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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. When investigating the tax avoidance phenomenon, we make the distinction between fiscal facilities provided by companies' holding structures and tax haven location. We discover that the impact of tax avoidance on TFP is not straightforward. On the one hand, fiscal facilities provided by holding structures have a mixed effect 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. 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 and resort to a bootstrap panel quantile regression.

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

JEL codes: D24, O13, P18, Q43

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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). Moreover, the existing literature fails to show how the impact of tax avoidance on firm productivity is influenced by their productivity level. Further, as far as we know, no previous study investigates the dynamics of total factor productivity (TFP) for energy companies.

Against this background, our purpose is to compute, as the first step, 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. From a theoretical point of view, 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).

Nevertheless, none of the previous papers investigated the asymmetric effect that tax avoidance might have on firm productivity. Indeed, the effect of tax avoidance on a firm's productivity might depend on the level of that firm's productivity. 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 compensate for a lack of firm productivity, we expect a stronger effect for less productive firms. 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 effects and represents a two-step estimator, relatively easy to compute. Unlike other panel quantile approaches (e.g. [Galvao, 2011](#); [Lamarche, 2010](#); [Rosen, 2012](#)), it allows parameter identification even in the presence of a fixed panel dimension ([Albulescu et al., 2021](#)). This is because fixed effects are considered as local shift variables. We therefore control for firm-specific and time-varying heterogeneity. In line with [Gkikopoulos et al. \(2022\)](#), we use a lag model to mitigate the reverse causality bias.¹ To check its robustness, we resort to a bootstrap panel quantile regressions, similar to [Albulescu and Turcu \(2022\)](#).

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 [Dyreg et al. \(2008\)](#), according to which tax avoidance is explained by the firm's tax burden. However, there is no consensus about the effectiveness of the use of these accounting-based tax avoidance measures ([Frank et al., 2009](#)). Therefore, we propose a different approach to estimate the tax avoidance phenomenon. We analyse the ownership structure and the configuration of energy companies in order to see if they have a holding structure or not. We posit that holding companies have different tax advantages, which allows them to avoid the tax systems. On the one hand, compared to the dividends paid to individuals, dividends paid to the holding company do not create a tax liability. 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. A significant portion of energy companies located in Europe are organized as holding companies, or have in their ownership structure some holding companies.²

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

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 evasion. In addition, productivity impacts firms' size and their asset structure.

² Several examples of complex organizational structures are presented in Appendix 1.

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 location of an energy 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 approach by Wooldridge (2009) and modify the Wooldridge’s estimator 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 Wooldridge’s (2009) approach as a benchmark, and, to check robustness, the well-known two-step TFP estimation procedures by Levinsohn and Petrin (2003) and Akerberg et al. (2015). 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.

Fourth, we compute the TFP for a set of energy companies 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). Ours is the first paper which investigates the impact of tax avoidance on TFP for energy companies.⁴ In line with other papers addressing the drivers of TFP, we control for the firm’s size and capital structure (Khuong et al., 2020). For example, Edwards et al. (2016) point out that financially constrained firms are more willing to avoid taxes. We also control for knowledge-based capital and research and development (R&D) investment, as well as for managerial independence in making decisions (Albulescu and Turcu, 2022; Doraszelski and Jaumandreu, 2013). We also control for the impact of energy prices. Indeed, as Oberndorfer

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

⁴ Indeed, Albulescu et al. (2022) assess the TFP for the German energy firms. However, the authors rather focus on the energy services field (NACE code 35), and not on the extractive industry, dominated by large companies.

(2009) underlines, the performances of energy firms, including their TFP, might be largely influenced by energy prices and oil price hikes.

Finally, in line with [Gkikopoulos et al. \(2022\)](#), this study contributes to several strands of the literature, with implications for both academics and policy makers. On the one hand, it contributes to the literature investigating the implications of tax avoidance for firms' economic outcomes and complements the research on capital investments (e.g. [Blaylock, 2016](#); [Brown et al., 2009](#); [Wang, 2017](#)). On the other hand, this research is connected to a set of studies investigating the drivers of productivity (e.g. [Albulescu and Turcu, 2022](#); [Gkikopoulos et al., 2022](#); [Ren et al., 2022](#)). 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](#)).⁵

The rest of the paper is as follows. Section 2 present a short literature review on the impact of tax avoidance on TFP. In Section 3 we present the data and TFP computation whereas Section 4 describes the empirical methodology. The next sections present the empirical findings and 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

⁵ 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 hypothesis of a high TFP persistence recorded at macro-level (see for example [Pancrazi and Vukotić, 2011](#)) is not validated in the case of European extractive industry.

