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Bonus Taxes and International Competition for Bank Managers*

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Abstract

We analyze the competition in bonus taxation when banks compensate their managers by means of fixed and incentive pay and bankers are internationally mobile. Banks choose bonus payments that induce excessive managerial risk-taking to maximize their private benefits of existing government bailout guarantees. In this setting the international competition in bonus taxes may feature a 'race to the bottom' or a 'race to the top', depending on whether bankers are a source of net positive tax revenue or inflict net fiscal losses on taxpayers as a result of incentive pay. A 'race to the top' becomes more likely when governments' impose only lax capital requirements on banks, whereas a 'race to the bottom' is more likely when bank losses are partly collectivized in a banking union.

Keywords: Bonus taxes, international tax competition, migration
JEL classification: H20, H87, G28

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1 Introduction

Bankers' bonuses have been the cause of much debate, and resentment, in recent years. Steep incentive schemes for bank managers have been identified as one of the root causes for the global financial crisis of 2008, as bonuses are believed to be responsible for excessive risk-taking in the banking sector.[1] Empirical evidence confirms that incentive pay has been positively correlated with risk-taking in the pre-crisis period (e.g. Bhagat and Bolton, 2014; Efing et al., 2015). In addition, bankers' bonuses play a significant role in the rising inequality of incomes in many developed countries. Bell and Van Reenen (2014) estimate, for example, that rising bonuses paid to bankers account for two-thirds of the increase in the share of the top 1% of the income distribution in the United Kingdom since 1999. For the United States, Philippon and Reshef (2012) find that, from the mid-1990s to 2006, chief executive officers (CEOs) in the finance industry have earned a 250% premium relative to CEOs in other sectors of the economy.

In response to these developments, several countries have introduced bonus taxes. The UK introduced a one-time 50% withholding tax on banker bonuses that exceeded GBP 25,000 and were paid between December 2009 and April 2010.[2] France followed with a similar, temporary bonus tax of 50% in 2010. In the United States, the House of Representatives approved, in 2009, a 90% bonus tax for traders, executives and bankers working for companies holding at least \$ 5 billion in bailout money and earning more than \$ 250,000 in family income. This bill was blocked in the U.S. Senate, however. Since 2010, Italy levies a permanent, 10% additional bonus tax for the banking sector, if variable compensation exceeds three times the fixed salary. In parallel to these national bonus taxes, the European Union has introduced, as of 2014, a regulation that limits bonuses paid to high-level managers in the financial sector to 100% of their fixed salary (200% with shareholder approval).

Given the massive side effects of bankers' bonuses and the strong public sentiment against them it is surprising, however, that bonus taxation has not become more common, or more persistent. One critical argument for why bankers' bonuses are not taxed

[1]See e.g. Alan Blinder's commentary "Crazy compensation and the crisis", The Wall Street Journal, 28 May 2009.

[2]The UK bonus tax has been empirically analyzed by Ehrlich and Radulescu (2017). The authors find that the introduction of the bonus tax has led to a 40% fall in bonus payments. However, other components of executive pay have simultaneously been raised so as to largely compensate bank managers for the reduction in their bonuses.

more is that top bankers might leave a country that taxes their bonuses severely, and work instead for a bank abroad. Indeed, there is ample evidence that bank managers are mobile across countries. The largest German bank, the Deutsche Bank, for example, has been consecutively governed by three non-German CEOs since 2002.[3] More generally, there is a substantial literature indicating that the international mobility of top managers has grown substantially over the past two decades (e.g. Greve et al., 2015). Focusing specifically on the finance industry, Greve et al. (2009) investigate the nationality of board executives in 41 large European firms in the banking and insurance industry and find that 26% of all executives in the sample are non-nationals. Similarly, Staples (2008) finds that among the 48 largest commercial banks in the world close to 70% have at least one non-national board member.

Despite the conclusive evidence for the international mobility of bank managers, almost all theoretical papers investigating the impact of banker bonus taxation and regulation use a closed-economy framework (see our literature review below). In this paper we aim to fill this gap by analyzing the non-cooperative setting of bonus taxes in a two-country model with one bank in each country and mobility of bankers between the two banks. Our model incorporates governments, banks, and bank managers that all behave optimally, given their incentives. The model has four stages. In the first stage, the two symmetric countries non-cooperatively set bonus taxes to maximize expected net revenues, which result as the difference between expected bonus tax revenues and the expected costs to taxpayers of bailing out the bank in the case of default. In the second stage, the two banks endogenously choose the managers' compensation structure, which consists of bonus payments and a fixed wage component. The contracts set in this stage determine where managers choose to work in Stage 3. Finally, in Stage 4, bank managers take simultaneous effort and risk-taking decisions in the country in which they work.

At the core of our analysis are two principal-agent problems. The first is between a bank's shareholders and its managers. Managers have private effort and risk-taking costs and thus choose lower effort and less risk-taking than would be optimal for shareholders. Second, there is a principal-agent problem between the banks' shareholders and taxpayers in the bank's home country, if shareholders anticipate that their bank is (partly) bailed out by the government in case of failure. Therefore, shareholders incen-

[3] Josef Ackermann (Switzerland) chaired the Deutsche Bank from 2002 to 2012. From 2012 until 2015, Anshuman Jain (UK) chaired the Deutsche Bank, together with Jürgen Fitschen. Since 2015, John Cryan (UK) is the Deutsche Bank's chief executive.

tivize bank managers to take on “excessive” risk, relative to what would be optimal for the country as a whole. Governments therefore choose bonus taxes for a double reason, to collect tax revenues and to make bonuses a more costly instrument from the bank’s perspective. Both banks and governments compete with their respective counterparts in the foreign country.

Our main result is that there can be either a ‘race to the bottom’ or a ‘race to the top’ with respect to the bonus taxes chosen in the non-cooperative tax equilibrium. Which result is obtained depends on the fiscal value of a bank manager, which equals the expected bonus tax income minus the expected bailout costs for the government. A ‘race to the top’ is more likely to occur if the risks of bank failures are large, and if taxpayers are heavily exposed to downside risks as a result of low capital requirements for banks. In this case governments regard each banker as a fiscal liability and optimally set bonus taxes in excess of those that are globally optimal, on order to shift these risks from domestic to foreign taxpayers. A ‘race to the top’ becomes less likely, however, when bank profits also enter the government’s objective function or when bailout costs for banks are collectivized. The latter occurs, for example, in the European Union’s newly established banking union. Together these results may explain why several countries levied high bonus tax rates in the immediate aftermath of the financial crises, but abolished these taxes later, as the perceived risks to taxpayers fell while bank profits resumed.

Our analysis is related to two strands in the literature. A first strand analyzes the effects of public policies towards bonus schemes.[4] Besley and Ghatak (2013) analyze the optimal bonus taxation of managers when bankers can choose both effort and risk-taking. Hakenes and Schnabel (2014) study how bailout expectations affect both the optimal bonus contract offered by the bank and the imposition of bonus caps by welfare-maximizing governments. Thanassoulis (2012) derives the role of bonus caps in a setting where the competition for bankers increases their compensation, which in turn drives up banks’ default risk. All these studies analyze policies towards bonus pay in a closed economy setting. Radulescu (2012) is the only study of bonus taxation in an open economy of which we are aware. This paper does not incorporate risk-taking decisions by bank managers, however, and bonus taxes are exogenous to the model.

[4]The incentive effects of bonus schemes are themselves the subject of a large literature. See e.g. Bannier et al. (2013) and Acharya et al. (2016) for recent analyses of bonus pay in the competition for managerial talent.

A second related literature analyzes policy competition in the presence of cross-country externalities. There is an established literature on international tax competition (see Keen and Konrad, 2013, for a recent survey) that has recently been applied to study non-linear income tax competition in the presence of mobile high-income earners (Simula and Trannoy, 2010; Bierbrauer et al., 2013; Lehmann et al., 2014; Lipatov and Weichenrieder, 2015). These models generally find a 'race to the bottom' in income taxation, as a result of policy competition for mobile individuals.[5] However, the mobile rich take no risks in these models, and they are always a source of positive tax revenue for the competing governments. As we show in this paper, the direction of tax competition may change when the competition is for bank managers, who may inflict fiscal losses on their home governments through overly risky investment choices.

This paper is structured as follows. Section 2 introduces the basic setup of our analysis. Section 3 analyzes the decisions of bank managers. Section 4 turns to the banks' choice of optimal managerial compensation. Section 5 derives the tax competition equilibrium between the two governments. Section 6 analyzes several model extensions and Section 7 concludes.

2 Model setup and roadmap

We consider a model of two banks, one in each of two symmetric countries $i \in (1, 2)$. Banks are run by risk-neutral shareholders. The size of each bank is variable, corresponding to the number of identical divisions within the bank. Running a division requires the specific knowledge of a bank manager. Hence each bank employs exactly one manager per division and the number of managers a bank hires equals the number of its divisions.

The total number of managers in our regional economy is fixed, and all managers are employed in one of the two countries in equilibrium. Managers differ in their individual attachment to the two countries and therefore are imperfectly mobile between the two countries. Apart from their location preferences, all managers are identical. Banks compete for the imperfectly mobile managers by means of a compensation package, which consists of both a fixed wage and a bonus payment. Managerial compensation

[5] Similar 'race to the bottom' results have been obtained for regulatory policies towards profitable banks that export part of their services to the foreign country. See e.g. Acharya (2003), Sinn (2003) and Dell'Ariccia and Marquez (2006).

is chosen so as to maximize the bank's after-tax profits, which is the product of the number of divisions within the bank, and the net expected profit per division.[6]

The bank's portfolio: Each division of a bank in country i has a total amount of fixed assets equal to one, which is lent in the world market. While the two banks in our model are large players in the regional market for managers, they are small investors in the world capital market. Hence the gross returns from investment are exogenous from each bank's perspective. Lending operations are risky. We assume that there are three possible returns for the bank, which can be high, medium, or low (Y^h, Y^m and Y^l). The portfolio realizes a high return Y^h with probability $p^h > 0$, a medium return $Y^m < Y^h$ with probability $p^m > 0$ and a low return $Y^l = 0$ with probability $p^l = 1 - p^h - p^m > 0$. While the portfolio returns are exogenous and observable, the corresponding probabilities are endogenously determined by the unobservable decisions of managers to exert effort and take risk.[7]

Specifically, we assume that the probabilities for the different returns are linear functions of the manager's effort e and risk-taking choice r:

$$\begin{aligned} p^h &= \alpha e + \beta r, \\ p^m &= p_0^m - r, \\ p^l &= p_0^l - \alpha e + (1-\beta) r, \end{aligned} \tag{1}$$

where $p^h + p^m + p^l = p_0^m + p_0^l \equiv 1$. The exogenous 'baseline' probability of a low state, p_0^l, can be interpreted as reflecting general business conditions in the banking sector. With the specification (1), a high return Y^h can only be obtained when managers either exert effort or take risk. More generally, the manager's effort e shifts probability mass from p^l to p^h and therefore increases the mean return of the division's portfolio. Risk-taking r instead shifts probability mass from the intermediate state to the high and the low states, thereby increasing the variance of the division's returns.

