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The impact of organisational structures on management compensation packages and investment decisions – a principal-agent approach investigating formula apportionment and separate accounting

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Abstract: This study investigates managerial effort choices, compensation and investment decisions by differentiating between: 1) centralised and decentralised organisational structures; 2) corporate income taxation schemes [separate accounting and formula apportionment (FA)]; 3) different FA schemes, which has not been undertaken hitherto. A principal-agent approach of a LEN model is applied within the framework of a multijurisdictional entity. The outcomes reveal the neutral impact of separate accounting on investment decisions, agents' efforts and compensation packages under both organisational structures, whereas investment decisions under centralised structures and management compensation packages (under both organisational structures) show distortions caused by FA. The extent of these distortions depends on the apportionment factors used and organisational structures. Interestingly, the Massachusetts formula signals that the formula allocation factors used not only distort firm-internal contracts on management compensation packages, but can also affect the extent of decisions delegated.

Keywords: organisational structures; principal-agent theory; formula apportionment; investment; nonlinear programming.

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Biographical notes: Hülya Çelebi holds a Master's in both Business Administration and Business Education from the University of Innsbruck. Currently, she is a PhD candidate at the Department of Accounting, Auditing and Taxation at the same university. Her research interests focus on international business taxation, financial and managerial accounting.

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1 Introduction

Today's competitive market, triggered by globalisation, changes in business structures, the business environment and technology, has enhanced the importance of the decentralisation of operations and the delegation of decisions. Especially for multijurisdictional entities (MJEs), decentralisation is important to be able to operate more agilely, quickly and efficiently in order to succeed and survive on today's competitive market. In the case of investment decisions under a decentralised system, it is important to consider the conflict of interests between managers (hereinafter referred to as agents, in singular as he) and owners or shareholders (hereinafter referred to as the principal or she). The principal-agent framework fulfils this purpose. It assumes that an agent chooses an investment and provides effort to the extent that maximises his expected utility (from the wage he receives), which is constrained by factors such as the agent's disutility caused by providing effort, risk-related behaviour or productivity. The principal always aims to maximise her own utility, namely the expected net profit resulting from the investments and the efforts provided by the agents. Figure 1 grants an overview of these investment and contract problems of the principal-agency theory within the framework of international taxation.

From the viewpoint of international taxation, the appropriateness of *separate accounting* (SA, also called separate taxation) for today's globalised business structures and environment has been in discussion for decades (see e.g., European Commission, 2011; Devereux et al., 2021). Discussions revolve around the harmonisation of tax rates and switching from SA to another *corporate income taxation* (CIT) scheme. For instance, the G20 countries have recently reached an agreement on a minimum *corporate income tax* rate (CIT rate) of 15% for large multinational corporations. On the other hand, various studies suggest *formula apportionment* (FA) at the international level as an alternative to SA in order to avoid issues caused by SA (such as tax revenue losses caused by companies' profit-shifting activities, harmful tax competition across tax jurisdictions or high administrative costs for companies and tax administrations) (see e.g., ICRICT, 2018; OECD, 2019; Avi-Yonah and Clausing, 2007; Eggert and Haufler, 2006; Eurostat, 2014; IMF, 2014; Matheson et al., 2021). For instance, after painstaking work, the European Commission proposed the *common consolidated corporate tax base* (CCCTB) as a solution to this dilemma (see e.g., European Commission, 2011). This proposal covers the harmonisation of tax regulations, consolidation of the tax base and a switch from SA to FA, however, without any harmonisation of the CIT rates (see European Commission, 2011; European Parliament, 2018). As FA will lead to a significant change in CIT practice, it is one of the most intensively debated parts of the CCCTB proposal. This envisaged CCCTB will also increase the FA practice significantly, which is already in use in the USA, Canada, Japan and Germany at the sub-national level (see, for instance, Matheson et al. (2021) or Krever and Mellor (2020) for an overview). Figures 2(a) and 2(b) represent SA and Massachusetts FA[1] for an MJE by way of an example of two subsidiaries.

Figure 1 Principal-agency theory within international taxation framework

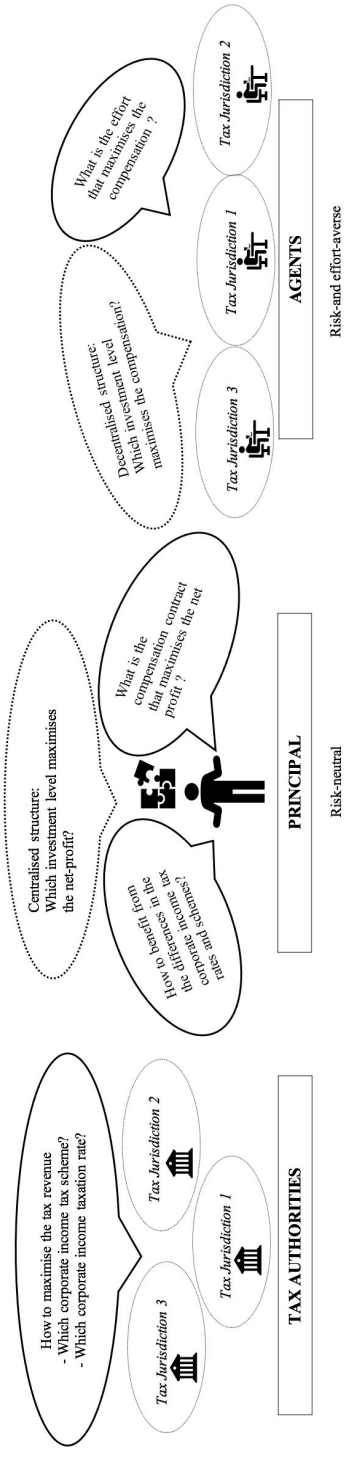
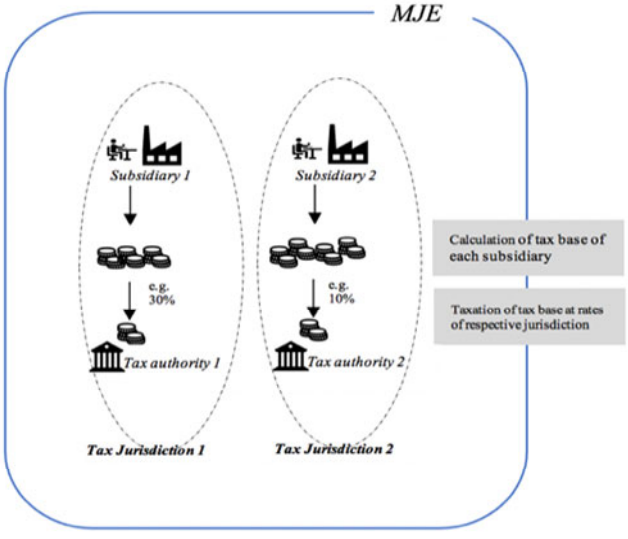
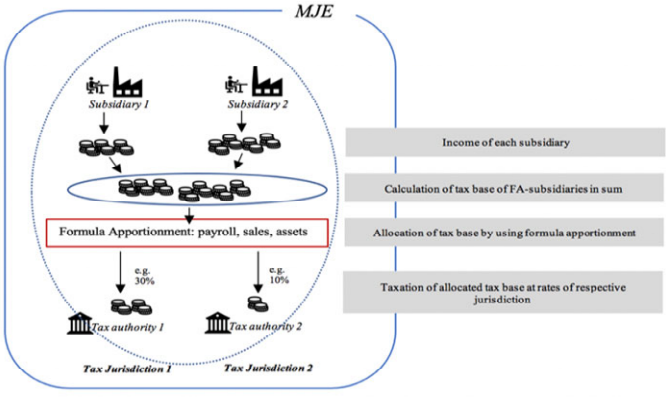


Figure 2 (a) MJE'S CIT under SA and (b) MJE's CIT under Massachusetts FA (see online version for colours)



(a)



(b)