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 (Gao et al., 2021; He et al., 2022; Ren 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).

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; Stancu et al., 2021), 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 a different approach 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).

3. Data

3.1. 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).⁶ Within this industry (NACE code 06), 884 companies are identified in Western Europe, 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, like Albuлесcu et al. (2022), we have retained only those firms for which at least 6 consecutive

⁶ 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.

observations are available for the value-added data (that is, 141 European extractive energy firms).⁷ To compute the TFP we need the stock of capital. In line with the previous literature, we compute the stock of capital using the Perpetual Inventory Method (PIM), and we use one observation. Therefore, the final sample covers the period 2007 to 2015.⁸

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 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.

3.2. TFP computation

Several methods can be used to compute the TFP (see for example [Moghaddasi and Pour, 2016](#)). The previous literature 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 a set of computation models, proposed by [Levinsohn and Petrin \(2003\)](#), [Akerberg et al. \(2015\)](#), [Wooldridge \(2009\)](#) and [Rovigatti and Mollisi \(2018\)](#).

Given that the simple fixed-effects and pooled Ordinary Least Squares (OLS) approaches used to compute TFP cannot control for different productivity shocks across firms, [Olley and Pakes \(1996\)](#) proposed for the first time a semi-parametric approach: a consistent two-step estimation procedure for the TFP.

The computation of the TFP starts from a Cobb-Douglas function as follows:

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

where AV is the value added; K is the stock of capital; L is the number of employees; $i = 1, \dots, 141$ firms; $t = 2007, \dots, 2015$; c is a constant that measures the average productivity of firms throughout the entire time span.

The error term ε_{it} can be decomposed as follows ([Olley and Pakes, 1996](#)):

⁷ Given the lack of added-value data for Central and Eastern European companies, we have not included them in our analysis. Firms with negative added values were also excluded from the analysis.

⁸ The PIM method supposes the computation of capital stock as follows: $K_{it} = (K_{it}^{BV} - K_{it-1}^{BV} + DEPR^{BV}) / EPI_{jt}$, where K_t^{BV} and K_{t-1}^{BV} represent the current and, respectively, the lagged book value of tangible fixed assets, while $DEPR^{BV}$ corresponds to depreciation and amortization. EPI_{jt} is the price index for "electricity, gas and other fuels", calculated at the national level (and extracted from the Eurostat database). Computed this way, the stock of capital might record negative values in specific periods, which renders impossible the use of the log form of a Cobb-Douglas function. Thus, similar to [Albulescu and Turcu \(2022\)](#), we compute a modified capital stock series - $K_{it} = K_{initial_{it}} + MIN_K$ (where MIN_K represents the minimum value of K for the entire sample).

$$\varepsilon_{it} = \omega_{it} + \delta_{it}, \quad (2)$$

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 of the non-randomness of firms dropping out of the sample (less productive firms exit the markets given their lower levels of productivity). Therefore, this bias is addressed by [Levinsohn and Petrin \(2003\)](#) who introduce the demand for intermediate goods. More specifically, they include the intermediate goods m_{it} in the estimated equation, assuming they depend on K_{it} . The productivity function is at this point invertible:

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

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

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

However, the choice of [Levinsohn and Petrin \(2003\)](#) to restrict the dynamics in the productivity process, namely $E(\omega_{it} | \omega_{it-1}, \dots, \omega_{i1}) = E(\omega_{it} | \omega_{it-1})$, 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 General Method of Moments (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 $\omega_{it} = f[h(m_{it-1} + K_{it-1})] + a_{it}$. We plug ω_{it} into Equation (4) and we obtain

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

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

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

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

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

Further, [Levinsohn and Petrin \(2003\)](#) assume that firms are able to instantly adjust some inputs, whereas [Akerberg 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. Therefore, they propose an instrumental variable approach where α and β (Equation 4) can be computed based on Robinson's (1988) estimator.