The managers' remuneration structure: To align the interests of each division manager and the bank's shareholders, the bank in country i pays a bonus, if the return

[6] An alternative setting would have national banking sectors that consist of a variable number of identical, small banks. In such a setting it is difficult, however, to model a meaningful principal-agent problem between the owner and the manager of a bank.

[7] This specification of an individual division's return structure follows Besley and Ghatak (2013).

for the bank division is high (Y^h). Beyond the bonus payment, the managers also receive an endogenous wage that is paid independently of the realized return. The bonus payment will induce bank managers to increase both effort and risk-taking, relative to a situation where they receive only the fixed pay. The higher risk-taking will, however, also increase the probability that the low return $Y^l = 0$ occurs. In this case the division fails. For analytical tractability, we assume that the returns of the different divisions of a bank are perfectly correlated. Hence, if one division of a bank fails, so do all the others. Therefore, the bank as a whole fails with probability p^l.[8]

If the bank in country i fails, the external creditors of the bank will be bailed out by country i's government. We take the bank's external funds to be savings deposits and assume that the share of deposit financing is exogenously fixed, for example by a binding minimum capital requirement. In this case the bailout occurs through savings deposit insurance, which exists in virtually all developed countries.[9] With these government guarantees, the bank does not face the full cost of failure. It therefore has an incentive to induce excessive risk-taking by its managers, as compared to the social optimum.[10]

By choosing their optimal compensation scheme, banks simultaneously influence the effort and risk-taking choices of their managers, and try to attract managers from abroad by offering an attractive overall level of managerial pay. Since effort and risk-taking choices can only be affected by the bonus, this instrument will always be part of the optimal compensation package. Whether the fixed wage will also be used in the bank's optimum then depends on which of the two compensation elements is more cost effective in attracting additional managers from abroad. Our analysis will therefore distinguish two regimes, depending on whether only the bonus is used in the bank's optimum (Regime I), or whether it is optimal for the bank to combine bonus payments and a fixed wage component (Regime II).

[8] If the returns of different divisions were imperfectly correlated, cross-subsidization between divisions within the bank would be possible. In this case a failure for the entire bank would still arise with a positive probability, but this probability would be a complex function of the correlation coefficient, the number of divisions, and the profitability of each division.

[9] The main argument in favor of deposit insurance is that it prevents bank-runs and thus stabilizes the banking system (Diamond and Dybvig, 1983). Barth et al. (2006) give an overview of deposit insurance schemes around the world, and discuss their benefits and costs.

[10] This argument also makes clear why the bank pays a bonus only in the high state. A bonus in the intermediate state m would not change effort and decrease risk-taking, thereby reducing the amount of loss-shifting to taxpayers [see eq. (1)]. Hence it would tend to reduce expected profits from the bank's perspective.

The government: Governments are aware of the moral hazard problem caused by their bailout policies and use bonus taxation to counteract the distorted incentives. Bonus taxes therefore have a corrective role in our setting, in addition to their objective of raising government revenue. In our benchmark model, we assume that the government maximizes its net tax revenue, which is given by total expected bonus tax revenue minus the expected bailout costs. This focus on tax revenue maximization corresponds to the declared objective of many governments to collect a 'fair and substantial contribution' from the financial sector for the fiscal cost this sector has caused during the financial crisis (International Monetary Fund, 2010).[11] More generally, as long as the value of government tax revenues exceeds that of private sector incomes, a bonus tax dominates the alternative policy instrument of a regulatory cap on bonus payments. This is because the latter has the same corrective role as the bonus tax, but does not collect tax revenue (cf. Keen, 2011). Therefore, we confine our analysis of policy instruments in this paper to a bonus tax.

Finally, we assume that the governments of banks' home countries $i \in \{1, 2\}$ choose their tax policies non-cooperatively. This implies that they are subject to similar competitive forces, arising from the international mobility of bank managers, as the national banking sectors are. However, the incentive structures of banks and governments are different. While attracting additional managers is always privately profitable for banks, governments may lose from an increased size of their national banking sector when the expected bailout costs exceed bonus tax revenue. For analytical tractability, our benchmark model focuses on fully symmetric countries. The symmetry assumption allows us, in particular, to directly compare the policies chosen under international tax competition, and those that are Pareto optimal for the region as a whole.[12]

Our following four-stage analysis proceeds by backward induction. Section 3 studies the decisions of bank managers. In Section 3.1, we derive the managers' effort- and risk-taking choices in Stage 4. Section 3.2 analyzes the managers' migration decisions in Stage 3. Section 4 then turns to the banks' optimal remuneration schemes in Stage 2 of the game, differentiating between the two regimes introduced above. Finally, in Section 5 we derive the governments' non-cooperative choice of bonus taxes in Stage 1.

[11] This government objective will be generalized in the extensions (Section 6.1) by incorporating bank profits into the government's objective.

[12] In Section 6.3, we numerically analyze one instance of asymmetric tax competition where capital requirements and thus implicit government subsidies differ between countries.

3 The decisions of bank managers

3.1 Effort- and risk-taking choices

In Stage 4, managers choose their effort and risk-taking levels. All managers respond in the same way to a given remuneration scheme. Taking effort and risk involves private, nonmonetary costs for the manager.[13] For analytical tractability, we assume that these cost functions are quadratic and given by $c^e(e) = \eta e^2/2$ and $c^r(r) = \mu r^2/2$. Due to these private costs, managers will neither exert enough effort nor take enough risk from the point of view of bank owners. Effort and risk-taking decisions are not observable. However, bank owners can mitigate the principal agent problem by a bonus payment z_i in the high return state, which occurs with higher probability p^h when effort and risk-taking are increased.

Managers located in country i maximize their location-specific utility u_i, which is the excess of expected bonus and fixed wage payments over the private costs of effort and risk-taking. Using (1) gives

$$u_i = p_i^h z_i + w_i - c^e(e_i) - c^r(r_i) = (\alpha e_i + \beta r_i) z_i + w_i - \frac{\eta e_i^2}{2} - \frac{\mu r_i^2}{2}. \tag{2}$$

Maximizing (2) with respect to the managers' choice variables e_i and r_i yields

$$e_i = \frac{\alpha z_i}{\eta}, \qquad r_i = \frac{\beta z_i}{\mu}. \tag{3}$$

Hence the managers' effort level e_i depends positively on the bonus payment z_i, and negatively on the effort cost parameter η. Analogously, the risk level r_i chosen by managers in country i is increasing in the bonus payment z_i and it is falling in the risk cost parameter μ. The fixed wage w_i does not affect managers' optimal effort or risk-taking decisions.

Using (3) in (1), we can derive the equilibrium probabilities of the states $\{h, m, l\}$:

$$p_i^{h*} = \alpha e_i + \beta r_i = \left[\frac{\alpha^2}{\eta} + \frac{\beta^2}{\mu}\right] z_i \equiv \gamma z_i, \tag{4a}$$

$$p_i^{m*} = p_0^m - \frac{\beta}{\mu} z_i, \tag{4b}$$

[13] As in Besley and Ghatak (2013), private costs of risk taking can be seen as the (psychological) costs of seeking out risk-taking opportunities above a 'natural' or benchmark level. This natural risk is here normalized to zero, but it could equally be set at a positive level without affecting any results.

$$p_i^{l*} = p_0^l + \left[\frac{\beta}{\mu} - \gamma\right] z_i \equiv p_0^l + \delta z_i. \tag{4c}$$

In eq. (4a), we have introduced the parameter $\gamma > 0$ to summarize the marginal effect of the bonus payment on the probability of a high return. This consists of two effects. A higher bonus leads to more effort and to more risk-taking, which both increase p^h. Similarly, in eq. (4c) the parameter δ summarizes the marginal effect of the bonus on the low return probability p^l. The sign of δ is ambiguous, in general. On the one hand, a higher bonus leads to more risk-taking, which increases p^l. On the other hand, a higher bonus payment induces more effort and this reduces p^l. In our following analysis we assume that $\delta > 0$, implying that the effect of the bonus on managers' risk-taking dominates the effect on managerial effort. Thus a higher bonus increases the probability of a low return.[14] Finally, the effect of the bonus on the medium return in (4b) is unambiguously negative.

Finally, substituting (3) in (2) gives the location-specific utilities of managers:

$$u_i^* = \left[\frac{\alpha^2}{\eta} + \frac{\beta^2}{\mu}\right] \frac{z_i^2}{2} + w_i \equiv \frac{\gamma z_i^2}{2} + w_i. \tag{5}$$

Both a higher bonus and a higher fixed wage in country i increase the utility of managers working in this country.

3.2 The migration decision

In Stage 3 managers take the bonuses z_i and fixed wages w_i as given and choose whether to work in country 1 or in country 2. Managers maximize their gross utility, which consists of the location-specific utility in (5), and the non-monetary attachment to a particular country. There are a total of $2\bar{N}$ managers in the region, which are all employed in one of the two countries in equilibrium:

$$N_1 + N_2 = 2\bar{N}. \tag{6}$$

Managers differ only in their country preferences. More precisely, managers are of type k, where k is the relative attachment to country 1 and we assume that k is distributed uniformly along $[-\bar{N}, +\bar{N}]$. Other things equal, all managers with $k > 0$ prefer to work in country 1, whereas managers with $k < 0$ prefer to work in country 2.

[14] This assumption corresponds to empirical evidence that higher risk-taking incentives are positively correlated with the probability of losses. See e.g. Cheng et al. (2015).