Thus, this paper combines FA and organisational design (structures) literature with that of principal-agency regarding investment decisions and managerial effort choices. In general, studies examining the impact of CIT within the framework of the principal-agency theory are characterised by their focus on SA (see Bauer et al., 2018). The review shows that the investment decisions undertaken by managers are mainly investigated with a focus on capital structures and financing policies under the assumptions of moral hazard and information asymmetry. As the seminal works in this area, Wolfson (1985) investigates the impact of taxation on lease-or-buy decisions, while Fellingham and Wolfson (1985) analyses the impact of income taxation on risk sharing. In another study, Banerjee and Besley (1990) deal with optimal tax design with respect to the debt financing of a risky investment. Further, Kale and Noe (1991) reveal that a favourable tax treatment of debt financing impacts the quality of investment, within the

framework of the pecking order theory. Bauer and Kourouxous (2017) investigate delegated investment decisions by integrating a capital charge to adjust the managerial investment incentives. They reveal that a neutral impact of CIT only holds true if managers' renumerations are fully tax-deductible. Morellec (2004) focuses on interrelations across taxation, leverage ratios, managerial discretion and corporate control mechanisms by investigating investments that provide managers with private benefits. He shows that managers tend towards high leverage ratios when tax rates are high. On the other hand, Niemann (2008) investigates the investment decisions taken by agents, where the focus lies on the agents' effort choice within the framework of differential taxation. Chetty and Saez (2010) investigate investment decisions made by managers (agents) and reveal higher distortions caused by dividend taxation than by CIT, which can result in unproductive investments. The literature investigating management incentives, effort choices and compensation packages is wide-ranging. In general, various studies reveal distortions caused by the tax treatment (e.g., non-deductibility) of the fixed and variable payments on the managerial effort choice and output (see e.g., Halperin et al., 2001; Göx, 2008; Meißner et al., 2014; Voßmerbäumer, 2012). Further, Voßmerbäumer (2013) as well as Koethenbuerger and Stimmelmayr (2014) reveal the impact of CIT and PIT on the provision of perks and fringe benefits as further managerial incentive tools used. In addition, Ewert and Niemann (2014) investigate tax planning and the operational effort of managers, which shows a positive correlation with CIT. D'Andria (2016) analyses the agents' effort choices by differentiating between standard tasks and innovative tasks within the framework of tax incentives for R&D activities. Chen and Chu (2005) highlight that CIT evasion influences managers' compensation schemes and efforts, esp. when they can undertake tax evasion activities. From another perspective, Martini and Niemann (2015) as well as Krenn (2017) disclose the advantageousness of being resident in a low-tax jurisdiction. Krenn (2017) focuses on the firms' competition for a highly skilled agent, while Martini and Niemann (2015) investigate the international assignment and contract problems.

A further key point of investigations with regard to MJEs' organisational structures and international taxation is transfer pricing. As the firm-internal transactions amount to 60% of worldwide trade, transfer pricing triggers a trade-off between managerial accounting (maximisation of pre-tax profitability and managers' effectiveness) and taxation objectives (tax minimisation) (see e.g., Bärsch, 2019; Löffler, 2019). To overcome this issue, the literature discusses the use of two sets of books, one for the outside parties and taxation (according to the arm's length principle), and one for managerial accounting (see, e.g., Smith, 2002; Baldenius et al., 2004). The main focus of this stream relies on the centralised or decentralised decision-making authority over transfer prices. For instance, Martini (2015) as well Dürr and Göx (2013) investigate the negotiated transfer price method, which is less centralised. Their outcomes reveal that the efficiency of this method depends on the international tax differences and the location of the highly productive division. In contrast, Bärsch et al. (2019) investigate transfer prices determined by the centralised tax department versus those set by each division's managers. Their outcomes reveal that centralised decision-making can cause a higher degree of the coordination conflicts between divisions' managers and the tax department, esp. when the intrafirm trade is complex (i.e., involving services and intellectual property with more complex pricing schemes). Further, Nielsen et al. (2008) investigate transfer prices when the output decision-making authority is decentralised. They show that a

decentralised structure is preferential only in the case of low tax differentials. In contrast, Löffler (2019) investigates the impact of divisionalisation (i.e., splitting a downstream subsidiary into two divisions), which has a real impact on the firm's organisational structure. His outcome reveals that divisionalisation is effective when the domestic transfer price takes not only the internal trade, but also the tax differentials into account. Another interesting outcome is that of Keuschnigg and Devereux (2013), who investigates centralised and decentralised trade under the existence of financial constraints. The authors reveal that any discrepancy from the arm's length principle triggered to adjust the financial market imperfections can lead to misinterpretations of the tax base shift and tax evasion. Consequently, transfer pricing under SA does not only cause an internal coordination conflict, but can also lead to tax penalties for business activities, even when they are not undertaken for the purpose of tax avoidance. As FA involves the consolidation of the tax base, one of its main characteristics is that it avoids MJEs' transfer pricing dilemma.

Table 1 Overview of literature

	Seminal studies	Jensen and Meckling (1992), Hirschleifer (1956), Holmstrom and Tirole (1991) and Spremann (1987)
Principal-agency literature and taxation	Investment decisions and capital structures within SA framework	Banerjee and Besley (1990), Bauer and Kourouxous (2017), Chetty and Saez (2010), Fellingham and Wolfson (1985), Kale and Noe (1991), Morellec (2004), Niemann (2008) and Wolfson (1985)
	Management compensation and incentives within SA framework	Chen and Chu (2005), D'Andria (2016), Göx (2008), Halperin et al. (2001), Koethenbuerger and Stimmelmayr (2014), Krenn (2017), Martini and Niemann (2015), Meißner et al. (2014) and Voßmerbäumer (2012, 2013)
Principal-agency and FA		*Martini et al. (2016)*
Formula apportionment	Allocation factors' impact on corporations' behaviour and jurisdictions' tax revenue	De Mooij et al. (2021), Hellerstein and McLure (2004), Mardan and Stimmelmayr (2017), Nerudová et al. (2021), Runkel and Schjelderup (2011), Shackelford and Slemrod (1998) and Sørensen (2004)
	Labour and sales as allocation factors	Clausing,(2016), Eberhartinger and Petutschnig (2017), Eichfelder et al. (2018), Gordon and Wilson (1986), Hines (2010), Pethig and Wagener (2007) and Riedel (2010)
	Capital or asset as allocation factor	Altshuler and Grubert (2010), Clausing (2016), Kiesewetter et al. (2018) and Nielsen et al. (2010)
Transfer prices	Centralised and decentralised decision-making authority	Baldenius et al. (2004), Bärsch et al. (2019), Dürr and Göx (2013), Martini (2015), Nielsen et al. (2008) and Smith (2002)
	Investment and organisational structures	Keuschnigg and Devereux (2013), Löffler (2019) and Martini et al. (2012)

In general, the stream of literature investigating FA covers a broad range of scopes and discusses the factors used for the apportionment of the tax base (e.g., property, sales, payroll) and their consequences for corporations' behaviour and jurisdictions' tax revenue within different settings (see Table 1). For instance, some asymmetrical consideration of revenues and expenses (e.g., excluding intangible assets, although they increase the tax base vs. taking the payroll as an allocation factor, even it leads to a decrease in the tax base) makes the accurateness of the allocation factors questionable and leads to ambivalent outcomes (see e.g., Altshuler and Grubert, 2010; Hellerstein and McLure, 2004; Hines, 2010; Sørensen, 2004). Further, various studies reveal distortions caused regarding labour or sales when they are used as tax-base allocation factors. This distortion can in turn have an impact on the wages and demand on the labour market and can therefore affect real economic factors (see e.g., Eichfelder et al., 2018; Gordon and Wilson, 1986; Martini et al., 2012; Pethig and Wagener, 2007; Riedel, 2010) and not only the book profits as in the case of SA. Furthermore, Runkel and Schjelderup (2011) investigate the relationship between the investment and tax rate changes. Their outcomes show that changes in tax rates impact the investment of the whole corporate group in the case of FA, whereas SA impacts the investment only in the country in which the tax rate is changed. Nielsen et al. (2010) investigated the impact of tax rates if capital is used as the sole FA factor. Here, they found out that FA enforces the cut in capital stock that depends on the profits, costs of profit shifting and tax-planning behaviour of the company. In contrast, Clausing (2016) reveals a modest impact of sales, payroll and investment as allocation factors. Further, Nerudová et al. (2021) empirically reveal that FA within the framework of CCCTB generally leads to a lower tax base compared to SA.

The review shows that literature combining international taxation, managerial accounting and organisational structures is characterised by its focus on transfer prices and SA, which is criticised with regard to its appropriateness in light of today's changed business environment. In this regard, although FA is proposed not only at the EU level, but even at the global level, the literature has so far lacked investigations at firm level characterised by two studies (see e.g., Bauer et al., 2018; McGaughey and Raimondos, 2019). The first study, Martini et al. (2016), focuses on the contract problem and agency costs. It reveals that FA distorts the management compensation packages and effort choice (i.e., managerial incentivisation) (see Martini et al., 2016). The second study by Martini et al. (2012) investigates FA and centralised and decentralised decision-making authority. They highlight that FA stimulates the adaption of economic decisions. The extent of this impact depends on the MJE's decision-making organisation and the accounting system it uses. However, this study disregards differences in interests and behaviours when investment decisions are taken at different levels of the organisational structures. As discussed before, FA eliminates the transfer pricing dilemma; however it entails other intensive discussions, esp. related to the factors used for the tax-base allocation. Hence, the motivation of this paper is to explore how investment-related decisions and managers' compensation packages are affected by SA and FA under centralised and decentralised organisational structures within the framework of the principal-agency theory. It aims to answer the questions: What is the impact of different FA schemes on economic factors? Do they vary depending on the kinds or nature of the investments undertaken? Further, as discussed above, various studies reveal within different frameworks that tax differentials are the key indicator. G20 countries recently agreed on a common minimum tax rate of 15%. However, the literature shows

ambivalent discussions on whether tax competition is harmful or not (see e.g., Fourçans and Warin, 2010; Matheson et al., 2021). Hence, the interrelation of CIT schemes and rate differences is another key point into which this work aims to provide new insights.