Finally, building upon Wooldridge (2009), Rovicatti and Mollisi (2018) make a simple innovation and modify Wooldridge's estimator, considering a matrix of dynamic panel instruments. Afterwards they introduce a new Stata command (*prodest*), which allows computing the TFP relying on Levinsohn and Petrin (2003) – *lp*, Wooldridge (2009) – *wrdg*, Akerberg et al. (2015) – *rob*, and Rovicatti and Mollisi (2018) – *mr*. Our main findings are based on the newly proposed approach by Rovicatti and Mollisi (2018), whereas the other TFP matrices are used for the purpose of checking the robustness.

3.3. Control variables

Our dependent variable is the TFP whereas the tax avoidance represents the explanatory variable of interest. In line with previous studies, we use a series of control variables to investigate this relation.

In line with other papers addressing the drivers of TFP, we control for the firm size (Albulescu et al., 2021; Khuong et al., 2020; Yu et al., 2017). Firm size can have either a positive or a negative effect on firm productivity. 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). Moreover, SMEs can enhance their productivity levels by investing in R&D activities (this phenomenon is explained by the “active learning” model of Pakes and Ericson, 1998). Firm size (*size*) is measured as the natural logarithm of firms' total assets.

Second, we control for the role of R&D investment, in line with Doraszelski and Jaumandreu (2013). Similar to Albulescu and Turcu (2022), we use the ratio of intangible to total fixed assets as a proxy for R&D activities (*intangibles*). Indeed, Duval et al. (2020) explain the productivity decline in the United States by the lack of investment in intangible capital. However, it is well known that intangible assets are considered long-term assets. Therefore, to enhance their productivity, firms are determined to invest in tangible assets, which generate short-term profits. This assumption is very appealing in the case of financially constrained firms (see, for example, Pérez-Orive, 2016). Therefore, the impact of investment in intangible capital on TFP can be either positive or negative.

Firms' leverage also influence their productivity. Apparently, firms' leverage is negatively correlated with their capacity to innovate and to invest in productive assets. Thus,

it is expected to yield a negative impact of financial constrained firms on TFP (in line with [Albulescu and Turcu, 2022](#); [Ferrando and Ruggieri, 2018](#); [Chen and Guariglia, 2013](#)). We use the ratio of loans to total liabilities to compute the firm's leverage (*leverage*).

In line with the corporate governance literature, we also investigate the effect of independence in making decisions on a firm's performance. Usually the ownership concentration is used as a *proxy* for the level of independence in the decision making process ([Jiraporn et al., 2018](#)). Analysing the ownership structure, we construct a dummy variable (*dummyO*), which takes the value 1 if the company has a multiple final owner, and 0 otherwise. In this case also the effect on firms' productivity can be either positive or negative.

In line with [Oberndorfer \(2009\)](#), [Sari et al. \(2016\)](#) and [Yasin \(2020\)](#), we also consider that energy prices impact the productivity level. The value added of energy companies can be considerably influenced by the energy price dynamics. As a consequence, we control for the energy prices, considering the rate of inflation in the "electricity, gas and other fuels" sector (*ep*), and using Eurostat data (the rate of inflation is calculated at the national level but does not vary across firms). Finally, we use a year dummy variable to capture any time-related effect generated by crisis episodes and/or energy price jumps.

3.4. Summary statistics

Before describing the empirical approaches used to investigate the asymmetric relation between TFP and tax avoidance, we present the summary statistics (Table 1). We notice a high variability in terms of R&D investment and firms' leverage, while the *lp* mean is 0, according to the theory. We also notice a high heterogeneity in terms of firm size.

[Insert Table 1 about here]

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 (P_m , 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.

[Insert Table 2 about here]

4. Methodology

4.1. Panel quantiles regression

We estimate the following general equation⁹:

$$tfp_{it} = \alpha + \beta_{1it}dummyH + \beta_{2it}dummyTH + \beta_{3it}size_{it-1} + \beta_{4it}intangibles_{it-1} + \beta_{5it}leverage_{it-1} + \beta_{6it}ep_{it-1} + \beta_{7it}dummyY + \varepsilon_{it}, \quad (7)$$

where tfp_{it} is the total factor productivity estimated through [Levinsohn and Petrin \(2003\)](#), [Wooldridge \(2009\)](#), [Akerberg et al. \(2015\)](#) and [Rovigatti and Mollisi \(2018\)](#), α is the intercept, $\beta_{k=1..7}$ represent the coefficients of the TFP's determinants, and ε_{it} is the error term.

