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ON THE MEASUREMENT OF  
INVESTMENT TYPES:  
HETEROGENEITY IN CORPORATE TAX  
ELASTICITIES

HENDRIK JUNGSMANN, SIMON LORETZ

WORKING PAPER No. 2016-01

# On the measurement of investment types: Heterogeneity in corporate tax elasticities

Hendrik Jungmann\* Simon Loretz†

## Abstract

This paper highlights the importance of different investment motives and to what extent they affect the responsiveness to corporate taxation. In particular, we discuss how to classify investment as non-related, horizontal, vertical and complex types using a combination of both firm-specific (ownership) information and sector-specific information from input-output tables. Hereby, we point out to what extent the resulting classification depends on assumptions made by the researcher. Following this, we examine the effects of host-country corporate taxation on the volume of investment within related firms (i.e., the intensive margin). We are able to quantitatively replicate the average result in the empirical literature with an overall tax semi-elasticity of approximately -1.5. Taking into account firm-heterogeneity we find that non-related investments react stronger to corporate taxation whereas horizontal investments are less responsive, though, significant negative tax semi-elasticities turn out for the subset of manufacturing industries where horizontal investment is much more prevalent. As the strict categorical classification still yields ambiguous results for both vertical and complex investments we extend the methodology by defining shares of investment and make the point that, by and large, stronger business motives reduce the tax responsiveness of investment.

**JEL classification:** C23, F23, H25, L25

**Keywords:** Corporate Taxation, Investment Strategy, Panel Econometrics

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# 1 Introduction

Ever since the seminal papers of Jorgenson (1963) and Hall and Jorgenson (1967) corporate taxation is seen – at least on a theoretical perspective – as a considerable determinant of firms’ investment decisions. Based on that, a large empirical literature has emerged quantifying the effect of corporate taxation on the investment behavior of (multinational) enterprises. Several meta-studies by, among others, Hines (1997), Devereux and Griffith (2002), De Mooji and Ederveen (2003, 2005, 2006), Devereux and Maffini (2006) or Feld and Heckemeyer (2011) take stock of the findings and conclude that the estimated elasticities show substantial heterogeneity. Devereux and Griffith (2002) or Overesch and Wamser (2009) refer to the broad range of distinct estimation designs as an explaining factor. In addition, Overesch and Wamser (2009, p. 1657) bring forward another argument: asymmetric tax effects might also be ‘an inherent characteristic of heterogeneous FDI’.

A number of empirical studies rely on a classification provided by the trade literature in order to capture distinct aspects of firm-heterogeneity. In particular, two investment motives are typically distinguished: Horizontal and vertical types. Nevertheless, as recently discussed in the trade literature and particularly by Alfaro and Charlton (2009), this classification still might fall short in identifying investment types. Specifically, they find that the absence of a more sophisticated differentiation might still lead to some sort of misspecification of investment types. Concerning the tax literature, any type of misspecification of investment types could result in biased tax elasticities. Herger et al. (2008) constitute – to our best knowledge – the only study estimating the impact of corporate taxation on the investment behavior of companies while accounting for a more sophisticated classification of investment types within micro data. Their results suggest that the impact of corporate taxation on investment decisions varies for different types of investments owing to distinct underlying investment motives. Restricting their analysis on cross-border acquisition (CBA) data from the United States (U.S.) they find evidence indicating asymmetric tax sensitivities. Along the same line, this paper makes a point for a more sophisticated classification of investment types to adequately estimate the impact of corporate taxation on the investment decisions of (multinational) corporations. In contrast to Herger et al. (2008), we focus on the intensive margin of investment and do not restrict our analysis on CBA data but also take into account the whole economic activity of multinational enterprises. Hereby, we employ a panel data set covering more than 70 distinct countries on a worldwide basis.

Furthermore, we highlight some important design features of the methodology employed by Alfaro and Charlton (2009) and show how they affect the classification into investment types. For example, the distinction between a direct and a global ultimate owner of a subsidiary as well as the relatedness to the overall multinational group strongly drives the classification of the investment types. Additionally, we allow for a bidirectional relationship of vertical integration which enables us to control also for a downward relatedness of (two) entities along the supply chain. Hereby, the occurrence of vertical relationships increases which in turn reclassifies some horizontal investment types to complex investments. As a consequence, we suggest a further refinement of the Alfaro and Charlton (2009) approach which makes more efficient use of the firm- and industry-level information embedded in the data. Specifically, we move beyond the strict categorization into four investment types and unbundle the complex investments again into its horizontal and vertical components.

The results suggest that non-related investments react strongest to corporate taxation, while the different business reasons for investment reduce the tax sensitivity to a varying degree. Vertical motives affect the tax semi-elasticity only to a minor extent, while horizontal investments – in most cases – exhibit no significant negative tax semi-elasticity.

Taking into account a strict classification identifying the distinct investment types the complex investment lies somewhere in-between regarding its tax sensitivity. However, by unbundling the complex investment into its components differences between the manufacturing industries sub-sample and the whole sample – covering all industries – become evident. This reinforces the importance of distinguishing between different design features when classifying investment types as these may largely drive the empirical results.

The remainder of the paper is organized as follows. Section 2 presents a brief literature survey and discusses possible channels for different tax sensitivities. In Section 3, we employ and extend a methodology discussed by Alfaro and Charlton (2009) identifying different types of investments. Section 4 presents the underlying data and introduces an estimation framework. Section 5 contains the empirical estimations and further sensitivity checks. Section 6 concludes with a summary of the most important findings.

## 2 Previous Literature

The present paper is located particularly at the intersection of the empirical public finance literature and the literature on (foreign direct) investment motives. Thus, Section 2 both places the current paper within each of the two strands of literature separately and collects their common features. In particular, this enables us to derive empirical predictions about heterogeneous tax elasticities for different types of investments.

### 2.1 Empirical evidence on tax elasticities

To broadly classify the extensive empirical literature on tax elasticities of investment we follow the distinction offered by Feld and Heckemeyer (2011). On the one hand, the underlying type of data can differ between studies (i.e., micro data or aggregate data). On the other hand, studies emphasize the role of continuous and/or discrete investment decisions. Table 1 classifies a number of empirical studies along these two dimensions.

**Table 1: Firm-heterogeneity in the tax literature**

	Continuous Investments	Location Decisions
Firm-Level Data	Buetter and Wamser (2009) Overesch and Wamser (2010)	Devereux and Griffith (1998)
		Mutti and Grubert (2004)
		Buettner and Wamser (2009)
		Overesch and Wamser (2009, 2010)
		Herger et al. (2015)
Aggregate Data	Shang-Jin (2000) Blonigen and Davies (2004) Hajkova et al. (2006) Bénassy-Quéré et al. (2007) Wolff (2007) Demekas et al. (2007) Egger et al. (2009)	

Note: This table is adapted from Feld and Heckemeyer (2011). Specifically, we restrict the entries in the table to studies which attempt to distinguish between horizontal and vertical investment.

Continuous investment decisions based on firm-level data are analyzed by, among oth-

ers, Buetter and Wamser (2009) and Overesch and Wamser (2010). While Buettner and Wamser (2009) emphasize the impact of non-profit taxes on both continuous and discrete investment decisions of German MNEs engaged in 22 OECD countries from 1996 to 2004, Overesch and Wamser (2010) focus on the impact of corporate tax policies implemented by the former ten European Union (EU) accession countries (as before the enlargement of the EU in 2004 and 2007) on continuous and discrete investment decisions of German MNEs between 1996 and 2005. On the contrary, Devereux and Griffith (1998), Mutti and Grubert (2004), Overesch and Wamser (2009, 2010) and Herger et al. (2015) accentuate discrete investment decisions of corporations. While Devereux and Griffith (1998) emphasize the impact of profit taxes on discrete investment decisions of U.S. multinationals engaged in France, Germany and/or the United Kingdom between 1980 and 1994, Mutti and Grubert (2004) analyze the effects of host-country taxation on discrete investment decisions of U.S. multinationals taking into account 60 different countries in 1996. Overesch and Wamser (2009), however, emphasize firm-heterogeneity while analyzing the impact of host-country corporate taxation on German outbound FDI taking into account 30 European countries between 1989 and 2005. In a similar vein, Herger et al. (2015) focus on firm-heterogeneity estimating the effects of various tax instruments on CBAs across 30 countries from 1999 to 2010.

In contrast, Shang-Jin (2000), Blonigen and Davies (2004), Hajkova et al. (2006), Bénassy-Quéré et al. (2007), Wolff (2007), Demekas et al. (2007) and Egger et al. (2009) rely on aggregate data analyzing the impact of (distinct aspects of) corporate taxation on continuous investment decisions of corporations. Shang-Jin (2000) analyzes the effects of both corporate taxation and corruption on bilateral FDI from twelve investing countries to 45 host-countries over the 1990s. By contrast, Blonigen and Davies (2004) emphasize the effects of bilateral tax treaties on in- and outbound U.S. FDI activity between 1980 and 1999. Hajkova et al. (2006) focus on bilateral FDI among OECD countries analyzing the impact of corporate taxation as well as of policy and non-policy factors for the years 1991 to 1999. Bénassy-Quéré et al. (2007) emphasize the role of public spendings in addition to corporate taxation as a determinant of bilateral FDI flows between the U.S. and 18 European countries from 1994 to 2002. Wolff (2007), however, focuses on bilateral FDI flows between 24 member states of the European Union covering the years 1994 to 2003. By contrast, Demekas et al. (2007) emphasize the role of different aspect of host-country policies as a determinant of both FDI stocks and flows between 24 source countries and 16 host-countries for the period 1995 to 2003. Finally, Egger et al. (2009) account for bilateral aspects of corporate taxation estimating the impact of (bilateral) effective corporate tax rates on outbound bilateral FDI stocks for 22 investing and 26 host-countries between 1991 and 2002.

## 2.2 Motives for (foreign direct) investment

The trade literature traditionally classifies (foreign) investment into two categories: Horizontal and vertical investments (see, among others, Helpman 1984, 1985, Brainard 1993, Markusen and Maskus 2001 and Markusen 2002). Horizontal investments are generally motivated exploiting the (absolute) size of a target market as well as by avoiding (or reducing) trade costs 'in the form of transport costs, tariffs and quotas, and more intangible proximity advantages' (Markusen 2002, p.19). Furthermore, the lower plant-level economies of scale relative to the corporate-level are, the more likely firms engage in a horizontal investment opposed to serving a market via exports (Brainard 1997). Thus, according to Brainard (1997), a horizontal investment can be characterized as a trade-off between proximity (in terms of direct access to a target market) and concentration (in terms of

plant-level economies of scale). By contrast, vertical investments are generally motivated by production-related differences of firm-specific factor intensities and distinct relative factor endowments of countries. Hereby, a fragmentation of the production chain results from an exploitation of international factor-price differences (Brainard 1997, Markusen 2002). Furthermore, Williamson (1979) stresses the role of transaction costs as a driving force for vertical integration while Acemoglu et al. (2009) emphasize the relevance of contracting costs in combination with the relative capital-intensity of industries and the financial development in a target market.

