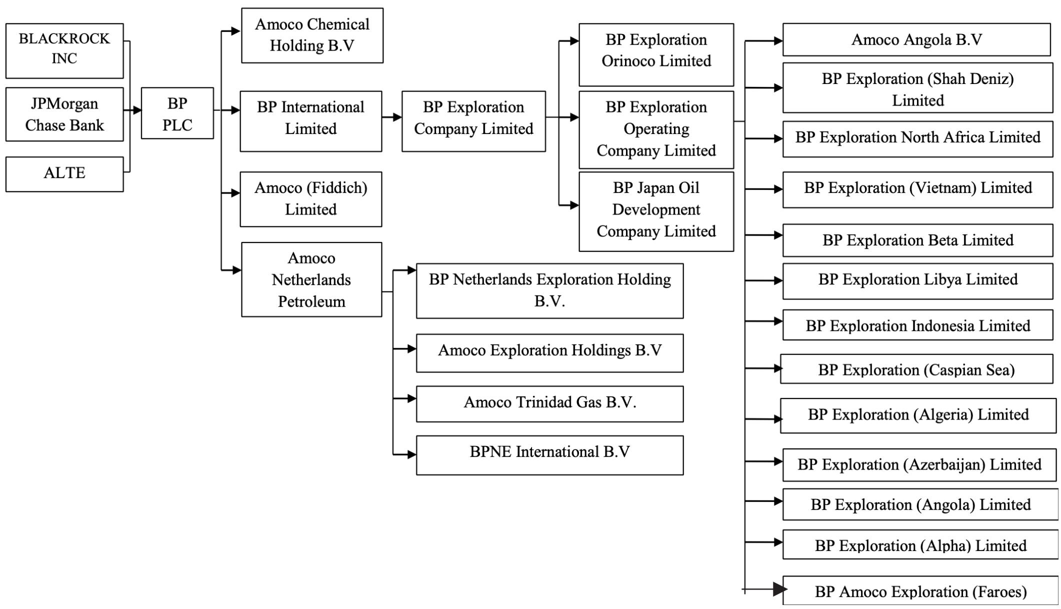
APPENDIX A – Ownership structure of the largest European oil and gas companies

FIGURE A1

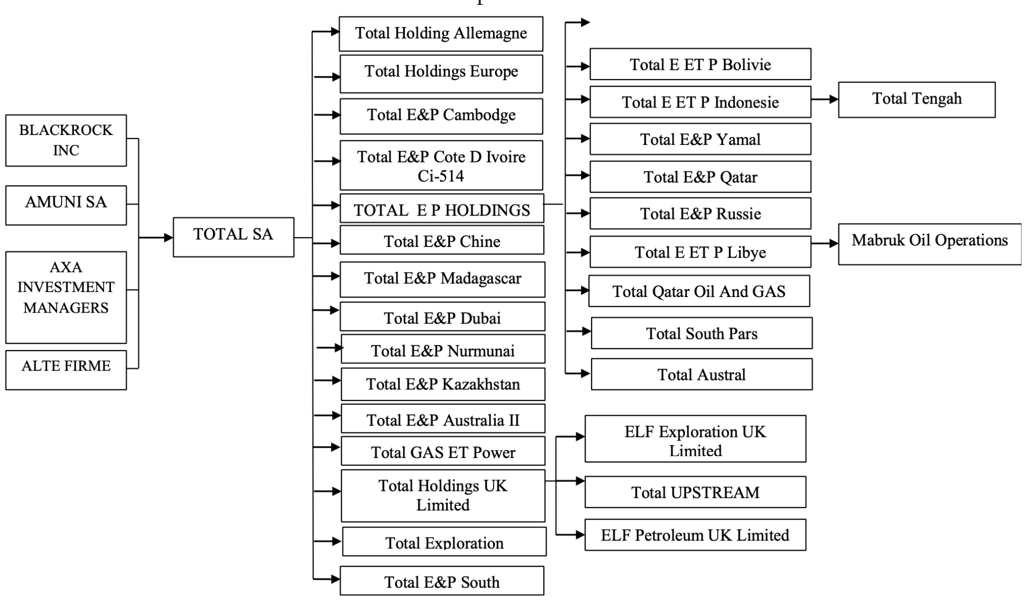
British Petroleum's ownership structure in 2015



Source: Own design based on AMADEUS data.