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

$$Y_{it} = X'_{it}\theta(U_{it}) + \alpha_i, \quad (8)$$

where $t = 1, \dots, T$; $i = 1, \dots, n$; 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

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

Assuming that $U_{it} \sim U[0,1]$, conditional on $X_i = (X'_{i1}, \dots, X'_{iT})'$ 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:

$$Y_{it} = X'_{it}\theta(U_{it}) + \alpha_i + e_{it}(\tau), \quad (10)$$

[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

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

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

⁹ As mentioned before, to avoid the reverse causality effect of TFP on companies' size and performance, we have used the first lag for our explanatory variables. In the absence of appropriate instruments which help to deal with the endogeneity bias, this practice is quite commonly used.

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

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

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

4.2. Panel bootstrap regression

To test the robustness of our main findings relying on [Canay's \(2011\)](#) fixed-effect model, we use a linear quantile regression model advanced by [Koenker and Bassett \(1978\)](#) and extended by [Hahn \(1995\)](#).

In a linear specification, the quantiles regression estimator $\hat{\beta}_\tau$ of β_i is

$$\hat{\beta}_N = \underset{\beta}{\operatorname{argmin}} \sum_{i=1}^N q_\tau(Y_i - \beta X_i), \quad (13)$$

where $q_\tau(u) = u(\tau \cdot \mathbf{1}_{|u| \geq 0} - (1 - \tau) \cdot \mathbf{1}_{|u| < 0})$.

Considering now a panel framework, the τ^{th} conditional quantile of Y 's response to a vector of covariates $X = x$ is denoted by $Q_Y(\tau|x) := \inf\{q: P(Y \leq q|X = x) \geq \tau\}$, so as $0 \leq \tau \leq 1$. The regression model of $Q_{y_{it}}(\tau|x_{it})$, at a given τ becomes

$$Q_{y_{it}}(\tau|x_{it}) = \beta_0(\tau) + x' \beta(\tau), \quad (14)$$

where $\beta_0(\tau)$ represents the intercept, $\beta(\tau)$ is the vector of coefficients, and x' denotes the vector transpose of x .

The choice of τ is crucial to analyse the tails of the conditional distribution, but assessing the accuracy of the τ^{th} quantile parametric regression is problematic. Thus, the use of a non-parametric bootstrap resampling method is recommended for the construction of confidence intervals ([Kapetanios, 2008](#)). For a given τ -quantile, the bootstrapped panel data estimator becomes

$$\hat{\beta}_{NT}^* = \underset{\beta}{\operatorname{argmin}} \sum_{i=1}^N \sum_{t=1}^T q_\tau(y_{it}^* - \beta x_{it}^*), \quad (15)$$

where (y_{it}^*, x_{it}^*) are the pairwise resampled data.¹⁰

¹⁰ In line with [Albulescu and Turcu \(2022\)](#), we perform 500 bootstrap estimations to check the robustness of our main findings.

5. Empirical results

Our main findings rely on [Rovigatti and Mollisi's \(2018\)](#) approach to compute the TFP and on [Canay's \(2011\)](#) panel quantile fixed-effects model. The results are presented in Table 3 and show that the organisation of a firm in a holding structure to benefit from fiscal facilities has a negative effect on tax avoidance at all quantiles. This means that the use of a holding structure for tax avoidance is counterproductive. The results can be explained by the fact that European Union authorities have a clear transfer pricing legislation, which controls the transactions between connected companies. At the same time the setup of a holding structure might be very costly in the short run, with negative implications on productivity. These findings are in line with the free cash flows ([Desai et al., 2007](#)) and future tax payments mechanism ([Hanlon et al., 2017](#)), which underline a negative effect of tax avoidance on firms TFP in the context of an increased tax uncertainty.

[Insert Table 3 about here]

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 use 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. About 40% of companies from our sample are located in tax havens.

Our results clearly show that the way the tax avoidance is estimated influences its impact on firms' TFP. We have, therefore, explained the mixed findings. 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 companies, 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, by the empirical approach we use, and also by the heterogeneity of our sample in terms of firm size. To check the robustness of our findings we thus perform three series of robustness checks.