In spite of the largely recognized distinction between the two forms of investments, Alfaro and Charlton (2009) as well as Yeaple (2003) point out that the distinction between horizontal and vertical investments might suffer from several shortages. In particular, companies certainly pursue further motives when investing (abroad) as compared to horizontal or vertical strategies (see for this, e.g., Ansoff 1957, Smith and Schreiner 1969, Kotler and Trias de Bes 2003, Baker et al. 2009 or Erel et al. 2012). Non-related (also referred to as conglomerate) investments are traditionally motivated by aspects of diversification, profitability and synergies (Smith and Schreiner 1969). As discussed in the strategic management literature and, in particular, by Ansoff (1957, p. 142), a non-related diversification strategy is defined as a 'move beyond the confines of the industry to which the company belongs'. Hereby, Ansoff (1957) distinguishes between two main categories motivating a non-related diversification of investments – stability and flexibility. The former objective is related to a 'protection against unfavorable trends and foreseeable contingencies' (Ansoff 1957, p.119) as an economic recession or a 'major technological 'breakthrough' whose characteristics can be foreseen but whose timing cannot at present be determined' (Ansoff 1957, p.116). The latter objective is related to unforeseeable contingencies as (unpredictable) changes in market structures, preferences or technologies (Ansoff 1957). Kotler and Trias de Bes (2003) emphasize in particular the second objective describing innovative methods of strategic marketing. As they argue, the increasing saturation of markets, the continually changing consumer behaviors and the homogenization of products lead to an intensifying level of competition. Thus, according to Kotler and Trias de Bes (2003), a management strategy to ensure a sustainable corporate growth consists of inventing new products and/or services by combining existing but un-related businesses to new and unprecedented markets. Summarizing, a diversification strategy is generally – whether directly or indirectly – related to the spread of business risks. The profitability motive of non-related investments relates to the 'basis of financial considerations' (Ansoff 1957, p.121) of corporations as the acquisition of (profitable) enterprises operating in an external sector (Smith and Schreiner 1969). For FDIs and CBAs, Baker et al. (2009) as well as Erel et al. (2012) observe a positive relationship between the level of investments and source-country stock market valuations (Baker et al. 2009), however, without distinguishing between different types of investments. Finally, synergies of non-related investments can emerge in terms of financial and demand-driven synergies of a corporation (Smith and Schreiner 1969) while the degree of production-related synergies decreases the further the corporation deviates from its core business (Kotler and Trias de Bes 2003). In contrast to non-related investment strategies, complex investments can be, as a combination of horizontal and vertical investments, characterized by a sophisticated combination of production-related motives while the driving motive can be – from a theoretical perspective – either horizontally or vertically.

Given these additional investment motives, Alfaro and Charlton (2009) argue that forcing investments into the traditional classification of horizontal and vertical might lead to a misspecification of investment types in the data. Therefore, they combine – alike Fan and Lang (2000) and Fan and Goyal (2006) – firm-level data with information from input-output tables and provide a more sophisticated distinction of investment types. In

addition to the traditional distinction between horizontal and vertical investment types they also classify investments as non-related or complex. While a non-related investment is defined as an investment strategy without any vertical or horizontal link, a complex strategy combines both horizontal and vertical motives. Overall, they find that parts of investments have been wrongly classified to date in particular owing to specific data limitations. As they discuss, 'the central challenge for the literature has been the absence of a global source for firm-level data' (Alfaro and Charlton 2009, p. 2096) allowing for a more sophisticated differentiation of investment modes.

Thus, neglecting further motives as compared to the horizontal or vertical distinction might lead to a bias of estimation results. However, this aspect has hardly been taken into account in the tax literature to date. The only exemption constitute Herger et al. (2008) who focus on CBA data from the US. Nevertheless, despite the recourse to a more sophisticated method to distinguish between different investment modes we argue that their analysis still might be subject to some misspecification. In particular, Herger et al. (2008) determine investment types within related firms on the basis of a reduced parent-subsidiary relationship as opposed to the entire corporate group (by building firm-specific ownership chains). Furthermore, their methodology disregards the existence of a (simultaneous) up- and downstream vertical integration.

### 2.3 Investment types and expected tax effects

As discussed by, among others, Devereux and Griffith (2002), any investment would be – in a world without taxation and other frictions – expanded until the marginal product of capital equals the (world) rate of return. According to theory, (corporate) taxation is characterized as a distorting factor of this equilibrium. In particular, a small open economy implementing profit taxes faces an increasing 'required pre-tax rate of return, leaving the post-tax rate of return unaffected' (Devereux and Griffith 2002). From a theoretical perspective firms adapt by reducing the capital stock until the equilibrium condition is fulfilled again. Thus, according to common perception tax policies generally involve a negative impact on the 'level and timing of investment expenditures [...] [and] the composition of investment' (Hall and Jorgenson 1967, p.392). Nevertheless, in case of perfect (and thus costless) profit shifting between related enterprises located in high-tax and low-tax jurisdictions an increase in corporate taxation should have no negative impact on the investment volume as discussed by, among others, Overesch and Wamser (2009).<sup>1</sup> However, in line with the literature, we expect – at least *on average* – a negative impact of corporate taxation on the intensive margin of investment which is in line with the bulk of literature.

As discussed by Mutti and Grubert (2004), Overesch and Wamser (2009) or Herger et al. (2015) we expect asymmetric tax elasticities when emphasizing the role of firm-heterogeneity, particularly, as the underlying motives of different types of investment (may) vary significantly. According to Mutti and Grubert (2004) and Overesch and Wamser (2009) host-country taxation should be of 'secondary importance' (Overesch and Wamser 2009, p.1660) for horizontal investment decisions in contrast to vertical investment decisions. By assuming high trade costs as a motive for horizontal investments companies should face a lower level of competitiveness from outside a market. Therefore, taxation should be of secondary importance as all enterprises are subject to the same corporate tax rate. Furthermore, the more pronounced a corporation seeks to overcome (non-)tariff

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<sup>1</sup>Further, Schneider (1992) show theoretically that a higher corporate tax rate is associated with a higher level of investment if the depreciation for tax purposes is sufficiently higher than the economic depreciation rate which is commonly known as tax paradox.



barriers to trade and/or quotas through a horizontal investment the less significant corporation taxation is expected to be. On the contrary, vertically integrated companies typically engage in exports. Hence – as competitors are subject to various tax systems – vertical investments are expected to be more sensitive to host-country taxation compared to horizontal investments (Mutti and Grubert 2004). Furthermore, vertical investment decisions are primarily driven by cost considerations in terms of relative factor price differences and/or contracting costs. Thus, the impact of corporate taxation on vertical investment decisions is expected to be of greater importance than for horizontal investments (Overesch and Wamser 2009).<sup>2</sup>

Complex investments are – as a combination of horizontal and vertical motives – generally motivated by a sophisticated production-related business strategy. Overall, the impact of corporate taxation on complex investment decisions depends primarily on whether horizontal motives or vertical motives are characterized as the driving factor. As non-related investments exhibit the 'least strongest' (core) business-related investment motives we expect a more pronounced impact of corporate taxation on these type of investment decisions. The investment types and the respective motives are summarized, in addition to tax-related motives, in Table 2.

**Table 2: Key investment and tax-related motives and expected tax responsiveness**

<b>Investment type</b>	<b>Non-tax related motives</b>	<b>Tax-related motives</b>	<b>Expected tax responsiveness</b>
Horizontal Investments	Avoid/reduce trade costs Exploit (corporate-level) economies of scale	Enable debt shifting (and loss consolidation)	Weak
Vertical Investments	Exploit factor price differences Reduce contracting costs	Enable debt shifting (and loss consolidation) Exploit transfer prices	Moderate (None)
Non-Related Investments	Diversify risk Increase profitability Exploit (financial and demand-driven) synergies	Enable debt shifting (and loss consolidation)	Strong
Complex Investments	Combine horizontal and vertical motives	Enable debt shifting (and loss consolidation) Exploit transfer prices	Ambiguous

Note: Most of these motives are more prevalent for the extensive margin decision, e.g. international loss consolidation.

In addition to the above mentioned motives, (international) loss consolidation can be a motive if one side of the parent-subsidiary combination is in a loss-making position while the other is profitable.<sup>3</sup> Furthermore, the possibility of debt shifting motive might constitute an additional motive for all four investment types. While the link between

<sup>2</sup>Note that both Mutti and Grubert (2004) and Overesch and Wamer (2009) focus particularly on the extensive margin of investment. Nevertheless, we expect similar effects for the intensive margin.

<sup>3</sup>International loss consolidation is strongly limited in most countries, but since our dataset also contains parent-subsidiary combinations in the same country, loss consolidation might be a tax motive.

investment and debt shifting possibilities is obvious for the extensive margin it may also apply for the intensive margin, particularly in the context of thin capitalization rules (see, e.g., Buettner et al., 2014).

The impact of corporate taxation at the intensive margin is less trivial when transfer prices are exploited in order to engage in profit shifting activities. If transfer pricing makes profit shifting 'very cheap', taxation should have no longer a negative impact on investment. On the contrary, if the transfer pricing possibilities depend on the invested capital stock, the influence of corporate taxation can be more pronounced.<sup>4</sup> While all four types of investments might offer some possibilities for profit shifting through distorted transfer prices, these opportunities should be strongest for vertical and complex investments since both tend to involve more intra-group transactions. Hence, the prediction for the tax elasticity for vertical investment becomes ambiguous; either it should be stronger than for horizontal investment or taxes should play no longer a role.

In sum, we expect highly heterogeneous tax elasticities between the four types of investments as the respective investment motives vary substantially. A considerable effect is expected for non-related investments, while we expect for horizontal investment decisions only a minor impact of corporate taxation. Expectations for vertical investments are less clear; the tax elasticity might even be stronger if transfer pricing possibilities also depend on the investment level. For complex investments: The effect depends primarily on the relative strength of the horizontal and vertical investment motives.

### 3 Identifying different investments modes in firm-level data

The starting point to distinguish between horizontal, vertical, complex and non-related investment types is a methodology employed by Alfaro and Charlton (2009). By combining firm-specific information with information from input-output tables this approach allows to characterize the investment in a subsidiary as one of the four types mentioned above. For this purpose, two sources of data are necessary: (i) Information on the sectors of both the subsidiary and the owner(s) and (ii) information on the strength of relatedness between these industries.

#### 3.1 The Alfaro and Charlton (2009) approach

Alfaro and Charlton (2009) identify the four investment types as follows: Let  $S$  and  $O$  denote a set of industry codes of the subsidiary and the owner, respectively. Furthermore, the term  $x \rightarrow z$  states that any element of  $x$  is an input for any element of  $z$ , while  $x \in S$  and  $z \in O$ . This relation holds, if the input coefficient between  $x$  and  $z$  is larger than a cut-off value defined in the following. Hereby, horizontal, vertical, non-related and complex investments are identified in the following way:

- (i) An investment is classified as horizontal if  $S$  and  $O$  have any element in common (if  $\exists x | x \in S \vee x \in O$ ) or if  $S = O$ .
- (ii) An investment is classified as vertical if any element of  $S$  provides an input for any element of  $O$  ( $\exists x | x \rightarrow z$  where  $x \in S$  and  $z \in O$ ) and if  $S \neq O$ .

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<sup>4</sup>See Loretz and Mokkas (2015) for an analysis of profit shifting where the possibility of profit shifting also depends on the capital stock.

- (iii) An investment is classified as complex if  $S$  and  $O$  have any element in common (if  $\exists x | x \in S \vee x \in O$ ), if any element of  $S$  provides an input for any element of  $O$  ( $\exists x | x \rightarrow z$  where  $x \in S$  and  $z \in O$ ) and if  $S \neq O$ .
- (iv) An investment is classified as non-related if none of these relationships apply, i.e. they show neither horizontal nor vertical (or complex) structures.

While this method certainly constitutes an improvement towards the traditional distinction between vertical and horizontal investment, the resulting investment classification still suffers from two major shortcomings: (i) The resulting classification of investment types is large depending on design features of the approach and (ii) the strict distinction into four investment types does not fundamentally overcome the problem of a strict categorization into distinct investment types. Hence, to further improve the approach as defined by Alfaro and Charlton (2009) we first investigate the role of design choices in the outcome of the investment classification and then propose an extension to the existing method which, among others, aims to overcome the strict categorical distinction of investment types.

### 3.2 Impact of design features on investment classification

The above described method by Alfaro and Charlton (2009) has several inherent design features which may significantly affect the outcome of an investment's classification. In the following, we discuss the impact of a non-exhaustive list of conceivable design features<sup>5</sup>:

- (i) The restriction of the dataset to the manufacturing industries
- (ii) The level of disaggregation in the industry classifications
- (iii) The choice of the threshold level for the input coefficients
- (iv) The restriction to one direction of the input relationship
- (v) The choice of the owner and subsidiary pair
- (vi) The treatment of complex relationships

The **restriction of the firm-level dataset to manufacturing industries** may be justified only by the argument that distinguishing between different investment modes is more relevant for this sub-group of industries. Further, a vertical investment might be characterized by the separation of head quarter activities from the production process which, in turn, would be excluded from the dataset if data is restricted to the manufacturing industries only. Thus, in addition to a lower share of vertical investments we expect the share of horizontal investment to be larger since the total number of reported industry codes by firms decreases which, in turn, should be associated with a higher likelihood of overlapping.