A common interpretation is that country 1 is the home country for all managers with $k > 0$, whereas country 2 is the home country for all managers with $k < 0$. We scale the location preference parameter k by the constant a. This constant captures the cultural, institutional and geographical distances between the two countries, where a large parameter a stands for large cross-country differences.[15] The gross utility U_i of a manager of type k in country i is then

$$U_1(z_1, k) = u_1^*(z_1) + ak, \qquad U_2(z_2) = u_2^*(z_2). \tag{7}$$

All managers choose to work in the country that gives them the higher gross utility. We characterize the manager that is just indifferent between working in country 1 or in country 2 by the location preference $\hat{k}$. Equating U_1 and U_2 in (7) and using (5), we derive $\hat{k}$ as a function of differences in bonus payments and fixed wages between the two countries:

$$\hat{k} = \frac{1}{a}\left[\frac{\gamma}{2}(z_2^2 - z_1^2) + (w_2 - w_1)\right]. \tag{8}$$

Managers with $k \in [\hat{k}, \bar{N}]$ work in country 1 and managers with $k \in [-\bar{N}, \hat{k}]$ work in country 2. Given the uniform distribution of k, there will be $\bar{N} - \hat{k}$ managers in country 1 and $\bar{N} + \hat{k}$ managers in country 2. Using (8) then determines the number of managers in country i as a function of the differences in bonus payments and fixed wages:

$$N_i = \bar{N} + \frac{1}{a}\left[\frac{\gamma}{2}(z_i^2 - z_j^2) + (w_i - w_j)\right] \qquad \forall\, i, j \in \{1, 2\},\ i \neq j. \tag{9}$$

The larger is the bonus of country i, relative to that of country j, the more managers will work in country i in equilibrium. The same holds for the fixed wage. To quantify the managers' response, we introduce the semi-elasticity of migration with respect to the fixed wage:

$$\varepsilon \equiv \frac{\partial N_i}{\partial w_i}\frac{1}{N_i} = \frac{1}{aN_i} \tag{10}$$

The migration elasticity ε is the higher, the weaker is the managers' attachment to a particular country (the lower is the parameter a).[16] Moreover, the migration elasticity falls in our model when the total number of managers in the country rises.

[15]See van Veen et al. (2014) for empirical evidence that a higher cultural, institutional and geographical distance between a manager's nationality and a company's country of origin makes it less likely that a manager of that nationality is employed by the company.

[16]See Kleven et al. (2014) for an empirical estimate of the migration elasticity of high income earners with respect to the after-tax wage factor. Their results for foreigners working in Denmark suggest a migration elasticity between 1.5 and 2 for this group.

4 Banks' compensation choices

In Stage 2, we turn to the remuneration decisions made by the owners of the single bank in each country. The bank in country i sets the bonus z_i and the fixed wage w_i to maximize its expected after-tax profits (which accrue to its shareholders).[17] The expected after-tax profit of the bank in country i is

$$\Pi_i = N_i \pi_i^D, \tag{11}$$

where the number of divisions, which equals the number of managers, is given in (9).

The expected profit of each division, π_i^D, is determined by the division's exogenous financing structure, its endogenous investment decision, and the endogenous work contract. Each division finances its unit investment by a combination of savings deposits and equity, where the shares of deposits and equity in total liabilities are s and $(1-s)$, respectively. These shares are determined by minimum capital requirements in each country, which are exogenous to our analysis. Since government guarantees are confined to external funds (i.e., savings deposits), banks will always exhaust the permissible level of external funds. Therefore, the share s of deposit finance is directly fixed by each country's capital requirement. Insured depositors face no risk and receive a risk-free interest rate fixed at d.

With this specification, and recalling that the division's gross return is zero in the low state, the expected profit of each division is

$$\pi_i^D = p_i^{h*}[Y^h - sd - z_i(1+t_i)] + p_i^{m*}[Y^m - sd] - w_i - (1-s)d. \tag{12}$$

The first two terms in (12) give the division's profits for the high and the intermediate return, respectively. When the representative division realizes Y^h (with probability p_i^{h*}), it pays sd to its depositors. Moreover, in state h the bank pays the net bonus z_i to its manager and the proportional bonus tax $t_i z_i$ to country i's government. In state m, the division receives a portfolio return of Y^m and pays back sd to its depositors. Bonuses are not paid in this state.

If a division obtains the low return $Y^l = 0$, then it is unable to pay back its depositors, and so is the entire bank, due to the perfect correlation between the divisional returns

[17] Our analysis thus abstracts from a wage bargaining process between the bank's owners and its top management. See e.g. Piketty et al. (2014) for an optimal tax analysis with wage bargaining in the closed economy.

(see Section 2). In this case the payments to depositors (sd) are covered by deposit insurance, and thus eventually by the taxpayers in country i. Hence, in state l, these payments do not enter the division's profit in (12).

However, the manager's fixed wage w_i is paid by the division in all states, implying that the bank's shareholders realize a loss, with a corresponding reduction in the value of their equity, if the low state occurs.[18] We thus assume that taxpayer-financed deposit insurance schemes are available to the bank in the low state l, before the bank's equity is wiped out completely. Finally, the last term in (12) gives the opportunity costs of the bank's equity $(1-s)$, which is valued at the risk-free interest rate d for notational simplicity. Incorporating this last term implies that division profits represent excess profits beyond the normal return to equity in our analysis.

In the following we differentiate two regimes. In Section 4.1 we derive the bank's optimal bonus payment when bonuses are the only remuneration for bank mangers (Regime I). Section 4.2 turns to the case where both the bonus and the fixed wage are paid in the bank's optimum (Regime II). We defer to the beginning of Section 4.2. the discussion of how the equilibrium regime is determined by the model's exogenous parameters.

4.1 Regime I: Bonus payment only

We first consider the case where the fixed wage w_i is set to zero in both banks and bonus payments in the high state are the only remuneration for bank managers. This implies that the bonus has the simultaneous tasks to incentivize bank managers with respect to their risk and effort choices, and to attract managers from the foreign country. Setting $w_i = 0$ in (12), maximizing the bank's after-tax profits in (11) and (12) with respect to the bonus z_i, and using (4a)–(4b) gives

$$\frac{\partial \Pi_i}{\partial z_i} = \frac{\gamma z_i}{a}\, \pi_i^D + N_i \left[\gamma(Y^h - sd) - \frac{\beta}{\mu}(Y^m - sd) - 2\gamma z_i(1+t_i) \right] = 0. \qquad (13)$$

The first effect in eq. (13) is unambiguously positive. A higher bonus z_i enables the bank to attract more managers and thereby run more divisions. This increases bank profits for any given expected profit per division. In an interior optimum, the second effect in (13) must therefore be negative, implying that the (after-tax) profit per division falls when the bonus is increased. This occurs by increasing the bonus until its effect on the

[18]We assume that fixed wage payments are less than the value of the bank's equity, $w_i < (1-s)d$.

expected gross return of the division (the first two terms in the squared bracket) is less than the bank's gross-of-tax cost of the bonus (the last term in the squared bracket).

Deriving the optimal bonus z_i from (13) gives

$$z_i^*|_{RI} = \frac{N_i\Omega}{2N_i(1+t_i) - (\pi_i^D/a)}, \qquad \Omega \equiv (Y^h - sd) - \frac{\beta}{\mu\gamma}(Y^m - sd) > 0, \tag{14}$$

where the term Ω summarizes the marginal effects of the bonus (via the managers' effort and risk-taking choices) on the bank's expected gross return. Clearly, this term must be positive for the bank to choose a positive bonus in equilibrium. Note, moreover, that the increase in the bank's expected gross profit exceeds the social return to the induced changes in managerial behavior, because the social cost of a higher failure probability induced by the bonus are not incorporated in Ω.[19] Since the bonus is rising in Ω, bonus incentives set by the bank will therefore be 'excessive' from a social welfare perspective, as a result of the government's guarantees.[20]

If bonuses are the only source of managerial pay, they are also set higher than they would be in a closed economy. This results from the international mobility of bank managers. The effect of bonuses on the number of managers is strictly positive in our international setting [the positive first term in (13)], while it would be zero in autarky. The international competition for managers thus increases the marginal benefit of bonuses, other things being equal, and therefore drives up bonus payments in equilibrium. As is shown in (14) this effect is the stronger, the lower is the strength of managers' country preferences, as measured by the parameter a.

4.2 Regime II: Bonus payment and fixed wage

We now turn to the case where the remuneration of bank managers is composed of both success-related bonus payments and a positive fixed wage w_i.[21]

[19] If these costs were incorporated, the term $\delta sd/\gamma$ would have to be subtracted from Ω in (14).

[20] See Laeven and Levine (2009) for empirical evidence that government guarantees provide banks with an incentive to increase risk-taking and Adams (2012) for evidence that banks with a higher performance pay for CEOs were more likely to receive government support in the financial crisis.

[21] In the European Union, for example, the employees of credit institutions and investment firms identified as having a material impact on the institution's risk profile had a ratio of variable over fixed remuneration of 65% in 2014. The highest ratios of variable over fixed pay for this group of bank employees are found in asset management (100%) and in investment banking (89%). See European Banking Authority (2016).

The first-order condition for the optimal bonus in (13) remains unchanged in this regime. Maximizing bank profits in (11) and (12) with respect to the fixed wage gives

$$\frac{\partial \Pi_i}{\partial w_i} = \frac{\pi_i^D}{a} - N_i = \frac{1}{a}\left[\pi_i^D - \frac{1}{\varepsilon}\right] \leq 0 \quad \forall\, i, \tag{15}$$

where the second step has used the migration elasticity in (10). Eq. (15) holds with equality, and the fixed wage is used as a component of managerial compensation, when the division profit π_i^D (i.e., the gain from attracting an additional manager) is high, or when the migration elasticity of managers is high ($1/\varepsilon$ is low). In this case, a small positive wage attracts a large number of additional managers to the bank, relative to the number of division managers to whom the higher wage must be paid. If a small fixed wage has a positive effect on firm profits, then the wage rate will be further increased, lowering division profits in (12) until the first-order condition (15) is met with equality.

Therefore, if ε is sufficiently high to ensure that $w_i > 0$, this implies $\pi_i^D/a = N_i$ from the complementary slackness condition (15). Substituting this into (14) the optimal bonus in this regime simplifies to

$$z_i^*|_{RII} = \frac{\Omega_i}{1+2t_i} \quad \forall\, i. \tag{16}$$

Comparing the optimal bonus in (16) with that in the regime without a fixed wage [eq. (14)] shows that the negative term $-\pi_i^D/a$ is now missing from the denominator. Hence the optimal bonus payment will be reduced when the fixed wage can also be optimally chosen by the bank. This reflects that the bonus is used only to affect managers' effort and risk-taking choices in this regime, whereas the fixed wage is the preferred instrument to attract additional managers from abroad.