6. Robustness checks

6.1. Alternative approaches for computing the TFP

In the first robustness check we use the approaches of [Levinsohn and Petrin \(2003\)](#), [Wooldridge \(2009\)](#), and [Akerberg et al. \(2015\)](#), as alternatives to the method of [Rovigatti and Mollisi \(2018\)](#).

Table 4 shows the results relying on [Levinsohn and Petrin \(2003\)](#). As in the previous case, the tax facilities provided by a holding structure have a negative effect on productivity, while being located in a tax haven positively impacts TFP. Similar to the main findings, the size is negatively correlated with firms' productivity, whereas a multiple final ownership structure has a positive impact. Unlike the main findings, the impact of intangibles becomes insignificant, although the sign of the coefficient remains negative.

[Insert Table 4 about here]

In Tables 5 and 6 we present the results relying on the [Wooldridge \(2009\)](#), and respectively [Akerberg 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 [Akerberg et al. \(2015\)](#). This evidence can also be seen in Figure B1.

Indeed, the holding structures have a negative impact on TFP whereas being located in a tax haven positively impacts the productivity. This is not surprising given the European Union transfer pricing legislation and a migration to tax havens after 2011, immediately after the 2008-2009 global financial crisis, which severely affected the firms' performances. Almost 10% of the selected energy companies have migrated towards tax havens after 2011.

[Insert Table 5 about here]

[Insert Table 6 about here]

6.2. Panel bootstrap regression results

In the second set of robustness checks we use a different method to investigate the relation between TFP and tax avoidance. We compute the TFP based on [Rovigatti and Mollisi's \(2018\)](#) approach and we resort to a panel bootstrap panel quantile regression with 500 bootstrap estimations. The results are presented in Table 7. Similar to the main findings, we show that being located in a tax haven has a positive impact on energy firms, except for the middle quantiles. However, unlike the main results, the impact of holding structure is no longer significant. Also different from the results reported in Table 3, we notice that firms' size is positively correlated with TFP. Therefore, in the last set of robustness checks, we split our sample and we perform the estimations for SMEs and large companies.

[Insert Table 7 about here]

6.3. 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 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 8 presents the findings for the sub-sample of SMEs ([Rovigatti and Mollisi's \(2018\)](#) and [Canay's \(2011\)](#) approaches). In this case, the holding structure positively influences TFP but only for the middle quantiles. However, similar to the main results, being located in a tax haven increase a firm's TFP. Size is positively correlated with the productivity, findings similar to those reported in Section 6.2. 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).

[Insert Table 8 about here]

Table 9 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. Unlike the SMEs, in the case of large companies the size is negatively correlated with the productivity, as in our main findings.

[Insert Table 9 about here]

7. Conclusions and policy implications

Tax avoidance represents a common practice, especially for multinational companies, in their pursuit of after-tax profits. However, the connection between tax avoidance and total factor productivity (TFP) is not clear. Opposite arguments are advanced in the existing literature regarding the relation between tax avoidance and TFP. To shed light on this question, we posit that the TFP – tax avoidance nexus is influenced by the 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 fiscal facilities 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.

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, we show that the productivity downturn is also recorded in the case of energy companies. Therefore, as in [Gkikopoulos et al. \(2022\)](#), our evidence could potentially provide lessons to a firm's 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.

