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The Impact of Taxation on International Assignment Decisions

– A principal-agent approach –

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Abstract In many industries like management consulting, IT consulting, or construction highly qualified employees, i.e., experts or executive managers, have to be assigned to temporary projects. In firms with many employees and various different projects, this assignment decision involves a complex optimization procedure. Obviously, the employees' productivities in the respective projects are crucial for the employer's optimal assignment decision, but assignment can also be affected by risk-incentive trade-offs. Moreover, taxation can alter the assignment decision, especially if employees are sent abroad as expatriates so that international tax law has to be taken into account. To address these issues simultaneously, we combine a human resource assignment problem with a principal-agent problem of the LEN type. Both wage taxation at the agents' level and corporate taxation at the principal's level are integrated.

We show that national tax rules as well as the methods for avoiding double taxation and the agents' tax characteristics are important determinants for international assignment decisions. The effects of tax rate variations can be ambiguous and depend on whether the exemption method or the credit method are applied, in particular if agents make differing choices of residence. From a tax policy perspective, the exemption method should be preferred because the tax effects are more transparent than under the credit method. Special deductions for incoming expatriates have only little effects on the optimal assignment decision.

Keywords Assignment · Expatriates · International taxation · Principal-agent model · LEN model

JEL Classification H24 · H25 · M41

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1 Introduction

In an increasingly volatile working environment with more and more project work human resource assignment decisions occur much more frequently than in a stationary working environment. For example, employed IT consultants or management consultants are assigned to projects with a duration from a few weeks to several months or even years. After a consulting project is completed, the consultant is assigned to another project. Similar situations can be observed in the construction industry. Specialized civil engineers are sent to supervise construction sites for a long-term, but temporary period. Typically, large construction projects have a time for completion of at least several months, but completion can also take years, depending on the complexity of the project.

The deployment of expatriates is another example for project-related human resource assignment. A parent company that establishes subsidiaries abroad needs top executives who run these subsidiaries. To ensure that the subsidiary is conducted in the interest and according to the guidelines of the parent company, the executives are often sent from the parent company's headquarters. As human resource assignment has domestic as well as international aspects, domestic and international tax consequences should be taken into account. However, the human resource literature has not yet picked up human resource related effects of taxation as a research question. Similarly, research in taxation related to human resource most often only refers to the tax advantages of certain fringe benefits.[1] Tax issues of expatriates are typically left for legal tax research.

Competent human resource departments should have detailed knowledge about the qualifications of their employees, i.e., their education and social skills, their project experience, and their past performance. As a consequence, an employer should ideally have forecasts of employees' productivities for different projects that have currently to be staffed. Clearly, these project-specific productivities are a crucial determinant of the employer's assignment decision.

Since the success and hence the profitability of a project for the employer depends on the employees' working efforts and their effort costs, an employee's optimal effort level is a decision variable for the employer in addition to the assignment decision. For unobservable effort, optimization of the effort level is more complicated. In this case, performance-related compensation contracts can motivate the employee to provide the desired effort. Therefore, the optimal contract parameters have to be calculated.

For observable as well as for unobservable effort, the employer faces a two-stage optimization problem: First, the optimal effort levels or compensation contract parameters have to be determined for each employee-project combination. As the second step, the optimal assignment given the optimal effort levels or contract parameters has to be found. In the literature, both steps are

[1] See, e.g., Voßmerbäumer (2013) and the references cited there.

addressed separately rather than in an integrated model by different research areas. While the design of incentive schemes is investigated in management accounting, assignment problems are typically analyzed in operations research.

The effects of taxation and especially of international taxation are widely neglected in these research areas. This research gap is rather surprising given current levels of individual and corporate income taxes in OECD countries and the resulting potential tax rate differentials.[2] Therefore, we integrate the decision on contract design and assignment into a single model and consider corporate as well as individual income taxes. We pay special attention to the effects of international tax rules. Our model addresses the following research questions:

- Are assignment decisions sensitive with respect to variations of the corporate tax rate and the wage tax rate?
- How does the method for eliminating international double taxation affect the optimal assignment decision?
- Do tax systems exist that are neutral with respect to assignment decisions?
- Do tax effects depend on whether or not the agents' efforts are observable?
- Does preferential tax treatment attract (highly productive) incoming expatriates?

The answers to these research questions are relevant for employers who are planning their international assignment decisions as well as for tax legislators who are assessing the impact and the effectiveness of current or planned tax rules.

We first solve a principal-agent model of the LEN type. We then insert the optimal effort levels in the first-best case or the optimal contract parameters in the second-best case into the assignment problem with two agents from the parent company's home country who have to be allocated to two jobs in different jurisdictions. Corporate taxation applies at the principal's level, wage taxation at the agent's level. International taxation with either the exemption or the credit method to eliminate double taxation is explicitly modeled at the agent's level. We derive tax effects by comparing the optimal pre-tax and after-tax assignment decisions. To the best of our knowledge, this is the first paper to combine an agency model with assignment decisions and taxes, and it is also one of the first agency models taking international taxation into account.

There are a few papers that address tax effects in agency relationships. However, international taxation is not considered in these papers. Integration of taxes into principal-agent models started in the 1980s with Wolfson (1985) and Fellingham and Wolfson (1985). Wolfson (1985) analyzes the influence of taxation on the lease-or-buy decision. He finds that taxes encourage risk taking of outside investors. Fellingham and Wolfson (1985) investigate risk sharing and incentive ar-

[2] In the OECD countries, top statutory personal income tax rates were between 15.0 and 60.2 percent with an average of 42.5 percent in 2012 and corporate tax rates between 12.5 and 39.1 percent with an average of 25.5 percent in 2013; see OECD (2013a, 2013b).

rangements in partnerships. They show that contracts with Pareto-optimal risk sharing are not necessarily tax-minimizing.

Halperin, Kwon and Rhodes-Catanach (2001) find that the deductibility limit on managerial compensation in the U.S. decreases fixed salary and increases performance-based compensation and total pay. Corporate profits and shareholder wealth decline, total tax revenues increase due to the deductibility limit. Göx (2008) also addresses the economic consequences of the U.S. deductibility limit. He shows that reward for luck can be the optimal response to tax law changes.

Dam and Perez-Castrillo (2006) model a principal-agent economy as a two-sided matching game and propose a mechanism to implement stable outcomes. Their model does not include taxes.

In a moral hazard model of the LEN type, Niemann (2008) investigates the impact of a tax system that differentiates between investment projects with different risk levels. He shows that symmetric taxation leaves the managerial portfolio choice unchanged compared to the pre-tax case. By contrast, a tax base reduction increases the proportion of risky projects, whereas a tax rate reduction for risky projects induces ambiguous results. The overall effect depends on the agent's degree of risk aversion.

Niemann (2011) integrates corporate taxation and wage taxation into a binary principal-agent model. He shows that symmetric corporate taxation at the principal's level does not affect the implementation and the design of compensation contracts. By contrast, wage taxation at the agent's level makes employment more expensive. Under asymmetric corporate taxation, employing the agent is less attractive for the principal than under symmetric taxation.

Voßmerbäumer (2013) uses a LEN-based model to investigate the incentive effects of employer-provided workplace benefits and derives rules for the optimal taxation of fringe benefits. He shows that the employer's costs of providing fringe benefits can be a more efficient tax base than the employee's willingness to pay. In general, taxing the employer is superior to taxing the employee.

Analysis of tax effects on incentives and compensation design is currently limited to domestic taxation. The effects of international tax rules are explored in none of the above-mentioned papers. By contrast, Niemann and Simons (2013) analyze the incentive effects of different international tax allocation rules. They find that a switch from separate taxation to formula apportionment, as currently proposed by European Commission (2011), might create additional tax planning opportunities despite the elimination of transfer pricing.

Many of the papers in the agency-tax literature are based on the LEN model that was first presented by Spremann (1987). The main advantage of this approach is the existence of analytical solutions for the underlying contract problem. Hemmer (2004) criticizes the restrictive assumptions of the LEN model, whereas Holmström and Milgrom (1987) offer justifications for

the linearity assumption.

In contrast to the principal-agent literature where at least a few contributions deal with the impact of taxation, we are not aware of any paper that picks up tax effects in assignment problems. The focus of the operations research literature on assignment problems lies on the identification, modeling, solvability, and solution of assignment problems.[3] Although the parametrization of the problems admits for the consideration of taxes, there is no analysis of tax effects. Similarly, the literature on human resource management and expatriates typically does not take tax issues explicitly into account.[4]

Our main findings are as follows: Neither in the first-best case nor in the second-best case does corporate taxation affect the contract problem. In accordance with the agency-tax literature,[5] the optimal effort levels and contract parameters are independent of the corporate tax rate. By contrast, wage taxation always reduces the agents' efforts and decreases the principal's utility.

With regard to the assignment problem, i.e., for given optimal solutions of the contract problems, all tax parameters influence the optimal decision. The effects of tax rate variations crucially depend on whether the exemption or the credit method is applied for eliminating international double taxation of wages. Therefore, our results are ambiguous: An increase of the wage tax rate can induce the principal to sent a more productive agent to a jurisdiction with a higher or a lower corporate tax rate. An increase of the corporate tax rate in one jurisdiction can induce the principal to sent a more productive agent to this or the other jurisdiction. Special deductions for incoming expatriates have only negligible effects on optimal assignment. Tax effects in the second-best case are very similar to those in the first-best case. This result implies that (non-)observability of efforts does not substantially influence the tax effects.

From a tax policy perspective, the exemption method should be preferred over the credit method for reasons of transparency and predictability. Tax neutrality with respect to assignment decisions can be possible in special cases of harmonized source-based taxation.

The remainder of this paper is organized as follows: We start with a description of the model in section 2. Section 3 analyzes the contract-assignment decision in the first-best case, section 4 in the second-best case. Both sections are structured such that first the contract problem and the assignment problem are presented in the pre-tax case. Then, taxation is integrated into the models. The main parts of both sections deal with the impact of taxation on the assignment decision. Section 5 analyzes the impact of special tax allowances for incoming expatriates. Section 6 summarizes and concludes.

[3] See Burkhard, Dell'Amico and Martello (2012) for a textbook introduction into assignment problems and Pentico (2007) for a research survey.

[4] See, e.g., Reiche and Harzing (2011). Suutari and Tornikoski (2001), however, report that low taxes are a crucial determinant of expatriates' satisfaction with their compensation.

[5] See, e.g., Niemann (2008) or Ewert and Niemann (2013).

2 Model setup

We consider a multinational enterprise (MNE) with two agents (employees, assignees) indexed by $i = 1,2$ and two jobs (tasks, projects) to be staffed indexed by $j = 1,2$. The jobs are associated with a foreign subsidiary of the MNE where the job has to be done. The human resource problem faced by the MNE's central management acting as the principal is to assign the agents to the jobs and to design the compensation contracts. As an example one might think of the assignment of consultants to projects, of civil engineers to construction sites, or of top managers to subsidiaries.