In Appendix 1, we use equations (15) and (16) for both countries to derive the optimal fixed wage. This is given by

$$w_i^*|_{RII} = p_0^m(Y^m - sd) - (1-s)d + \frac{1}{6}\gamma\Omega^2\left[\frac{4t_i - 1}{(1+2t_i)^2} + \frac{1}{(1+2t_j)}\right] - \bar{N}a. \tag{17}$$

The last term in (17) shows that an increase in manager mobility (i.e., a decrease in a) increases the fixed wage. Since the task of attracting managers from abroad is shifted to the fixed wage instrument, a low value of a, and hence a weaker attachment to home, will now be reflected in a higher fixed wage that banks in each country offer to attract mobile managers.

In both regimes, increasing international mobility will thus lead to a higher overall compensation of managers in equilibrium. We summarize our results in:

Proposition 1 *For given bonus taxes t_i, the more mobile managers are between countries (the lower is a), the higher is the overall remuneration of managers in equilibrium. In Regime I, the higher pay is reflected in a higher bonus payment, whereas in Regime II the premium is paid in the form of a higher fixed wage.*

From Proposition 1, the higher international mobility of managers in recent decades (see Greve et al. 2015) can thus provide a possible explanation for the concurrent increase in banker compensation. This explanation complements the one given in the existing literature, which has focused on increased competition in national banking sectors as an explanation for the rise in managerial pay (Thanassoulis, 2012; Bannier et al., 2013). The further effects of higher international manager mobility depend, however, on which part of managerial compensation is raised. When international competition for managers occurs primarily via bonus payments (Regime I), the resulting higher bonuses will increase the risk-taking decisions of managers [see eq. (3)], and this will raise the probability of bank failures. In this case there is thus a direct, negative impact of the higher international mobility of bank managers on the stability of the financial system. In contrast, if the higher compensation occurs primarily through an increased fixed wage, then the higher international mobility of managers has no repercussions on their risk-taking choices in equilibrium.

4.3 The effects of bonus taxes on managerial remuneration

Before turning to governments' non-cooperative tax choices, we derive the effects that bonus taxes in each of the two countries have on managerial remuneration, and on the equilibrium number of managers working in each country. These effects will differ for the two regimes introduced above.

Regime I ($w_i = 0$): In Regime I, an increase in the bonus tax changes bonus payments in both countries. Using (13) for both countries i and j and solving the system of two equations, Appendix 2 derives the effects of changes in bonus tax rates t_i and t_j on bank i's optimal bonus payment z_i. This leads to:

$$\left.\frac{\partial z_i}{\partial t_i}\right|_{RI} < 0, \qquad \left.\frac{\partial z_i}{\partial t_j}\right|_{RI} < 0. \tag{18}$$

The direct, first effect in (18) is straightforward. A higher bonus tax in country i makes bonus compensation more expensive for the bank in country i and thus reduces the optimal bonus payment z_i.[22] Interestingly, however, a higher foreign tax t_j will also reduce the optimal bonus in country i. This is because a rise in t_j reduces the bonus payment z_j paid in country j. This reduces the attractiveness of working in country j and drives more managers to work in country i. Thus, an increase in z_i now has a negative effect on profits in more divisions in country i's bank, whereas the marginal effect of z_i on attracting additional managers to country i is independent of the number of managers in country i [see eq. (9)]. On net, therefore, bonuses become more costly for banks in country i when country j raises its bonus tax.

Since the bonus is the only form of managerial pay in this regime, tax-induced changes in bonus payments directly affect the equilibrium number of managers in each country. From (9), this effect is given by

$$\left.\frac{\partial N_i}{\partial t_i}\right|_{RI} = \frac{\gamma}{a}\left(z_i \left.\frac{\partial z_i}{\partial t_i}\right|_{RI} - z_j \left.\frac{\partial z_j}{\partial t_i}\right|_{RI} \right) < 0. \tag{19}$$

This must be negative in a symmetric equilibrium with $z_i = z_j$, because $\partial z_i/\partial t_i$ and $\partial z_i/\partial t_j$ are both negative from (18), but $|\partial z_i/\partial t_i| > |\partial z_j/\partial t_i|$ follows from the stability of the equilibrium. Hence the net effect in (19) describes the equilibrium decrease in the number of managers working in country i when this country increases its tax rate and the bonus paid by country i's bank falls by more than the bonus paid in country j.

Regime II ($w_i > 0$): In Regime II, a bonus tax in country i only affects the bonus payment in this country, but it also changes the fixed wage in both banks. For the bonus payment, we get from (16):

$$\left.\frac{\partial z_i}{\partial t_i}\right|_{RII} = \frac{-2\Omega_i}{(1+2t_i)^2} < 0, \qquad \left.\frac{\partial z_i}{\partial t_j}\right|_{RII} = 0. \tag{20}$$

As in Regime I, a higher bonus tax in country i, t_i, reduces the optimal bonus z_i paid by the bank in i. Country j's bonus tax t_j has no impact on the optimal bonus payment in bank i. This is because bonuses are only used to induce bankers' effort and risk-taking choices in this regime, whereas the competition for internationally mobile bank managers occurs via the fixed wage.

[22]Tax incidence results might differ, if bank managers were strongly risk averse. Dietl et al. (2013) show that a bonus tax can increase the bonus payment in this case, because the tax has an insurance effect that counteracts the higher costs of the bonus. However, the empirical evidence on the risk preferences of bank managers suggests that they are risk-neutral, or only very mildly risk-averse (see Thanassoulis, 2012).

The effects of bonus taxes in both countries on bank i's fixed wage w_i are derived from (17):

$$\frac{\partial w_i}{\partial t_i} = \frac{4\gamma\Omega_i^2}{3}\left[\frac{(1-t_i)}{(1+2t_i)^3}\right], \qquad \frac{\partial w_i}{\partial t_j} = \frac{-\gamma\Omega^2}{3(1+2t_j)^2} < 0. \tag{21}$$

As long as $t_i < 1$, a higher bonus tax in country i will increase the fixed wage paid by bank i. Effectively, bank i shifts the compensation of its managers away from the more expensive bonus payment [see (20)] and towards the fixed wage, which is not covered by the additional tax.[23] When $t_i > 1$, however, the effect is turned around and a higher bonus tax reduces the fixed wage. Intuitively, in this case the high bonus tax makes it so costly to incentivize managers that it becomes less attractive for the banks to attract managers from abroad. Hence banks reduce their fixed wage. In contrast, an increase in country j's bonus tax will always decrease bank i's fixed wage. The higher bonus tax in j drives managers to country i. This increases the marginal cost of the wage w_i, which has to be paid to more managers, but it does not change the number of additional managers that a marginal increase in w_i can attract. The argument here is thus analogous to the one explaining that $\partial z_i/\partial t_j < 0$ in Regime I [eq. (18)].

These results can be used to derive the change in N_i caused by the bonus tax. Differentiating (9) with respect to t_i leads to

$$\left.\frac{\partial N_i}{\partial t_i}\right|_{RII} = \frac{1}{a}\left[\gamma z_i \left.\frac{\partial z_i}{\partial t_i}\right|_{RII} + \frac{\partial w_i}{\partial t_i} - \frac{\partial w_j}{\partial t_i}\right] = \frac{-\gamma\Omega^2}{3a(1+2t_i)^2} < 0, \tag{22}$$

where the second step follows from substituting in (20) and (21). In sum, the negative effect of a bonus tax in i on the bonus compensation of country i's managers dominates the changes in fixed wages in both countries. Therefore, a higher bonus tax in country i also causes an outflow of managers in this regime.

5 International competition in bonus taxes

5.1 Governments' bonus tax decision

In Stage 1, governments set the bonus tax t_i that maximizes their net tax revenue W_i. In our model, net tax revenues are given by the expected bonus tax revenues minus

[23] Our benchmark analysis abstracts from general income taxes that would fall, at a uniform rate, on all forms of managerial compensation. In Section 6.1 we discuss how our results are affected when an additional income tax on managers' overall compensation is introduced.

expected bailout costs. Expected bonus tax revenue is collected from N_i managers in the domestic bank, multiplied by the expected bonus tax revenue per manager $p_i^h t_i z_i$. Bailout costs arise from compensating the depositors of the domestic bank in the event that the bank fails. They are obtained by multiplying the number of divisions N_i of the domestic bank with the expected bailout costs per division $p_i^l sd$.

We introduce F_i as the *net fiscal value* of a manager in country i, which equals expected tax income minus expected bailout costs per division. The government's net tax revenue is then given by

$$W_i = N_i F_i, \qquad F_i \equiv \left[p_i^{h*} t_i z_i - p_i^{l*} sd\right]. \tag{23}$$

Importantly for our analysis, the fiscal value of a manager can be positive or negative. It is positive if, in the government's tax optimum, the revenue from taxing the manager's bonus exceeds the expected bailout costs for the government when the manager's division fails. This is more likely when the the share of subsidized deposit financing s is low (i.e., the bank's equity requirement is high), and when business conditions in the banking sector are favorable (the 'baseline' failure probability p_0^l in eq. (1) is low). It is also possible, however, that the reverse set of condition holds and s and p_0^l are both large. In this case the fiscal value of a manager, and hence also the total net domestic tax revenue W_i, is negative, even when the government chooses its bonus tax optimally.

In the case where $W_i < 0$, we assume that there are unmodelled and fixed benefits for the economy from having a domestic banking sector, even though the exact size of the domestic bank does not matter for the real economy.[24] The non-tax benefits of having a domestic bank will then cause each government to accept negative net tax revenues from the banking sector, if fiscal conditions are unfavorable. Therefore, each government will still solve an interior tax optimization problem, rather than shutting down its domestic banking sector entirely.