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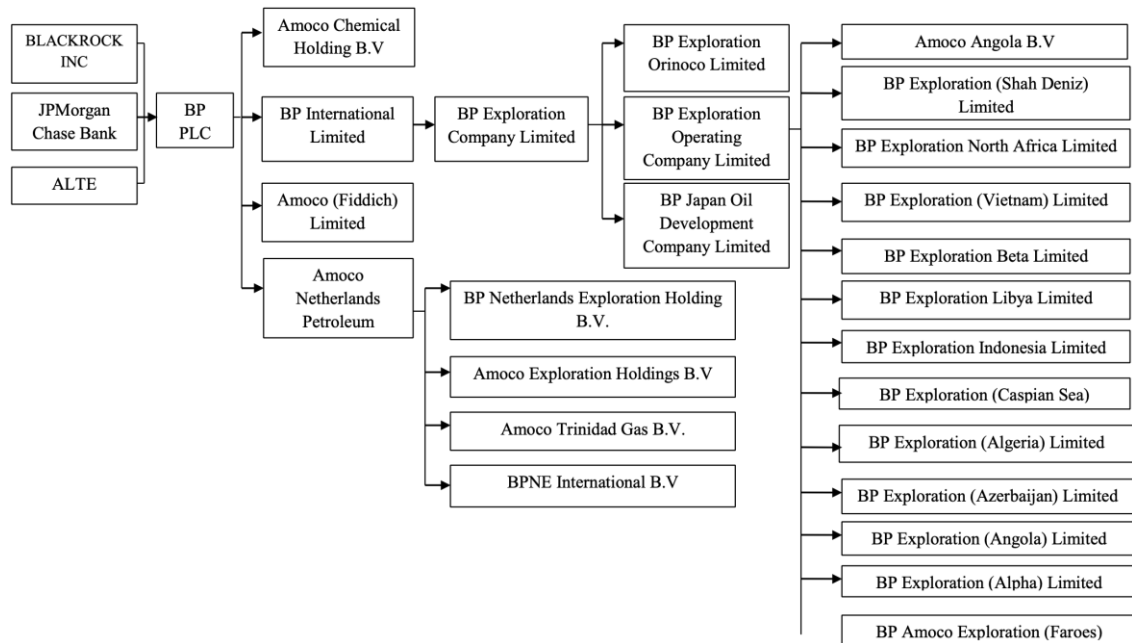
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Appendix

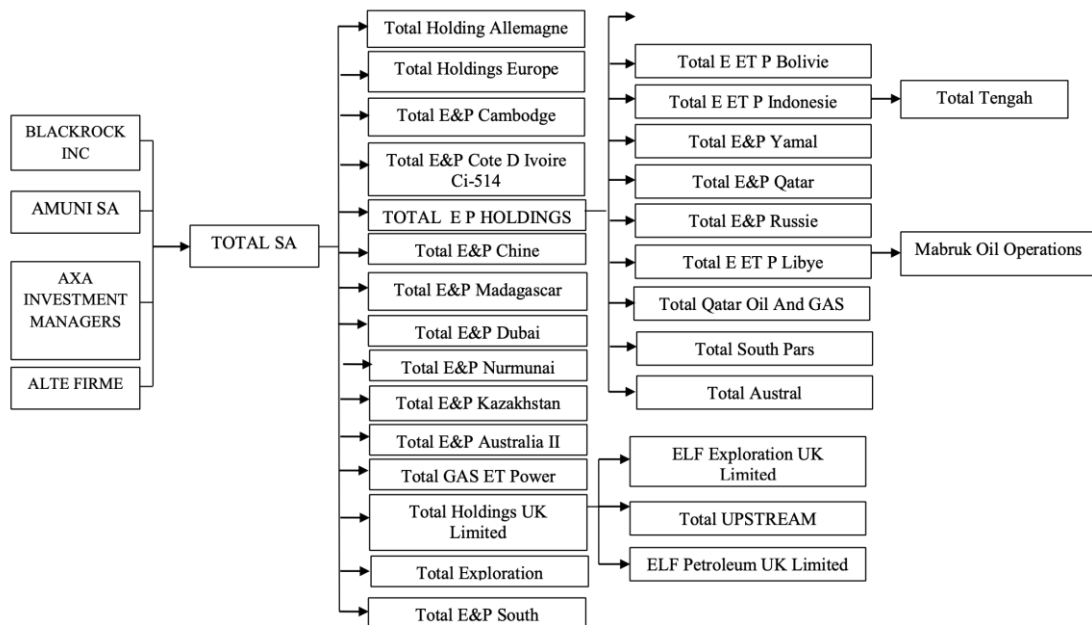
Appendix A – Ownership structure of the largest European oil and gas companies