The goal of the principal is to maximize the MNE's expected total profit after compensation and taxes over both jobs. Compensation is based on the jobs' profits before compensation and taxation.[6] The (random) profit x_{ij} before compensation and taxes from job j when assigning agent i to it depends on the agent's productivity parameter $\pi_{ij} > 0$, the agent's effort choice $e_{ij} \geq 0$, and a noise term θ_j:

$$x_{ij} = \pi_{ij} e_{ij} + \theta_j. \tag{1}$$

The noise terms are stochastically independent and normally distributed random variables with zero mean and variance $\sigma_j^2 > 0$. The principal gets to know everything, but the agents' efforts. The implied hidden-action problem is modeled by means of an LEN model. Accordingly, agent i's utility from total pre-tax wage $W_{ij} = \underline{w}_{ij} + w_{ij} x_{ij}$ and effort costs $v_{ij} = e_{ij}^2/2$ amounts to $u_{ij} = -\exp[-r_i(W_{ij} - v_{ij})]$, where r_i denotes the (constant) coefficient of absolute risk aversion, $\underline{w}_{ij}$ the fixed remuneration, and w_{ij} the bonus coefficient.[7] The effective wage tax rate of agent i with host country j is denoted $t_{ij} \in [0,1)$. Thus, if wage taxes apply, agent i's utility is based on his after-tax wage $(1 - t_{ij})W_{ij}$ because the wage tax base is defined by the total compensation and wage taxation does not discriminate between fixed and performance-based remuneration.

We assume that both agents share the same home country, in particular the country of the parent company. We further assume that either the agents are present in the host country for a sufficiently long period or that the remunerations are borne by a permanent establishment in the host country. This assumption ensures that wages are always taxable by the host countries;[8] the wage tax rate in host country j is $t_j \in [0,1)$. Depending on the characteristics of the agent and the involved countries as well as international tax rules this tax rate may differ from the effective

[6] See Niemann (2008), Niemann (2011), or Voßmerbäumer (2013) for a discussion of gross and net performance measures.

[7] Observe that, in combination with the specification of π_{ij}, this formulation is as general as $\tilde{e}_{ij}^2/\alpha_i$ with $\alpha_i > 0$. To see this, rescale the unit in which effort is measured according to $e_{ij} = \sqrt{2/\alpha_i}\tilde{e}_{ij}$, so that effort costs amount to $\tilde{e}_{ij}^2/\alpha_i = e_{ij}^2/2$. The job's return, $\tilde{\pi}_{ij}\tilde{e}_{ij}$, then becomes $\tilde{\pi}_{ij}\sqrt{\alpha_i/2}e_{ij}$. The required rescaling of the productivity parameter is therefore $\pi_{ij} = \sqrt{\alpha_i/2}\tilde{\pi}_{ij}$.

[8] See Article 15 (2) of the OECD model tax convention. The assumption of a long-term assignment is typically met for expatriates. Moreover, in the construction industry long-term building sites are regularly considered as permanent establishments. See Article 5 No. 3 of the OECD model tax convention.

wage tax rate t_{ij}.[9]

Typically, the agent keeps a permanent home in the home country and establishes an additional permanent home in the host country. Then, it depends on his center of vital interests in which country the agent resides for the purposes of a double taxation treaty between the home country and the host country. As a rule of thumb, an agent with a family in the (not too distant) home country typically is a resident of this home country. Otherwise, the agent can but need not necessarily be a resident of the host country. For the determination of the effective wage tax rate it can be relevant that an agent might be willing to move his center of vital interests to a particular host country, but not to another one.[10]

If the agent becomes a resident of the host country, he is subject only to the host country's tax rate.[11] This implies $t_{ij} = t_j$ for the effective wage tax rate. By contrast, if the agent is a resident of his home country, it depends on the method of eliminating double taxation which wage tax rate applies.[12] If the double taxation treaty prescribes the credit method then the relevant wage tax rate is given by $t_{ij} = \max\{t_0, t_j\}$ where $t_0 \in [0,1)$ denotes the wage tax rate of the home country.[13] An example for this practice are an Anglo-American country as the home country and a non-Anglo-American country as the host country. Otherwise, i.e., if the double taxation treaty prescribes exemption, the effective wage tax rate is defined as $t_{ij} = t_j$. Germany as the home country serves as an example for the exemption method. It should be noted that different double taxation treaties of the home country can use different methods for eliminating double taxation. Austria as home country, for instance, uses the credit method with the U.K. as host country, but the exemption method with Germany as host country.[14] Another example for this practice is Croatia as the home country in relation to Austria and Germany.[15] For the sake of simplicity, we refer to $t_{ij} = t_j$ as the exemption case and to $t_{ij} = \max\{t_0, t_j\}$ as the credit case. As a consequence, country-specific as well as agent-specific characteristics determine the effective wage tax rate. Since our model includes two agents and two host countries, there are four potentially different

[9] We assume that a double taxation treaty between the home country and the host country exists. Therefore, we neglect the case of unrelieved double taxation.

[10] In principle, the agent's (non-)willingness to move his center of vital interests could be modeled endogenously by country-dependent productivity coefficients π_{ij}. However, to keep the model simple we rather assume an exogenously given center of vital interests.

[11] See Article 15 of the OECD model tax convention. Throughout the paper we do not take the nationality principle into account. This principle means that taxpayers are taxed according to their citizenship. Except for the U.S., the nationality principle is rarely applied.

[12] See, e.g., Articles 23A, 23B of the OECD model tax convention. Jacobs et al. (2005) give an international overview of the taxation of expatriates.

[13] We neglect carrybacks or carryforwards of foreign tax credits and do not distinguish between a worldwide or a per-country limitation. See, e.g., Blouin (2012, pp. 10) for the U.S. case.

[14] See Articles 15, 24 (2) of the Double Taxation Treaty between Austria and the U.K. and Articles 15, 23 (2) of the Double Taxation Treaty between Austria and Germany.

[15] See Articles 15, 23 (2) of the Double Taxation Treaty between Croatia and Austria and Articles 15, 23 (2) of the Double Taxation Treaty between Croatia and Germany.

wage tax rates. Given that for each wage tax rate two different methods for eliminating double taxation can be effective, there are $2^4 = 16$ different combinations of how the effective tax rates emerge.

Corporate profits at the principal's level are defined as the difference of return x_{ij} and remuneration W_{ij}. Accordingly, we assume that the compensation paid to the employee assigned to a job is fully deductible from the MNE's tax base of the associated foreign subsidiary.[16] Corporate profits are taxed at source, i.e., in the jurisdiction where the subsidiary (job) is located. The corporate tax rate in jurisdiction j is $\tau_j \in [0,1)$. Due to the one-period nature of our model, possible repatriation taxes are not taken into account.

The principal's overall optimization problem consists of two steps, namely the contract problem and the assignment problem. The contract problem aims at the optimal design of the contract for agent i assigned to job j and thus takes the assignment of agents to jobs as given. Its goal is to maximize the expected after-tax return from job j less the expected compensation for agent i. The corresponding objective functions are denoted by p_{ij} for the case without taxes and p_{ij}^{τ} for the case with corporate and wage taxes, so that we have $p_{ij} = \mathrm{E}(x_{ij} - W_{ij})$ and $p_{ij}^{\tau} = \mathrm{E}[(1-\tau_j)(x_{ij} - W_{ij})]$. The resulting maximal expected profits given the optimal contracts are denoted by P_{ij} and P_{ij}^{τ}, respectively.

While the contract problem takes the assignment of agent i to job j as given, solving the assignment problem concentrates on the optimal matching of agents and jobs given the optimal contracts for all possible assignments from the solution of the contract problem. The objective is to maximize the expected total (after-tax) profit, i.e., the sum of the partial profits over both jobs. We assume that it is always profitable for the principal to staff both jobs due to, e.g., severe negative consequences from not staffing a project. Then the assignment problem boils down to the question which job agent 1 is assigned to because the other agent is assigned to the other project. The essential step in finding the optimal assignment is to compare the expected total (after-tax) profit resulting from assigning agent 1 to job 1 and from assigning him to job 2. To be more precise, it is optimal for the principal to assign agent 1 to job 1, if and only if $P_{11} + P_{22} \geq P_{21} + P_{12}$ holds for the case without taxes and $P_{11}^{\tau} + P_{22}^{\tau} \geq P_{21}^{\tau} + P_{12}^{\tau}$ for the case with taxes. After reformulating these conditions as $P_{11} - P_{21} \geq P_{12} - P_{22}$ and $P_{11}^{\tau} - P_{21}^{\tau} \geq P_{12}^{\tau} - P_{22}^{\tau}$ we see that it is optimal to assign agent 1 to job 1, if and only if the (after-tax) advantage from assigning him instead of the other agent to this job is not less than the (after-tax) advantage from assigning him instead of the other agent to the other job. Note that this assignment problem is a special case of the linear sum assignment problem (LSAP) analyzed in the operations research literature.[17]

[16] We neglect deduction limits like Section 162 (m) of the U.S. Internal Revenue Code. For the economic effect of deduction limits see, e.g., Göx (2008) for the U.S. case or Voßmerbäumer (2012) for the current discussion in Germany.

[17] See Burkhard, Dell'Amico and Martello (2012, §§ 1.2, 4). Taking the assignment problem with taxes as an example,

3 Optimal contracts and assignments in the first-best case

3.1 Contract problem without taxes

In the first-best case with observable managerial effort, it is optimal for the risk-neutral principal to protect the risk-averse agent from risk so that he only receives a fixed compensation, i.e., the bonus coefficient is $w_{ij} = 0$. The remaining contract problem for the assignment of agent i to job j is

$$\max_{e_{ij},\underline{w}_{ij}} p_{ij} = \max_{e_{ij},\underline{w}_{ij}} \pi_{ij} e_{ij} - \underline{w}_{ij} \tag{2}$$

$$\text{s.t.} \quad \underline{w}_{ij} - e_{ij}^2/2 \geq \underline{u}_i \tag{PC}$$

where $\underline{u}_i \geq 0$ denotes agent i's reservation remuneration. The left-hand side of (PC) is the agent's certainty equivalent of his compensation $\underline{w}_{ij}$ and effort costs $e_{ij}^2/2$.

In the optimum, (PC) is binding and the agent receives a fixed compensation amounting to $\underline{w}_{ij} = \underline{u}_i + e_{ij}^2/2$. This leads to the following optimization problem for the principal:

$$\max_{e_{ij}} p_{ij} = \max_{e_{ij}} \pi_{ij} e_{ij} - \left(\underline{u}_i + e_{ij}^2/2\right) \tag{3}$$

The optimal effort level is $e_{ij} = \pi_{ij}$ which entails compensation $\underline{w}_{ij} = \underline{u}_i + \pi_{ij}^2/2$ and expected profit $\pi_{ij}^2/2 - \underline{u}_i$.

3.2 Assignment problem without taxes

Given the optimal contracts for each assignment, the assignment problem concentrates on finding the optimal assignment of the agents. The assignment decision is captured by the binary variable $a_{11} \in \{0,1\}$ assuming value 1 if job 1 is assigned to agent 1 and 0 otherwise. The assignment of agent 2 follows from that of the first agent because both jobs have to be staffed.