Maximizing net tax revenue as given in (23) with respect to t_i then gives

$$\frac{\partial W_i}{\partial t_i} = N_i \, \frac{\partial F_i}{\partial t_i} + F_i \, \frac{\partial N_i}{\partial t_i} = N_i \left[z_i^2 \gamma + 2\gamma z_i t_i \, \frac{\partial z_i}{\partial t_i} - \delta sd \, \frac{\partial z_i}{\partial t_i} \right] + F_i \, \frac{\partial N_i}{\partial t_i} = 0. \tag{24}$$

We assume in the following that an interior tax optimum exists for each government. For the simpler Regime II, it is straightforward to derive the conditions under which

[24] One possible setting that is in line with this assumption is that the production sector in each country can obtain credit from either the domestic or the foreign bank. In the complete absence of a domestic bank, however, the access to credit is either limited for the domestic economy, or it becomes discretely more expensive as a result of the foreign bank's monopoly power.

the government's objective W_i is a strictly concave function of the bonus tax rate t_i, and an interior tax optimum must exist. These conditions are derived in Appendix 3 and are summarized in:

Proposition 2 *In Regime II, an interior tax optimum with $0 < t^* < \infty$ exists for both governments, and for both positive and negative fiscal values of bank managers $F_i \lesseqgtr 0$, if the following condition holds:*

$$\gamma\Omega\left(1 - \frac{\varepsilon p_0^l sd}{3}\right) - 2\delta sd > 0.$$

Proof: See Appendix 3.

Intuitively, the government's bonus tax revenue is unambiguously concave in the bonus tax rate. Therefore, a first condition for W_i to be strictly concave in t_i is that the effect of the tax rate change on bonus tax revenue dominates the effect on the government's bailout costs. This will be the case if the marginal effect of the bonus on the probability of the high return state (as parameterized by $\gamma > 0$) dominates the marginal effect of the bonus on the probability of the low state (as parameterized by $\delta > 0$).[25] The second condition ensuring an interior solution is that the tax-induced net revenue changes resulting from the changed incentives of existing managers in a country dominate the revenue changes resulting from the inflow or outflow of managers. This condition will be met when the migration elasticity of managers, ε, is not too large.[26]

If the conditions summarized in Proposition 2 are met, each country will choose an interior tax rate t^* in its tax optimum, for both positive and negative fiscal values of managers F_i. From the first-order condition (24) we can then interpret the fundamental trade-off for governments in more detail. The derivatives $\partial z_i/\partial t_i$ and $\partial N_i/\partial t_i$ are regime-specific, but we have shown in Section 4.3 that both derivatives have the same sign in Regimes I and II. Starting with the second term in (24), a bonus tax causes an outmigration of managers in both regimes [from eqs. (19) and (22)]. Therefore the second term in (24) has the opposite sign as the fiscal value of a manager, F_i.

[25] Recall from our discussion in Section 3.1 [eqs. (4a)–(4c)] that γ is unambiguously positive from both the effort and risk-taking choices of bank managers. In contrast, the effects of effort and risk taking on the parameter δ are mutually offsetting.

[26] Note that moderate migration elasticities required for an interior tax equilibrium do not preclude an equilibrium where fixed wages are part of managerial compensation [see eq. (15)]. In particular, when the division profits π_i^D are sufficiently high due to a high exogenous return Y^h, then even moderate migration elasticities will ensure that (15) holds with equality, implying a Regime II equilibrium.

The sign of the first term depends on the sum of three terms in the squared bracket, which give the change in net tax revenue for a representative division ($\partial F_i/\partial t_i$). The first term gives the direct effect of a tax increase at an unchanged tax base and is clearly positive. The second term is unambiguously negative, because a higher bonus tax reduces bonus payments, and hence the bonus tax base, in both regimes [eqs. (18) and (20)]. The third term is again positive, as the tax induced fall in bonus payments lowers the probability of bank default and thus reduces taxpayer losses when $\delta > 0$.

We can thus differentiate two cases. If the fiscal value of a manager, F_i, is positive, then the outmigration of managers caused by the tax increase leads to a negative second effect in (24). In an interior optimum, the first term in (24) must therefore be positive, on net. This requires that the negative second term in the squared bracket is small, implying a low bonus tax rate t_i in equilibrium.

In the opposite case where $F_i < 0$, the falling number of managers and bank divisions creates a net revenue gain for the government (i.e., a reduction in the net subsidies paid to the banking sector) from the second effect in (24). In this case the increase in the bonus tax rate must therefore reduce the net revenue obtained from each division in an interior tax optimum, and the first term in (24) must be negative. This requires that the negative second term in the squared bracket is large, implying a high bonus tax rate t_i in the non-cooperative tax equilibrium.

5.2 Are non-cooperative bonus taxes too high or too low?

The next step is to compare the optimal bonus taxes chosen by non-cooperating governments to the bonus tax rates that would be optimal from a regional welfare perspective. We start from an interior, symmetric equilibrium where $\partial W_i/\partial t_i = 0$ holds for both countries $i \in \{1, 2\}$. Since countries are symmetric, we can define regional welfare as the sum of national welfare levels

$$W_W = W_i + W_j \quad \forall\, i, j \in \{1, 2\}, i \neq j, \tag{25}$$

where W_i is given in eq. (23). Choosing t_i so as to maximize regional welfare, eq. (25) would imply $\partial W_W/\partial t_i = 0$. The nationally optimal bonus taxes derived in the previous section are instead chosen so that $\partial W_i/\partial t_i = 0$ [see eq. (24)]. Hence, any divergence between nationally and globally optimal bonus taxes is shown by the effect of country i's policy variable t_i on the welfare of country j. If $\partial W_j/\partial t_i > 0$, bonus taxes chosen at the national level are 'too low' from a global welfare perspective, as an increase in t_i would generate a positive externality on the welfare of country j. The reverse holds if $\partial W_j/\partial t_i < 0$. In this case the externality on the foreign country is negative and nationally chosen bonus taxes are 'too high' from a regional welfare perspective.

Using this argument and employing symmetry, which implies $\partial W_j/\partial t_i = \partial W_i/\partial t_j$, we differentiate (23) with respect to the foreign tax rate t_j. This gives:

$$\frac{\partial W_i}{\partial t_j} = (2t_i\gamma z_i - \delta sd)\,\frac{\partial z_i}{\partial t_j}N_i \; + F_i\frac{\partial N_i}{\partial t_j}. \tag{26}$$

We analyze eq. (26) for the two different regimes in our model.

Regime I ($w_i = 0$): In Regime I, there are two main externalities of bonus taxes. The first term in eq. (26) stems from the fall in country i's bonus payment z_i that is induced by the tax increase in country j [see eq. (18)]. The falling bonus in i is associated with lower bonus tax revenues, but also with lower expected bailout cost. Hence this effect is ambiguous, in general. The second effect in (26) is driven by the migration decision of managers. Since the sum of managers working in one of the two countries is fixed, we get $\partial N_i/\partial t_j = -\partial N_j/\partial t_j > 0$ from (19). A rise in t_j decreases the bonus in country j by more than in country i, and thus increases the number of managers in country i in equilibrium.

The overall sign of the second term thus hinges critically on the sign of F_i, the *fiscal value* of a manager. If this term is positive, a bonus tax increase in country j will benefit country i through the immigration of managers, who are net contributors to tax revenues. In this case the net fiscal externality is likely to be positive, implying that bonus taxes set in the non-cooperative equilibrium are lower than the bonus taxes that would be chosen under policy coordination. This is the conventional case of a 'race to the bottom' in the setting of bonus taxes. From (23) this scenario will be the more likely, the lower are the implicit government subsidies through deposit insurance (the lower is s), and the lower is the baseline probability of a low return, p_0^l.

Conversely, if the expected bailout costs for governments dominate the expected revenue from a bonus tax so that $F_i < 0$, then the second effect in (26) is negative. In Appendix 4 we show that $F_i < 0$ is indeed a *sufficient* condition for the overall externalities of bonus taxation to be negative. Non-cooperatively set bonus taxes are thus unambiguously higher than those in the coordinated equilibrium and there is a 'race to the top' in bonus taxation. Intuitively, managers are unwanted by governments in this case, as the expected bailout costs for the government dominate the revenue potential from bonus taxation. Hence each country attempts to drive bank managers to the other country by means of a high bonus tax, thus shifting fiscal risks from domestic to foreign taxpayers. This case is more likely, if the probability of government guarantees for the banking sector are large (s is high), and if business conditions for the banking sector are unfavorable (p_0^l is high).

Regime II ($w_i > 0$): In Regime II the first term on the right-hand side of (26) equals zero, as country j's bonus tax has no impact on the bonus paid by country i's bank [see eq. (20)]. In the second term of (26), the effect of a change in t_j on the number of managers in country i is again positive [see eq. (22)]. Hence in Regime II the sign of the fiscal externality is always equal to the sign of the fiscal value per manager, F_i. If this term is positive, a higher bonus tax in country j will benefit country i through the immigration of managers and a 'race to the bottom' occurs. If F_i is negative, the immigration of managers associated with a rise in country j's bonus tax is instead harmful for country i and a 'race to the top' results.

We can thus conclude that the effects of tax competition are very similar in the two regimes. We summarize our results in this section in:

Proposition 3 *When non-coordinated bonus taxation leads to a symmetric, interior tax equilibrium, the following holds:*

(i) In both regimes, a positive fiscal value of a manager ($F_i > 0$) is a necessary condition for non-coordinated bonus taxes to be below their globally optimal levels, and hence for a 'race to the bottom' to occur. In Regime II ($w_i > 0$) the condition is also sufficient.

(ii) In both regimes, a negative fiscal value of a manager ($F_i < 0$) is a necessary and sufficient condition for non-coordinated bonus taxes to be above their globally optimal levels, and hence for a 'race to the top' to occur.

Proof: See Appendix 4.

5.3 Discussion

Our results in Proposition 3 incorporate two different settings. When the fiscal value of managers is positive, governments undertax bonuses, relative to the globally efficient level, in an attempt to attract more 'fiscally valuable' bank managers. In this case, therefore, governments will not fully correct the distortion arising from the excessive bonus incentives set by banks, as a result of their limited liability. When the fiscal value of bank managers is negative, however, government's incentives to correct for the banks' limited liability and their strategic incentive to reduce bank size are mutually reinforcing. Hence, each country overtaxes bonuses in this case, in order to drive 'fiscally harmful' managers to the other country.