Figure A1. British Petroleum's ownership structure in 2015



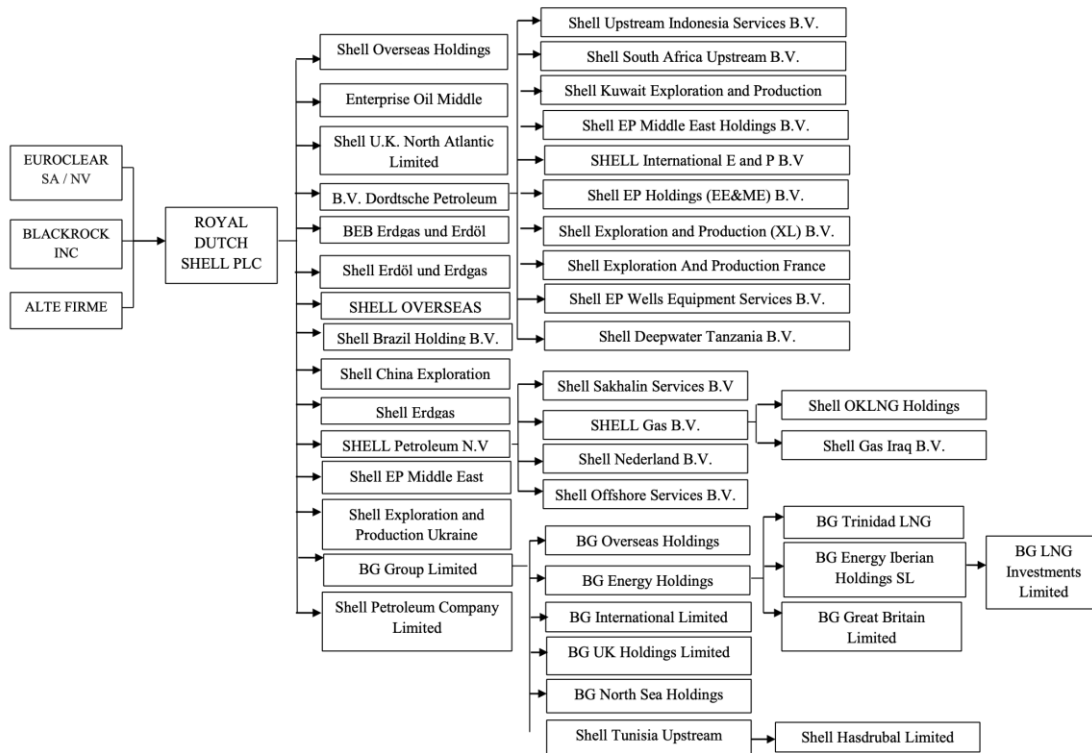
Source: Own design based on AMADEUS data.

Figure A2. Total's ownership structure in 2015



Source: Own design based on AMADEUS data.

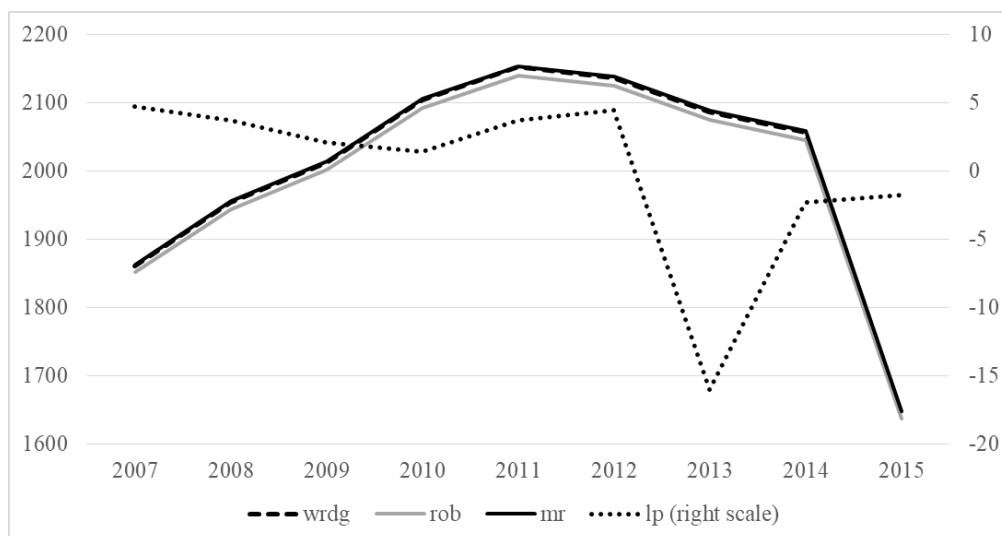
Figure A3. Royal Dutch Shell's ownership structure in 2015



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, Akerberg et al. (2015) – rob, and Rovigatti and Mollisi (2018) – mr.



Source: Own computations based on AMADEUS statistics