In order to solve the principal's assignment problem we have to compare the total profit from assigning agent 1 to job 1, $P_{11} + P_{22}$, and from assigning him to job 2, $P_{12} + P_{21}$:

$$\max_{a_{11} \in \{0,1\}} \frac{1}{2}\left(\pi_{11}^2 + \pi_{22}^2\right) a_{11} + \frac{1}{2}\left(\pi_{12}^2 + \pi_{21}^2\right)(1 - a_{11}) - \underline{u}_1 - \underline{u}_2 \tag{4}$$

or, equivalently

$$\max_{a_{11} \in \{0,1\}} (\pi_{11}^2 + \pi_{22}^2) a_{11} + (\pi_{12}^2 + \pi_{21}^2)(1 - a_{11}) \tag{5}$$

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the non-negative costs in the canonical LSAP formulation associated to the assignment of agent i to job j can be defined as $-(1-\tau_j)P_{ij}^{\tau} + \max_{i,j}(1-\tau_j)P_{ij}^{\tau}$.

Hence, the principal prefers to assign agent 1 to job 1 or is indifferent with respect to his assignment, respectively, if and only if

$$\pi_{11}^2 + \pi_{22}^2 \{\geqq\} \pi_{12}^2 + \pi_{21}^2 \tag{6}$$

holds. Hence, if the principal knows that agent 1 is more productive in one job and the other agent in the other job, i.e., $\pi_{11} > \pi_{12}$ and $\pi_{22} > \pi_{21}$ or $\pi_{12} > \pi_{11}$ and $\pi_{21} > \pi_{22}$, then both agents are assigned to the jobs they do best. It is not necessary to know more than which jobs the agents do best. However, if both agents perform best in the same job, $\pi_{1j} > \pi_{1,3-j}$ and $\pi_{2j} > \pi_{2,3-j}$, than the principal needs to know whether $\pi_{11}^2 + \pi_{22}^2$ is greater or less $\pi_{12}^2 + \pi_{21}^2$. The constant reservation remunerations do not affect the assignment decision.

3.3 Contract problem with taxes

In addition to the first-best situation without taxes, the principal has to account for her corporate taxes and the agents' wage taxes. The partial after-tax profit from assigning agent i to job j is defined by

$$\max_{e_{ij},\underline{w}_{ij}} p_{ij}^{\tau} = \max_{e_{ij},\underline{w}_{ij}} (1-\tau_j)(\pi_{ij} e_{ij} - \underline{w}_{ij}) \tag{7}$$

$$\text{s.t.} \quad (1-t_{ij})\underline{w}_{ij} - e_{ij}^2/2 \geq \underline{u}_i^t \tag{PC}$$

Compared to the scenario without taxes, the agent's reservation remuneration in a world with taxes changes to $\underline{u}_i^t \geq 0$. We cannot exactly determine the relation between $\underline{u}_i$ and $\underline{u}_i^t$, because this would require detailed assumptions concerning the agent's default alternatives that are typically neglected in the principal-agent literature. However, it is plausible that $\underline{u}_i^t$ decreases in the agent's tax rate so that $\underline{u}_i^t < \underline{u}_i$. Moreover, due to non-deductible effort costs, it is reasonable to conjecture that $\underline{u}_i^t > (1-t_{ij})\underline{u}_i$.[18] Second, compensation before and after income taxes diverge. Effectively, the agent is interested in his compensation after taxes, while the principal has to pay a compensation before income taxes. That is, with regard to the first-best solution without taxes we have to gross up the fixed compensation resulting from (PC):

$$\underline{w}_{ij} = \frac{\underline{u}_i^t + e_{ij}^2/2}{1-t_{ij}} \tag{8}$$

[18] For a discussion of reservation utilities before and after taxes see Niemann (2008), Niemann (2011), and Voßmerbäumer (2013).

Plugging this into the contract problem gives

$$\max_{e_{ij}} p_{ij}^{\tau} = \max_{e_{ij}} (1-\tau_j) \left(\pi_{ij} e_{ij} - \frac{\underline{u}_i^t + e_{ij}^2/2}{1-t_{ij}} \right) \tag{9}$$

and implies the optimal effort level $e_{ij} = (1-t_{ij})\pi_{ij}$ entailing the final gross fixed compensation $\underline{w}_{ij} = \underline{u}_i^t/(1-t_{ij}) + (1-t_{ij})\pi_{ij}^2/2$ and expected profit

$$P_{ij}^{\tau} = (1-\tau_j) \left(\frac{(1-t_{ij})\pi_{ij}^2}{2} - \frac{\underline{u}_i^t}{1-t_{ij}} \right) \tag{10}$$

Corporate taxation reduces the principal's partial objective function proportionally, but does not alter its algebraic sign. By contrast, for positive reservation remunerations $\underline{u}_i^t > 0$, a sufficiently high wage tax rate turns the partial profit function negative.

3.4 Assignment problem with taxes

The principal's assignment problem,

$$\begin{aligned} \max_{a_{11} \in \{0,1\}} & \left[(1-\tau_1) \left(\frac{(1-t_{11})\pi_{11}^2}{2} - \frac{\underline{u}_1^t}{1-t_{11}} \right) + (1-\tau_2) \left(\frac{(1-t_{22})\pi_{22}^2}{2} - \frac{\underline{u}_2^t}{1-t_{22}} \right) \right] a_{11} \\ & + \left[(1-\tau_2) \left(\frac{(1-t_{12})\pi_{12}^2}{2} - \frac{\underline{u}_1^t}{1-t_{12}} \right) + (1-\tau_1) \left(\frac{(1-t_{21})\pi_{21}^2}{2} - \frac{\underline{u}_2^t}{1-t_{21}} \right) \right] (1-a_{11}), \end{aligned} \tag{11}$$

is solved by comparing total after-tax profits $P_{11}^{\tau} + P_{22}^{\tau}$ and $P_{12}^{\tau} + P_{21}^{\tau}$. Thus, the principal prefers to assign agent 1 to job 1 or is indifferent as to the assignment, if and only if

$$\begin{aligned} (1-\tau_1) & \left[\frac{(1-t_{11})\pi_{11}^2}{2} - \frac{\underline{u}_1^t}{1-t_{11}} \right] + (1-\tau_2) \left[\frac{(1-t_{22})\pi_{22}^2}{2} - \frac{\underline{u}_2^t}{1-t_{22}} \right] \\ & \{\geqq\} \; (1-\tau_2) \left[\frac{(1-t_{12})\pi_{12}^2}{2} - \frac{\underline{u}_1^t}{1-t_{12}} \right] + (1-\tau_1) \left[\frac{(1-t_{21})\pi_{21}^2}{2} - \frac{\underline{u}_2^t}{1-t_{21}} \right] \end{aligned} \tag{12}$$

or equivalently

$$\begin{aligned} (1-\tau_1) & \left[(1-t_{11})\pi_{11}^2 - (1-t_{21})\pi_{21}^2 - \left(\frac{2\underline{u}_1^t}{1-t_{11}} - \frac{2\underline{u}_2^t}{1-t_{21}} \right) \right] \\ & \{\geqq\} \; (1-\tau_2) \left[(1-t_{12})\pi_{12}^2 - (1-t_{22})\pi_{22}^2 - \left(\frac{2\underline{u}_1^t}{1-t_{12}} - \frac{2\underline{u}_2^t}{1-t_{22}} \right) \right] \end{aligned} \tag{13}$$

hold. The interpretation is similar to the one without taxes. In contrast to the pre-tax case, it is not possible to neglect the reservation remunerations for optimization purposes, because the

relevant wage tax rates t_{ij} can differ depending on the actual assignment.

3.5 The influence of taxation on assignment

The principal's objective function (11) depends on all tax parameters defined in our model. As a consequence, generally all tax variables influence the principal's optimal assignment decision. These include the corporate tax rates so that, in contrast to the one-principal-one-agent situation typically analyzed in the literature,[19] corporate taxation is no longer neutral since the principal's global objective function is a function of four partial objective functions with potentially different corporate tax rates. As can be readily seen from the indifference condition (13), the relation of corporate tax rates $(1-\tau_1)/(1-\tau_2)$ determines which a_{11} the principal chooses. The following scenarios allow a deeper look into the ways taxes affect this decision.

To highlight the tax effects on optimal assignment some simplifying assumptions concerning the variety of the parameters are necessary. In particular, we neglect differences in the agents' reservation remunerations and do not investigate all possible combinations of productivity differences or each of the 16 ways how the effective tax rates emerge; we rather focus on descriptive settings.

Exemption method for both host countries

As a first scenario we assume that the double taxation treaties of the agents' home country with both host countries prescribe the exemption method (German case). Hence, the agents' effective wage tax rates are given by the nominal rates, $t_{ij} = t_j$, irrespective of what the agents' resident countries are. The wage tax rate of the home country, t_0, becomes irrelevant.[20]

Under the assumption that one agent is more productive in both jobs than the other, tax effects are straightforward: For equal corporate tax rates, the more productive agent is sent to the jurisdiction with the lower wage tax rate, and an increase in the wage tax rate t_j can be compensated by a decrease in the corporate tax rate τ_j. Similarly, for equal wage tax rates, the more productive agent is assigned to the jurisdiction with the lower corporate tax rate, and an increase in the corporate tax rate can be compensated by a decrease in the wage tax rate. Alternatively, the effect on the assignment decision of raising the wage tax rate in one country can be offset by an increase of the other country's wage tax rate or its corporate tax rate, and vice versa. Most of these findings are confirmed by Figure 1.

Figure 1 is based on a parameter setting in which agent 1 is always more productive than agent 2: $\pi_{11} = \pi_{12} = 5$, $\pi_{21} = \pi_{22} = 4$, and $\underline{u}_1^t = \underline{u}_2^t = 0$. The corporate tax rate in host country 1 can take the values $\tau_1 \in \{0.1, 0.3, 0.5, 0.7, 0.9\}$, whereas the corporate tax rate in the other country

[19] See, for example, Niemann (2008), Niemann (2011), Voßmerbäumer (2013), and the references cited there.
[20] Income from the home country as well as the progression proviso are neglected here.

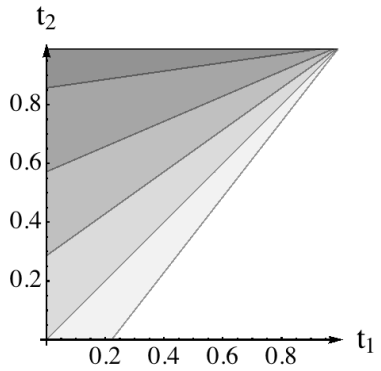

Figure 1: Optimal assignment for $t_{ij} = t_j$

is constant, $\tau_2 = 0.3$. The layered shading in all figures from this section indicates the optimal assignment for different combinations of the host countries' nominal wage tax rates t_1 and t_2. More precisely, the shaded areas indicate the combinations of nominal wage tax rates for which it is optimal for the principal to assign agent 1 to country / job 1, i.e., $a_{11} = 1$; outside the shaded area of a given shade of gray, it is optimal to send him to country / job 2, i.e., $a_{11} = 0$. The intensity of shading in Figure 1 corresponds to increases in the corporate tax rate in jurisdiction 1, i.e., the darker the shading the higher τ_1.