The case where bonus taxes are below their efficient levels corresponds to the setting that is well known from the tax competition literature (see Keen and Konrad, 2013, for a recent survey). The recent literature has generalized this result to non-linear income tax competition between governments pursuing a redistributive objective (Lehmann et al., 2014; Lipatov and Weichenrieder, 2015), and it has shown that tax competition may even eliminate all taxes on the high-skilled when they are perfectly mobile across countries (Bierbrauer et al., 2013). More generally, Sinn's (1997) conclusion applies in this setting that governments in competition will be unable to fully correct the externalities that arise from (allocative or distributional) market failures.

The opposite setting with inefficiently high bonus taxes rarely occurs in the tax competition literature, which typically excludes risk-taking decisions, and hence the possibility of negative returns. This setting has some similarities with the NIMBY (Not In My Backyard) scenario, however, that is known from the taxation of environmentally hazardous plants or products (e.g. Markusen et al., 1995). The main difference to this scenario is that the negative externalities in our case are fiscal ones: High bonus taxes are used by each country to shift the fiscal risks associated with bailout guarantees from domestic to foreign taxpayers.

The ambiguity about the direction of tax competition is particularly relevant in the banking sector, due to the possibility that bank managers cause fiscal losses for taxpayers. In our model, governments use price signals (i.e., taxes) to change the behavior of banks and, via the change in bonus payments, the behavior of managers in the direction of lower risk-taking. Similar effects can also be obtained by forcing banks to hold more equity capital by means of minimum capital requirements. A small literature has studied regulatory competition in capital standards and has typically found that this competition leads to a 'race to the bottom' in capital standards when governments focus primarily on maximizing domestic bank profits (Acharya, 2003; Sinn, 2003; Dell'Ariccia and Marquez, 2006). Recently, Haufler and Maier (2016) have shown, however, that regulatory competition in capital standards will instead lead to a 'race to the top' when the governments' objective function is broadened and also includes fiscal risks as well as consumer surplus, which is affected by the overall availability of credit. In sum, therefore, the direction of regulatory competition is ambiguous in this literature, similar to our results for bonus taxation.

6 Extensions

In the following we extend our model in various directions. In Section 6.1 we incorporate bank profits into the welfare functions of governments. Section 6.2 then investigates the situation in a banking union, where the two symmetric countries internalize a share of each other's bailout costs. Our focus in both sections lies on the fiscal externalities that are added to our benchmark analysis, and how these affect the direction of bonus tax competition. Finally, Section 6.3 studies, by means of numerical analyses, the asymmetric tax competition equilibrium that arises when exogenous capital requirements, and hence the shares of subsidized savings deposits, differ between countries.

6.1 Bank profits in the government's objective

So far we have included only bonus tax revenue and bailout costs in the welfare functions of governments. We now analyze the case where each government additionally takes into account a share θ of the domestic bank profits Π_i. The objective function thus changes to:

$$\tilde{W}_i = N_i F_i + \theta N_i \pi_i^D. \tag{27}$$

The new second term on the right-hand side gives the income that domestic capital owners derive from the profits of the domestic banking sector. The welfare weight θ thus jointly reflects the share of the domestic banking sector that is owned by domestic residents, and the relative valuation of this profit income in the government's objective.

In **Regime I**, differentiating (27) with respect to t_j gives

$$\left.\frac{\partial \tilde{W}_i}{\partial t_j}\right|_{RI} = (2t_i\gamma z_i - \delta sd)\frac{\partial z_i}{\partial t_j}N_i + F_i\frac{\partial N_i}{\partial t_j} + \theta\left\{\underbrace{\left[N_i\frac{\partial \pi_i^D}{\partial z_i} + \pi_i^D\frac{\partial N_i}{\partial z_i}\right]}_{=0}\frac{\partial z_i}{\partial t_j} + \pi_i^D\frac{\partial N_i}{\partial t_j}\right\}. \tag{28a}$$

The first two terms in (28a) correspond to those in our benchmark model [eq. (26)]. The new terms resulting from the change in country i's profit income are due to the effects that a higher tax in country j has on bonus payments by both banks. The effects induced by the change in bank i's bonus payment z_i must sum to zero from this bank's optimal bonus choice [see eq. (13)], so that only the effects operating through bank j's bonus z_j remain (the second term in the curly bracket). These effects are unambiguously positive for country i as the higher tax in j induces a reduction in z_j. This in turn drives managers to country i [see eq. (19)] and increases the size of country i's bank.

In **Regime II**, differentiating (27) gives

$$\left.\frac{\partial \tilde{W}_i}{\partial t_j}\right|_{RII} = F_i \frac{\partial N_i}{\partial t_j} + \theta \pi_i^D \frac{\partial N_i}{\partial t_j} \ . \tag{28b}$$

The first term in (28b) corresponds to the only fiscal externality in our benchmark model, as $\partial z_i / \partial t_j = 0$ holds in this regime. The additional term on bank profits in country i results again from the changed bank size in country i following the increase in t_j. This effect is positive from eq. (22). The simultaneous change in w_i caused by a rise in t_j has no first-order welfare effect on country i, because w_i is optimally chosen by country i's bank [eq. (15)].

In sum, adding bank profits to the government's objective adds a positive term to the fiscal externalities in both regimes. This implies that a 'race to the bottom' becomes more likely under this extension. Intuitively, by increasing its tax rate, the government of country j causes some bank managers to move to country i. This will increase *bank profits* in country i, even when the net contribution of bank managers to country i's *tax revenues* is negative.

A related extension is to add a general income tax, levied at an exogenous rate, that bank managers have to pay on all their income (i.e., the fixed wage and the bonus). This extension is therefore relevant only in Regime II. Incorporating income taxes does not add an additional component to the government's objective, as in (28b), but it adds a positive revenue term to F_i. This makes it more likely that $F_i > 0$ holds in equilibrium, and hence it increases the probability that the single remaining externality in (28b) is positive. Therefore, adding exogenous income taxes for bank managers to the model also increases the likelihood of a 'race to the bottom' in bonus taxation.

6.2 Joint liability of bailout costs

Another relevant extension of our benchmark model is to incorporate joint liability of the two countries in the case of individual bank failures. In the Euro area, such a scheme exists as the so-called 'Single Resolution Mechanism' within the EU's banking union. In the following we assume that taxpayers in the two countries jointly come up for the losses caused by each national bank.[27] We take ρ to be the share that taxpayers in country i pay for the expected losses of bank failures in country j, whereas $(1-\rho)$ is the share of losses that taxpayers in each country pay for the bank losses in their own country. Joint liability of bailout costs then implies

$$\hat{W}_i = N_i\left[T_i - (1-\rho)B_i\right] - \rho N_j B_j \quad \forall\, i \neq j, \tag{29}$$

where T_i is the tax revenue per manager and B_i is the bailout cost per manager in i:

$$T_i \equiv p_i^{h*} t_i z_i, \qquad B_i \equiv p_i^{l*} sd \quad \forall\, i.$$

To analyze the fiscal externalities associated with bonus taxation in **Regime I**, we differentiate (29) with respect to t_j. This gives

$$\frac{\partial \hat{W}_i}{\partial t_j} = \frac{\partial N_i}{\partial t_j}\left[T_i - (1-\rho)B_i\right] + N_i\left[\frac{\partial T_i}{\partial t_j} - (1-\rho)\frac{\partial B_i}{\partial t_j}\right] - \rho\left[B_j\,\frac{\partial N_j}{\partial t_j} + N_j\,\frac{\partial B_j}{\partial t_j}\right]. \tag{30}$$

To see how the fiscal externalities change with respect to the collectivization of bailout costs, we differentiate (30) with respect to ρ. This gives, after using symmetry and summarizing terms

$$\frac{\partial \hat{W}_i/\partial t_j}{\partial \rho} = 2B_i\frac{\partial N_i}{\partial t_j} - N_i \delta sd\left(\frac{\partial z_j}{\partial t_j} - \frac{\partial z_i}{\partial t_j}\right). \tag{31}$$

The first term in (31) is always positive, since $\partial N_i/\partial t_j > 0$. This effect captures that the negative externality from shifting bailout costs abroad via manager migration becomes smaller when the degree of collectivizing bailout costs is increased (ρ rises). The second term in (31) is also positive when $\delta > 0$. This is because an increase in t_j reduces the bonus in country j, thus reducing risk-taking and hence the expected losses arising in country j's banking sector. For a higher level of ρ a larger part of this net revenue gain is transferred to country i. Finally, from the stability condition $|\partial z_j/\partial t_j| > |\partial z_i/\partial t_j|$, the change in z_j induced by a rise in t_j dominates the counteracting effect from the simultaneous change in the bonus of bank i.

[27] We thus abstract from insurance funds paid by the banking sector. In Europe, member states of the banking union are building up an EU-wide 'resolution fund', financed by levies on member states' banks. This fund, however, is built up only gradually and with a moderate overall target volume of 1% of the covered deposits of banks (55 billion Euro, based on the volume of deposits in 2010).

In **Regime II** the only difference is that the second term in (31) simplifies because $\partial z_i/\partial t_j = 0$ from (18). This, however, does not change any qualitative results. In sum, the effects in (31) are thus unambiguously positive in both regimes, implying that a higher degree of collectivizing bailout costs (a rise in ρ) increases the value of the net externality $\partial \hat{W}_i/\partial t_j$ and makes a 'race to the bottom' more likely. We summarize our results in the first two extensions of this section in:

Proposition 4 *A 'race to the bottom' in bonus taxes becomes more likely, if*

(i) *domestic bank profits receive a higher weight in the welfare function of governments (θ is increased), or if*

(ii) *bailout costs are more strongly collectivized between countries (ρ rises).*

Proposition 4 (i) can be used to rationalize the development of bonus taxation in the recent past. In the aftermath of the 2008 financial crisis, large-scale bank bailouts occurred in many countries, implying that the net fiscal value per bank manager (F_i) was frequently negative. Given this experience, the protection of national taxpayers was the dominant concern in many countries, relative to the incentive to increase banking sector profits (i.e., θ was low). These conditions may explain why very high bonus tax rates were enacted, or at least prepared, in several OECD countries in 2009 and 2010 (see the introduction). In the following years, however, perceived risks for taxpayers fell and banking sector profits resumed, and with it the incentive to attract banking sector profits from abroad (a rise in θ). These developments may have caused the competition via bonus taxes to change directions, moving from a 'race to the top' to a 'race to the bottom', and to the repeal of previously enacted bonus taxes.