The impact of the **level of disaggregation in the industry classification** (e.g., the distinction between 4-digit industry codes and 6-digit industry codes) is unambiguous for the share of horizontal investments. The broader the system of industry classifications is

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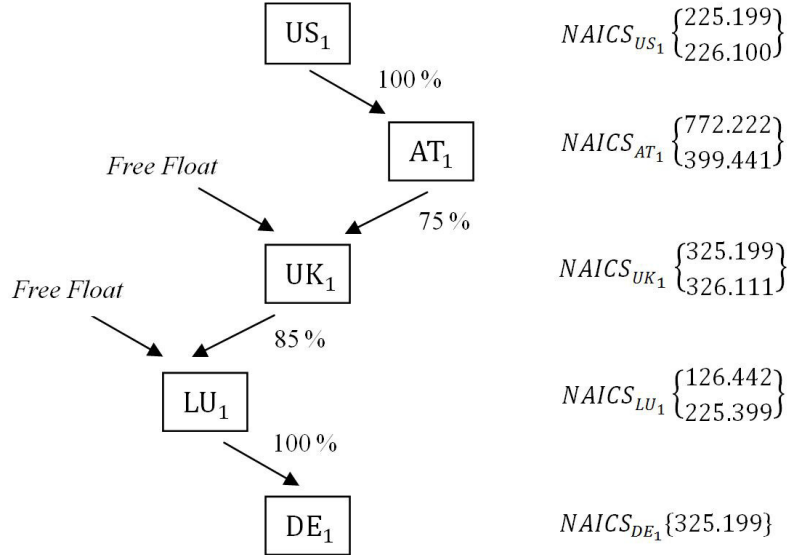
<sup>5</sup>Further aspects which are likely to be of importance constitute, e.g., the choice of the industry classification system (NAICS vs. NACE), country specific input coefficients or the use of reported secondary industry codes.

the more likely investments should be classified as horizontal. By contrast, the impact on vertical linkages is less clear since we aggregate the input coefficients by averaging them.

The **choice of the threshold level for input coefficients** has no direct impact on the classification of horizontal investments, however, a lower threshold results in a higher share of vertical investments which, in turn, might reclassify some of the previously determined horizontal linkages (in combination with some newly determined vertical linkages) as complex investment types.

In the original approach Alfaro and Charlton (2009) employ a **restriction to one direction of the input relationship**. In particular, only upstream integration along the supply chain is characterized as a vertical investment. In order to provide a relaxation of this restriction, we also allow for a bidirectional integration (i.e., up- and downstream integration) which, in turn, should increase the share of both vertical and complex investments. By contrast, simply replacing the upstream integration with downstream integration should only have a minor impact on the distribution of investment types.<sup>6</sup>

Finally, one of the most important and least obvious design feature is the **choice of the owner-subsidiary pair**. For the sake of illustration, Figure 1 provides an example highlighting the impact of an owner-subsidiary pair chosen.



**Figure 1: Ownership structure of a corporate group**

As illustrated, subsidiary  $DE_1$  reports four distinct majority-owning shareholders, i.e.,  $LU_1$ ,  $UK_1$ ,  $AT_1$  or  $US_1$ . Depending on the specific research question the literature typically emphasizes either the role of the direct owner (i.e.,  $LU_1$ ) and/or the role of the global ultimate owner (i.e.,  $US_1$ ) of a subsidiary.<sup>7</sup> However, with respect to the method presented above the existence of more than one owner raises a fundamental question: Which type of owner is appropriate to identify the characteristics of a subsidiary within a multinational group? Alfaro and Charlton (2009) define the global ultimate owner as reference for identifying the characteristics of a subsidiary. However, by means of constructing firm-specific ownership chains we are able to further amend this approach. In particular, we assign the

<sup>6</sup>Note that the classification of the individual investments may well change, but unless the parent or subsidiaries are more likely to be present in particular industries, the overall distribution of investment types should not be affected much.

<sup>7</sup>A global ultimate owner is characterized as the (last available) majority-owning shareholder of a subsidiary in a corporate group.

(industry codes of a) subsidiary to three different 'categories' of (collections of industry codes of) owners: (i) The global ultimate owner, (ii) the direct owner and (iii) the whole corporate group. Thus, in addition to the global ultimate owner and the direct owner we are also able to characterize the role of a subsidiary with respect to all other entities of the same corporate group. Referring to the illustrated example above: There is no argument, why the linkages between the subsidiary and the whole group should be weaker compared to both the direct or the global ultimate owner. Instead, linkages are expected to be even stronger than to either the direct or the global ultimate owner. Hence, restricting the analysis to both the direct owner and the global ultimate owner is very likely to overestimate the share of non-related investments.

The example provided in Figure 1 also highlights the importance of the **treatment of complex relationships**. Determining the characteristics of subsidiary  $DE_1$  with respect to the whole corporate group we observe a horizontal link to the  $UK_1$  entity. Further, if there exists an input relationship between the reported industry of  $DE_1$  with any other reported industry of any other entity within the same corporate group the investment would be classified as complex. The researcher, however, may prefer to still classify  $DE_1$  as horizontal since the vertical linkage is already present within the corporate group (through entity  $UK_1$  which reports the identical industry code). Therefore, one can restrict the characterization by counting industries with horizontal links only once (i.e., 'single counting'). Hereby, vertical (and therefore complex) investments could just be determined with additional reported industry codes. In other words,  $DE_1$  could only be classified as complex if it would report an additional industry code which is characterized by a new vertical link with respect to the corporate group. This is in contrast to the 'double counting' employed by Alfaro and Charlton (2009) who would classify  $DE_1$  as complex also in the case when the vertical link is already present in the corporate group (by the parent or the direct owner). Single rather than double counting should leave the purely horizontal and the purely vertical investment types unaffected but potentially reclassifies a rather large share of complex investments as horizontal.

To further undergird the crucial role of employed design features Table 3 provides a numerical argument for both the relevance and impact of choices made to determine the four types of investments. Rather than presenting the resulting distribution of the four investment types under all possible combinations, we present the impact of each choice through a simple regression on dummies for the respective assumptions during the classification.<sup>8</sup>

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<sup>8</sup>In total we have 2 samples, 3 levels of industry aggregation, 2 levels of thresholds, 3 combinations of directions of the vertical integration, 3 ownership concepts and 2 ways of treating complex investments. Thus, the total number of industry classifications and therefore the number of observations for the regression amounts to  $2 \times 3 \times 2 \times 3 \times 3 \times 3 \times 2 = 216$ .

**Table 3: Impact of design features on investment classification**

Design feature	Share of investment which is classified as			
	horizontal	vertical	complex	non-related
Manufacturing only	0.232 (0.009) ***	-0.186 (0.008) ***	-0.003 (0.009)	-0.043 (0.008) ***
5 digit NAICS code	-0.046 (0.011) ***	0.024 (0.010) **	0.013 (0.011)	0.009 (0.010)
6 digit NAICS code	-0.114 (0.011) ***	0.053 (0.010) ***	0.049 (0.011) ***	0.012 (0.010)
5 % threshold input coeff.	0.024 (0.009) ***	-0.177 (0.008) ***	-0.024 (0.009) ***	0.177 (0.008) ***
Upstream only	0.009 (0.011)	-0.042 (0.010) ***	-0.0009 (0.011)	0.042 (0.010) ***
Up- and downstream	-0.007 (0.011)	0.077 (0.010) ***	0.007 (0.011)	-0.077 (0.010) ***
Global owner	-0.027 (0.011) **	0.006 (0.010)	-0.002 (0.011)	0.024 (0.010) **
Groupwide relation	0.123 (0.011) ***	-0.037 (0.010) ***	0.106 (0.011) ***	-0.192 (0.010) ***
Single counting	0.110 (0.009) ***	-0.000 (0.008)	-0.110 (0.009) ***	-0.000 (0.008)
Constant	0.172 (0.015) ***	0.357 (0.013) ***	0.080 (0.014) ***	0.391 (0.013) ***

Note: The results are based on the classification of 339,489 subsidiaries for the full sample, while the manufacturing sample consists of 19,664 subsidiaries. Standard errors in brackets, \*\*\* significant at the 1% level, \*\* significant at the 5% level, \* significant at the 10% level.

The comparison group for the share of different investment types is represented in the coefficient of the constant. In particular, this classification is characterized by the following assumptions: All industries are included, the industries are aggregated up to the 4-digit level of the North American Industry Classification System (NAICS), the threshold for a vertical relationship is set at an input coefficient of 1 %, only downstream integration is employed, the relationship with the direct owner is evaluated and industries with horizontal links are also used for vertical links (i.e., double counting). Given these assumptions the distribution of investment types is as follows: 17.2 % horizontal, 35.7 % vertical, 8 % complex and 39.1 % non-related. Further, in several cases Table 3 reports both large and highly significant coefficients for the distinct design features. In particular, this reveals that the classification depends to a large degree on the researchers' choice. By restricting, e.g., the dataset to the manufacturing industries the share of horizontal investment increases substantially. On the contrary, defining a higher threshold for the relatedness of different industries (i.e., 5 %) reduces – in line with expectations – the share of both vertical and complex investments. Further, assigning the subsidiaries to the (remaining) corporate group leads to a strong decrease in the share of non-related investments. Finally, employing the single counting of industries with horizontal links causes a considerable shift of certain parts of complex investments back into the horizontal investment category. Overall, it turns out that distinct design features have a non-negligible impact on the investment types' distributions.

### 3.3 Move beyond strict categorization

The last example in the previous subsection illustrates rather well the remaining shortcoming of the Alfaro and Charlton (2009) approach. The strict categorization into one of four categories may not fully reflect the different nuances of the investment types. If, e.g., only one of several industries in the sets of  $S$  and  $O$  overlap the investment is, according to Alfaro and Charlton (2009), classified as horizontal. As such, it is characterized similarly compared to a case where two sets with a large number of industries fully overlap. In order to address this, we propose to relate the (number of) horizontal and vertical links to the maximum possible links rather than just defining dummies for their presence. Interestingly, the necessary information is already present in the underlying data but remains unused in the Alfaro and Charlton (2009) approach.

Let  $n$  denote the number of distinct industries reported by a subsidiary (i.e., in the set of  $S$ ) and  $k$  define the number of different industries reported by an owner (i.e., in the set of  $O$ ). Further, define  $h \geq 0$  as the total number of horizontal links (i.e., the number of industries which are present in both  $S$  and  $O$ ). Hence, the maximum of  $h$  is given through  $\min(n, k)$ . Along the same logic, define  $V$  as the total number of vertical links (i.e., the number of industry pairs which have an input relationship above the defined threshold). As it turns out, the maximum of  $V$  depends on the treatment of complex relationships: If we allow for double counting of horizontally linked industries the maximum of  $V$  amounts to  $n \times k - h$  while the maximum number of total links simply results from  $n \times k$ . In contrast, if horizontally linked industries are only used once (i.e., single counting) the maximum of  $V$  reduces to  $n(k - h)$  while the maximum number of total links is  $n(k - h) + h$ . Given that we can observe the maximum of possible links between a subsidiary and the respective owner(s) we are able to define the relative horizontal link as a share of the total possible links, i.e., either  $H = h/(n \times k)$  or  $H = h/[n(k - h) + h]$ . Correspondingly, the relative vertical link is characterized either by  $V = v/(n \times k)$  or by  $V = v/[n(k - h) + h]$ . As it turns out, the sum of both  $H$  and  $V$  cannot be greater than unity which allows the interpretation of  $1 - H - V$  as the non-related investment. Alternatively, one could define both the horizontal and vertical links relative to their respective maximum, i.e.,  $H = h/\min(n, k)$  and  $V = v/(n \times k - h)$  respectively  $V = v/[n(k - h)]$ . However, this approach implies that the interpretation of  $1 - H - V$  as the non-related investment is no longer valid as it allows, in sum, for more than 100 % of links between a subsidiary and the owner(s).