Credit method for both host countries

If both double taxation treaties prescribe the credit method (U.S. case) and both agents remain residents of their home country, the effective tax rates are $t_{ij} = \max\{t_0, t_j\}$. Hence, for wage tax rates in the host countries not falling short of the level in the home country, the tax effects are identical to the preceding scenario. Figure 2, which is based on the same parameter setting as Figure 1, illustrates this property: The upper right quadrant is the same as in Figure 1, where the quadrants indicated by the dashed lines are defined with respect to the home country's tax rate $t_0 = 0.4$.

For wage tax rates below the home country's tax rate t_0, i.e., in the lower left quadrant, the credit method implies $t_{ij} = t_0$ and thereby the simple assignment rule to send the more productive agent to the country with the lower corporate tax rate is valid irrespective of the host countries' wage tax rates.

In the remaining two quadrants one of the effective wage tax rates is constant in the corresponding country rate, while the other one varies. Consequently, the compensatory effects between the various tax rates vanish whenever the wage tax rate falling short of the rate in the home country is involved.

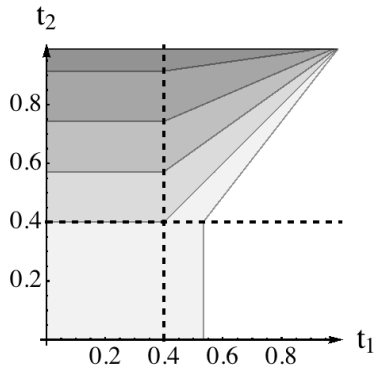

Figure 2: Optimal assignment for $t_{ij} = \max\{t_0, t_j\}$

Credit method for one and exemption method for the other host country

In this scenario the methods for eliminating double taxation differ across the host countries (Austrian case). We assume that both agents remain residents of their home country, and that the double taxation treaty with country 1 prescribes the credit method, whereas the treaty with country 2 prescribes the exemption method. Thus, the effective wage tax rates are $t_{i1} = \max\{t_0, t_1\}$ and $t_{i2} = t_2$.

The preceding scenarios with a uniform method of eliminating double taxation offer the intuitive rule to assign the more productive agent to the country with the lower corporate tax rate, at least if the host countries' wage tax rates are equal. In order to show that the scenario at hand involving mixed methods does not allow to stipulate such a simple rule, we refer to Figure 3 which shares the parameter setting with Figures 1 and 2. For very low wage tax rates in both host countries, e.g., $t_1, t_2 < 0.2$, agent 1 is assigned to job 2 instead of job 1. The reason for this apparently counterintuitive result is the credit method shifting the effective tax rate on agent 1's remuneration to the higher level of his home country amounting to $t_0 = 0.4$ in our example. This high effective wage tax rate makes the agent too expensive to be employed in country 1 compared to the other country and agent. This effect is aggravated for higher levels of the corporate tax rate τ_1, as indicated by the darker areas. Only for high levels of the wage tax rate t_2 is the principal willing to assign agent 1 to job 1.

Credit method for one and exemption method for the other agent

The emerging tax effects are more complicated when the agents' individual characteristics are considered. Assume that both agents establish a permanent home in the host country, but agent 1 keeps his center of vital interests in his home country, whereas agent 2 moves his center of vital interests to the host country (no matter which one). Then, agent 1 is a resident of his home country and agent 2 is a resident of his host country. In addition, assume that both double taxation

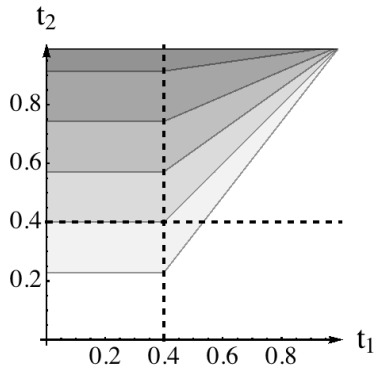

Figure 3: Optimal assignment for $t_{i1} = \max\{t_0, t_1\}$ and $t_{i2} = t_2$

treaties prescribe the credit method of eliminating double taxation (U.S. case). In this scenario, the agents' effective tax rates are given by $t_{1j} = \max\{t_0, t_j\}$ for agent 1 and $t_{2j} = t_j$ for agent 2. Hence, only agent 1 is subject to the credit method, while the income of agent 2 is effectively exempted from taxation in the home country due to the change of the residence country.

At first sight, it might seem that there is not much of a difference whether the method of eliminating double taxation switches from one host country to the other as in the preceding scenario or from one agent to the other as in this scenario. This conjecture, however, is inconsistent with Figure 4 showing the optimal solutions of the assignment problem. The figure is based on the same parameter setting as the previous ones; for reasons of clarity only two possible corporate tax rates in country 1 are considered, namely $\tau_1 = 0.1$ and $\tau_1 = 0.6$.

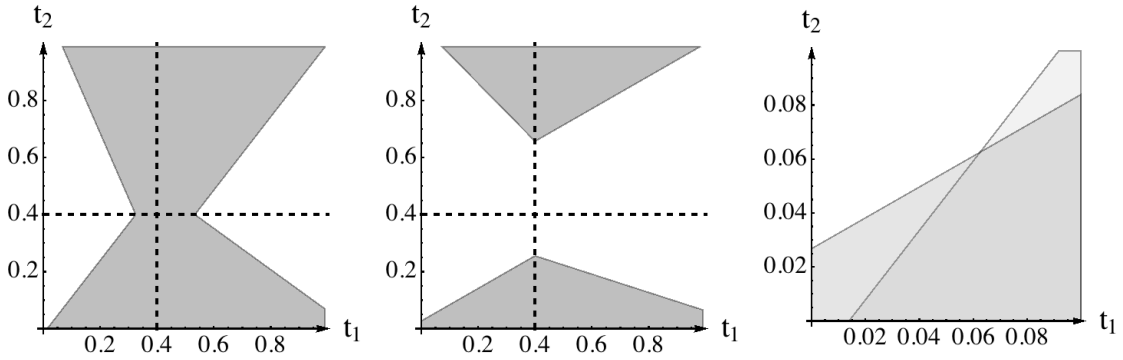

Figure 4: Optimal assignment for $t_{1j} = \max\{t_0, t_j\}$ and $t_{2j} = t_j$ with $\tau_1 = 0.1$ (left), $\tau_1 = 0.6$ (middle), and $\tau_1 \in \{0.1, 0.6\}$ (right)

A ready observation from Figure 4 is that increasing the corporate tax rate τ_1 from 0.1 to 0.6 reduces the gray areas, i.e., the combinations of wage tax rates for which the more productive agent 1 is assigned to host country 1. While this result is intuitive, there are also apparently

paradoxical tax effects. As a first example, it is true that increasing the wage tax rate t_1 can actually make the assignment of agent 1 to job 1 more attractive. This effect can be observed for tax rates $t_1 < t_0$, i.e., on the left hand side of the vertical dashed lines when moving from a white area on the left into a gray area on the right hand side. The explanation for this tax effect is that agent 1's effective wage tax rate, t_{1j} is given by $\max\{t_0, t_j\}$ (credit method) so that it does not change in reaction to an increase of t_1 provided that $t_1 < t_0$. Yet, this does not hold for the other agent whose effective wage tax rate is given by $t_{2j} = t_j$. Consequently, an increase of t_1 makes it less attractive to assign agent 2 to host country 1 which, in turn, implies a relative, though not absolute, benefit for the assignment $a_{11} = 1$ over the assignment $a_{11} = 0$.

Another apparently paradoxical tax effect can be observed from the third part of Figure 4 which is a magnified view of the other two parts of the same figure. For tax rate combinations in the gray quadrangle including $(t_1, t_2) = (0, 0)$ the principal chooses $a_{11} = 0$ for $\tau_1 = 0.1$, but $a_{11} = 1$ for $\tau_1 = 0.6$, i.e., the more productive agent 1 is sent to the high-tax rather than to the low-tax jurisdiction. For an explanation of this effect we refer to optimality condition (12) for zero reservation remunerations ($\underline{u}_i^t = 0$):

$$(1-\tau_1)\frac{(1-t_{11})\pi_{11}^2}{2} + (1-\tau_2)\frac{(1-t_{22})\pi_{22}^2}{2} \\ \{\geqq\}\ (1-\tau_2)\frac{(1-t_{12})\pi_{12}^2}{2} + (1-\tau_1)\frac{(1-t_{21})\pi_{21}^2}{2} \quad (14)$$

Accordingly, the effect from increasing the corporate tax rate τ_1 is determined by the profits before (corporate) taxes from assigning agent 1 or 2 to host country 1, i.e., $(1-t_{i1})\pi_{i1}^2/2$. These do not only depend on the agents' productivity parameters π_{i1}, but also on the effective wage tax rates t_{11} and t_{21}. The assignment decision can therefore be reversed if agent 1 exhibits the higher productivity parameter, $\pi_{11} > \pi_{21}$, but at the same time higher effort costs due to a higher wage tax rate, $t_{11} > t_{21}$.[21]

The two diagrams in Figure 5, which is still based on the same parameter values as the preceding figures, suggest that exchanging the methods for eliminating double taxation between the agents causes substantial changes of the optimal assignment decisions. The diagram on the left hand side corresponds to the credit method for agent 1, i.e., $t_{1j} = \max\{t_0, t_j\}$, and the exemption method for agent 2, i.e., $t_{2j} = t_j$, whereas the methods are exchanged for the diagram on the other side, i.e., $t_{1j} = t_j$ and $t_{2j} = \max\{t_0, t_j\}$. The corporate tax rates are again $\tau_1 \in \{0.1, 0.3, 0.5, 0.7, 0.9\}$ and $\tau_2 = 0.3$.

The assignment decisions coincide whenever the agents' wage taxation does not depend on the

[21] Given the setting of Figure 4, i.e., $t_{1j} = \max\{t_0, t_j\}$, $t_{2j} = t_j$, and $\pi_{11} = \pi_{12} > \pi_{21} = \pi_{22}$, condition (14) allows us to conclude for $t_1 = t_2 < t_0$ and $\pi_{1j}^2(1-t_0) < \pi_{2j}^2(1-t_j)$ that $a_{11} = 1$ is an optimal assignment, if and only if $\tau_1 \geq \tau_2$.

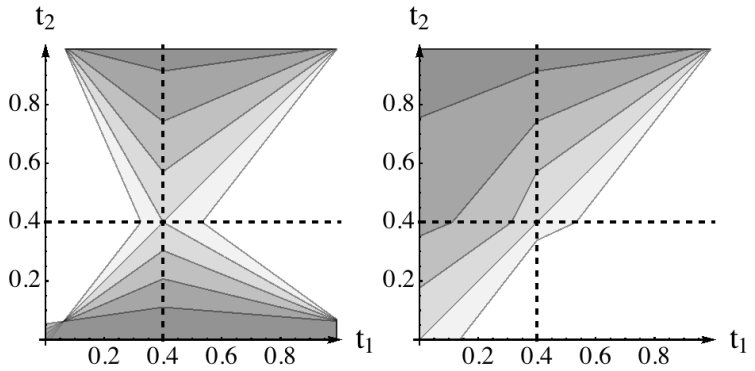

Figure 5: Optimal assignment for $t_{1j} = \max\{t_0, t_j\}$ and $t_{2j} = t_j$ (left) or $t_{1j} = t_j$ and $t_{2j} = \max\{t_0, t_j\}$ (right)

method used for eliminating double taxation. This happens to be the case when $t_1 = t_2$, i.e., on the diagonal from the lower left to the upper right corner, or when $t_1, t_2 \geq t_0$, i.e., in the upper right quadrant. In all other cases, exchanging the methods alters the wage taxation of the more and the less productive agent which causes substantial and asymmetric changes in the optimal assignment. For instance, on the left hand side of Figure 5 the setting $\tau_1 = 0.3$, $t_1 = 0.35$, and $t_2 = 0.4\overline{8}$ induces indifference with respect to the optimal assignment[22], whereas on the right hand side neither $\tau_1 = 0.3$, $t_1 = 0.35$, and $t_2 = 0.4\overline{8}$ nor $\tau_1 = 0.3$, $t_1 = 0.4\overline{8}$, and $t_2 = 0.35$ imply indifference.