Moreover, from Proposition 4 (ii), collectivizing the costs of bank restructuring in the European banking union may further contribute to a 'race to the bottom' in bonus taxation when bonus taxes are set unilaterally and non-cooperatively. Setting a lower bound on bonus taxes or, alternatively, limiting bonus payments by regulatory means may thus be a desirable coordination measure complementing the banking union. And indeed, the latter occurred with the coordinated 2014 regulation limiting bonus payments in the EU to 100% of bankers' fixed salary.

6.3 Asymmetries between countries

Finally, we depart from the assumption that the two countries considered in our analysis are identical in all respects. More specifically, we consider cross-country differences in the share of deposit finance, s_i, and let country 1 have the higher share of deposit finance so that $s_1 > s_2$. This is most easily interpreted as a difference in the (exogenous) capital adequacy ratios for banks stipulated by national regulators, which are assumed to be less tight in country 1 as compared to country 2. Hence banks in country 1 receive higher implicit taxpayer subsidies, equal to $p_1^l s_1 d$ [cf. eq. (23)].

Our analysis in this subsection focuses on **Regime I**. Let us first consider the effects of a change in s_1 on the optimal bonus decision of the bank in country A. From the optimal bonus choice in (13) and using $\beta/\mu - \gamma \equiv \delta$ from (4a)–(4c), we get

$$\frac{\partial z_1}{\partial s_1} = \frac{\partial^2 \Pi_1 / \partial z_1 \partial s_1}{-(\partial^2 \Pi_1 / \partial z_1^2)} \quad \text{where} \quad \frac{\partial^2 \Pi_1}{\partial z_1 \partial s_1} = \frac{\gamma z_1}{a}(1 - p_1^l) d + N_1 d \delta. \tag{32}$$

Eq. (32) gives the change in the optimal bonus for fixed levels of bonus taxes t_i. It shows that the bank in country 1 will pay a higher bonus in response to the lower capital adequacy ratio (the increase in s_1). Firstly, when banks are financed by a larger share of savings deposits, the taxpayers of country 1 bear a larger share of the losses when the low state l is realized. This increased level of insurance, and hence profitability, will induce the bank in country 1 to offer a higher bonus in order to increase bank size. Secondly, the positive effect on the bonus is further increased when a higher bonus increases the likelihood of a low outcome ($\delta > 0$), as this is the event that is subsidized more heavily when s_1 rises. Hence $\partial z_1 / \partial s_1 > 0$ follows unambiguously when $\delta \geq 0$. In this section we also allow for $\delta < 0$, however. In this case, the second effect changes its sign and the relationship between the deposit share s_1 and the bonus rate z_1 is no longer unambiguous, even for a fixed bonus tax rate t_1.

To determine the effects of a rise in s_1 on the tax rate in country 1, we use the first-order condition of country 1's tax rate in (24). The differentiation is carried out in Appendix 5. It is shown there that the overall effects depend critically on the sign of δ. When $\delta > 0$, so that a higher bonus primarily increases risk-taking, a rise in s_1 is likely to raise t_1 in the government's optimum. Intuitively, the increase in the insured deposit share s_1 increases the exposure of country 1's government to the losses occurring in state l. Therefore, the tax will be adjusted upward, in order to discourage bonus payments and minimize the likelihood of the low state. Conversely, if $\delta < 0$ a higher bonus primarily increases managerial effort and thus reduces the likelihood of the low state. In this case, it is therefore optimal for country 1's government to reduce the bonus tax, in order to boost bonus payments by the local bank.

Table 1 confirms these expectations with the help of some numerical analyses. We

Table 1: Bonus payments and tax rates for different shares of deposit finance

α	δ	z_1	z_2	t_1	t_2
$s_1 = 0.8$, $s_2 = 0.5$					
0.40	0.180	0.326	0.348	1.326	1.068
0.45	0.095	0.450	0.462	0.884	0.778
0.50	0	0.589	0.593	0.615	0.581
0.55	–0.105	0.734	0.733	0.450	0.454
0.57	–0.150	0.791	0.788	0.403	0.418

Note: Parameters held constant: $\beta = 0.5$, $p_0^l = 0.2$, $p_0^m = 0.8$, $\eta = 0.5$, $\mu = 0.5$, $Y^h = 3$, $Y^m = 1.5$, $a = 0.1$, $d = 1$.

specify a higher share of deposit finance in country 1 as compared to country 2 ($s_1 = 0.8$, $s_2 = 0.5$). In the examples we continuously increase the impact of managerial effort, α. Hence the parameter δ, which gives the net effect of changes in the bonus z_i on the probability of the low state, p_i^l [see eq. (4c)] switches from a positive to a negative sign. As long as $\delta \geq 0$, the bonus tax rate in country 1 exceeds that of country 2, as the government of country 1 has the higher fiscal exposure to the losses generated by its bank in the low state, and hence has the stronger incentive to reduce bonus pay by means of high taxes. In fact, the tax difference is so large that equilibrium bonus payments are lower in country 1, as compared to country 2, despite the positive direct effect of s_1 on z_1 given in (32). When δ turns negative, however, the tax difference turns around and country 1 levies the lower bonus tax. This is because bonus payments now primarily increase effort and thus reduce the probability of the low state, p^l. Again, it is country 1 which has the stronger incentive to minimize p^l, and hence it now charges a lower tax rate than country 2 in the asymmetric tax competition equilibrium.

7 Conclusion

In this paper we have incorporated international mobility of bank managers into a framework with two principal-agent problems. Banks choose their compensation structure, which consists of a fixed wage and bonus pay, so as to simultaneously induce managers to take the effort and risk choices desired by the principal, and to attract additional managers from abroad. In the event of failure, banks impose negative externalities on taxpayers, due to the existence of government guarantees. This gives rise to excessive bonus payments by banks, relative to those that would be socially optimal. Governments therefore choose bonus taxes to collect tax revenue and to counteract the distorted incentives of banks and their managers. In doing so governments, like banks, are subject to the international competition arising from bank managers' mobility.

In such a setting non-cooperative levels of bonus taxes can generally be above or below the levels that would be optimal under policy coordination. Therefore there can be a 'race to the bottom' or a 'race to the top' in bonus taxes. The 'race to the top' result arises if bank managers have a negative fiscal value for the jurisdiction in which they work, inflicting expected losses on taxpayers that exceed bonus tax revenues. In this case, governments set bonus taxes above their Pareto efficient levels, in order to shift fiscal risks from domestic to foreign taxpayers.

The 'race to the top' result is specific to highly paid agents that, despite being a source of tax revenue, take risky decisions without bearing the full cost of it. It may explain the wave of very high marginal taxes on bankers' bonuses in the immediate aftermath of the 2008 financial crisis. More recently, however, the perceived risks from bank failures have fallen again, while jobs and profits in the banking sector have gained new importance. This may have changed incentives for governments once more, in the direction of a 'race to the bottom'. In the newly created European banking union the costs of bank defaults are furthermore shared between its member states, strengthening the incentives to adjust bonus taxes downwards. The coordinated cap on bonus payments that EU countries have recently enacted can therefore be seen as a direct complement to the creation of the banking union.

Our analysis can be extended in various directions. A first possible extension is to extend the set of government instruments and endogenize regulatory policies, which have been taken as exogenous in the present analysis. To introduce a meaningful trade-off for governments with respect to minimum capital requirements, however, this extension would require to model a real sector that depends on bank loans to finance its investments. A further interesting extension is to consider bank managers that are overconfident (see Ho et al., 2016 for recent evidence) and therefore overvalue the bonus component of their compensation. What does this imply for the banks' optimal compensation structure, and for the tax incentives of governments? We plan to address these issues in future research.

Appendix

A.1 Derivation of equation (17)

The bank in country i chooses the bonus z_i and the fixed wage w_i, which depends on z_j and w_j. Hence the system of first-order conditions in (15) is interdependent, and given by

$$\begin{aligned}\frac{\partial \Pi_i}{\partial w_i} &= \frac{1}{a}\left\{p_i^{h*}[Y^h - sd - z_i(1+t_i)] + p_i^{m*}(Y^m - sd) - w_i - (1-s)d\right\} \\ &\quad - \bar{N} - \frac{1}{a}\left[\frac{\gamma}{2}(z_i^2 - z_j^2) + w_i - w_j\right] = 0, \qquad \text{(A.1)} \\ \frac{\partial \Pi_j}{\partial w_j} &= \frac{1}{a}\left\{p_j^{h*}[Y^h - sd - z_j(1+t_j)] + p_j^{m*}(Y^m - sd) - w_j - (1-s)d\right\} \\ &\quad - \bar{N} - \frac{1}{a}\left[\frac{\gamma}{2}(z_j^2 - z_i^2) + w_j - w_i\right] = 0. \qquad \text{(A.2)}\end{aligned}$$

Solving both (A.1) and (A.2) for w_j, setting the two expressions equal to each other, and solving for w_i gives

$$\begin{aligned}w_i =& \frac{1}{3}p_j^{h*}[Y^h - sd - z_j(1+t_j)] + \frac{1}{3}p_j^{m*}(Y^m - sd) + \frac{2}{3}p_i^{h*}[Y^h - sd - z_i(1+t_i)] \\ &+ \frac{2}{3}p_i^{m*}(Y^m - sd) - (1-s)d - a\bar{N} + \frac{1}{6}\gamma(z_j^2 - z_i^2).\end{aligned}$$

Substituting in the equilibrium bonuses z_i and z_j from (16) and the equilibrium probabilities from (4a)–(4c) yields

$$\begin{aligned}w_i =& \frac{1}{3}\frac{\gamma\Omega_j}{(1+2t_j)}\left[Y^h - sd - \frac{\Omega_j(1+t_j)}{1+2t_j}\right] + \frac{1}{3}\left(p_0^m - \frac{\beta}{\mu}\frac{\Omega_j}{1+2t_j}\right)(Y^m - sd) \\ &+ \frac{2}{3}\frac{\Omega_i\gamma}{(1+2t_i)}\left[Y^h - sd - \frac{\Omega_i(1+t_i)}{1+2t_i}\right] + \frac{2}{3}\left(p_0^m - \frac{\beta}{\mu}\frac{\Omega_i}{1+2t_i}\right)(Y^m - sd) \\ &- (1-s)d - a\bar{N} + \frac{1}{6}\gamma\left[\left(\frac{\Omega_j}{1+2t_j}\right)^2 - \left(\frac{\Omega_i}{1+2t_i}\right)^2\right].\end{aligned}$$

Using $\Omega = Y^h - sd - \frac{\beta}{\mu\gamma}(Y^m - sd)$ from (14) and symmetry, this simplifies to

$$w_i = p_0^m(Y^m - sd) - (1-s)d + \frac{\gamma\Omega^2}{6}\left[\frac{1}{(1+2t_j)} + \frac{4t_i - 1}{(1+2t_i)^2}\right] - \bar{N}a, \qquad \text{(A.3)}$$

which corresponds to eq. (17) in the main text.