To further illustrate this idea consider an example with  $n = 2$  and  $k = 5$ . Assume that both industries in  $S$  are overlapping with two industries in  $O$  which, in turn, results in  $h = 2$ . Furthermore, both industries in  $S$  mutually provide inputs and are vertically related to one more industry reported at the owner level (i.e., in the set of  $O$ ). Hence, the vertical link is  $v = 4$  if double counting is permitted and  $v = 2$  if it is ruled out. This results in a categorization of  $H = h/(n \times k) = 2/(2 \times 5) = 1/5$  and  $V = v/(n \times k) = 4/(2 \times 5) = 2/5$  under double counting of horizontal links and  $H = h/[n(k - h) + h] = 2/[2(5 - 2) + 2] = 1/4$  and  $V = v/[n(k - h)] = 2/[2(5 - 2) + 2] = 1/4$  under single counting. This illustrates rather well that double counting of the horizontal links also attributes intra-subsidiary vertical links (as both industries in  $S$  mutually provide inputs) to the subsidiary-owner relationship. Furthermore, this example highlights that the assumption of unity for total linkages scales down the – in principle strongest possible – horizontal link (which is given by  $h = 2 = \min(n, k)$ ) drastically to  $H = 1/5$  and  $H = 1/4$ , respectively. As a result, the share of  $H$  is even below the share of vertical link in the case of double counting (i.e.,  $H = 1/5 < V = 2/5$ ). As discussed, one can alternatively measure the strength of both the vertical and the horizontal links relative to their respective maximum. Hence, the shares are

characterized by  $H = h/\min(n, k) = 2/2 = 1$  and  $V = v/(n \times k - h) = 2/(2 \times 5 - 2) = 1/4$  respectively  $V = v/[n(k - h)] = 2/[2(5 - 3)] = 1/2$ .

Note, that the category of complex investment as introduced by Alfaro and Charlton (2009) is unbundled and split into its horizontal and vertical components in all of the employed approaches of this subsection. Absent a conclusive theoretical argument why the combination of horizontal and vertical motives (i.e., a complex investment) should matter for a specific research question we argue that the category complex investment is better captured through its horizontal and vertical components. In this respect, it is straightforward to test whether complex investments exhibit a distinct effect.<sup>9</sup>

## 4 Data

In order to account for heterogeneous investment motives following the (extended) Alfaro and Charlton (2009) approach (at least) two sources of data are necessary: (i) Firm-level data on the investment flows as well as information about the respective activities (i.e., the sector) and (ii) industry-level data about vertical linkages between different activities/industries. In addition, it requires country-specific information in order to appropriately evaluate the impact of investment heterogeneity on the respective tax elasticities; this includes the respective tax measures as well as further relevant control variables.

### 4.1 Firm-level information

The necessary information about both the investments and the ownership structure of the corporate groups is taken from the Orbis database provided by the Bureau van Dijk. The main advantage of this data source is particularly the standardized information about balance sheets and profits and losses accounts in combination with detailed ownership information. At the same time, some limitation apply, e.g., the country coverage outside of Europe is somewhat limited. Overall, we use a download from the online version which leaves us with data for a ten year time window from 2003 to 2012 while the ownership information is valid for the end of this period. The latter particularly points to another limitation of data: The ownership information available is only cross-sectional. The respective firms we downloaded from Orbis are, by definition, part of a multinational group, i.e., at least two entities of a corporate group are located in two distinct countries while subsidiaries are majority owned. Taking advantage of the ownership information in this large dataset we are able to construct ownership chains from each subsidiary to the reported global ultimate owner.<sup>10</sup>

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<sup>9</sup>In particular, we employ an interaction term between the horizontal and vertical linkage in the empirical Section 5.

<sup>10</sup>Specifically, we work out the ownership chains for more than 1.6 million subsidiaries in 191 countries.



**Table 4: Summary statistics: Firm-level data**

<b>Sample for investment classification, all industries (339,489 observations)</b>				
<b>Variable</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min.</b>	<b>Max.</b>
4 digit NAICS classification, direct owner				
No. industries subsidiary	1.217	0.486	1.000	18.000
No. industries owner	1.143	0.408	1.000	14.000
6 digit NAICS classification, whole group				
No. industries subsidiary	1.741	1.252	1.000	34.000
No. industries group	13.041	27.270	1.000	286.000
<b>Sample for investment classification, manufacturing sub-sample (19,664 observations)</b>				
<b>Variable</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min.</b>	<b>Max.</b>
4 digit NAICS classification, direct owner				
No. industries subsidiary	1.090	0.356	1.000	14.000
No. industries owner	1.059	0.265	1.000	14.000
6 digit NAICS classification, whole group				
No. industries subsidiary	1.635	1.187	1.000	26.000
No. industries group	7.199	10.564	1.000	67.000
<b>Sample for tax elasticities regressions, all industries</b>				
<b>Variable</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min.</b>	<b>Max.</b>
log(Tangible Assets) ( $TANG_{st}$ )	12.631	2.703	0.000	24.243
log(Total Assets) ( $ASSETS_{st}$ )	15.010	2.086	0.693	25.362
4 digit NAICS classification, direct owner (287,219 firms, 1,617,836 observations)				
Dummy horizontal investment ( $HOR_s^{4D}$ )	0.192	0.394	0.000	1.000
Dummy vertical investment ( $VER_s^{4D}$ )	0.565	0.496	0.000	1.000
Dummy complex investment ( $COM_s^{4D}$ )	0.031	0.174	0.000	1.000
Share horizontal investment ( $shHOR_s^{4D}$ )	0.222	0.415	0.000	1.000
Share vertical investment ( $shVER_s^{4D}$ )	0.578	0.485	0.000	1.000
6 digit NAICS classification, whole group (286,457 firms, 1,605,265 observations)				
Dummy horizontal investment ( $HOR_s^{6G}$ )	0.073	0.260	0.000	1.000
Dummy vertical investment ( $VER_s^{6G}$ )	0.437	0.496	0.000	1.000
Dummy complex investment ( $COM_s^{6G}$ )	0.402	0.490	0.000	1.000
Share horizontal investment ( $shHOR_s^{6G}$ )	0.468	0.496	0.000	1.000
Share vertical investment ( $shVER_s^{6G}$ )	0.647	0.385	0.000	1.000
<b>Sample for tax elasticities regressions, manufacturing sub-sample</b>				
<b>Variable</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min.</b>	<b>Max.</b>
log(Tangible Assets) ( $TANG_{st}$ )	14.196	2.615	0.000	23.389
log(Total Assets) ( $ASSETS_{st}$ )	16.052	2.100	3.664	24.607
4 digit NAICS classification, direct owner (16,116 firms, 102,679 observations)				
Dummy horizontal investment ( $HOR_s^{4D}$ )	0.493	0.500	0.000	1.000
Dummy vertical investment ( $VER_s^{4D}$ )	0.160	0.367	0.000	1.000
Dummy complex investment ( $COM_s^{4D}$ )	0.030	0.172	0.000	1.000
Share horizontal investment ( $shHOR_s^{4D}$ )	0.523	0.499	0.000	1.000
Share vertical investment ( $shVER_s^{4D}$ )	0.185	0.385	0.000	1.000
6 digit NAICS classification, whole group (16,099 firms, 102,000 observations)				
Dummy horizontal investment ( $HOR_s^{6G}$ )	0.192	0.394	0.000	1.000
Dummy vertical investment ( $VER_s^{6G}$ )	0.230	0.421	0.000	1.000
Dummy complex investment ( $COM_s^{6G}$ )	0.424	0.494	0.000	1.000
Share horizontal investment ( $shHOR_s^{6G}$ )	0.609	0.485	0.000	1.000
Share vertical investment ( $shVER_s^{6G}$ )	0.393	0.393	0.000	1.000

Note: Unconsolidated accounts only. Both up- and downstream integration is taken into account for the industry classification with a threshold of 1 % for the input coefficient. Horizontal links are double counted and the shares for horizontal and vertical investment are calculated in relation to their respective maxima. The subscripts  $s$  and  $t$  denote the subsidiary respectively the time.

The construction of firm-specific ownership chains enables us to replace public entities or persons characterized as a global ultimate owner by the highest corporate owner in order to avoid a systematic dropout bias. However, as subsidiaries, direct owners and global ultimate owners need to report at least one industry classification (which can be matched to the input-output tables provides by the Bureau of Economic Analysis, BEA) reduces the sample considerably. Nevertheless, we still used the largest possible set of corporations to determine the role of a subsidiary towards its owner/the rest of the corporate group. In particular, we drop observations with missing balance sheet information not until a later stage. Therefore, the upper part of Table 4 reports the relevant information for characterizing the role of a subsidiary towards its owner(s)/the remaining corporate group while the lower part reports the descriptive statistics for the data used in the regressions employed in Section 5.

The discussion in Section 3 highlights the importance of the underlying design feature(s) when classifying investment types. In the interest of space we only present two main 'compositions' of data which, however, represent very distinct outcomes. Firstly, we take into account a very disaggregated level of industry classifications (i.e., 6-digit NAICS codes) in combination with the group-wide approach and the strict categorization of investment types (i.e., the dummy variable approach). Overall, we expect relatively few investments being classified as horizontal. Secondly, we characterize the subsidiaries with respect to their direct owners while employing a more aggregate level of industry classifications (i.e., 4-digit NAICS codes), again, for the strict categorization. This, in turn, should result in higher amount of horizontally classified investments. As discussed, the upper part of Table 4 depicts the total number of industries reported by both the subsidiaries and their direct owner respectively the (remaining) corporate group while employed for both all industries and the manufacturing sub-sample (i.e., the sample restricted to firms which are active in at least one manufacturing industry). A comparison between both samples reveals a strong drop in the number of observations, i.e., a decrease from 339,489 to 19,664 subsidiaries. Further, by taking into account the direct owners indicates that the average number of industries at the subsidiary level is not much above one, particularly in the manufacturing sub-sample. Bearing in mind that the classification of complex relationships is not possible when both the subsidiary and the owner report only one industry code makes a strong argument for the group-wide approach. Thus, looking at the (remaining) corporate group the average number of reported industries is up to more than 13 for the full sample and still up to more than 7 for the manufacturing sub-sample.

The lower part of Table 4 presents, among others, the key variable of interest for the estimation of tax elasticities, namely the *tangible fixed assets*. Focusing on the intensive margin of investment one would ideally take into account data on the actual (yearly) *volume* of investment. However, owing to limitations of data we are required to proxy – in line with previous studies – investment by the *stock* of company-specific (tangible) assets. Nevertheless, by estimating a fixed effects model we are able to capture the impact of corporate taxation on the *deviation* of the capital stock from the mean value. To additionally control for the size of the respective subsidiary we further account for its total assets. Both variables are measured in thousands of USD and taken in logarithm in order to obtain semi-elasticities.

The remaining lower part of Table 4 shows the resulting classifications for the investment. As discussed, out of the broad possibility of different combinations for classifying the investment we focus on the above mentioned two cases and keep the all other design features constant. In particular, these include the definition of a 1 % threshold level for the input coefficient, the accounting for both up- and downstream integration and the double counting of industries with horizontal links. Comparing the outcome for the 4-digit

NAICS codes in conjunction with the direct owner to the 6-digit NAICS codes in combination with the whole corporate group one can see that the links are, not surprisingly, much more pronounced in the group-wide case.<sup>11</sup> By employing the strict classification (i.e., defining dummies) this is reflected in a much larger share of complex investment, while the share of both horizontal and vertical investments increases under the continuous approach. Comparing the investment classifications between the full sample and the manufacturing sub-sample broadly results in a similar picture. Note, however, that the horizontal links are more pronounced owing to the restricted set of industries which is in line with expectations.

## 4.2 Industry-level and country-level data

To measure the strength of vertical relatedness we follow the original Alfaro and Charlton (2009) approach and make use of the 2007 U.S. Benchmark Input-Output Tables of the Bureau of Economic Analysis (BEA). These provide us with input coefficients for bilateral combinations of 6-digit NAICS industries.<sup>12</sup> In the case of more aggregated industry classifications (i.e., the 4-digit NAICS codes) we employ a simple average of the input coefficients.