Neutral tax systems

In light of the involved effects taxes have on optimal assignment it should be investigated whether any neutral tax system exists. Neutrality with respect to the assignment decision means that the tax rules ensure that for arbitrary productivities π_{ij} and reservation remunerations $\underline{u}_i$ the optimal after-tax assignment decision is identical to that in a world without taxes; this means that the optimality conditions (6) and (13) are equivalent.

The optimality conditions are equivalent for arbitrary reservation remunerations, if both tax rate products $(1-\tau_j)(1-t_{ij})$ and $(1-\tau_j)(1-t_{i,3-j})$ do not vary with the agents nor with the host countries. This requires a considerable degree of tax harmonization across the three jurisdictions. The conditions are comparatively easy to satisfy when the exemption method is used for both agents; then the conditions come down to equal corporate and wage tax rates across the countries, i.e., $\tau_1 = \tau_2$ and $t_1 = t_2$. Under the assumption that reservation remunerations are zero, i.e., $\underline{u}_i = \underline{u}_i^t = 0$, which is an assumption frequently made in the literature,[23] the second of the two

[22] This result can be checked by substituting $\tau_1 = \tau_2$, $\pi_{11} = \pi_{12} = 5$, $\pi_{21} = \pi_{22} = 4$, and $t_0 = 0.4$ into expression (14) which yields the indifference condition $t_2 = 10/9 - 16/9 \cdot t_1$.

[23] See, e.g., Dutta and Reichelstein (1999, p. 239), Dutta and Zhang (2002, p. 74), Wagenhofer (2003, p. 293), and

neutrality conditions can be dropped. However, still a high degree of harmonization is needed in order to satisfy the remaining neutrality condition. For the case that the exemption method is used for both agents, the tax rates have to satisfy $(1-\tau_1)/(1-\tau_2) = (1-t_2)/(1-t_1)$. The fact that the neutrality conditions depend on the agents' choices of their residences whenever wages are not tax-exempt in their home country suggests that tax exemption is the only practically feasible road to achieve tax neutrality irrespective of the agents' behavior.

4 Optimal contracts and assignments in the second-best case

4.1 Contract problem without taxes

For unobservable managerial effort the principal can offer performance-based remuneration contracts to motivate the agents to provide the desired effort levels. In this case the principal's contract problem given the assignment of agent i to job j reads:

$$\max_{\underline{w}_{ij},w_{ij}} p_{ij} = \max_{\underline{w}_{ij},w_{ij}} \pi_{ij}e_{ij} - (\underline{w}_{ij} + w_{ij}\pi_{ij}e_{ij}) \tag{15}$$

$$\text{s.t.} \quad \underline{w}_{ij} + w_{ij}\pi_{ij}e_{ij} - w_{ij}^2 r_i \sigma_j^2/2 - e_{ij}^2/2 \geq \underline{u}_i \tag{PC}$$

$$e_{ij} = \underset{\tilde{e}_{ij}}{\operatorname{argmax}}\, \underline{w}_{ij} + w_{ij}\pi_{ij}\tilde{e}_{ij} - w_{ij}^2 r_i \sigma_j^2/2 - \tilde{e}_{ij}^2/2 \tag{IC}$$

Both the participation constraint (PC) and incentive constraint (IC) are formulated in terms of the agent's certainty equivalent corresponding to his compensation and effort costs. The solution of the contract problem is well known in the principal-agent literature,[24] so we skip the details of the derivations.

The optimal effort choice is given by $e_{ij} = w_{ij}\pi_{ij}$. In the optimum, again, (PC) is active so that the expected compensation can be written as $\mathrm{E}(W_{ij}) = \underline{w}_{ij} + w_{ij}\pi_{ij}e_{ij} = \underline{u}_i + w_{ij}^2(\pi_{ij}^2 + r_i\sigma_j^2)/2$. This leads to the following maximization problem for the principal:

$$\max_{w_{ij}} p_{ij} = \max_{w_{ij}} w_{ij}\pi_{ij}^2 - \left[\underline{u}_i + w_{ij}^2\left(\pi_{ij}^2 + r_i\sigma_j^2\right)/2\right] \tag{16}$$

Solving the optimization problem and inserting the resulting optimal bonus coefficient $w_{ij} = \pi_{ij}^2/(\pi_{ij}^2 + r_i\sigma_j^2)$ yields the principal's partial objective function:

$$P_{ij} = w_{ij}\pi_{ij}^2 - \left[\underline{u}_i + w_{ij}^2\left(\pi_{ij}^2 + r_i\sigma_j^2\right)/2\right] = \frac{1}{2}\frac{\pi_{ij}^4}{\pi_{ij}^2 + r_i\sigma_j^2} - \underline{u}_i \tag{17}$$

the numerical examples in this paper.

[24] See, e.g., Spremann (1987).

4.2 Assignment problem without taxes

The assignment problem parallels that for the first-best case:

$$\max_{a_{11}\in\{0,1\}} \frac{1}{2}\left(\frac{\pi_{11}^4}{\pi_{11}^2+r_1\sigma_1^2}+\frac{\pi_{22}^4}{\pi_{22}^2+r_2\sigma_2^2}\right)a_{11}+\frac{1}{2}\left(\frac{\pi_{12}^4}{\pi_{12}^2+r_1\sigma_2^2}+\frac{\pi_{21}^4}{\pi_{21}^2+r_2\sigma_1^2}\right)(1-a_{11}) \\ -\underline{u}_1-\underline{u}_2 \quad (18)$$

or equivalently

$$\max_{a_{11}\in\{0,1\}} \left(\frac{\pi_{11}^4}{\pi_{11}^2+r_1\sigma_1^2}+\frac{\pi_{22}^4}{\pi_{22}^2+r_2\sigma_2^2}\right)a_{11}+\left(\frac{\pi_{12}^4}{\pi_{12}^2+r_1\sigma_2^2}+\frac{\pi_{21}^4}{\pi_{21}^2+r_2\sigma_1^2}\right)(1-a_{11}) \quad (19)$$

Hence, the principal assigns agent 1 to job 1 or is indifferent, if and only if

$$\frac{\pi_{11}^4}{\pi_{11}^2+r_1\sigma_1^2}+\frac{\pi_{22}^4}{\pi_{22}^2+r_2\sigma_2^2} \{\geqq\} \frac{\pi_{12}^4}{\pi_{12}^2+r_1\sigma_2^2}+\frac{\pi_{21}^4}{\pi_{21}^2+r_2\sigma_1^2} \quad (20)$$

holds. Like in the first-best case without taxes, the reservation remunerations do not influence the assignment decision.

4.3 Contract problem with Taxes

In analogy to the first-best situation, the second-best contract problem with taxes accounts for corporate taxes in the principal's objective function and for wage taxes in the constraints:

$$\max_{\underline{w}_{ij},w_{ij}} p_{ij}^{\tau} = \max_{\underline{w}_{ij},w_{ij}} (1-\tau_j)\left[\pi_{ij}e_{ij}-(\underline{w}_{ij}+w_{ij}\pi_{ij}e_{ij})\right] \quad (21)$$

$$\text{s.t.} \quad (1-t_{ij})(\underline{w}_{ij}+w_{ij}\pi_{ij}e_{ij})-(1-t_{ij})^2 w_{ij}^2 r_i\sigma_j^2/2-e_{ij}^2/2 \geq \underline{u}_i^t \quad \text{(PC)}$$

$$e_{ij}=\underset{\tilde{e}_{ij}}{\operatorname{argmax}}(1-t_{ij})(\underline{w}_{ij}+w_{ij}\pi_{ij}\tilde{e}_{ij})-(1-t_{ij})^2 w_{ij}^2 r_i\sigma_j^2/2-\tilde{e}_{ij}^2/2 \quad \text{(IC)}$$

The corresponding constraints (PC) and (IC) are formulated in terms of the agent's certainty equivalent corresponding to his net compensation, i.e., after wage taxes, $(1-t_{ij})(\underline{w}_{ij}+w_{ij}x_{ij})$, and his effort costs $e_{ij}^2/2$. The derivation of the certainty equivalent as well as the solution to the contract problem is known from the literature,[25] so we only give the results here.

In order to maximize his expected utility the agent maximizes his net certainty equivalent and thus chooses effort level $e_{ij}^* = (1-t_{ij})w_{ij}\pi_{ij}$. Substituting this effort level yields the expected gross remuneration that is necessary to compute the principal's partial objective function p_{ij}^{τ}. After exploiting the binding participation constraint for substituting the fixed remuneration we

[25] See, e.g., Niemann (2008) or Ewert and Niemann (2013).

have:

$$p_{ij}^{\tau} = (1-\tau_j)\left[(1-t_{ij})w_{ij}\pi_{ij}^2 - \frac{\underline{u}_i^t}{1-t_{ij}} - \frac{1}{2}(1-t_{ij})w_{ij}^2\left(\pi_{ij}^2 + r_i\sigma_j^2\right)\right] \tag{22}$$

Maximizing p_{ij}^{τ} with respect to w_{ij} yields the optimal bonus coefficient that is identical to the one in the pre-tax case:

$$w_{ij}^* = \frac{\pi_{ij}^2}{\pi_{ij}^2 + r_i\sigma_j^2} \tag{23}$$

With the optimal bonus coefficient, the other variables can be written as explicit functions of the initial parameters. Agent i's effort choice in job j is:

$$e_{ij}^* = (1-t_{ij})w_{ij}\pi_{ij} = (1-t_{ij})\frac{\pi_{ij}^3}{\pi_{ij}^2 + r_i\sigma_j^2} \tag{24}$$

At the principal's level the optimal bonus coefficient leads to an optimal partial objective value of:

$$P_{ij}^{\tau} = (1-\tau_j)\left[\frac{1}{2}(1-t_{ij})\frac{\pi_{ij}^4}{\pi_{ij}^2 + r_i\sigma_j^2} - \frac{\underline{u}_i^t}{1-t_{ij}}\right] \tag{25}$$