A2. Derivation of equation (18)

We start from the set of first-order conditions for the banks' optimal bonus payments in eq. (13):

$$\frac{\partial \Pi_i}{\partial z_i} \equiv H_i(z_i, z_j, t_i) = 0, \qquad \frac{\partial \Pi_j}{\partial z_j} \equiv H_j(z_i, z_j, 0) = 0, \quad i \neq j,$$

where z_i and z_j are the endogenous variables in Stage 2 and the tax rate t_i is an exogenous shifter.

Totally differentiating and employing matrix notation gives

$$\mathbf{A} \begin{bmatrix} dz_i \\ dz_j \end{bmatrix} = \begin{bmatrix} -(\frac{\partial H_i}{\partial t_i}) dt_i \\ 0 \end{bmatrix}, \qquad \mathbf{A} = \begin{bmatrix} \frac{\partial H_i}{\partial z_i} & \frac{\partial H_i}{\partial z_j} \\ \frac{\partial H_j}{\partial z_i} & \frac{\partial H_j}{\partial z_j} \end{bmatrix} .$$

This can be solved for dz_i/dt_i and dz_j/dt_i to give

$$\frac{dz_i}{dt_i} = -\frac{1}{|A|}\frac{\partial H_j}{\partial z_j}\frac{\partial H_i}{\partial t_i}, \qquad \frac{dz_j}{dt_i} = \frac{1}{|A|}\frac{\partial H_j}{\partial z_i}\frac{\partial H_i}{\partial t_i}, \qquad |A| = \left(\frac{\partial H_j}{\partial z_j}\right)^2 - \left(\frac{\partial H_j}{\partial z_i}\right)^2 > 0 \tag{A.4}$$

where $|A|$ has used the symmetry of the model and $|A| > 0$ follows from the stability of the Nash equilibrium. The derivatives in (A.4) are obtained from the first-order condition (13), which is reproduced here for convenience:

$$\frac{\partial \Pi_i}{\partial z_i} \equiv H_i = \frac{\gamma z_i}{a}\, \pi_i^D + \left[N + \frac{\gamma}{2a}(z_i^2 - z_j^2)\right] \frac{\partial \pi_i^D}{\partial z_i} = 0 \quad \forall\, i \neq j. \tag{A.5}$$

The division profit π_i^D and its derivative with respect to z_i are given by

$$\pi_i^D = p_i^{h*}[Y^h - sd - z_i(1+t_i)] + p_i^{m*}[Y^m - sd] - (1-s)d,$$

$$\frac{\partial \pi_i^D}{\partial z_i} = \gamma[Y^h - sd - z_i(1+t_i)] - p_i^{h*}(1+t_i) - \frac{\beta}{\mu}(Y^m - sd) < 0, \tag{A.6}$$

and (A.6) must be negative in an interior optimum from (A.5).

To sign the terms in (A.4) we assume first that the second-order condition for an optimal choice of z_i holds. This implies $\partial H_j/\partial z_j < 0$. From (A.5), we obtain by differentiation

$$\frac{\partial H_i}{\partial z_j} = \frac{-\gamma z_j}{a}\frac{\partial \pi_i^D}{\partial z_i} > 0 \quad \forall\, i \neq j, \tag{A.7}$$

which can be signed from (A.6). Finally, using $p_i^h = \gamma z_i$ from (4a) gives

$$\frac{\partial H_i}{\partial t_i} = -p_i^{h*}\frac{\gamma}{a}z_i^2 - 2N_i\gamma z_i < 0. \tag{A.8}$$

Substituting (A.7)–(A.8) into (A.4) yields the signs in eq. (18) in the main text.

A3. Proof of Proposition 2

We confine our analysis to the governments' optimal tax problem in Regime II. Substituting (16), (20) and (22), along with F_i in (23) into (24), the government's first-order condition can be rewritten as

$$\frac{\partial W_i}{\partial t_i} = \frac{N_i \Omega}{(1+2t_i)^2}\left[\gamma\Omega - \frac{4t_i\gamma\Omega}{(1+2t_i)} + 2\delta sd\right] + \frac{\gamma\Omega^2}{3a(1+2t_i)^2}\left[p_0^l sd + \frac{\delta sd\Omega}{(1+2t_i)} - \frac{\gamma t \Omega^2}{(1+2t_i)^2}\right]. \tag{A.9}$$

To show the concavity of W_i in t_i we establish the conditions under which W_i is rising in t_i at $t_i = 0$, but falling in t_i when $t_i \to \infty$. Evaluating (A.9) at $t_i = 0$ gives

$$\left.\frac{\partial W_i}{\partial t_i}\right|_{t=0} = \Omega\left[N_i(\gamma\Omega + 2\delta sd) + \frac{\gamma\Omega sd}{3a}(p_0^l + \delta\Omega)\right], \tag{A.10}$$

which is always positive for $\delta \geq 0$.

Evaluating (A.9) at $t_i \to \infty$, using L'Hôpital's rule and inserting the migration elasticity (10) gives

$$\left.\frac{\partial W_i}{\partial t_i}\right|_{t\to\infty} = \frac{\Omega N_i}{(1+2t_i)^2}\left[-\gamma\Omega\left(1 - \frac{\varepsilon p_0^l sd}{3}\right) + 2\delta sd\right]. \tag{A.11}$$

This is negative if the term in squared brackets is negative. The condition for this to hold is summarized in Proposition 2.

Further, W_i must be continuous in t_i because all terms in (A.9) are continuous functions of t_i. Therefore, if the condition for (A.11) to be negative is met, then W_i must be strictly concave in t_i and an interior optimum with $0 < t^* < \infty$ must exist. □

A4. Proof of Proposition 3

The proof is confined to showing that a negative fiscal value of a manager ($F_i < 0$) is sufficient for $\partial W_i/\partial t_j < 0$ to hold in Regime I. Rearranging the countries' first-order condition for the optimal bonus tax (24), multiplying through by $(\partial z_i/\partial t_j)/(\partial z_i/\partial t_i)$ and using symmetry gives

$$[2\gamma z_i t_i - \delta sd]\, N_i \frac{\partial z_i}{\partial t_j} = -N_i z_i^2 \gamma \frac{\partial z_i/\partial t_j}{\partial z_i/\partial t_i} - F_i \frac{\gamma z_i}{a}\left(1 - \frac{\partial z_i/\partial t_j}{\partial z_i/\partial t_i}\right). \tag{A.12}$$

Substituting (A.12) in (26) gives, after cancelling terms

$$\frac{\partial W_i}{\partial t_j} = F_i \frac{\gamma z_i}{a}\frac{\partial z_i}{\partial t_j}\left(\frac{\partial z_i/\partial t_j}{\partial z_i/\partial t_i} - \frac{\partial z_i/\partial t_i}{\partial z_i/\partial t_j}\right) - N_i z_i^2 \gamma \frac{\partial z_i/\partial t_j}{\partial z_i/\partial t_i}. \tag{A.13}$$

Since dz_i/dt_i and dz_i/dt_j are both negative and since $|dz_i/dt_i| > |dz_i/dt_j|$ follows from the stability of the Nash equilibrium, the first term in (A.13) has the same sign as F_i, whereas the second term in (A.13) is always negative. Hence $F_i > 0$ is a necessary, but not a sufficient condition for $dW_i/dt_j > 0$ [see Proposition 3(i)]. In contrast, $F_i < 0$ is a sufficient condition for $dW_i/dt_j < 0$ to hold, as stated in Proposition 3(ii). □

A5. Asymmetries between countries

Differentiating (24) with respect to s_A gives

$$
\begin{aligned}
\frac{\partial^2 W_i}{\partial t_i \partial s_i} &= \left[z_i^2\gamma + 2\gamma z_i t_i \frac{\partial z_i}{\partial t_i} - \boldsymbol{\delta s_i d}\frac{\partial z_i}{\partial t_i}\right] \frac{\gamma z_i}{a}\left[\frac{\partial z_i}{\partial s_i} - \frac{\partial z_j}{\partial s_i}\right] \\
&+ N_i\left[2z_i\gamma\frac{\partial z_i}{\partial s_i} + 2\gamma t_i \frac{\partial z_i}{\partial t_i}\frac{\partial z_i}{\partial s_i} - \delta d\frac{\partial z_i}{\partial t_i} + 2\gamma z_i t_i \frac{\partial^2 z_i}{\partial t_i \partial s_i} - \boldsymbol{\delta s_i d}\frac{\partial^2 z_i}{\partial t_i \partial s_i}\right] \\
&+ F_i\frac{\gamma}{a}\left[\frac{\partial z_i}{\partial s_i}\frac{\partial z_i}{\partial t_i} - \frac{\partial z_j}{\partial s_i}\frac{\partial z_j}{\partial t_i} + z_i\left(\frac{\partial^2 z_i}{\partial t_i \partial s_i} - \frac{\partial^2 z_j}{\partial t_i \partial s_i}\right)\right] \\
&+ \frac{\gamma z_i}{a}\left[\frac{\partial z_i}{\partial t_i} - \frac{\partial z_j}{\partial t_i}\right]\left[t_i z_i \gamma \frac{\partial z_i}{\partial s_i} + p^h t_i \frac{\partial z_i}{\partial s_i} - \boldsymbol{\delta s_i d}\frac{\partial z_i}{\partial s_i} - p^l d\right] \qquad \text{(A.14)}
\end{aligned}
$$

Our focus is on the boldfaced terms in the first, second and fourth lines of this equation. These terms all have the same sign as δ when $\partial z_i/\partial s_i > 0$ holds in (32), because $\partial z_i/\partial t_i < 0$ holds from (A.4) and $\partial^2 z_i/\partial t_i \partial s_i < 0$ holds from (A.8) and $\partial z_i/\partial s_i > 0$. Hence the boldfaced terms tend to cause an increase in t_i following a rise in s_i when $\delta > 0$, but lead to a decrease in t_i when $\delta < 0$.

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