As FA limits the closed-form solutions (see e.g., Martini et al., 2016), this study proposes a nonlinear programming to overcome this issue. For this purpose, a LEN[2] model was set up, which is one of the most used models within the framework of the agency theory. The model designed represents an MJE (principal) consisting of subsidiaries in different jurisdictions. The model takes into account that the agents' outputs do not only depend on their efforts, but also on further factors, which are represented in the model by means of investments in the broad scope (such as real investments in business machines and equipment; immaterial investments in marketing, staff training or operational leasing of machines or equipment). In the case of a decentralised structure, investment decisions are made by the managers of subsidiaries, whereas in the case of a centralised structure the principal undertakes investments.

This work contributes to the existing literature that investigates organisational structures within the framework of international taxation by taking the differences in the behaviour of the agents and principals into account and by differentiating between different CIT schemes: SA and FA with different allocation factors (Massachusetts, payroll-and sales-oriented FA). The model set up made it possible to take the payroll and sales as further allocation factors of FA, which has not been done hitherto. The outcomes reveal that the impact of each CIT scheme on investment decisions, management compensation packages, the principal's net profit and jurisdictions' tax revenue is significantly determined by organisational structures. Further, the schemes applied for FA can affect firm-internal contracts in a broader scope, which can have consequences for the delegated decision-making power with regard to what kinds of investments are made. The augmentation of the model to include the *agents' personal income taxation* (PIT) reveals that the impact of PIT on compensation packages, agents' efforts and investment decisions depends on the organisational structures and CIT schemes.

2 Model setup

The model is based on an MJE with subsidiaries in different countries. In order to investigate the investment decisions under a decentralised structure compared to a centralised one, a one-period LEN model is used. The principal (shareholders or owners of the MJE; hereinafter referred to as she) designs the compensation packages of risk-averse agents (i.e., managers of subsidiaries; hereinafter referred to as *they* or in singular *he*) located in different jurisdictions (i = 1, 2, …, z). In the following, the Definitions 2 to 7 are standard definitions of the LEN model, where the *organisational structures* (hereinafter abbreviated as *org. str.*) and the investment parameter are integrated.

Definition 1: The term investment is used in the broad scope in the model to include real (acquisition of business machines, equipment) and non-real (immaterial) investments (in marketing, personnel training or operational leasing of equipment or machines). The principal has an annual initial cash of I, which is available to make investments in the amount of β_i, in order to increase the outputs of the agents' efforts (or operations) of the existing subsidiaries:

$$I = \sum_{i=1}^{z} b_i \qquad \forall i \tag{1}$$

$$b_i = c_i \beta_i \qquad \forall i \tag{2}$$

$$\beta_i = \begin{cases} \beta_i^D & \text{if org. str. is decentralised} \\ \beta_i^C & \text{if org. str. is centralised} \end{cases} \qquad \forall i \tag{3}$$

where b_i defines the cost of the investment and c_i the cost coefficient of investment in the jurisdiction of each agent. As the model represents β_i as a productive investment with an impact on the agents' output x_i, it is assumed that it has no personal utilisation value for the agents (in contrast to the perk investments, see, for instance, Voßmerbäumer, 2013). Therefore, its cost of b_i is regarded in the principal's objective function [see e.g., equation (12)]. Under the decentralised organisational structure, each agent makes the decision regarding the investment amount β_i^D in his own jurisdiction, whereas under the centralised organisational structure, the principal decides on β_i^C in each jurisdiction.

Definition 2: The agents realise the output x_i, which depends linearly on their efforts e_i, marginal productivity p_i, the amount of investment β_i and its marginal impact on productivity q_i as well as on a normally distributed noise term $\varepsilon_i \sim N(0, \sigma_i)$ as formulated in equation (4). This error term represents exogenous factors impacting the output, which is independent of the agents' efforts.

$$x_i = e_i p_i + e_i \beta_i q_i + \varepsilon_i \qquad \forall i \tag{4}$$

We apply the second-best solution approach, meaning that the principal cannot observe the agents' efforts (triggered, for instance, by the location of the principal and agents in different jurisdictions).[3] In spite of this unobservability of efforts, the principal knows the agents' effort-and risk-averse behaviour, and their constraints. Hence, she is able to formulate the agents' objective function.

Definition 3: The principal offers the compensation package w_i to the agents. In order to incentivise them, she includes a variable or performance-based bonus payment of v_i in addition to the fixed payment (f_i) [equation (5)], which is based on the local output the agents realise before CIT.[4]

$$w_i = v_i x_i + f_i \qquad \forall i \tag{5}$$

Definition 4: As the agents are effort-averse, they have a disutility from providing effort given by k_i. The risk-averse behaviour of the agents requires a risk-premium for the variable part of the compensation given by ρ_i, where r_i represents the agents' absolute risk-aversion coefficient:

$$k_i = \frac{e_i^2}{2} \qquad \forall i \tag{6}$$

$$\rho_i = \frac{r_i}{2}\sigma_{w_i}^2 = \frac{r_i}{2} v_i^2 \left(q_i \beta_i\right)^2 p_i^2 \sigma_i^2 \qquad \forall i \tag{7}$$

Definition 5: The agents aim to maximise their objective function, namely the certainty equivalent function ($CE_i[U(w_i)]$). This equals their expected monetary compensation ($E[w_i]$) minus their disutility caused by providing effort (k_i) and their risk premium (ρ_i)[5]:

$$CE_i\left[U\left(w_i\right)\right] = E\left[w_i\right] - k_i - \frac{r_i}{2}\sigma_{w_i}^2 \qquad \forall i \qquad (8)$$

$$\begin{aligned} &\textit{Subject to}: \\ &PC: CE_i\left[U\left(w_i\right)\right] \geq u_i \qquad \forall i \end{aligned} \qquad (9)$$

$$IC_e: e_i^* = \arg\max_{e_i} CE_i\left[U\left(e_i, \beta_i, v_i, f_i\right)\right] \qquad \forall i \qquad (10)$$

$$IC_\beta: \begin{cases} \beta_i^{D*} = \arg\max_{\beta_i} CE_i\left[U\left(e_i, \beta_i, v_i, f_i\right)\right] & \textit{if org. str. is decentralised} \\ \beta_i^{D*} = 0 & \textit{otherwise} \end{cases} \qquad \forall i \quad (11)$$

Definition 6: u_i represents the reservation utility the agents would have received from alternative employment. The participation constraint *PC* states that the agents would accept the compensation package offered only if the utility received by $CE_i[U(w_i)]$ is higher than the reservation utility of u_i. Incentive constraint IC_e ensures that the agents choose their effort at the level that maximises their objective function $CE_i[U(w_i)]$. In the case of a decentralised structure, the incentive constraint IC_β states that they choose the investment at the level that maximises their $CE_i[U(w_i)]$. Consistent with the literature, in this model u_i is assumed to be 0 (see e.g., Martini et al., 2016; Niemann, 2008). Hence, w_i can be reformulated as: $w_i = k_i + \rho_i = \frac{e_i^2}{2} + \frac{r_i}{2} v_i^2 (q_i \beta_i)^2 \, p_i^2 \sigma_i^2$.

Definition 7: The principal's objective is to maximise her net profit (Π), resulting from the outputs the agents realise minus the wages paid to the agents and the costs of investments [equation (12)]. She aims to design a compensation package that is accepted by the agents.