4.4 Assignment problem with taxes

On the basis of the partial profits P_{ij}^{τ} the objective function of the assignment problem reads:

$$\begin{aligned}&\left[(1-\tau_1)\left(\frac{1-t_{11}}{2}\frac{\pi_{11}^4}{\pi_{11}^2 + r_1\sigma_1^2} - \frac{\underline{u}_1^t}{1-t_{11}}\right) + (1-\tau_2)\left(\frac{1-t_{22}}{2}\frac{\pi_{22}^4}{\pi_{22}^2 + r_2\sigma_2^2} - \frac{\underline{u}_2^t}{1-t_{22}}\right)\right] a_{11} \\ &+ \left[(1-\tau_1)\left(\frac{1-t_{21}}{2}\frac{\pi_{21}^4}{\pi_{21}^2 + r_2\sigma_1^2} - \frac{\underline{u}_2^t}{1-t_{21}}\right) + (1-\tau_2)\left(\frac{1-t_{12}}{2}\frac{\pi_{12}^4}{\pi_{12}^2 + r_1\sigma_2^2} - \frac{\underline{u}_1^t}{1-t_{12}}\right)\right](1-a_{11})\end{aligned} \tag{26}$$

The principal thus prefers to assign agent 1 to job 1 or is indifferent as to the assignment, if and only if

$$\begin{aligned}&(1-\tau_1)\left[(1-t_{11})\frac{\pi_{11}^4}{\pi_{11}^2 + r_1\sigma_1^2} - (1-t_{21})\frac{\pi_{21}^4}{\pi_{21}^2 + r_2\sigma_1^2} - \left(\frac{2\underline{u}_1^t}{1-t_{11}} - \frac{2\underline{u}_2^t}{1-t_{21}}\right)\right] \\ &\qquad \{\geqq\}\ (1-\tau_2)\left[(1-t_{12})\frac{\pi_{12}^4}{\pi_{12}^2 + r_1\sigma_2^2} - (1-t_{22})\frac{\pi_{22}^4}{\pi_{22}^2 + r_2\sigma_2^2} - \left(\frac{2\underline{u}_1^t}{1-t_{12}} - \frac{2\underline{u}_2^t}{1-t_{22}}\right)\right]\end{aligned} \tag{27}$$

holds. This decision rule is very similar to the one in the first-best case, see (13), the only difference being the "risk-adjusted" productivity terms $\pi_{ij}^4/(\pi_{ij}^2 + r_i\sigma_j^2)$ instead of π_{ij}^2 used in the first-best case.

4.5 The influence of taxation on assignment

Since the first-best and the second-best case only differ in the adjustment for risk, all tax effects on the assignment decision derived in the first-best situation are also possible in the second-best situation if the agents' risk aversion or the risks inherent in the projects are sufficiently small. For this reason, we do not repeat the discussion of these effects and instead refer to Section 3.5. However, if the agents are sufficiently risk averse or projects are sufficiently risky, the assignment decision and tax effects in the second-best case may even reverse compared to the first-best case. In the following, we highlight several striking differences between the first-best and the second-best situation.

We first revisit the scenario where both host countries prescribe the exemption of foreign-source income, so that the effective wage tax rates are $t_{ij} = t_j$. Taking up the corresponding example from Section 3.5, the parameter values are $\pi_{11} = \pi_{12} = 5$, $\pi_{21} = \pi_{22} = 4$, $\underline{u}_1^t = \underline{u}_2^t = 0$, $t_0 = 0.4$, $\tau_1 \in \{0.1, 0.6\}$, and $\tau_2 = 0.3$. Additionally, we assume that the risk aversion coefficients are $r_1 = 1.4$ for agent 1 and $r_2 = 0.2$ for agent 2. The risk levels of both projects are identical: $\sigma_1 = \sigma_2 = 4$. The corresponding assignment decision is illustrated in Figure 6.

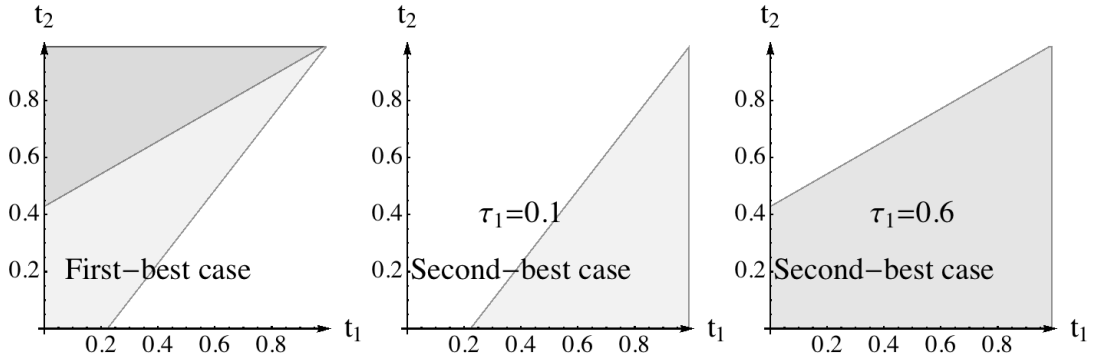

Figure 6: Optimal assignment for $t_{ij} = t_j$ in the first-best (left) and the second-best case (middle, right)

In the first-best case (left part of Figure 6) the more productive agent 1 is sent to the jurisdiction with the lower corporate tax rate unless the productivity advantage is impaired by an increase of the wage tax rate in this country or a decrease in the other country. By contrast, in the second-best case (middle and right part of Figure 6) these properties seem to reverse as the more productive agent is frequently sent to the high-tax jurisdiction. This property can be observed by comparing the middle ($\tau_1 = 0.1$) and the right part ($\tau_1 = 0.6$) of Figure 6. The gray area, i.e., the (t_1, t_2)-combinations for which $a_{11} = 1$, is much larger for $\tau_1 = 0.6$. Moreover, a host country becomes more attractive for the assignment of agent 1 if it raises its wage tax rate or if the other country lowers its rate.

This apparently counterintuitive result is due to the differences in the agent's risk aversion. Formally, the reason for this effect is that agent 1's productivity exceeds that of agent 2 in the first-best case, i.e., $\pi_{1j}^2 > \pi_{2j}^2$. Yet, in the second-best case, agent 2 is the more productive agent in terms of the "risk-adjusted" productivity, i.e., $\pi_{2j}^4/(\pi_{2j}^2 + r_2\sigma_j^2) > \pi_{1j}^4/(\pi_{1j}^2 + r_1\sigma_j^2)$, due to his lower risk aversion, i.e., $r_2 < r_1$.

Another striking difference between the first-best and the second-best situation may occur in the scenario where the agents differ with respect to the method used to eliminate double taxation of wages. Taking up the corresponding scenario from the first-best case, assume that agent 1 remains a resident of his home country, whereas agent 2 becomes a resident of his host country and both double taxation treaties prescribe the credit method. Then, the effective wage tax rates are $t_{1j} = \max\{t_0, t_j\}$ for agent 1 and $t_{2j} = t_j$ for agent 2. Further assume that now agent 2 is the more risk averse person, $r_1 = 1 < r_2 = 2$, so that the productivity differential in favor of agent 1 even increases compared to the first-best case given that the other parameters remain unchanged ($\pi_{11} = \pi_{12} = 5$, $\pi_{21} = \pi_{22} = 4$, $\underline{u}_1^t = \underline{u}_2^t = 0$, $t_0 = 0.4$, $\tau_1 \in \{0.1, 0.6\}$, $\tau_2 = 0.3$, and $\sigma_1 = \sigma_2 = 4$). The result is Figure 7.

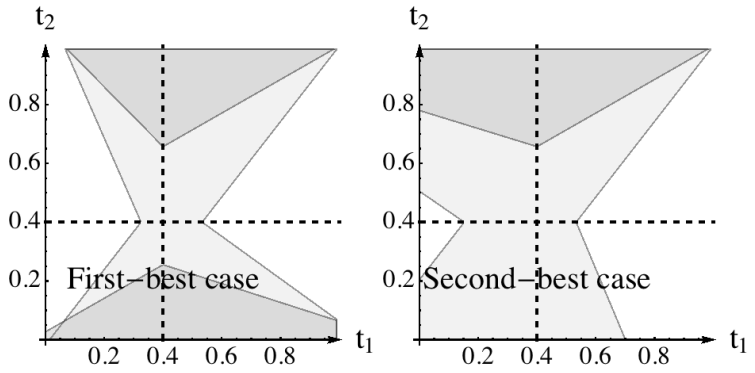

Figure 7: Optimal assignment for $t_{1j} = \max\{t_0, t_j\}$ and $t_{2j} = t_j$ in the first-best (left) and the second-best case (right)

The figure shows that, depending on the corporate tax rate differential, the emerging effects differ substantially between the first-best and the second-best case. In the second-best case with a low corporate tax rate $\tau_1 = 0.1$ the more productive agent 1 is sent to the low-tax country more frequently than in the first-best case, as can be observed from the (light and dark) gray areas. By contrast, if jurisdiction 1 is the host country with the higher corporate tax rate, $\tau_1 = 0.6$, only the dark gray areas apply and we observe that the lower one of the dark gray areas disappears in the second-best case. This means that agent 1 will always be sent to country 2 unless the wage tax rate there is extremely high. The conclusion from this result is that corporate taxation may gain in importance when moving to the second-best situation.

Hitherto, we have assumed that an agent's productivity does not vary across jobs in order to focus on the tax effects. However, everyday intuition tells us that this assumption is a restrictive one because different people have different abilities and qualifications. Since there are various productivity combinations we present only a special setting in which wage taxation reverses the principal's "natural" (pre-tax) assignment decision.

For parameter values $\pi_{11} = \pi_{22} = 5$, $\pi_{12} = \pi_{21} = 4.5$, $\underline{u}_1^t = \underline{u}_2^t = 0$, $r_1 = r_2 = 1$, and $\sigma_1 = \sigma_2 = 4$, the optimal pre-tax assignment is obviously $a_{11} = 1$. With respect to taxation, we consider a situation in which the home country has double taxation treaties that both prescribe the credit method for wage taxation. If agent 1 is willing to move his center of vital interests to host country 2 but not to country 1 and if the opposite is true for agent 2, the effective wage tax rates are $t_{11} = \max\{t_0, t_1\}$, $t_{12} = t_2$, $t_{21} = t_1$, and $t_{22} = \max\{t_0, t_2\}$.

If the "natural" pre-tax assignment decision was maintained in a world with taxes, the shading of a figure depicting optimal assignment would be entirely gray. However, as can be observed from the white areas in Figure 8, which is based on the home country tax rate $t_0 = 0.4$ and identical corporate tax rates in the host countries amounting to $\tau_1 = \tau_2 = 0.3$, wage taxation can alter the assignment decision if at least one of the wage tax rates is sufficiently low. This effect is less pronounced in the second-best than in the first-best case although the qualitative impact of taxation is similar. The reduced size of the effect in the second-best case is due to smaller absolute risk-adjusted productivity differentials, $\pi_{ij}^4/(\pi_{ij}^2 + r_i\sigma_j^2) < \pi_{ij}^2$.