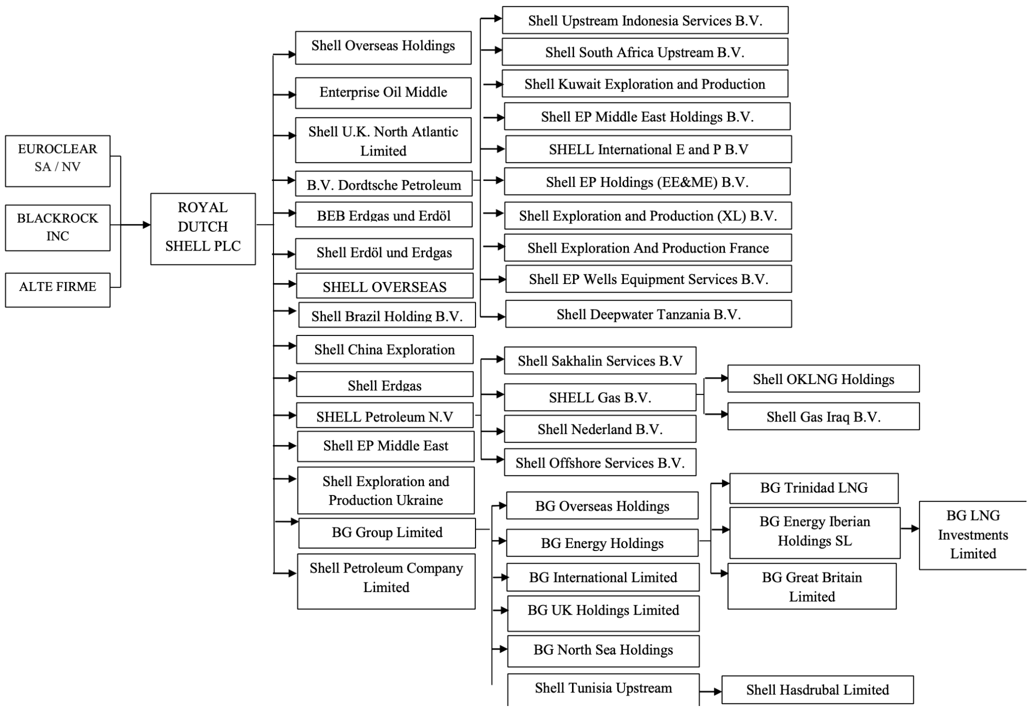
FIGURE A2

Total's ownership structure in 2015



Source: Own design based on AMADEUS data.

FIGURE A3
Royal Dutch Shell's ownership structure in 2015



Source: Own design based on AMADEUS data.

APPENDIX B – Dynamics of TFP for the European oil and gas companies

FIGURE B1
TFP dynamics using Levinsohn and Petrin (2003) – lp, Wooldridge (2009) – wrdg, Ackerberg et al. (2015) – rob, and Rovigatti and Mollisi (2018) – mr.

Source: Own computations based on AMADEUS statistics

APPENDIX C – Firm dataset composition by country

TABLE C1
Dataset composition by country

Country	Firm number
Austria	1
France	9
Germany	1
Ireland	6
Italy	12
Spain	17
United Kingdom	95
TOTAL	141

APPENDIX D – TFP determinants

TABLE D1
Explanatory variables' description

Variables	Explanations	Expected sign	Previous studies
dummyH	**Holding dummy** equals 1 if the firm has a holding structure and 0 otherwise. Holding structures facilitate international debt shifting and tax deferral. At the same time, they represents complex structures, implying a costly tax planning strategy.	+/–	–
dummyTH	**Tax haven dummy** equals 1 if the firm (or its shareholders) are located in a tax haven and 0 otherwise. If profits are shifted to tax havens, firm's productivity increases.	+	Aussilloux et al. (2021)
size	**Natural log of total assets**. On the one hand large firms have the financial capacity and benefit from managerial skills which allow them to avoid taxes. On the other hand, small and medium size enterprises (SMEs) are forced to grow, being constrained by their productivity level (Jovanovic, 1982), and invest in R&D activities (Pakes and Ericson, 1998).	+/–	Khuong et al., (2020); Yu et al., (2017)
intangibles	**Intangible assets to total assets ratio** represents a proxy for R&D activities. R&D investment allows firm to innovate and to become more performant. At the same time, firms are determined to invest in tangible assets, which generate short-term profits, helping thus those form to boost their productivity level.	+/–	Albulescu and Turcu (2022); Doraszelski and Jaumandreu (2013)
leverage	**Loans to total liabilities ratio** indicates the firm leverage, which is negatively correlated with their capacity to innovate and to invest in productive assets.	–	Ferrando and Ruggieri (2018); Chen and Guariglia, (2013)
ep*	**Energy prices,** represented by the inflation in the "electricity, gas and other fuels" sector, positively impact firms' productivity. The indicator varies across countries but does not vary across firms.	+	Oberndorfer (2009)
dummyO	**Independence level dummy** equals 1 if the independence is high and 0 otherwise (in the case of multiple final ownership). On the one hand, in the presence of a single final owner the decision-making process becomes faster, which can increase firm productivity. On the other hand, a low level of cooperation in the decision-making process might amplify the risk taken.	+/–	Albulescu and Turcu (2022); Gaitán et al. (2018)
dummyT	**Time (year) dummy variable** to capture any time-related effect generated by crisis episodes and/or energy price jumps	NA	NA

Note: * Eurostat data are used for energy price index. All other variables are extracted from AMADEUS database.

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