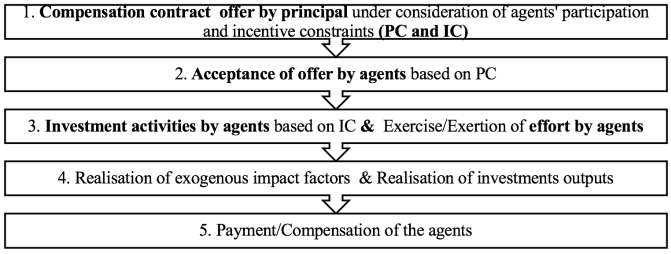
$$\max \Pi = \sum_{i=1}^{z} E\left[\left(x_i - w_i - b_i\right)\right] \qquad (12)$$

$$\begin{aligned} &\text{Subject to:} \\ &v_i, \beta_i^C \geq 0 \qquad \forall i \\ &\text{Equations (9) } \textit{to} \text{ (11)} \end{aligned} \qquad (13)$$

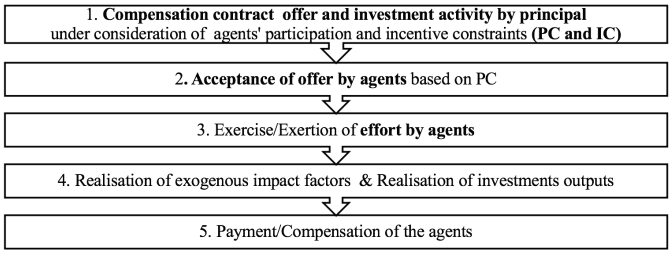
The constraint set (13) defines the principal's decision variables, namely the amount of variable payment v_i, and in the case of a centralised system, the amount of investment β_i^C for each agent. The constraint set [equations (9) to (11)] ensures that the principal fulfils the agents' constraints.

Figure 3(a) summarises the timeline of the principal's and agents' actions under the decentralised organisational structures formulated above. When investment decisions are made by the principal, the timeline of the principal's and agents' activities changes, as in Figure 3(b).

Figure 3 (a) Timeline under decentralised organisational structures and (b) Timeline under centralised organisational structures



(a)



(b)

2.1 Without taxation

By maximising $CE_i[U(w_i)]$ in equation (8) with respect to e_i based on the *IC* in equation (10), the principal can formulate the agents' optimal effort level:

$$e_i^* = v_i\left(p_i + \beta_i q_i\right) \tag{14}$$

Under the decentralised structure, maximising equation (8) with respect to β_i by considering equation (14) gives the optimal investment level (β_i^{D*}) given in the first line of equation (15). In contrast, under the centralised structure, inserting e_i^* of equation (14) into the principal's objective function Π in equation (12) and maximising it with respect to β_i gives the following β_i^C :

$$\beta_i^* = \begin{cases} \beta_i^{D*} = \dfrac{p_i}{q_i\left(r_i p_i^2 \sigma_i^2 - 1\right)} & \text{if org. str. is decentralised} \\ \beta_i^{C*} = \dfrac{2p_i q_i v_i - p_i q_i v_i^2 - c_i}{q_i^2 v_i\left(r_i v_i p_i^2 \sigma_i^2 + v_i - 2\right)} & \text{if org. str. is centralised} \end{cases} \tag{15}$$

Maximising the principal's objective function Π [equation (12)] with respect to v_i gives the following optimal variable (bonus) payment v_i^* :

$$v_i^* = \begin{cases} v_i^{D*} = \dfrac{p_i^2 r_i \sigma_i^2}{p_i^2 r_i \sigma_i^2 + 1} & \text{if org. str. is decentralised} \\ v_i^{C*} = \dfrac{\left(p_i + \beta_i q_i\right)^2}{\left(p_i + \beta_i q_i\right)^2 + p_i^2 \beta_i^2 q_i^2 r_i \sigma_i^2} & \text{if org. str. is centralised} \end{cases} \tag{16}$$

Under the centralised structure, inserting β_i^* [equation (15)] in v_i^* [equation (16)] and vice versa makes an analytical solution infeasible. Hence, in the numerical analysis section, equation (12) is optimised with respect to β_i and v_i by considering e_i^* in equation (14).

2.2 With income taxation at the principal's level

Definition 8: As the investment β_i is used for the realisation of output or to exert an impact on output x_i, the costs of the productive investment b_i are assumed to be tax-deductible from the principal's tax base. Here, t_i states the principal's CIT rate in the jurisdiction where each agent is resident.

As the agents' v_i is based on the output x_i before CIT, as mentioned above, their objective function $CE_i[U(w_i)]$ constraints (PC, IC), and thus their optimal level of effort e_i^* remain unchanged, as in equations (8) and (14). Under decentralised organisational structures, the agents' optimal investment level β_i^* also remains as in equation (15).

When considering income taxation at the principal's level, the practice diverges depending on the CIT schemes applied, SA and FA.

Definition 9: Under SA, the principal's objective function Π^{SA} is reformulated as in equation (17):

$$\max \Pi^{SA} = \sum_{i=1}^{z} E\left[(1-t_i)(x_i - w_i - b_i)\right] \tag{17}$$

Subject to:

Equations (9) to (11) and equation (13).

Maximising equation (17) with respect to β_i^* shows that the principal's optimal investment level under centralised structures also remains unchanged, as in equation (15). Further, maximising equation (17) with respect to v_i^* shows that the agents' equation payment is not affected by CIT under SA, which remains unchanged, as in equation (16) under both organisational structures. Hence, equation (17) is optimised with respect to β_i and v_i in the numerical analysis in the next section.

Under FA, the principal's tax base is summed up and apportioned to the jurisdictions where each agent is resident based on the allocation factors (FA factors). The practice diverges in the FA factors used for the allocation of the tax base. Due to its wide practice and discussions within the EU regarding the CCCTB, the model refers to the Massachusetts formula with the three equally weighted allocation factors of sales, payroll and assets (see European Commission, 2011).

Definition 10: w_i represents the payroll. The agents' output x_i is used in order to represent the allocation factor of sales (or the impact of the model on sales, respectively) that are realised and sold to third parties in the jurisdiction where they originate.[6] When β_i refers to a real investment impacting the MJE's assets, it represents the third allocation factor, namely assets, as given in the first line of equation (19). The MJE's tax base is allocated to each jurisdiction based on λ_i according to the first line of equation (19). However, when β_i does not refer to a real investment (hereinafter referred to as a non-real investment), the model represents the impact on the two tax-base allocation factors of wages w_i and sales x_i, which are equally weighted, as in the second line of equation (19).

$$\max \Pi^{FA} = E\left[\left(1-\sum_{i=1}^{z} t_i \lambda_i\right)\sum_{i=1}^{z}(x_i - w_i - b_i)\right] \tag{18}$$

$$\lambda_i = \begin{cases} \frac{1}{3}\left(\frac{w_i}{\sum_{i=1}^{2} w_i}\right)+\frac{1}{3}\left(\frac{x_i}{\sum_{i=1}^{2} x_i}\right)+\frac{1}{3}\left(\frac{\beta_i}{\sum_{i=1}^{2} \beta_i}\right) & \text{if investment. is a real investment} \\ \frac{1}{2}\left(\frac{w_i}{\sum_{i=1}^{2} w_i}\right)+\frac{1}{2}\left(\frac{x_i}{\sum_{i=1}^{2} x_i}\right) & \text{if investment. is a non-real investment} \end{cases} \quad \forall i \tag{19}$$

Subject to:

Equations (9) to (11) and equation (13).

Maximising equation (18) with respect to v_i was not feasible because of the nonlinearity, non-convexity and high-degree of the equations. In the numerical analysis, equation (18) is optimised with respect to v_i and β_i in the case of the centralised structure, by taking e_i^* in equation (14) into account.

2.3 With income taxation at the agents' level

Definition 11: Considering the agents' PIT reformulates their w_i, σ_{w_i} and $CE_i[U(w_i)]$ as in the following. Here, τ_i provides the personal *income tax rate* (PIT rate) of each agent:

$$w_i = (1-\tau_i)(v_i x_i + f_i) \qquad \forall i \tag{20}$$

$$\sigma_{w_i} = (1-\tau_i)^2 v_i^2 (q_i \beta_i)^2 p_i^2 \sigma_i^2 \qquad \forall i \tag{21}$$

$$CE_i[U(w_i)] = (1-\tau_i)\left(E[v_i x_i] - k_i - \frac{r_i}{2}\sigma_{w_i}^2\right) \geq u_i \qquad \forall i \tag{22}$$

Subject to:

$$PC: CE_i \geq u_i \qquad \forall i \tag{23}$$

Equations (10) *to* (11)

Maximising $CE_i[U(w_i)]$ with respect to e_i shows that the optimal effort is affected by τ_i, as:

$$e_i^* = (1-\tau_i) v_i (p_i + q_i \beta_i) \tag{24}$$

Under the decentralised organisational structure, maximising equation (22) with respect to β_i, by taking equations (10), (11), (23), and (24) into account, shows that the optimal investment is not impacted by τ_i [see equation (25)]. Under centralised structures, when SA is applied, maximising equation (17) with respect to β_i, by considering equation (24), shows that the principal's optimal investment level is impacted by the agents' τ_i:

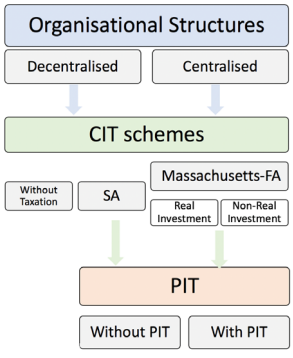
$$\beta_i^* = \begin{cases} \dfrac{p_i}{p_i^2 q_i r_i \sigma_i^2 - q_i} & \text{if org. str. is decentralised and SA is applied} \\ \dfrac{(1-\tau_i)(p_i q_i v_i)(v_i - 2) + c_i}{(1-\tau_i)(q_i v_i)(2 - r_i v_i p_i^2 \sigma_i^2 - v_i)} & \text{if org. str. is centralised and SA is applied} \end{cases} \tag{25}$$

Under both organisational structures, maximising Π^{SA} in equation (17) with respect to v_i, by taking e_i^* and β_i^* in equation (24) and (25) into account, shows that v_i^* is unaffected by the agents' PIT and the principal's CIT and remains unchanged as in equation (16). Under the centralised organisational structure, Π^{SA} in equation (17) is optimised with respect to v_i and β_i by considering e_i^* in equation (24) in the next section. Under FA e_i^* and β_i^* in equations (24) and (25) are taken into account for the optimisation of the principal's Π^{SA} in equation (18) with respect to v_i^* and β_i^*.

3 Numerical analysis

As mentioned above, the nonlinearity, non-convexity and high-degree characteristics of the model (esp. under FA) do not fulfil the optimisation conditions. Therefore, a nonlinear optimisation was programmed on MATLAB. It is assumed that the MJE has two subsidiaries (i = 1, 2) and hence two agents. Here, both agents are assumed to be identical with the parameters: p_i = 1, σ_i = 1.5, r_i = 1, c_i = 0.85, q_i = 1, u_i = 0, where the annual initial cash available for investments is set as $I = \beta_1 + \beta_2 = 1.7$. The optimisation is conducted for the CIT (t_i) and PIT (τ_i) rate combinations of t_i, $\tau_i \in$ {0.1, 0.2, 0.3, 0.4, 0.5}. In the next section the outcomes are discussed for the combinations of t_i, $\tau_i \in$ {0.1, 0.3}.[7] In the tables, the outcomes are rounded to four decimal digits. Figure 4 gives an overview of the models investigated, which were formulated mathematically in the previous section.

Figure 4 Models investigated (see online version for colours)



3.1 Without taxation

Table 2 represents the outcomes of the nonlinear programming without taxation (represented in Section 2.1 above). It shows that the investment amount β_i, and the other decision variables therefore diverge to a wide extent across the organisational structures. Under the decentralised structure, the principal provides the agents with a lower variable payment v_i to incentivise them compared to centralised structures. Here, the agents choose a higher investment (β_i) and effort (e_i) levels, and they realise a higher output x_i. In contrast, under centralised structures the principal chooses a lower level of investment (β_i) and a higher level of v_i. Although this decreases the agents' e_i and x_i, the principal achieves a higher net profit Π compared to decentralised structures.

Table 2 Results without taxation

	Decentralised		*Centralised*	
	i = 1	*i = 2*	*i = 1*	*i = 2*
v_i	0.6923	0.6923	0.9697	0.9697
β_i	0.8	0.8	0.1335	0.1335
w_i	1.1215	1.1215	0.623	0.623
e_i	1.2462	1.2462	1.0992	1.0992
x_i	2.2431	2.2431	1.2459	1.2459
Π	0.8831		1.019	

3.2 Taxation at the principal's level

The outcomes of the nonlinear programming are summarised in Table 3 for decentralised structures and in Table 4 for centralised structures for the CIT rates $t_1 = 0.3$; $t_2 = 0.1$ (represented in Section 2.2). Hereinafter, tb_i represents the principal's tax burden, and in turn the jurisdiction's tax revenue where each agent is resident and *TB* states the principal's tax burden in sum in both jurisdictions resulting from CIT.

Table 3 Results with CIT under decentralised structures for $t_1 = 0.3$; $t_2 = 0.1$

	SA		*FA – real investment*		*FA – non-real investment*	
	i = 1	*i = 2*	*i = 1*	*i = 2*	*i = 1*	*i = 2*
v_i	0.6923	0.6923	0.6749	0.7088	0.6661	0.7166
β_i	0.8	0.8	0.8	0.8	0.8	0.8
w_i	1.1215	1.1215	1.066	1.1757	1.0383	1.2018
e_i	1.2462	1.2462	1.2149	1.2759	1.199	1.29
x_i	2.2431	2.2431	2.1868	2.2966	2.1582	2.3219
λ_i	-	-	0.4878	0.5122	0.4726	0.5274
tb_i	0.1325	0.0442	0.129	0.0452	0.1248	0.0464
Π/TB	0.7065	0.1766	0.7075	0.1742	0.7089	0.1712

As shown analytically above, SA does not distort the agents' compensation packages (v_i, w_i) nor the investment behaviour (β_i) under both organisational structures (see

Tables 2 to 4). This leads to a proportional decrease in the principal's net profit Π (see Tables 2 to 4 and 14 in Appendix).

When FA is applied, under decentralised organisation structures the principal offers a higher v_i (w_i) to the agent in the low-tax jurisdiction, which causes a higher effort choice and higher output there. This occurs to a wider extent when the agents choose a non-real investment. Hence, the agent in the low-tax jurisdiction is better off when he undertakes a non-real investment, whereas the opposite applies for the agent in the high-tax jurisdiction. In general, the principal is better off when she grants the agents the right to choose only an investment that does not impact the FA allocation λ_i directly (i.e., non-real investments) (see Π in Tables 3, and 14 to 16 in Appendix).

In contrast, under centralised structures, under FA both β_i and v_i decrease (increase) in the high-(low-) tax jurisdiction. This results in a lower tax burden in sum (*TB*), and hence in a higher net profit (Π) in the case of real investments compared to non-real ones. Here, the principal adapts two factors v_i and β_i and v_i decrease (increase) in the high-(low-) tax jurisdiction. This result in a lower tax of the tax-base allocation (see λ_i in Tables 4, 18 and 19 in Appendix). However, this adaption of v_i and β_i to t_i occurs in the case of non-real investments to a wider extent than when the principal undertakes real investments (see Tables 17 to 19 in Appendix for further outcomes). From the viewpoint of tax jurisdictions, the tax revenue of the high-tax jurisdiction is distorted most seriously in the case of real investments compared to non-real ones, which benefits the low-tax jurisdiction to a higher extent. Further, under FA the impact of the CIT rates is determined by the kind of investment undertaken. An increase in t_i improves the tax revenue of the respective jurisdiction to a minor extent when a real investment is undertaken, whereas in the case of a non-real investment the tax revenue of the respective jurisdiction increases to a wider extent. In general, an increase in t_i improves the tax revenue of the other jurisdiction even if its t_i remains unchanged (see Tables 18 and 19 in Appendix). Moreover, because of the neutrality of CIT under SA, the agent in the high-tax jurisdiction is better off under SA, and under FA with real investments. On the other hand, the other agent benefits more from being in the low-tax jurisdiction when the principal undertakes non-real investments (see Tables 17 to 19 in Appendix).

Table 4 Results with CIT under centralised structures for $t_1 = 0.3$; $t_2 = 0.1$

	SA		*FA – real investment*		*FA – non-real investment*	
	i = 1	*i = 2*	*i = 1*	*i = 2*	*i = 1*	*i = 2*
v_i	0.9697	0.9697	0.9402	0.9852	0.9096	0.9886
β_i	0.1335	0.1335	0	0.1875	0.0309	0.2156
w_i	0.623	0.623	0.442	0.7228	0.4406	0.7732
e_i	1.0992	1.0992	0.9402	1.17	0.9378	1.2017
x_i	1.2459	1.2459	0.9402	1.3894	0.9668	1.4608
λ_i	-	-	0.261	0.739	0.3806	0.6194
tb_i	0.1528	0.0509	0.0787	0.0743	0.1147	0.0622
Π/*TB*	0.8152	0.2038	0.8523	0.153	0.8274	0.1769

3.3 Taxation at the agents' level

As shown analytically above in Section 2.3, when the principal's income is subject to SA, v_i^* shows independence from PIT under decentralised organisational structures. Hence, SA triggers a proportional decreasing effect of the PIT rate τ_i on e_i, where β_i and v_i remain neutral across the different t_i and τ_i (see Tables 3, 5 to 7 and 20 in Appendix). In the following, pit_i represents the agents' tax burden caused by PIT, where tr_i states the tax revenue of each jurisdiction resulting from CIT and PIT.