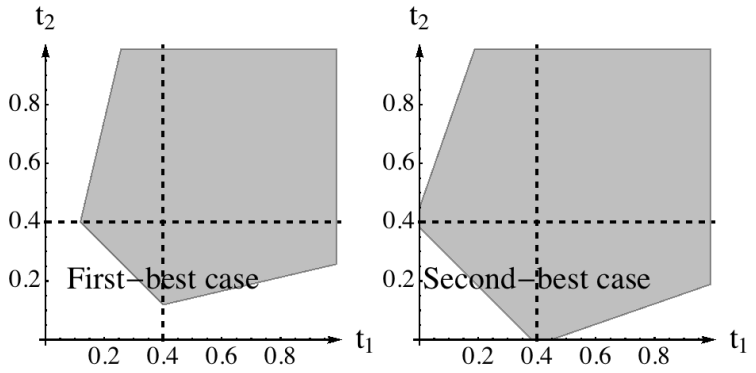

Figure 8: Optimal assignment for $t_{11} = \max\{t_0, t_1\}$, $t_{12} = t_2$, $t_{21} = t_1$, and $t_{22} = \max\{t_0, t_2\}$ in the first-best (left) and the second-best case (right)

This example also demonstrates that the agents' individual preferences regarding potential host countries can induce tax effects that should not be neglected. Of course, this example is a special case that relies upon restrictive assumptions. However, the resulting effects also show that a principal is well advised to explore the international tax consequences in detail prior to an assignment decision.

Due to the similarities of the assignment decisions in the first-best case and the second-best case the implications for neutral tax systems are identical in both cases.

5 Special tax provisions for expatriates

5.1 Tax assumptions

Some jurisdictions provide a beneficial tax treatment for incoming expatriates. These tax benefits can be granted either as reduced tax rates or as deductions from the tax base, e.g., special allowances, personal exemptions, or deductions.[26] The assignment effects of preferential tax rates for incoming expatriates can be easily deduced from the preceding analysis by interpreting t_j as the preferential wage tax rate or by reducing the wage tax rate t_j by the amount of the rate deduction. Therefore, we do not repeat the results here.

By contrast, the effects of preferential tax bases for expatriates are not as straightforward, in particular due to possible tax base differences between the jurisdictions. We assume that host country j grants a special deduction $d_j \geq 0$ for incoming expatriates who earn income from employment in this country.[27] This deduction d_j is an absolute amount rather than a fraction of the agent's remuneration. The resulting wage tax base for agent i in country j is $W_{ij} - d_j$, the net wage before taxation in the home country is $W_{ij} - t_j(W_{ij} - d_j)$.[28] If the agent becomes a resident of his host country or if the double taxation treaty between the home country and the host country prescribes the exemption method, $W_{ij} - t_j(W_{ij} - d_j)$ is also the final net remuneration. If, however, the credit method applies the agent's final net remuneration also depends on the home country's tax rate and tax base.

For reasons of analytical simplicity we focus on the first-best case for analyzing the assignment effects of preferential tax bases. The relevant tax effects can already be observed from this simplified case with fixed remunerations.

5.2 Exemption method or credit method with identical preferential tax bases

In case the exemption method applies, the agent's remuneration after wage taxes amounts to $\underline{w}_{ij} - t_j \cdot (\underline{w}_{ij} - d_j)$. Assuming the credit method applies for the taxation of the agent's wage and that the home country grants an identical deduction for outgoing expatriates as the host country for incoming expatriates, the agent's net remuneration is $\underline{w}_{ij} - \max\{t_0, t_j\}(\underline{w}_{ij} - d_j)$. With $t_{ij} = t_j$

[26] See, e.g., the Swiss federal and cantonal regulations on the deduction of special job-related expenses of expatriates working in Switzerland. The monthly lump-sum deduction is typically CHF 1,500.

[27] In real-world assignments deductions for expatriates can be temporary.

[28] For reasons of analytical simplicity we assume either that the deduction d_j is sufficiently small compared to the gross wage or that positive and negative tax bases are taxed symmetrically.

or $t_{ij} = \max\{t_0, t_j\}$ as the effective wage tax rate, the agent's net remuneration is therefore equal to $\underline{w}_{ij} - t_{ij} \cdot (\underline{w}_{ij} - d_j)$. Hence, the principal's contract problem for assigning agent i to host country j changes from the one in Section 3.4 to:

$$\max_{e_{ij}, \underline{w}_{ij}} p_{ij}^{\tau} = \max_{e_{ij}, \underline{w}_{ij}} (1 - \tau_j)(\pi_{ij} e_{ij} - \underline{w}_{ij}) \tag{28}$$

$$\text{s.t.} \quad \underline{w}_{ij} - t_{ij}(\underline{w}_{ij} - d_j) - e_{ij}^2/2 \geq \underline{u}_i^t \tag{29}$$

The only difference is the tax shield $t_{ij} d_j$ by which the agent's net remuneration increases. This tax shield lowers the agent's required fixed salary, which is now given by:

$$\underline{w}_{ij} = \frac{\underline{u}_i^t + e_{ij}^2/2 - t_{ij} d_j}{1 - t_{ij}} \tag{30}$$

Plugging $\underline{w}_{ij}$ into the objective function leads to the simplified contract problem:

$$\max_{e_{ij}} p_{ij}^{\tau} = \max_{e_{ij}} (1 - \tau_j) \left(\pi_{ij} e_{ij} - \frac{\underline{u}_i^t + e_{ij}^2/2 - t_{ij} d_j}{1 - t_{ij}} \right) \tag{31}$$

Differentiating with respect to e_{ij} shows that the agent's optimal effort is unaffected by the special deduction; it is still $e_{ij}^* = (1 - t_{ij}) \pi_{ij}$. However, due to the reduction of the fixed compensation by $t_{ij} d_j / (1 - t_{ij})$, the principal's expected partial profit increases to:[29]

$$P_{ij}^{\tau} = (1 - \tau_j) \left(\frac{(1 - t_{ij}) \pi_{ij}^2}{2} - \frac{\underline{u}_i^t - t_{ij} d_j}{1 - t_{ij}} \right) \tag{33}$$

Since the agent is always left just with his reservation remuneration, only the principal benefits from the special deduction at the agent's level.

The resulting assignment problem is very similar to (11). The only difference is that the deduction reduces the "effective" reservation remuneration from $\underline{u}_i^t$ to $\underline{u}_i^t - t_{ij} d_j$:

$$\begin{aligned} \max_{a_{11} \in \{0,1\}} & \left[(1-\tau_1) \left(\frac{(1-t_{11}) \pi_{11}^2}{2} - \frac{\underline{u}_1^t - t_{11} d_1}{1 - t_{11}} \right) + (1-\tau_2) \left(\frac{(1-t_{22}) \pi_{22}^2}{2} - \frac{\underline{u}_2^t - t_{22} d_2}{1 - t_{22}} \right) \right] a_{11} \\ + & \left[(1-\tau_2) \left(\frac{(1-t_{12}) \pi_{12}^2}{2} - \frac{\underline{u}_1^t - t_{12} d_2}{1 - t_{12}} \right) + (1-\tau_1) \left(\frac{(1-t_{21}) \pi_{21}^2}{2} - \frac{\underline{u}_2^t - t_{21} d_1}{1 - t_{21}} \right) \right] (1 - a_{11}) \end{aligned} \tag{34}$$

[29] The principal's partial objective function in the second-best case is very similar to (33) and given by:

$$P_{ij}^{\tau} = (1 - \tau_j) \left(\frac{(1 - t_{ij}) \pi_{ij}^4}{2(\pi_{ij}^2 + r_i \sigma_j^2)} - \frac{\underline{u}_i^t - t_{ij} d_j}{1 - t_{ij}} \right) \tag{32}$$

Collecting the additional deduction-related terms in the a_{11}-coefficient of the objective function in (34) yields:

$$a_{11}\left[(1-\tau_1)\frac{t_{11}d_1}{1-t_{11}}+(1-\tau_2)\frac{t_{22}d_2}{1-t_{22}}-(1-\tau_1)\frac{t_{21}d_1}{1-t_{21}}-(1-\tau_2)\frac{t_{12}d_2}{1-t_{12}}\right] \tag{35}$$

That means that the special deductions leave the assignment problem unchanged, if $t_{11}=t_{21}$ and $t_{12}=t_{22}$ for which the corresponding terms cancel each other out. This is certainly the case when the agents' wages are exempt from taxation in their home country, i.e., if $t_{ij}=t_j$ holds. Given the credit method applies for both agents, i.e., $t_{ij}=\max\{t_0,t_j\}$ for both agents and host countries, the conditions are also met. They are not met when different methods apply to the agents, for instance, as in the corresponding scenario from Section 3.5 where agent 1's wage is subject to the credit method, but agent 2's wage is taxed following the exemption method, i.e., $t_{1j}=\max\{t_0,t_j\}$ and $t_{2j}=t_j$.

Summing up, provided that 1) the agents do not differ with respect to the method of avoiding double taxation of their wages and 2) the special deductions granted in the host countries are equally applied to the tax base in the home country under the credit method, preferential tax bases do not bring about any changes in the principal's assignment decision. However, in any case, preferential tax bases do increase her profit by $(1-\tau_1)t_{i1}d_1/(1-t_{i1})+(1-\tau_2)t_{3-i,2}d_2/(1-t_{3-i,2})$ with i as the agent assigned to host country 1 in the optimum, while not changing the agents' utility levels.

5.3 Credit method with differing preferential tax bases

In contrast to the assumption in the preceding section, special deductions provided by the host countries are typically not recognized under the credit method for the determination of the tax base in the home country. Assuming that the home country denies any deduction, the agent's net remuneration for given fixed wage $\underline{w}_{ij}$ is

$$\underline{w}_{ij}-t_j\cdot(\underline{w}_{ij}-d_j)-(t_0\underline{w}_{ij}-FTC_{ij})=\begin{cases}\underline{w}_{ij}-t_0\underline{w}_{ij} & \text{for } t_j\leq\frac{\underline{w}_{ij}}{\underline{w}_{ij}-d_j}t_0\\ \underline{w}_{ij}-t_j\cdot(\underline{w}_{ij}-d_j) & \text{otherwise}\end{cases} \tag{36}$$

where $FTC_{ij}=\min\{t_0\underline{w}_{ij},t_j\cdot(\underline{w}_{ij}-d_j)\}$ denotes the foreign tax credit. Note that the effective wage tax now depends on both tax bases $\underline{w}_{ij}$ and $\underline{w}_{ij}-d_j$ in addition to the tax rates t_0 and t_j. This circumstance complicates the contract problem considerably because the effective tax rate now depends on the tax base which, in turn, depends on the agent's effort.

The principal's profit function for finding the optimal effort level reads

$$p_{ij}^{\tau} = \begin{cases} (1-\tau_j)\left(\pi_{ij}e_{ij} - \frac{\underline{u}_i^t + e_{ij}^2/2}{1-t_0}\right) & \text{for 1) } t_j \leq t_0 \text{ or 2) } t_j > t_0 \\ & \wedge\, \underline{u}_i^t \leq \frac{(1-t_0)t_j d_j}{t_j - t_0} \wedge e_{ij} \leq \hat{e}_{ij} \\ (1-\tau_j)\left(\pi_{ij}e_{ij} - \frac{\underline{u}_i^t + e_{ij}^2/2 - t_j d_j}{1-t_j}\right) & \text{otherwise} \end{cases} \tag{37}$$

with

$$\hat{e}_{ij} = \sqrt{2\left(\frac{(1-t_0)t_j d_j}{t_j - t_0} - \underline{u}_i^t\right)} \tag{38}$$

as a critical effort level. At this effort level, the wage taxes paid in the host country just cover the wage taxes imposed by the home country, $t_0\underline{w}_{ij} = t_j \cdot (\underline{w}_{ij} - d_j)$.