The importance of an adequate *tax measure* for estimating tax elasticities of investments has been – amongst others – stressed by Devereux and Griffith (2002). Given that backward looking measures are calculated from actual tax payments (as stated in the profit and loss account) they appear most likely to be endogenous in regressions for tax effects with respect to investments. This particularly resulting as the taxable profit itself is a result of the tax burden. Hence, Devereux and Griffith (2002) argue in favor of forward looking tax rates, preferably taking into account tax base aspects. Thus, in line with the recent literature we employ three different tax measures. First, the top statutory corporate tax rate (*STR*) is the simplest and most salient tax rate.<sup>13</sup> Some of the recent empirical literature, e.g., Overesch and Wamser (2009) argue in favor of the statutory tax rate since it constitutes most probable the best information available from a company’s perspective.

In addition to the statutory tax rate we also employ forward looking effective tax rates in the tradition of King and Fullerton (1984) and further developed by Devereux and Griffith (1998). In particular, we take into account effective marginal tax rates (*EMTR<sub>t</sub>*) and effective average tax rate *EATR*.<sup>14</sup> Following the argumentation of Devereux and Griffith (2002) the latter should be the appropriate tax measure for the extensive margin of investment while the *EMTR* is more adequate for analyzing the intensive margin of investment decisions. The top of Table 5 shows that the statutory tax rate, with an average of 30.1 %, is somewhat higher than the effective tax measures with 26.7 % for the *EATR* and 24.9 % for the *EMTR*.

In order to capture non-tax motives for an investment decision we follow the literature by employing a gravity approach.<sup>15</sup> The gravity approach is a workhorse model in the trade literature which basically stipulates that the strength of a bilateral relationship is

<sup>11</sup>However, note that the samples slightly differ since the country coverage for the additional control variables affects the final sample. In particular, this results from the variation of the owner-countries.

<sup>12</sup>After having adapted the industry classification system of the BEA to the NAICS.

<sup>13</sup>Note, that we include generally applicable local profit taxes. For large countries like Germany we employ an average of the local business tax, while for small countries like Luxembourg we use the rate of a typical investment location, e.g., Luxembourg City.

<sup>14</sup>Since the tax data used in this paper is an update of the dataset compiled for Loretz (2008) we refer the interested reader to this publication for more detailed information on the parameterization.

<sup>15</sup>See also De Mooij and Ederveen (2003, 2005, 2006) for a extensive discussion of the empirical approaches in the tax literature.

proportionate to the size of two entities and inversely proportionate to the bilateral distance between both. Following the application of the gravity model determining the tax elasticity of FDI as discussed by Bénassy-Quéré et al. (2005) we capture the country sizes of both the subsidiary- and the owner-country through their respective gross domestic product (*GDP*). Overall, a larger investment and market potential in the host-country is associated with a positive impact on the total investments volume (Bénassy-Quéré et al. 2005). Note, however, that further variables of the classical gravity specification, e.g., bilateral distance and a common language dummy are time-invariant and therefore fully captured through the subsidiary-level fixed effects.<sup>16</sup>

**Table 5: Summary statistics**

Variable	Mean	Std. Dev.	Min.	Max.
Statutory tax rate subsidiary c. ( $STR_{ht}$ )	0.301	0.054	0.000	0.421
Effective average tax rate subsidiary c. ( $EATR_{ht}$ )	0.267	0.051	0.000	0.411
Effective marginal tax rate subsidiary c. ( $EMTR_{ht}$ )	0.249	0.055	0.000	0.409
Log( <i>GDP</i> ) subsidiary c. ( $GDP_{ht}$ )	27.492	1.146	21.865	30.286
Log( <i>GDP</i> ) owner c. ( $GDP_{ot}$ )	27.562	1.155	21.865	30.286
Log(population) subsidiary c. ( $POP_{ht}$ )	17.301	1.122	12.896	21.019
Log(population) owner c. ( $POP_{ot}$ )	17.330	1.164	12.896	21.024
Log(average wage) subsidiary c. ( $WAGE_{ht}$ )	7.801	0.790	4.435	8.919
Log(average wage) owner c. ( $WAGE_{ot}$ )	7.845	0.769	4.008	8.919
Openness to trade subsidiary c. ( $TRADE_{ht}$ )	71.346	33.853	22.090	439.657
Openness to trade owner c. ( $TRADE_{ot}$ )	71.233	35.348	22.090	447.058
Unemployment rate subsidiary c. ( $UE_{ht}$ )	7.925	3.298	2.500	37.300
Unemployment rate owner c. ( $UE_{ot}$ )	7.801	3.245	0.600	37.000
Inflation rate subsidiary c. ( $INFL_{ht}$ )	2.974	3.184	-4.480	53.229
Inflation rate owner c. ( $INFL_{ot}$ )	2.866	3.105	-4.480	53.229
Trade freedom subsidiary c. ( $TRADE\_Freed_{ht}$ )	81.863	6.833	23.000	90.000
Trade freedom owner c. ( $TRADE\_Freed_{ot}$ )	81.762	6.916	23.000	95.000
Investment freedom subsidiary c. ( $INV\_Freed_{ht}$ )	67.416	17.585	20.000	95.000
Investment freedom owner c. ( $INV\_Freed_{ot}$ )	67.954	17.441	5.000	95.000
Freedom f. corruption subsidiary c. ( $COR\_Freed_{ht}$ )	66.580	19.466	19.000	99.000
Freedom f. corruption owner c. ( $COR\_Freed_{ot}$ )	67.888	19.088	10.000	99.000

Note: The summary statistics refer to the specification with all industries and the global ultimate owner-country. Overall, this results in 1,605,265 observations in 286,457 subsidiaries. The subsidiaries are located in 57 different countries with 80 different owner-countries. *GDP* is in thousand USD, average wages in USD, openness to trade, the unemployment rate and inflation is in percent, respectively. Index *h* denotes the location of a subsidiary (i.e., the host-country), index *o* stands for the location of the global ultimate owner, while index *t* describes the respective year.

Since the main argument of this paper hinges on the heterogeneity of investment motives it requires to include further control variable to account for relevant country characteristics. To partly capture the motive of factor-price differences we take into account the (logarithm of the) average nominal wages (*WAGE*) for both the subsidiary- and owner-country.<sup>17</sup> However, the expected sign remains theoretically indeterminate. On the one hand, a higher average wage is associated with higher costs and a less competitive investment

<sup>16</sup>This is due to the time-invariant nature of our ownership structure. A further time-invariant variable of interest would be a dummy for domestic investment since Dischinger et al. (2014) can show that enterprises' investment and profits tend to be biased towards the home-country of the corporation.

<sup>17</sup>The average wages are taken from the International Labour Organization and converted into USD using the end of the year exchange rate.

environment. On the other hand, higher average wages are typically related to higher capital intensities which, in turn, are associated with a positive impact on the total volume of investment (Overesch and Wamser 2009). In addition to the economic size measured by the GDP we also account for the (logarithm of the) population (*POP*) as a measure of the market size. Further, we take into account the trade openness (*TRADE*), the unemployment rate (*UE*) and the inflation rate (*INFL*) capturing further determinants of the attractiveness of the business environment. The level of population, the degree of openness, the unemployment rate and the inflation rate are sourced from the World Bank. Finally, we employ three further indicators controlling for distinct aspects of the business and investment environment in the respective home- and host-countries. A higher level of investment freedom (*INV\_Freed*) in a country is associated with lower 'constraints on the flow of investment capital'. Hence, the indicator is expected to have a positive impact on the investment volume. In the same vein, business freedom (*BUS\_Freed*) constitutes a 'measure of the ability to start, operate, and close a business' capturing 'the overall burden of regulation as well as the efficiency of government in the regulatory process'. As before, higher values express a higher level of business freedom. Therefore, a positive sign is expected. The indicator trade freedom (*TRADE\_Freed*) is a 'composite measure of the absence of tariff and non-tariff barriers' in a countries. Higher values express a higher level of trade freedom. As a consequence, a positive sign is expected. The measures for the freedom from corruption (*COR\_Freed*), the investment freedom, the business freedom and the trade freedom are obtained from the Heritage Foundation.

The descriptive statistics in Table 5 highlight the broad country coverage which results in substantial variation in the country controls. At the same time, Table 5 shows that the values for the subsidiary-countries are close to the values for the owner-countries, respectively. This reflects that our sample contains domestic subsidiaries which, in turn, make up a rather large share of our sample. Hence, employing the empirical approach we may face difficulties in distinguishing between subsidiary-country effects and home-country effects. We therefore will restrict the analysis to the tax effect of the subsidiary tax rate measures. With respect to the remaining country-controls we are, however, less concerned regarding the distinct coefficients and include both subsidiary- and owner-country controls.

## 5 Estimating tax elasticities

In particular, we are interested in (potentially) heterogeneous tax elasticities for different types of investment and to what extent the omission of this distinction may result in biased estimates. To this end, we firstly set out the empirical strategy and then present the obtained results.

### 5.1 Empirical strategy

Given the limitation of our dataset – relying on time-invariant ownership information – we restrict our analysis to the intensive margin of investment decision for a given location of a subsidiary. Furthermore, we follow the bulk of studies by estimating a reduced investment model, however, acknowledging the high complexity of firms' investment decisions.<sup>18</sup>

Starting point of our analysis constitutes a standard subsidiary-fixed effects model to assess the general impact of corporate taxation on the intensive margin of investment,

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<sup>18</sup>This is in contrast to a structural model as discussed by Devereux and Griffith (2002) and Devereux (2006).

i.e., neglecting firm-heterogeneity.<sup>19</sup> Given the bilateral nature of our gravity specification some ambiguity about the correct choice of owner-country variables arises. Following the discussion in Section 3, subsidiaries of highly interrelated multinational corporate groups can be attributed either to the direct owner, the global ultimate or the (rest of the) corporate group. By characterizing the role of a subsidiary with respect to both their direct owner or their global ultimate owner the identification of the home-country of investment is straightforward. By contrast, employing the group-wide approach we have to approximate the home-country of investment by the location of the global ultimate owner.<sup>20</sup>

Based on the data definitions in Section 4 we estimate the following equation

$$TANG_{st} = \beta_1 TAX_{ht} + \beta_2 ASSETS_{st} + \beta_3 \mathbf{X}_{ht} + \beta_4 \mathbf{X}_{ot} + \mu_s + \lambda_t + \epsilon_{st} \quad (1)$$

where  $TAX_{ht}$  covers the respective tax type (i.e., *STR*, *EATR* or *EMTR*) which constitutes the key variable of interest. In addition to the subsidiary-specific variable  $ASSETS_{st}$  further sets of control variables are included. The terms  $\mathbf{X}_{ht}$  and  $\mathbf{X}_{ot}$  denote matrices capturing additional covariates varying at the subsidiary-country and owner-country level, respectively. Note that the owner-country  $o$  denotes the location of either the direct owner or the global ultimate owner. The term  $\mu_s$  describes the subsidiary-level fixed effects covering time-invariant unobserved individual heterogeneity. Additionally, we employ time-fixed effects in order to control for (common) cyclical trends and/or shocks, denoted by  $\lambda_t$ . The term  $\epsilon_{st}$  stands for the remainder error term. Further, as discussed by Cameron and Trivedi (2010), the assumption of independently and identically distributed error terms of the regressors is – in all probability – not satisfied for a panel data set. Instead, observations are likely to fall into clusters which would lead to incorrectly estimated standard errors. To address this, we employ the weaker assumption of dependent observations within a cluster but independent observations between clusters by estimating cluster robust standard errors at the subsidiary-country-level.