Table 5 Results with PIT under decentralised structures for $\tau_1 = 0.1$; $t_1 = 0.3$; $t_2 = 0.1$

	SA		*FA – real investment*		*FA – non-real investment*	
	i = 1	*i = 2*	*i = 1*	*i = 2*	*i = 1*	*i = 2*
v_i	0.6923	0.6923	0.678	0.7061	0.6707	0.7127
β_i	0.8	0.8	0.8	0.8	0.8	0.8
w_i	1.0094	1.0094	0.968	1.05	0.9473	1.0696
e_i	1.1215	1.1215	1.0983	1.1439	1.0865	1.1545
x_i	2.0188	2.0188	1.9769	2.0589	1.9557	2.0781
λ_i	-	-	0.4898	0.5102	0.4773	0.5227
tb_i	0.0988	0.0329	0.0967	0.0336	0.0941	0.0343
pit_i	0.1009	0.1009	0.0968	0.105	0.0947	0.107
tr_i	0.1998	0.1339	0.1935	0.1386	0.1888	0.1413
Π/TB	0.527	0.1318	0.5277	0.1303	0.5285	0.1284

Table 6 Results with PIT under decentralised structures for $\tau_1 = 0.3$; $\tau_2 = 0.1$; $t_1 = 0.3$; $t_2 = 0.1$

	SA		*FA – real investment*		*FA – non-real investment*	
	i = 1	*i = 2*	*i = 1*	*i = 2*	*i = 1*	*i = 2*
v_i	0.6923	0.6923	0.6806	0.7012	0.6747	0.7054
β_i	0.8	0.8	0.8	0.8	0.8	0.8
w_i	0.7851	1.0094	0.7586	1.0354	0.7457	1.0478
e_i	0.8723	1.1215	0.8575	1.1359	0.8502	1.1427
x_i	1.5702	2.0188	1.5435	2.0446	1.5303	2.0569
λ_i	-	-	0.451	0.549	0.4212	0.5788
tb_i	0.0315	0.0329	0.0587	0.0238	0.0548	0.0251
pit_i	0.2355	0.1009	0.2276	0.1035	0.2237	0.1048
tr_i	0.267	0.1339	0.2863	0.1274	0.2785	0.1299
Π/TB	0.37	0.0645	0.3515	0.0826	0.3537	0.0799

When FA is applied, independent of the kind of the investment the agents undertake, the outcomes reveal that taking PIT into account decreases the difference in v_i between FA and SA (see Tables 3, 5 to 7). An increase in the PIT rate τ_i leads to an increase in the respective v_i and a decrease in v_i in the other jurisdiction. In other words, considering PIT limits the principal's tax-base shift action under FA and decreases the gap in v_i (thus the agents' compensation w_i) between high-and low-tax jurisdictions (see Tables 5, 6, and 21,

22 in Appendix). This results in a lower net profit (Π) under FA compared to SA when PIT and CIT rates (τ_i, t_i) move in the same direction; i.e., a jurisdiction applies high rates for both CIT and PIT (see Tables 6, and 20 to 22 in Appendix). However, when t_i and τ_i move in inverse directions, the principal is better off under FA with real investments compared to non-real ones and SA. This inverse relation of t_i and τ_i causes the principal a higher tax burden *TB* in sum under all CIT schemes (see Tables 6 and 7, and 20 to 22 in Appendix for further t_i and τ_i). Thus, from the viewpoint of tax jurisdictions, taxing the agents' wages w_i at a higher τ_i and the principal's Π at a lower t_i increases their tax revenue tr_i more than vice versa. On the contrary, due to the decreasing impact of τ_i, being in a jurisdiction with a high t_i and a low τ_i is more beneficial for the agents than vice versa (see w_i in Table 7).[8]

Table 7 Results with PIT under decentralised structures for $\tau_1 = 0.1$; $\tau_2 = 0.3$; $t_1 = 0.3$; $t_2 = 0.1$

	SA		*FA – real investment*		*FA – non-real investment*	
	i = 1	*i = 2*	*i = 1*	*i = 2*	*i = 1*	*i = 2*
v_i	0.6923	0.6923	0.6829	0.7041	0.678	0.7099
β_i	0.8	0.8	0.8	0.8	0.8	0.8
w_i	1.0094	0.7851	0.9821	0.8119	0.9682	0.8254
e_i	1.1215	0.8723	1.1063	0.8871	1.0984	0.8944
x_i	2.0188	1.5702	1.9913	1.5968	1.9771	1.6099
λ_i	-	-	0.5341	0.4659	0.5455	0.4545
tb_i	0.0988	0.0105	0.0696	0.0202	0.0709	0.0197
pit_i	0.1009	0.2355	0.0982	0.2436	0.0968	0.2476
tr_i	0.1998	0.246	0.1678	0.2638	0.1678	0.2673
Π/*TB*	0.3251	0.1093	0.3443	0.0898	0.3429	0.0907

Table 8 Results with PIT under centralised structures for $\tau_i = 0.1$; $t_1 = 0.3$; $t_2 = 0.1$

	SA		*FA – real investment*		*FA – non-real investment*	
	i = 1	*i = 2*	*i = 1*	*i = 2*	*i = 1*	*i = 2*
v_i	0.9958	0.9958	0.939	1.0292	0.9055	1.0407
β_i	0.0451	0.0451	0	0.0945	0	0.1162
w_i	0.4895	0.4895	0.3968	0.5806	0.3689	0.622
e_i	0.9367	0.9367	0.8451	1.0138	0.8149	1.0454
x_i	0.9789	0.9789	0.8451	1.1095	0.8149	1.1669
λ_i	-	-	0.2794	0.7206	0.3918	0.6082
tb_i	0.1353	0.0451	0.0752	0.0646	0.1049	0.0543
pit_i	0.0489	0.0489	0.0397	0.0581	0.0369	0.0622
tr_i	0.1843	0.0941	0.1149	0.1227	0.1417	0.1165
Π/*TB*	0.7218	0.1804	0.7572	0.1398	0.733	0.1591

When the principal makes the investment decisions, not only e_i, but also β_i depend directly on PIT rates τ_i. This makes v_i indirectly dependent on τ_i under SA. Here, PIT

distorts β_i to a wider extent, which leads to a higher v_i, a lower β_i and a proportional decrease in e_i, (see Tables 8 to 10 and 23 in Appendix).

Due to the neutrality of SA regarding CIT, the interrelation of the CIT and PIT rates (t_i, τ_i) does not matter. However, under FA, an inverse relation of t_i and τ_i affects both real and non-real investment levels negatively (see Table 10). The principal benefits from this inverse relation to a higher extent when she undertakes a real investment (see Π in Tables 9 and 10). Furthermore, compared to the decentralised structure, where SA is more advantageous for the principal when the CIT and PIT rates (t_i and τ_i) move in the same direction, under the centralised structure, the principal is better off with a real investment independent of the interrelation of the CIT and PIT rates (see Tables 8 to 10, and 23 to 25 in Appendix).

Table 9 Results with PIT under centralised structures for $\tau_1 = 0.3$; $\tau_2 = 0.1$; $t_1 = 0.3$; $t_2 = 0.1$

	SA		*FA – real investment*		*FA – non-real investment*	
	i = 1	*i = 2*	*i = 1*	*i = 2*	*i = 1*	*i = 2*
v_i	1	0.9958	0.9341	1.0247	0.8992	1.0348
β_i	0	0.0451	0	0.0871	0	0.105
w_i	0.35	0.4895	0.3054	0.5664	0.283	0.6003
e_i	0.7	0.9367	0.6539	1.0025	0.6295	1.0291
x_i	0.7	0.9789	0.6539	1.0898	0.6295	1.1371
λ_i	-	-	0.2418	0.7582	0.3384	0.6616
tb_i	0.105	0.0451	0.0579	0.0605	0.0806	0.0525
pit_i	0.105	0.0489	0.0916	0.0566	0.0849	0.06
tr_i	0.21	0.0941	0.1495	0.1171	0.1655	0.1126
Π/*TB*	0.651	0.1501	0.6795	0.1184	0.6609	0.1331

Table 10 Results with PIT under centralised structures for $\tau_1 = 0.1$; $\tau_2 = 0.3$; $t_1 = 0.3$; $t_2 = 0.1$