The profit levels resulting from optimal contracts are:

$$P_{ij}^{\tau} = \begin{cases} (1-\tau_j)\left(\frac{(1-t_0)\pi_{ij}^2}{2} - \frac{\underline{u}_i^t}{1-t_0}\right) & \text{for 1) } t_j \leq t_0 \text{ or 2) } t_j > t_0 \\ & \wedge\, \underline{u}_i^t \leq \frac{(1-t_0)t_j d_j}{t_j - t_0} \wedge (1-t_0)\pi_{ij} \leq \hat{e}_{ij} \\ (1-\tau_j)\left(\pi_{ij}\hat{e}_{ij} - \frac{t_j d_j}{t_j - t_0}\right) & \text{for } t_j > t_0 \wedge \underline{u}_i^t \leq \frac{(1-t_0)t_j d_j}{t_j - t_0} \\ & \wedge (1-t_j)\pi_{ij} < \hat{e}_{ij} < (1-t_0)\pi_{ij} \\ (1-\tau_j)\left(\frac{(1-t_j)\pi_{ij}^2}{2} - \frac{\underline{u}_i^t - t_j d_j}{1-t_j}\right) & \text{otherwise} \end{cases} \tag{39}$$

The partial profit from the top of (39) corresponds to the situation where the wage taxes paid in the host country do not cover the wage taxes imposed by the home country. This is due to a low wage tax rate t_j in the host country or a high special deduction d_j. The corresponding profit figure is known from the contract problem without special deductions, see (10). The partial profit from the bottom of (39) reflects the opposite situation of high wage taxes in the host country due to a high wage tax rate in the host country and a small special deduction. The corresponding profit figure is known from the contract problem with identical preferential tax bases, see (33). The middle of (39) corresponds to the situation where it is optimal for the principal to choose the effort level $\hat{e}_{ij}$ so that the wage taxes imposed by the home and the host country are identical. This happens to be the case if the wage tax rate in the host country as well as the special deduction assume intermediate values. The fact that this situation is not only a knife-edge case, but that there is a range of parameter settings supporting it, follows from the differential recognition of the special deduction in both countries.

In general, special deductions that are recognized only in the host countries do have an impact on the assignment decision. For very high special deductions in both host countries, for instance, we observe from the top case of (39) that only the wage tax rate of the home country affects the principal's partial profits, and thereby the assignment decision, while the host countries' wage tax rates become irrelevant. This obviously contrasts with the findings in Section 3.5 where we assumed that there are no special deductions, $d_1 = d_2 = 0$. However, special deductions are typically moderate so that their effects are confined to small wage tax rate intervals around the home country's rate. This effect can be shown using the parameter setting $\pi_{11} = \pi_{12} = 20$, $\pi_{21} = \pi_{22} = 15$, $\underline{u}_1^t = \underline{u}_2^t = 5$, $\tau_1 = \tau_2 = 0.3$, and $t_0 = 0.4$. The host countries grant special deductions for incoming expatriates amounting to $d_1 = 4$ and $d_2 = 2$; these deductions reduce the agents' tax bases by up to approximately 16 percent for country 1 and 5 percent for country 2. Figure 9 displays the principal's optimal assignment decision for the tax rate intervals $t_1, t_2 \in [0.39, 0.43]$.

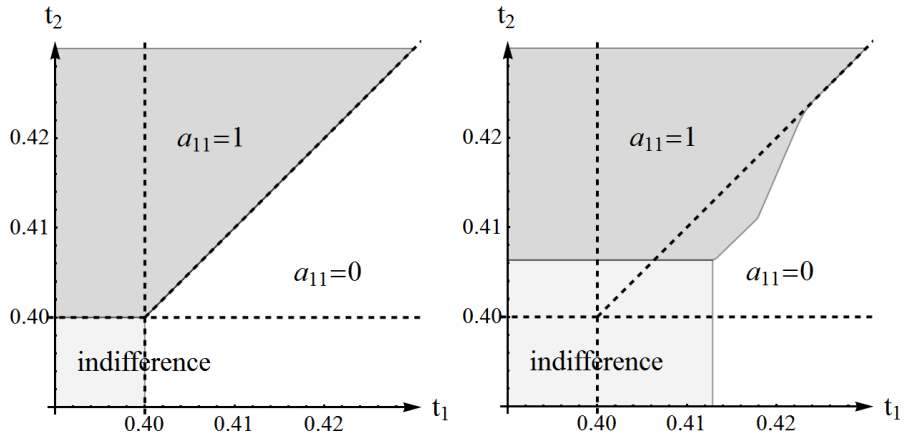

Figure 9: Optimal assignment for different tax rate combinations in the first-best case without (left) and with special deductions for incoming expatriates (right)

The light gray areas represent tax rate combinations for which the principal is indifferent with respect to the assignment. For the dark gray areas $a_{11} = 1$ is optimal, for the white areas $a_{11} = 0$. The diagonal dashed lines indicate tax rate combinations $t_1 = t_2$ for which the principal is indifferent without deduction. As can be observed from the light gray areas, both special deductions extend the indifference area; the extension is larger for higher deductions. This effect can be traced back to the top case of (39). The extension of the dark gray area on the right hand side shows that special deductions can indeed attract more productive agents. As a consequence, jurisdictions can have incentives to grant special deductions in special cases.

5.4 Consequences

Although special deductions for incoming expatriates can be substantial in individual cases, their impact on assignment decisions is very limited. In the exemption case and in the credit case with identical tax bases in the home and the host country, special deductions do not affect assignment decisions at all. In the more realistic credit case with differential tax bases, special deductions tend to attract the more productive agent, but only for very narrow tax rate intervals around the home country's wage tax rate. Given the multitude of potential home countries with different wage tax rates, the beneficial treatment of expatriates is very inaccurate with regard to the desired effect and seems like a windfall profit for the beneficiaries, which are the principals because the agents are always left with their reservation utilities in our model. We also have to mention that in the credit case with different tax bases the principal's optimization becomes much more involved which adds to her costs for tax planning.

6 Conclusions

To our knowledge, this paper is the first to combine human resource assignment decisions with a principal-agent model and taxation. We integrate the solutions of a contract problem into an assignment problem with two agents and two jobs in different jurisdictions to investigate the effects of various international tax rules. Thus, our model is a simultaneous model that integrates taxation into economic decisions rather than an ex-post tax optimization model that takes economic decisions as given.[30]

In our LEN framework, taxation affects the contract problem as well as the assignment decision. With regard to the contract problem, corporate taxation reduces the principal's profit proportionally and does not bear on the agents' efforts or the remuneration parameters for a given assignment. Wage taxation, by contrast, makes the agents' efforts more expensive for the principal so that optimal efforts decrease, the gross remunerations necessary for the agents' participation possibly increase, and the principal's utility decreases whereas the agents' utilities stay the same. In the second-best case, neither corporate nor wage taxes affect the bonus coefficients.

The solution of the assignment problem for given optimal solutions of the contract problems is driven by the profits net of wages and corporate taxes generated by the agents from the different jobs. These profits depend on the agents' productivities and the taxation of wages and profits; in the second-best case the agents' risk attitudes also have to be considered. Due to our assumption, that all jobs have to be staffed, all these profits have to be taken into account at once so that both wage and corporate taxation affect the assignment decision.

[30] For a distinction of the different types of tax models see Wagner (1984, pp 205).

For given effective wage and corporate tax rates, the solution of the assignment problem is a straightforward generalization of the assignment problem without taxes. Yet, in terms of statutory tax rates, tax effects crucially depend on whether the exemption or the credit method applies for eliminating international double taxation of wages. Under the exemption method, the effective wage tax rate coincides with the host country's statutory rate. But under the credit method, this identity only holds if the host country taxes wages at a higher rate than the agent's home country; otherwise, the tax rate of the home country applies. Under both methods, the effects of taxation are intuitive even if host countries differ with respect to the application of the two methods. Under the exemption method, for instance, a host country typically attracts the more productive agent by a sufficiently strong reduction of either its wage tax rate or its corporate tax rate. Under the credit method, by contrast, the host country loses its influence on the assignment decision if its wage tax rates falls short of that of the home country.

It becomes evident from the analysis that tax effects on the assignment decision get more involved if the asymmetry across the countries and/or the agents increases. The assignment becomes a complicated decision especially if taxation depends on the agents. This happens to be the case if the credit method applies and the agents make different choices of residence so that one agent is taxed under the credit method whereas the other agent's wage is effectively exempt from taxation in the home country. In such a scenario, there are tax effects which are not intuitive. In particular, it may happen that increasing the wage tax rate or the corporate tax rate does not prevent the assignment of the more productive agent to the corresponding host country, but rather favors it.

While the asymmetry across agents leads to ambiguous tax effects, special deductions for incoming expatriates are less ambiguous: These tax benefits usually have either no or only negligible effects on optimal assignment, even if they differ across the countries.

The analysis implies several helpful tax lessons for principals facing international assignment decisions:

- International tax rules must be considered *prior* to assignment decisions, not when agents have already been sent abroad.
- It is necessary to have the tax code of *all* involved jurisdictions in mind.
- It is not sufficient to take only national tax laws into account. Rather, the relevant double taxation treaties must be applied in detail.
- Apart from the country-specific rules, agent-specific characteristics must be regarded because the agents' preferences can determine their center of vital interests and thus their country of residence.
- Special deductions for expatriates rarely affect the assignment decision, but complicate human resource and tax planning significantly. Double taxation treaties and national tax

laws should be given more attention instead.

Our model results also permit tax policy conclusions. The tax effects in the exemption cases are quite transparent. Increases of the wage or corporate tax rate in a host country make it more attractive to send the more productive agent to the other host country. However, the effects might even reverse if the credit method has to be applied in at least one jurisdiction for at least one agent. Thus, with respect to transparency and predictability, the exemption method should be preferred. Our considerations concerning neutral tax systems provide at least some further support in favor of harmonized source-based taxation.

Our model in the exemption case can also be used for domestic tax planning. Potentially different wage tax rates indicate progressive tax schedules, different corporate tax rates permit the analysis of different legal structures within the principal's organization. Thus, the relevance of combined contract-assignment problems reaches far beyond the scope of this paper.

As a restriction to be relaxed by future research in this field, we assume that there is a one-to-one relation of agents and projects. In real-world cases, this assumption is not necessarily true. Consequently, the assignment situation should be extended to a more general setting with m agents and n projects. The model extension could permit unemployed agents as well as idle projects with penalty clauses where appropriate. It should be analyzed whether the emerging tax effects are compatible with our results.

As tax asymmetries are pivotal elements of real-world tax systems, our model could be extended by loss-offset restrictions, especially at the principal's level. However, asymmetric taxation typically cannot be implemented within the LEN framework. Rather, models with discrete state spaces are necessary.

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