To account for the different types of investment we firstly make use of the above described approach of Alfaro and Charlton (2009) and employ the strict classification into the four investment types. Since both the ownership information and the reported industry codes constitute time-invariant information a set of time-invariant dummy variables results. Thus, instead of employing regressions separately we interact three of these dummy variables with the variable of interest which enables us to obtain heterogeneous tax effects. This leaves us with the following estimation equation

$$TANG_{st} = \beta_1 TAX_{ht} + \beta_2 TAX_{ht} \times HOR_s^X + \beta_3 TAX_{ht} \times VER_s^X + \beta_4 TAX_{ht} \times COM_s^X + \beta_5 ASSETS_{st} + \beta_6 \mathbf{X}_{ht} + \beta_7 \mathbf{X}_{ot} + \mu_s + \lambda_t + \epsilon_{st} \quad (2)$$

where  $TAX_{ht}$  covers the respective tax measures. In addition to the direct tax effect, equation 2 is characterized by three interaction terms consisting of the dummy variables  $HOR_s^X$ ,  $VER_s^X$  and  $COM_s^X$ . This implies that the reference category can be directly assigned to the non-related investment while the coefficient  $\beta_1$  can be interpreted as its tax

<sup>19</sup>In a previous version of this paper (Jungmann, 2014) we also investigated the appropriateness of a random effects model. However, the Hausman's specification test (Hausman 1978) preferred the fixed effects model over the random effects model for all specifications.

<sup>20</sup>This assumption can be partly justified in the case of a centralized organizational structure and in the light of worldwide taxation in the global ultimate owner-country.

elasticity. For the remaining investment categories: The respective tax elasticity results from the linear combination of the coefficient for the reference category and the respective coefficient for the interaction term. Note that superscript  $X$  denotes the different assumptions made for classifying the investment types. As discussed, we focus on presenting detailed regression results not for all the different combinations as described in Section 3 but for two relatively polar cases as presented in Table 4. In particular, we firstly employ a specification based on the link between a subsidiary and its direct owner while taking into account the 4-digit NAICS classification. Secondly, we assign a subsidiary to the (rest of the) respective corporate group while taking into account the 6-digit NAICS classification. All remaining specifications are summarized graphically which highlights the broad tendencies in estimated tax elasticities in a very condensed way.

Finally, we move beyond the strict categorization into the four distinct investment types and employ the relative strength of horizontal and vertical links between a subsidiary and its respective owner. This yields equation

$$\begin{aligned} TANG_{st} = & \beta_1 TAX_{ht} + \beta_2 TAX_{ht} \times shHOR_s^X + \beta_3 TAX_{ht} \times shVER_s^X \\ & + \beta_4 TAX_{ht} \times shHOR_s^X \times shVER_s^X + \beta_5 ASSETS_{st} + \beta_6 \mathbf{X}_{ht} \\ & + \beta_7 \mathbf{X}_{ot} + \mu_s + \lambda_t + \epsilon_{st} \end{aligned} \quad (3)$$

which differs only in the interaction terms compared to equation 2. In particular, the terms  $TAX_{ht} \times shHOR_s^X$  and  $TAX_{ht} \times shVER_s^X$  capture the difference in tax elasticities resulting from the strength of the horizontal respectively vertical link. Since this approach reapportions the complex investment type into the horizontal and vertical components we also include a triple interaction term,  $TAX_{ht} \times shHOR_s^X \times shVER_s^X$ . As a consequence, a significant coefficient for  $\beta_4$  implies that complex investments react differently to corporate taxation than simply the sum of both horizontal and vertical investment reactions. Further, note that the interpretation of the coefficients  $\beta_2$  and  $\beta_3$  changes compared to the previous equation 2. The strict classification implies that we investigate the full switch to a horizontal, vertical or complex investment compared to a non-related investment. By employing equation 3, however, the coefficient  $\beta_2$  ( $\beta_3$ ) measures to what extend a stronger horizontal (vertical) link affects the tax semi-elasticity. Thus, evaluating the linear combination at a value of unity for both the variables  $shHOR_s^X$  and  $shVER_s^X$  yields results comparable to the strict classification approach.

## 5.2 Results

Estimating the regression as defined in equation 1 for both the full sample and the manufacturing sub-sample we obtain the results as summarized in Table 6.<sup>21</sup> Based on a very broad sample of 1,605,265 observations (in the case of the full sample and 102,000 observations in the case of the manufacturing sub-sample) in 286,457 distinct subsidiaries (16,099 distinct subsidiaries in the manufacturing sub-sample) the main results are in line with expectations. All specifications report an overall semi-elasticity of investment between -1.123 and -1.660 which is closely in line with the results obtained in the existing literature. For example, Feld and Heckemeyer (2011) – employing a meta-study on discrete and continuous investment decisions with aggregate data and micro data – find a median

<sup>21</sup> The owner-country is defined by the location of the global ultimate owner. Employing the same regression with the location of the direct owner as home-country yields qualitatively the same and quantitatively very similar results. These results are available from the authors upon request.

semi-elasticity of 1.68 in absolute terms and a median result of 1.39 for the most precise estimates.

With respect to the remaining covariates, the subsidiary specific variable  $ASSETS_{st}$  is both highly significant and positive while for the manufacturing sub-sample close to unity. The country-specific control variables are mostly insignificant irrespective of the underlying sample which can mostly be attributed to the large overlap of subsidiary- and owner-countries. Nevertheless, the average wages in the owner-countries display a negative and highly significant coefficient in all specifications. By contrast, the average wages in the host-countries reveal – particularly for the manufacturing sub-sample – a significant positive coefficient indicating that higher wages are associated with a higher intensity of capital as discussed in Section 4. For the full sample the coefficients for both the freedom from corruption (positively associated with investment) and unemployment level (negatively affecting investment) show the expected signs and are statistically significant.



Table 6: Overall tax elasticities

Tax measure used:	All industries			Manufacturing sub-sample		
	<i>STR</i>	<i>EATR</i>	<i>EMTR</i>	<i>STR</i>	<i>EATR</i>	<i>EMTR</i>
$TAX_{ht}$	-1.236 (0.474)**	-1.660 (0.669)**	-1.389 (0.630)**	-1.411 (0.401)***	-1.551 (0.520)***	-1.123 (0.471)***
$ASSETS_{st}$	0.829 (0.024)***	0.829 (0.024)***	0.830 (0.024)***	0.944 (0.023)***	0.945 (0.023)***	0.946 (0.023)***
$GDP_{ht}$	-0.272 (0.248)	-0.355 (0.259)	-0.369 (0.279)	-0.411 (0.274)	-0.427 (0.264)	-0.422 (0.271)
$GDP_{ot}$	-0.252 (0.210)	-0.266 (0.211)	-0.270 (0.214)	-0.140 (0.266)	-0.150 (0.262)	-0.149 (0.261)
$POP_{ht}$	1.273 (0.625)*	1.298 (0.611)**	1.258 (0.624)**	0.570 (0.662)	0.679 (0.699)	0.647 (0.708)
$POP_{ot}$	-0.043 (0.400)	-0.063 (0.396)	-0.067 (0.389)	-0.134 (0.581)	-0.158 (0.570)	-0.141 (0.561)
$WAGE_{ht}$	0.271 (0.157)*	0.245 (0.149)	0.238 (0.148)	0.307 (0.109)***	0.279 (0.106)**	0.278 (0.106)**
$WAGE_{ot}$	-0.164 (0.054)***	-0.160 (0.052)***	-0.163 (0.052)***	-0.188 (0.045)***	-0.185 (0.043)***	-0.190 (0.042)***
$TRADE\_Freed_{ht}$	-0.002 (0.001)	-0.003 (0.001)*	-0.002 (0.001)	-0.001 (0.002)	-0.002 (0.003)	-0.002 (0.003)
$TRADE\_Freed_{ot}$	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.002)	0.000 (0.002)	0.000 (0.002)
$INV\_Freed_{ht}$	0.001 (0.001)*	0.001 (0.001)*	0.001 (0.001)	0.003 (0.001)**	0.003 (0.001)**	0.003 (0.001)*
$INV\_Freed_{ot}$	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)
$COR\_Freed_{ht}$	0.004 (0.002)*	0.003 (0.002)*	0.003 (0.002)	0.004 (0.002)**	0.003 (0.002)*	0.003 (0.002)*
$COR\_Freed_{ot}$	0.002 (0.001)**	0.002 (0.001)**	0.002 (0.001)*	0.003 (0.002)*	0.003 (0.002)*	0.003 (0.002)*
$TRADE_{ht}$	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.000 (0.001)	0.001 (0.001)	0.001 (0.001)
$TRADE_{ot}$	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
$UE_{ht}$	-0.007 (0.004)	-0.008 (0.004)*	-0.008 (0.005)*	-0.007 (0.006)	-0.008 (0.006)	-0.008 (0.006)
$UE_{ot}$	-0.008 (0.004)**	-0.008 (0.004)**	-0.008 (0.004)**	0.002 (0.005)	0.002 (0.005)	0.002 (0.005)
$INFL_{ht}$	-0.004 (0.004)	-0.004 (0.004)	-0.004 (0.003)	-0.006 (0.005)	-0.006 (0.004)	-0.006 (0.004)
$INFL_{ot}$	0.002 (0.003)	0.001 (0.003)	0.001 (0.002)	0.001 (0.004)	0.001 (0.004)	0.001 (0.004)
Time FE	✓	✓	✓	✓	✓	✓
Subsidiary FE	✓	✓	✓	✓	✓	✓
Within $R^2$	0.228	0.229	0.229	0.329	0.329	0.329

Note: The dependent variable is  $TANG_{st}$ . For the full sample the regressions are based on 1,605,265 observations in 286,457 distinct subsidiaries. For the manufacturing sub-sample the figures are given by 102,000 and 16,099, respectively. Cluster robust standard errors in parentheses. Index  $h$  denotes the country of the subsidiaries, index  $o$  stands for the respective owner-country, index  $t$  denotes the years and index  $s$  stands for subsidiaries. All estimations include subsidiary- and time-fixed effects. The levels of significance are defined as follows: \*\*\* p-value <0.01, \*\* p-value <0.05, \* p-value <0.1.

In the following, we account for firm-heterogeneity when estimating the impact of corporate taxation on the intensive margin of investment. For both the (respective) tax variables and the interaction terms results are summarized in Table 7. In line with the original approach of Alfaro and Charlton (2009) we firstly employ the strict classification of investment types. Comparing the obtained results for the variable  $TAX_{ht}$  as summarized in Tables 6 and 7 reveals a substantial quantitative increase in coefficients when taking into account both the full sample and the manufacturing sub-sample; the latter, however, just when making use of the 6-digit NAICS classification in conjunction with the group-wide approach. In particular, this reflects a higher tax elasticity for non-related investments compared to the overall tax elasticity.

In order to evaluate whether the overall tax semi-elasticity for the different types of investments is both significant and negative depends on the respective linear combinations. In particular, we calculate a linear combination by combining (i.e., summing up) the tax effect of the baseline category  $TAX_{ht}$  with the respective interaction term represented by the individual investment type dummy (and taking into account the respective covariation). Hence, Table 7 additionally reports the overall tax semi-elasticities for the four investment types. In the upper half of the table, i.e., the summary of the results for the 6-digit NAICS classification and the group-wide comparison, the emerging picture is unambiguous and qualitatively similar both for the whole sample and the manufacturing sub-sample. The non-related investment exhibits the highest and most significant negative tax semi-elasticity with values between -1.885 and -2.589.<sup>22</sup> The tax semi-elasticity for vertical investment is in the range of -1.392 to -1.948 and thus slightly lower, however, the coefficients for the interaction term show that the difference is not statistically significant. By contrast, the coefficients for the interaction terms identifying horizontal investments exhibit a positive sign, respectively. Further, in three of six specifications the coefficient indicates a significant lower tax responsiveness to corporate taxation compared to non-related investments. Summarizing, this results in an even insignificant overall tax semi-elasticity for investment that is classified as horizontal. For complex investments: The obtained overall tax semi-elasticities lie in-between horizontal and vertical tax semi-elasticities and reveal both a significant and negative coefficient, respectively. The tax responsiveness compared to non-related investment types is, however, just in two specifications significantly lower.