	SA		*FA – real investment*		*FA – non-real investment*	
	i = 1	*i = 2*	*i = 1*	*i = 2*	*i = 1*	*i = 2*
v_i	0.9958	1	0.9436	1.0643	0.9096	1.0964
β_i	0.0451	0	0	0	0	0
w_i	0.4895	0.35	0.4007	0.3964	0.3723	0.4208
e_i	0.9367	0.7	0.8492	0.745	0.8186	0.7675
x_i	0.9789	0.7	0.8492	0.745	0.8186	0.7675
λ_i	-	-	0.3451	0.6549	0.4928	0.5072
tb_i	0.1353	0.035	0.0825	0.0522	0.1172	0.0402
pit_i	0.0489	0.105	0.0401	0.1189	0.0372	0.1262
tr_i	0.1843	0.14	0.1226	0.1711	0.1545	0.1665
Π/*TB*	0.6308	0.1703	0.6624	0.1347	0.6356	0.1575

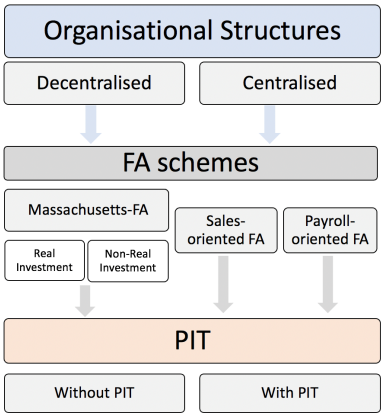
In contrast to the previous part above, taxing the agents' wages w_i at a higher τ_i and the principal's Π at a lower t_i is more beneficial for tax jurisdictions under FA, independent of the kinds of investment, whereas under SA a higher CIT rate t_i and a lower PIT rate τ_i

increase the tax revenue significantly (see Table 10). As in the case of the decentralised structure, from the viewpoint of agents in the high-CIT jurisdiction, because of the neutrality of SA regarding CIT, SA is more beneficial, while under FA they are better off when the principal decides for a real investment instead of a non-real one. This holds true independently of the PIT rates (see Tables 8 to 10 and 23 to 25 in Appendix).

3.4 Extension: payroll-vs. sales-oriented FA

As the use of the appropriate allocation factors within the framework of FA is one of the major points discussed, as mentioned above, this part augments the model by FA with the sole allocation factors of payroll and sales. As the MJE's assets are not part of the tax-base allocation, a differentiation between a real and a non-real investment is dispensable. Figure 5 illustrates the FA schemes investigated:

Figure 5 FA schemes investigated (see online version for colours)



In the case of the sales-oriented FA, the outputs x_i represent the sales in the model (as done above). Here, λ_i in the principal's objective function Π^{FA} [equation (18)] is replaced by the first line of equation (26). Conversely, in the case of payroll as the sole tax-base allocation factor (i.e., payroll-oriented FA), the second line of the equation (26) replaces λ_i in equation (18). The nonlinear optimisation is conducted by using the same parameters and steps as in the numerical analysis for the previous parts above.

$$\lambda_i = \begin{cases} \dfrac{x_i}{\sum_{i=1}^{2} x_i} & \text{if sales-oriented FA is applied} \\ \dfrac{w_i}{\sum_{i=1}^{2} w_i} & \text{if payroll-oriented FA is applied} \end{cases} \qquad \forall i \tag{26}$$

Equation (18)

Subject to:

Equations (8) to (11) and equation (13) if PIT is not considered.

Equations (10), (11), (13), and equation (23) if PIT is considered.

Comparing the outcomes across the FA schemes reveals that under decentralised structures the payroll-oriented FA causes the highest distortion with a shift of v_i to a wider extent to the low-tax jurisdiction, which results in the highest Π across all CIT schemes and distorts the agents' efforts e_i to the highest extent (see Tables 3 and 11, 14 to 16, 26 and 27 in Appendix). Under the centralised structure, the principal is still better off under the Massachusetts FA. Here, the investment level β_i in the high-tax jurisdiction is distorted to a wider extent under the Massachusetts FA with real investments, whereas other FA schemes lead to a lower decrease in the high-tax jurisdiction and a higher increase in the low-tax jurisdiction (see Tables 4 and 11, 18, 19, 28 and 29 in Appendix).

Table 11 Results with CIT under payroll-and sales-oriented FA for for $t_1 = 0.3$; $t_2 = 0.1$

	Decentralised organisational structures				*Centralised organisational structures*			
	Payroll-oriented FA		*Sales-oriented FA*		*Payroll-oriented FA*		*Sales-oriented FA*	
	i = 1	*i = 2*	*i = 1*	*i = 2*	*i = 1*	*i = 2*	*i = 1*	*i = 2*
v_i	0.6574	0.724	0.6749	0.7089	0.8823	1.0064	0.9384	0.9698
β_i	0.8	0.8	0.8	0.8	0.0311	0.2088	0.0313	0.2207
w_i	1.0113	1.2266	1.0659	1.1758	0.4147	0.7896	0.4693	0.7523
e_i	1.1833	1.3032	1.2149	1.2759	0.9098	1.2165	0.9678	1.1839
x_i	2.1299	2.3458	2.1868	2.2967	0.9381	1.4704	0.9981	1.4452
λ_i	0.4519	0.5481	0.4877	0.5123	0.3443	0.6557	0.4085	0.5915
tb_i	0.119	0.0481	0.129	0.0452	0.1033	0.0656	0.1235	0.0596
Π/*TB*	0.7107	0.1671	0.7075	0.1742	0.8314	0.1689	0.8244	0.1831

Table 12 Results with PIT under payroll-and sales-oriented FA for $\tau_1 = 0.3$; $\tau_2 = 0.1$; $t_1 = 0.3$; $t_2 = 0.1$

	Decentralised organisational structures				*Centralised organisational structures*			
	Payroll-oriented FA		*Sales-oriented FA*		*Payroll-oriented FA*		*Sales-oriented FA*	
	i = 1	*i = 2*	*i = 1*	*i = 2*	*i = 1*	*i = 2*	*i = 1*	*i = 2*
v_i	0.669	0.7094	0.6806	0.7012	0.8694	1.0501	0.9314	1.0176
β_i	0.8	0.8	0.8	0.8	0	0.0997	0	0.1089
w_i	0.733	1.0599	0.7587	1.0354	0.2646	0.6112	0.3036	0.5855
e_i	0.8429	1.1493	0.8575	1.1359	0.6086	1.0393	0.652	1.0156
x_i	1.5172	2.0687	1.5436	2.0446	0.6086	1.143	0.652	1.1263
λ_i	0.4088	0.5912	0.4302	0.5698	0.3021	0.6979	0.3666	0.6334
tb_i	0.0531	0.0256	0.056	0.0247	0.0717	0.0552	0.0876	0.0504
pit_i	0.2199	0.106	0.2276	0.1035	0.0794	0.0611	0.0911	0.0586
tr_i	0.273	0.1316	0.2836	0.1283	0.1511	0.1163	0.1787	0.109
Π/*TB*	0.3543	0.0787	0.3533	0.0808	0.6641	0.1269	0.6585	0.1381

Under decentralised as well as under centralised structures, the principal is better off under every FA scheme than under SA (see Tables 3, 4 and 11). From the viewpoint of

the agents, under both structures the agent in the high-CIT jurisdiction is worse off when payroll-oriented FA is applied, whereas the sales-oriented FA distorts his compensation (w_i) to a lower extent (esp. in the case of the centralised structure). Being in the low-tax jurisdiction benefits the agent under the payroll-oriented FA more under both structures compared to FA with other allocation factors (see Tables 3, 4 and 11).

When taking PIT into account, the outcomes highlight that here, too, the payroll-oriented FA causes a lower (higher) v_i in the high (low)-CIT jurisdiction and benefits the principal with a higher net profit Π under the decentralised structure. However, she is still best off under SA (see Tables 6 and 12). Only when CIT and PIT move in inverse directions is the principal better off under the Massachusetts FA, when agents undertake real investments (see Tables 7 and 13). Moreover, when the principal decides on the investment, she is still better off when she undertakes real investments when the Massachusetts FA is applied (see Tables 9, 10, 12 and 13). As in the case without PIT, here the Massachusetts FA also makes a wider tax-base shift possible (see λ_i in Tables 6 to 13).

Table 13 Results with PIT under payroll-and sales-oriented FA for $\tau_1 = 0.1$; $\tau_2 = 0.3$; $t_1 = 0.3$; $t_2 = 0.1$

	Decentralised organisational structures				*Centralised organisational structures*			
	Payroll-oriented FA		*Sales-oriented FA*		*Payroll-oriented FA*		*Sales-oriented FA*	
	i = 1	*i = 2*	*i = 1*	*i = 2*	*i = 1*	*i = 2*	*i = 1*	*i = 2*
v_i	0.6732	0.7155	0.6829	0.7041	0.879	1.1219	0.941	1.0669
β_i	0.8	0.8	0.8	0.8	0	0	0	0
w_i	0.9543	0.8385	0.982	0.812	0.3477	0.4405	0.3984	0.3984
e_i	1.0905	0.9015	1.1062	0.8872	0.7911	0.7853	0.8469	0.7469
x_i	1.9629	1.6227	1.9912	1.5969	0.7911	0.7853	0.8469	0.7469
λ_i	0.5323	0.4677	0.555	0.445	0.4411	0.5589	0.5314	0.4686
tb_i	0.0691	0.0202	0.0723	0.0193	0.1043	0.0441	0.127	0.0373
pit_i	0.0954	0.2516	0.0982	0.2436	0.0348	0.1322	0.0398	0.1195
tr_i	0.1645	0.2718	0.1705	0.2629	0.1391	0.1762	0.1669	0.1569
Π/*TB*	0.3435	0.0894	0.3425	0.0916	0.6399	0.1484	0.6325	0.1644

Independent of taking PIT into account or not, the payroll-oriented FA gives the principle a better tax-planning opportunity compared to the sales-oriented FA (see Tables 11 to 13). From the viewpoint of jurisdictions, the sales-oriented FA and Massachusetts with real investments distort the tax revenue (tr_i) of the high-tax jurisdiction to a smaller extent and benefit the low-tax jurisdiction to a smaller extent under the decentralised structure. Here, the payroll-oriented FA distorts the high-tax jurisdictions' revenue to a larger extent, while benefiting the low-tax jurisdictions to a wider extent (see e.g., Tables 3 and 11). On the other hand, under the centralised structures, the high-tax jurisdiction is better off when it applies sales-oriented FA (see Tables 4 and 11).

4 Conclusions

The discussions about the appropriateness of the sourced-based taxation principle of SA in light of today's changed business environment consider FA as an alternative (see e.g., OECD, 2019; Matheson et al., 2021). The literature highlighted the distortions caused by FA at the firm level, namely with regard to the managerial incentives (see Martini et al., 2016) and the economic decisions, the extent of which is determined by the companies' decisions-making organisations (organisational structures) (see Martini et al., 2012). Nielsen et al. (2008) also reveal an interrelation between the organisational structures and CIT rates, however within the framework of SA. This study focused on this topic by taking the differences in the decision-making behaviours of owners and managers into account. The standard LEN model is expanded by the fact that the agents' outputs not only depend on their efforts, but also on further factors (such as the equipment/machines they use, their soft skills being improved by the trainings provided). This is represented by means of investments undertaken either by the principal (i.e., centralised structure) or agents (decentralised structure). As shown in Martini et al. (2016), even with one allocation factor (payroll), FA causes a high-degree polynomial issue, which makes a closed-form solution infeasible. Investigating FA with further allocation factors (sales, assets) increases the complexity of the model. To overcome this issue, this study introduced nonlinear programming for the investigation of FA.

In general, the outcomes reveal that the impact of CIT schemes, CIT and PIT rates under both organisational structures show significant differences. Allocation factors used for FA are not only important for the managers' compensation packages, but also for the delegations regarding to what extent they should occur (e.g., should the agents be endowed with the right to undertake investments such as the acquisition of assets or be limited to operational leasing or investments in essential trainings?). In contribution to previous studies, considering the agents' PIT reveals varying effects on the agents' compensation packages and the investment across the organisational structures:

- Decentralised structures: PIT decreases the agents' effort choice without impacting their investment decisions and variable payments.
- Centralised structures: PIT has a negative impact on the principal's investment behaviour. It increases the agents' variable payments with a proportional decrease in their effort.

Furthermore, the payroll-oriented FA leads to the highest distortions of the agent's compensation in the high-tax jurisdiction and benefits the other agent to the widest extent compared to SA and other FA schemes. In contribution to Nielsen et al. (2008), the results reveal that also in the case of high personal income tax rates (PIT rates), it is better when the principal undertakes the investments under every CIT scheme.

From the viewpoint of jurisdictions, the outcomes reveal that the impact of CIT schemes on their tax revenues is determined by firm-internal factors: namely the MJE's organisational structures and the extent of the decision-making power delegated under the Massachusetts FA. An interesting outcome is that under decentralised structures the tax jurisdictions achieve higher tax revenue when they charge the principal's profit at lower tax rates and the agents' income at higher tax rates under every CIT scheme. Under centralised structures, however, it is more profitable for the jurisdictions to charge:

1 higher CIT rates and lower PIT rates under SA and sales-oriented FA

2 higher PIT rates and lower CIT rates under the Massachusetts and payroll-oriented FA.

In the field of international business taxation, the discussions focus on the change of the CIT scheme and the harmonisation of tax rates (e.g., CCCTB, recent cooperation among G20 regarding the minimum CIT rate for large MJEs), hence this study emphasised the interrelation between organisational structures and these two key points of CIT. Therefore, the numerical analysis referred to identical agents and identical tax treatment of investments. However, the model set up can be applied to different settings related to agents and investments (referring, for example, to the agents' risk-averse behaviour or productivity, the cost of investment and the differences in the tax treatment of investments).

From another point of view, in general, the pandemic that has recently been experienced, has underlined the importance of organisational structures. This has required flexibility regarding the changes on the local market, the quick essential changes in production procedures according to the local requisitions or the switch to home office (e.g., providing the essential office equipment to employees or incentives offered to employees). Hence, this investigation can be adapted to further settings. For instance, an investment decision made by the principal can cause higher administrative costs, and delays in investments can affect the outputs negatively. In contrast, agents can tend towards (unproductive) perk investments.

As one of the aims of this study was to introduce FA into the principal-agency theory and organisational structures, CIT was chosen as the framework for this purpose. As mentioned in the introduction, FA is also applied at national levels for other kinds of taxation, e.g., for business tax in Germany (see e.g., Eichfelder et al., 2018). Hence, the model set up and nonlinear programming can also be applied to the investigation of other taxation types within the framework of organisational structures.

As this study is based on a theoretical model and nonlinear programming, it entails several limitations: Some simplifications were essential, as a representation of the real world with its all-relevant factors is infeasible. Further, the LEN assumption limits the frame of compensation contracts that are possible. These are the general unavoidable critiques of theoretical modelling and LEN. However, these simplifications made the investigation of FA possible, which entails high-degree polynomials and challenges analytical and numerical investigations. As one of the main characteristics of FA is that it avoids the transfer pricing dilemma, firm-internal interactions and transfer pricing issues were not considered and went beyond the scope of this work. Due to this and the aforementioned aims, the nonlinear programming focused on the investigation of organisational structures and CIT schemes and rates within a basic framework of identical agents and investments.

Appendices are available on request by emailing the author.

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Notes

1 In the latest amendment, the data factor is added as the fourth factor of FA (see European Parliament, 2018). The data factor covers collection and use of the personal data of online platform and service users. The report states that if any allocation factor is not applicable because of the nature of the tax payer's activities, the tax base has to be allocated equally weighted based on the other applicable factors (see European Parliament, 2018; European Commission, 2011). Hence, this paper considers FA with the allocation factors of payroll, assets and sales that are equally weighted and applicable to the nature of the model designed.

2 LEN stands for linear production function and compensation, a negative expected exponential utility function of the agent and normally distributed performance measure or error term (see e.g., Spremann, 1987).

3 When the principal can observe the agents' effort, it is called the first-best solution. Here, the principal can force the agents to provide the effort that maximises her net profit. In contrast, in the case of the unobservability of the agents' efforts (second-best solution), the principal offers variable payments as incentives to motivate the agents to provide higher effort and to maximise her net profit. In general, the changes in business structures and the latest changes caused by the pandemic (such as the home-office trend, limitations on travel) have increased the unobservability of the agents' efforts.

4 As discussed in Martini et al. (2016), using global output for v_i would lead to a dependency of the agents' compensation on each other and cause a free-riding issue without providing more information. In order to avoid these issues, the model is also based on the local outputs x_i.

5 As the derivation of $CE_i[U(w_i)]$ from the expected utility of compensation $U(w_i)$ has been discussed in previous studies in detail, it is not dealt with here (see e.g., Martini et al., 2016; Niemann, 2008).

6 As the transfer pricing issues are not the scope of this study (analysed, for instance, by Martini et al. 2012) and as the CCCTB foresees a tax-base consolidation, it is assumed that both subsidiaries are independent of each other. They do not share any internal transactions or tax-planning efforts.

7 As shown in Appendix, the results also hold true for other tax rate combinations. On request, further outcomes can be shared by e-mail.

8 Independent of the levels of t_i, the decrease in effort e_i caused by τ_i leads to a net loss (negative Π) when τ_i in both jurisdictions are at higher levels under all CIT schemes (see Tables 20 to 22 in Appendix).