Turning to the lower part of Table 7, i.e., taking into account both the 4-digit NAICS classification and the relationship between a subsidiary and its direct owner, the somewhat higher and significant negative tax semi-elasticities for the non-related investment are confirmed. The slightly lower and (mostly) significant overall tax semi-elasticities for vertical investment also hold in this specification. By contrast, results are very different for both the complex investment and the horizontal investment in the full sample compared to the manufacturing sub-sample. While investment classified as complex exhibits the highest overall tax semi-elasticities in the full sample the coefficients are insignificant for the manufacturing sub-sample. This points towards rather different characteristics of complex investment whether the horizontal and vertical links occur only within the manufacturing sector or between all industries. Nevertheless, it should be noted that these results are based on approximately 3 % of the data implying that they ought to be interpreted with some caution. Similarly, almost half of the sample is classified as horizontal investment in the manufacturing sub-sample which certainly contributes to explain the significant and negative overall tax semi-elasticity of horizontal investment.

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<sup>22</sup> A notable exception constitutes the case for the *EMTR* measure in the manufacturing sub-sample where a relatively small share of firms is characterized as non-related (8.8%) which results in an insignificant estimate of the overall tax semi-elasticity.

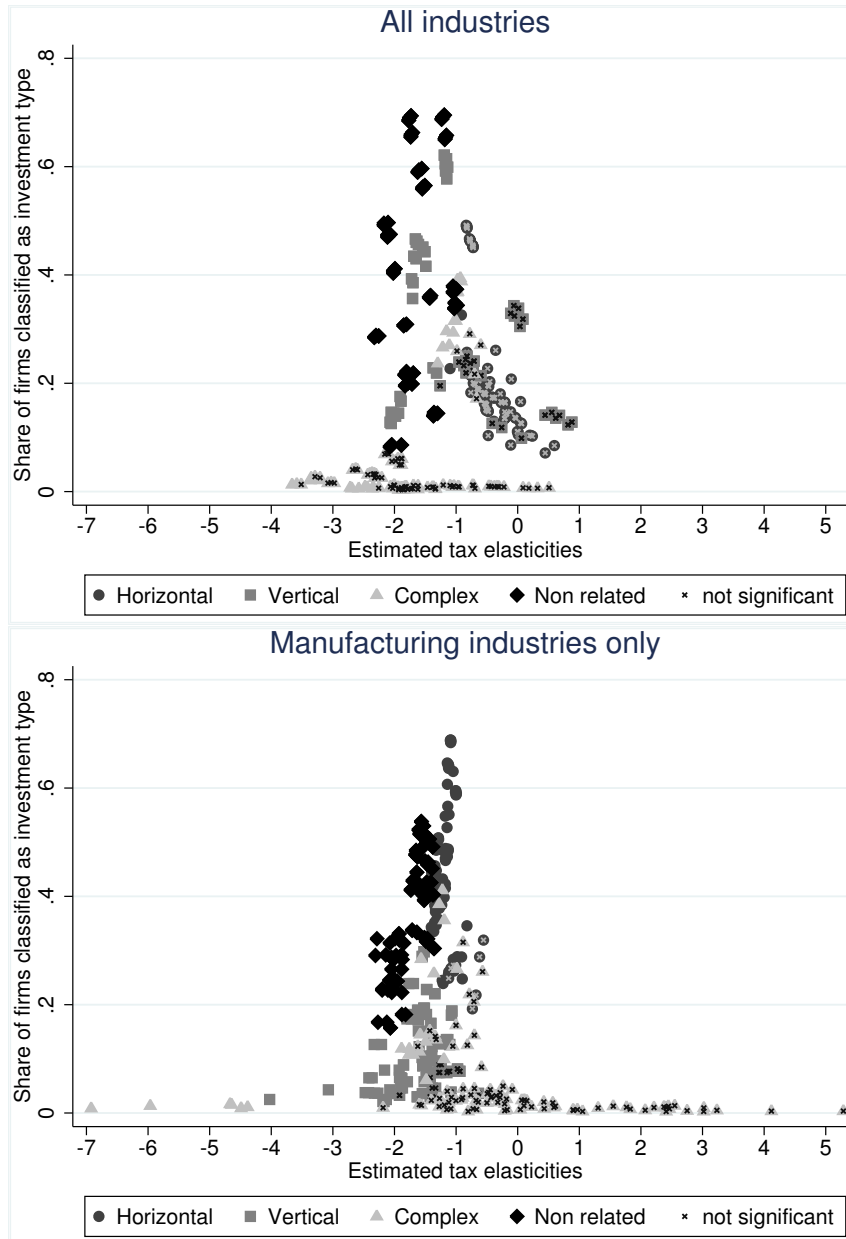
**Table 7: Investment heterogeneity - Strict classification**

Tax measure used:	All industries			Manufacturing sub-sample		
	<i>STR</i>	<i>EATR</i>	<i>EMTR</i>	<i>STR</i>	<i>EATR</i>	<i>EMTR</i>
<b>6-digits NAICS classification – links to rest of corporate group</b>						
$TAX_{ht}$	-1.885 (0.805)**	-2.589 (0.934)***	-2.153 (0.870)**	-2.067 (0.721)***	-2.117 (1.038)**	-1.331 (0.953)
$HOR_s^{6G} \times TAX_{ht}$	2.332 (0.538)***	2.270 (0.851)**	1.504 (0.959)	1.332 (0.645)**	1.121 (0.829)	0.511 (0.741)
$VER_s^{6G} \times TAX_{ht}$	0.347 (0.675)	0.641 (0.755)	0.576 (0.688)	0.376 (0.847)	0.219 (1.226)	-0.061 (1.101)
$COM_s^{6G} \times TAX_{ht}$	0.910 (0.588)	1.249 (0.498)**	1.024 (0.505)**	0.845 (0.567)	0.741 (0.823)	0.306 (0.735)
<i>Tax elasticities for different investment types - linear combinations</i>						
$HOR_s^{6G} \times TAX_{ht}$	0.446 (0.676)	-0.320 (0.887)	-0.649 (0.866)	-0.735 (0.487)	-0.996 (0.662)	-0.820 (0.558)
$VER_s^{6G} \times TAX_{ht}$	-1.539 (0.499)***	-1.948 (0.709)***	-1.576 (0.642)**	-1.692 (0.502)***	-1.897 (0.628)***	-1.392 (0.508)***
$COM_s^{6G} \times TAX_{ht}$	-0.975 (0.429)**	-1.340 (0.652)**	-1.129 (0.639)*	-1.223 (0.482)**	-1.375 (0.651)**	-1.024 (0.606)*
<b>4-digits NAICS classification – links to direct owner only</b>						
$TAX_{ht}$	-1.776 (0.672)**	-2.483 (0.706)***	-2.133 (0.641)***	-1.512 (0.470)***	-1.480 (0.562)**	-0.931 (0.460)**
$HOR_s^{4D} \times TAX_{ht}$	1.306 (0.251)***	1.358 (0.230)***	1.010 (0.381)***	0.190 (0.403)	-0.108 (0.529)	-0.305 (0.438)
$VER_s^{4D} \times TAX_{ht}$	0.622 (0.713)	1.126 (0.655)*	1.095 (0.604)*	0.101 (0.513)	-0.126 (0.769)	-0.281 (0.701)
$COM_s^{4D} \times TAX_{ht}$	-1.514 (1.218)	-1.857 (1.494)	-1.563 (1.365)	1.331 (0.762)*	0.855 (1.019)	0.271 (0.828)
<i>Tax elasticities for different investment types - linear combinations</i>						
$HOR_s^{4D} \times TAX_{ht}$	-0.470 (0.556)	-1.126 (0.772)	-1.123 (0.765)	-1.323 (0.500)**	-1.587 (0.681)**	-1.236 (0.616)**
$VER_s^{4D} \times TAX_{ht}$	-1.154 (0.515)**	-1.357 (0.725)*	-1.037 (0.673)	-1.411 (0.462)***	-1.606 (0.667)**	-1.212 (0.637)**
$COM_s^{4D} \times TAX_{ht}$	-3.290 (1.686)*	-4.341 (1.959)**	-3.696 (1.788)**	-0.182 (0.829)	-0.625 (0.952)	-0.661 (0.785)

Note: The design feature is summarized in Table 4. The dependent variable is  $TANG_{st}$ . All regressions include the full set of covariates (including subsidiary- and time-fixed effects) as employed in Table 6. The regressions for the full sample (manufacturing sub-sample) and the 6-digit NAICS classification are based on 1,605,265 (102,000) observations in 286,457 (16,099) subsidiaries. Using the 4-digit NAICS codes and the direct owner, observations are 1,617,836 (102,679) in 287,219 (16,116) distinct subsidiaries. Cluster robust standard errors in parentheses. Index  $h$  denotes the country of the subsidiaries, index  $t$  denotes the years and index  $s$  stands for subsidiaries. The levels of significance are defined as follows: \*\*\* p-value <0.01, \*\* p-value <0.05, \* p-value <0.1.

The large number of distinct combination possibilities with respect to the choice of design feature rules out a comprehensive presentation of all potential regression results. To nevertheless embed the above employed specifications into an overall picture Figure 2 provides a graphical summary of the various possible estimation outcomes in a condensed way. In particular, we plot the estimated tax semi-elasticities against the share of firms classified into the respective investment types. The logic behind this is twofold: Firstly,

it reiterates that the large variation in outcomes is related to the choices made by the researcher. Secondly, it puts the importance of obtained results into perspective by showing the respective share of data to which the estimated elasticities apply.



**Figure 2: Overview of estimated tax semi-elasticities**

By illustrating the results for all industries, the top half of Figure 2 highlights that for some specifications almost 70 % of all firms are classified as non-related (represented by the black diamonds). In contrast, restricting the sample to the manufacturing industries as depicted in the lower half of Figure 2 some specifications are characterized by almost up to 70 % of firms classified as horizontal (dark gray points). Regardless of the underlying sample many specifications reveal only a very low share of firms classified as complex (light gray triangles). This particularly reflects that single counting of horizontal investments considerably reduces the number of relationships classified as complex which is in line with

expectations formulated in Section 3. Finally, the gray squares show that the share of investment classified as vertical is clearly higher if all industries are taken into account while being very low for the manufacturing sub-sample.

The horizontal axes in Figure 2 denote the estimated tax semi-elasticities with regard to the statutory tax rate for the different investment types. Further, a cross imprinted on the respective symbols identifies outcomes where the estimated semi-elasticities are not statistically significant at the 95 % level. Broadly, the classification into the four distinct investment categories results in a slightly higher tax semi-elasticity for non-related investment compared to the overall effect as summarized in Table 6. Remarkably, the estimates for non-related investment types are all significant at least at the 95 % level and lie within the interval of -0.98 and -2.33. In contrast, the tax semi-elasticity for horizontal investment is less pronounced and, in the case of the full sample, insignificant for almost all instances. Further, the obtained estimates for the manufacturing sub-sample are only significant – but still visibly lower – if a very large share of data is classified as horizontal which is in line with the results summarized in Table 7. The picture is less clear for vertical investments. Depending on the design choice the estimated tax semi-elasticities are either insignificant or even higher in absolute terms. This applies particularly for the manufacturing sub-sample where the estimated tax semi-elasticities range from -4.03 to insignificant -0.64. The mixed nature of estimated tax semi-elasticities is even more pronounced for complex investments. However, it is also visible that a large number of these estimates is only based on a small proportion of the dataset. Summarizing, the comprehensive illustration of estimated tax semi-elasticities for the distinct investment types is in line with the predictions derived from the literature and discussed in Section 2: Non-related investment reacts stronger to corporate taxation than horizontal investments while results are mixed for vertical and complex investments. Particularly the latter result remains somewhat unsatisfactory. Thus, the remaining question to address is whether complex investment behaves inherently differently compared to vertical or horizontal investments which cannot be answered by employing the strict classification into dummies as employed by Alfaro and Charlton (2009). As discussed, we therefore move beyond this type of classification and take into account the relative strengths of horizontal and vertical links.

By estimating equation 3 we replace the interaction terms comprising dummy variables by two interaction terms representing the strength of horizontal and vertical links (focusing on the relative strength of links towards the respective maximum). This enables us to include an additional interaction term capturing the strength of *both vertical and horizontal* links. This interaction term captures any effect on the tax semi-elasticity for an investment that is complex in nature. Thus, a significant coefficient points towards the importance of distinguishing complex investment from vertical or horizontal investment. The obtained results are summarized in Table 8. As it turns out, the interaction terms indicating the strength of horizontal links each exhibit a positive sign and are mostly significant for the full sample (particularly for the 4-NAICS classification in conjunction with the direct owners). This results – calculating the respective linear combination – roughly in a halving of the overall semi-elasticities which are mostly insignificant (again, particularly in the bottom half of Table 8). These results differ, however, between the full sample and the manufacturing sub-sample. In particular, employing 4-digit NAICS codes and assigning the subsidiaries to their direct owners leads to both significant and negative overall tax semi-elasticities for the share of horizontal investment. Nevertheless, as discussed in Section 3 the likelihood of overlap is rather high for this design approach. Taking into account vertical investment strengths the interaction terms show, by and large, no statistical significance. Furthermore, calculating the respective linear combinations the tax semi-elasticities are both negative and significant for the most part. Overall, the ob-

tained results are in line with the previous outcomes indicating that vertical investments react both significantly negatively and slightly less to corporate taxation while horizontal investment tend to exhibit (mostly) a significant lower tax-responsiveness resulting and an overall tax semi-elasticity which is of minor importance or even insignificant.

The results for the double interaction terms are rather interesting. For the 6-digit NAICS classification in conjunction with the group-wide comparison the coefficients are all negative and insignificant on their own both for the full sample and for the manufacturing sub-sample. This results in an overall negative tax semi-elasticity which is rather low and barely significant. By contrast, taking into account the 4-digit NAICS classification in conjunction with the direct owner the obtained results are more unstable and depend on the underlying sample which is, however, in line with the strict classification approach summarized in Table 7. In particular, the triple interaction term for the full sample is both significant and negative resulting in very large tax semi-elasticities for complex investment. By contrast, taking into account the manufacturing sub-sample the triple interaction terms are each insignificant which is also reflected in an insignificant overall tax response. Summarizing, we find that complex investments tend to show no significant different tax-responsiveness than the sum of both horizontal and vertical investment reactions, however, with some limitations.

**Table 8: Investment heterogeneity - Non-strict classification**

Tax measure used:	All industries			Manufacturing only		
	<i>STR</i>	<i>EATR</i>	<i>EMTR</i>	<i>STR</i>	<i>EATR</i>	<i>EMTR</i>
<b>6-digits NAICS classification – links to rest of corporate group</b>						
$TAX_{ht}$	-2.026 (0.915)**	-2.869 (1.029)***	-2.444 (0.972)**	-1.970 (0.532)***	-2.044 (0.753)***	-1.327 (0.699)**
$shHOR_s^{6G} \times TAX_{ht}$	1.280 (0.736)*	1.383 (1.021)	1.008 (1.022)	1.141 (0.572)*	1.130 (0.738)	0.672 (0.689)
$shVER_s^{6G} \times TAX_{ht}$	0.652 (1.128)	1.246 (1.270)	1.188 (1.164)	0.212 (0.680)	0.013 (1.016)	-0.218 (0.926)
$shHOR_s^{6G} \times$ $shVER_s^{6G} \times TAX_{ht}$	-0.628 (1.262)	-0.712 (1.796)	-0.519 (1.683)	-0.743 (1.344)	-0.757 (1.653)	-0.458 (1.514)
<i>Tax elasticities for different investment types - linear combinations</i>						
$shHOR_s^{6G} \times TAX_{ht}$	-0.746 (0.517)	-1.486 (0.661)**	-1.436 (0.639)**	-0.829 (0.466)*	-0.915 (0.588)	-0.655 (0.536)
$shVER_s^{6G} \times TAX_{ht}$	-1.374 (0.629)**	-1.623 (0.872)*	-1.256 (0.778)	-1.758 (0.579)***	-2.031 (0.758)***	-1.545 (0.633)**
$shHOR_s^{6G} \times$ $shVER_s^{6G} \times TAX_{ht}$	-0.722 (0.509)	-0.952 (0.782)	-0.768 (0.768)	-1.361 (0.747)*	-1.659 (0.921)*	-1.331 (0.823)
<b>4-digits NAICS classification – links to direct owner only</b>						
$TAX_{ht}$	-1.839 (0.680)***	-2.553 (0.716)***	-2.183 (0.654)***	-1.512 (0.470)***	-1.459 (0.560)***	-0.902 (0.458)*
$shHOR_s^{6G} \times TAX_{ht}$	1.368 (0.260)***	1.427 (0.243)***	1.061 (0.400)***	0.194 (0.409)	-0.120 (0.536)	-0.326 (0.442)
$shVER_s^{6G} \times TAX_{ht}$	0.729 (0.754)	1.255 (0.712)*	1.198 (0.668)*	0.096 (0.527)	-0.194 (0.796)	-0.375 (0.730)
$shHOR_s^{6G} \times$ $shVER_s^{6G} \times TAX_{ht}$	-3.637 (2.076)*	-4.644 (2.293)**	-3.940 (2.263)*	1.034 (0.790)	1.029 (0.826)	0.788 (0.745)
<i>Tax elasticities for different investment types - linear combinations</i>						
$shHOR_s^{6G} \times TAX_{ht}$	-0.470 (0.558)	-1.126 (0.774)	-1.122 (0.765)	-1.318 (0.501)**	-1.579 (0.683)**	-1.229 (0.618)*
$shVER_s^{6G} \times TAX_{ht}$	-1.109 (0.530)**	-1.297 (0.741)*	-0.985 (0.691)	-1.416 (0.469)***	-1.653 (0.689)**	-1.277 (0.662)*
$shHOR_s^{6G} \times$ $shVER_s^{6G} \times TAX_{ht}$	-3.378 (1.732)*	-4.514 (1.990)**	-3.864 (1.819)**	-0.188 (0.875)	-0.744 (1.004)	-0.815 (0.825)

Note: The design feature is summarized in Table 4. The dependent variable is  $TANG_{st}$ . All regressions include the full set of covariates (including subsidiary- and time-fixed effects) as employed in Table 6. The regressions for the whole sample (manufacturing sub-sample) and 6-digit NAICS classification are based on 1,605,265 (102,000) observations in 286,457 (16,099) subsidiaries. Using the 4-digit NAICS classification and the direct owner, observations are 1,617,836 (102,679) in 287,219 (16,116) distinct subsidiaries. Cluster robust standard errors in parentheses. Index  $h$  denotes the country of the subsidiaries, index  $t$  denotes the years and index  $s$  stands for subsidiaries. The levels of significance are defined as follows: \*\*\* p-value <0.01, \*\* p-value <0.05, \* p-value <0.1.

Finally, to provide robust results with respect to the choice(s) of design feature(s) we reiterate the 216 different regressions, i.e., all possible combinations as discussed in Section 3 while defining shares of investment. In the baseline category, i.e., for non related

investment we find significant negative tax semi-elasticities for all 216 cases (5 % level) while for a great majority of 186 cases significant results even at the 1 % level. The results for (the share of) horizontal investment (i.e., the interaction term) are also unambiguous with 215 positive coefficients. Further, it turns out that 96 (123) of the obtained estimates are significant even at the 1 % (5 %) level, indicating that a stronger horizontal link tends to reduce the tax responsiveness. In contrast, looking at the (share of) vertical links we obtain for 208 (177) of 216 coefficients (i.e., the interaction term) no statistically significant result at the 1 % (5 %) level. This confirms that vertically linked investments are only weakly less tax responsive than non-related investment and is consistent with the significant negative tax semi-elasticities (for the linear combinations) for vertical investment as summarized in Table 7. Overall, using the share of horizontal and vertical investment, by and large, produces results which are in line with the expectations formulated in Table 3.

## 6 Conclusion

The present study contributes to the current tax literature by analyzing the impact of corporate taxation on different types of investments. Hereby, we emphasize the role of firm-heterogeneity within micro data and stress the necessity of going beyond the traditional distinction of horizontal and vertical investment types. Starting with a methodology employed by Alfaro and Charlton (2009) we combine firm-specific (ownership) information with industry-specific information about the vertical connectedness between distinct industries. In this respect we can show that the choice of design feature(s) for the process of investment types' classification considerably drives the resulting outcomes. In particular, the definition of an appropriate threshold for the input coefficient identifying vertical relationships or the level of aggregation of industry classification codes exert a substantial impact. Thus, we extend the employed methodology of Alfaro and Charlton (2009) in various directions. Firstly, we account for an up- and downstream vertical integration which addresses a potential misclassification when neglecting the downward relatedness of two entities along the supply chain. Secondly, we propose to determine the role of a subsidiary towards the (rest of the) corporate group rather than simply accounting for the direct or the global ultimate owner. Furthermore, we introduce a novel approach in treating complex investments which enables us to overcome the strict classification into the distinct investment types. In particular, we unbundle complex investments into its horizontal and vertical components by taking advantage of the underlying data.

Following these discussions, we employ the numerous approaches of investment classification in analyzing the sensitivity of investment towards corporation taxation. In order to provide a benchmark of results we firstly estimate the overall tax semi-elasticity of investment, i.e., neglecting firm-heterogeneity. The obtained results are close to the semi-elasticities reported by previous studies. Both the statutory and the effective corporate tax rates exert a significant negative impact on the intensive margin of investment while the tax semi-elasticities range from -1.1 to -1.6. In a second step, we take into account firm-heterogeneity in analyzing the sensitivity of continuous investment decisions towards corporation taxation. In line with expectations it turns out that the overall semi-elasticities are likely to represent a weighted average of different investment types.

Taking into account a strict classification for investment types we find that non-related investments react strongest to corporate taxation with a semi-elasticity in the range of -1.8 to -2.6. Different (core-)business motives reduce the tax sensitivity to varying degree. In particular, vertical investment motives tend to lower the tax semi-elasticities slightly whereas the difference is mostly not statistically significant. By contrast, horizontal invest-



ments exhibit a significant lower tax semi-elasticity compared to non-related types which results in most specifications in an insignificant overall tax semi-elasticity. This seems somewhat unexpectedly according to the neoclassical investment model, however, it confirms recent results in Herger et al. (2015) also for the intensive margin of investment. Further, taking into account the strict classification into investment types the complex category lies somewhere in-between both the horizontal and vertical type with a, by and large, negative and significant tax semi-elasticity.

Employing the continuous approach and unbundling the complex type into its horizontal and vertical components we are able to test whether the combination of horizontal and vertical motives (thus, a complex investment) exhibits a distinct effect and find that a complex investment has, in some very specific cases, an additional effect on the tax responsiveness. However, the obtained results vary considerably between the full sample and the manufacturing sub-sample which highlights that the exact choice of parameters for classifying investment types is of utmost importance. Nevertheless, we are convinced that – preferably given a theoretically founded choice of classification design – more insights can be gained from unbundling the complex investment into its horizontal and vertical components. That said, the (traditional) distinction between horizontal and vertical investments for certain falls short of fully capturing the heterogeneity of firms as our results indicate a clearly higher tax semi-elasticity of non-related investments which would, neglecting this type of investment, confound with the tax sensitivities of horizontal and vertical investments. Summarizing, our results indicate that the broad range of estimated tax elasticities in the tax literature might be rooted in both distinct estimation designs and inherent characteristic of heterogeneous investment types.

Overall, we are convinced that the correct measurement of investment types is of utmost importance when estimating corporate tax elasticities which is, in turn, also highly relevant from a political point of view. Our results indicate that a change in the corporate tax rate might lead to highly asymmetric effects on the structure and composition of investments within a country. Given the current debates about (substantial) corporate tax reforms by the OECD (see, e.g., the Action Plan on Base Erosion and Profit Shifting) or by the European Commission (see, e.g. the discussions about a Common Consolidated Corporate Tax Base in Europe) it is all the more important to recognize that (corporate) tax effects have not to be symmetric both within and between countries as investment strategies of corporations are multifarious. Assuming *one* corporate tax elasticity for all types of investments falls, in all probability, too short.

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