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Incentive pay and bank risk-taking: Evidence from Austrian, German, and Swiss banks

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ABSTRACT

We use payroll data in the Austrian, German, and Swiss banking sector to identify incentive pay in the critical banking segments of treasury/capital market management and investment banking for 67 banks. We document an economically significant correlation of incentive pay with both the level and volatility of bank trading income—particularly for the pre-crisis period 2003–2007, in which incentive pay was strongest. This result is robust if we instrument the bonus share in the capital market divisions with the strength of incentive pay in unrelated bank divisions like retail banking. Moreover, pre-crisis incentive pay appears too strong for an optimal trade-off between trading income and risk, which maximizes the net present value of trading income. Further analyses indicate that the bonus moderation during the crisis has removed excessive pre-crisis incentive pay.

1. Introduction

In 2013, the European Parliament proposed new EU-wide legislation on bank bonuses, and even in the U.S. executive pay was scrutinized in the post-crisis years (e.g. the Say-on-Pay rule included in the 2010 Dodd–Frank Act). Large bonus payments for employees in the banks' financial market divisions were allegedly responsible for excessive risk-taking. Limits on bonus payments were justified as a way to curb risk-taking incentives (e.g. Dunning, 2010).

Yet there is only scarce empirical evidence about the nexus between the proportion of performance contingent pay and the amount of risk-taking in financial institutions. One obstacle to such an analysis is the lack of publicly available information about banks' internal incentive and bonus systems. Reporting requirements are typically limited only to a bank's CEO and board members, who may neither earn the highest bonuses nor make the most pertinent risk choices. This paper exploits a large payroll data set to extract incentive pay measures for 67 banks in Austria, Germany, and Switzerland in the period 2004–2011. In particular, we are able to measure performance-contingent pay in the two most critical bank segments, investment banking and treasury/capital markets, at all levels of the bank hierarchy.

Our analysis pursues four objectives. First, we document the importance of bonus payments across bank functions and hierarchies in the Austrian, German, and Swiss banking systems for the period 2004–2011. We show that the *Bonus Share*, defined as the average bonus relative to the total salary, decreased by roughly 20% across bank functions in the crisis period 2008–2011 relative to the pre-crisis period 2004–2007. The decrease is much stronger, at approximately 40%, for employees in the investment banking and treasury/capital market segments, even though overall trading income did not decrease during the crisis period 2008–2011.

Second, we document the robust correlation of pay incentives with the bank's trading income and its volatility. On average, trading income in our sample amounts to 9% of the gross interest income of a bank and shows a systematic correlation with both the equally and hierarchy-weighted strengths of bonus payments in a bank. This positive correlation is particularly pronounced in the pre-crisis period and extends to the volatility of trading income. By averaging our pay incentive measure over a four-year period we attempt to mitigate concerns for reverse causality whereby favorable trading profit realizations generate higher pay-outs of performance-contingent contracts. Nevertheless, averaging

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the incentive pay by itself is unlikely to solve the endogeneity problem completely.

A third contribution consists in a causal analysis for which we propose two instruments: If banks vary exogenously in the degree to which they feature an "incentive culture", we can use the *Bonus Share* in other bank segments, like retail banking or corporate banking, as proxies for pay incentives in the bank's capital market segment. To further validate this instrument, we check whether the *Bonus Share* in these functionally unrelated bank segments exhibits any significant intertemporal correlation with annual trading income. This is not the case, which suggests that bank bonus pools are indeed segment-specific.[1] A second instrument consists in the share of employment outside the capital market divisions relative to total employment. This serves as a proxy for governance deficiencies, as a bank with a large retail, private, and corporate banking segment might monitor its traders with a different intensity than banks whose core business is investment banking. Previous research has found weaker bank governance to be related to higher incentive pay (Fahlenbrach, 2009) and bank risk (Hau and Thum, 2009).

Our two instruments show a strong first-stage correlation with the *Bonus Share* of a bank's capital market employees. The instrumental variable regressions produce large and statistically significant coefficients for traders' *Bonus Share*—suggesting that high incentive pay causes both a high level and a high volatility of trading income.

In a fourth step we analyze the trade-off between trading income and its volatility. It is straightforward to show that, if trading revenue is generated mostly through self-financing trading strategies without net capital requirements, the net present value (NPV) maximization of the risk-adjusted cash flow of trading is equivalent to the maximization of its Sharpe ratio. From the perspective of NPV (or asset value) maximization, the optimal incentive pay for a bank's trading operation should maximize the Sharpe ratio of trading income, defined as the ratio of trading returns and their standard deviation. Our regression analysis suggests that bonus incentives were too strong to maximize the Sharpe ratio of trading income in the pre-crisis period.[2] This contrasts with the crisis period 2008–2011, for which bonus incentives are shown to have a positive marginal effect on the Sharpe ratio of trading income. The drastic bank bonus reduction during the crisis might have been a political overreaction, changing investment bankers and traders from overinto underincentivized employees.

A limitation of the analysis is that we cannot observe the exact type of speculative activity that a bank engages in. For the same reason, we cannot identify which bank employees within the investment banking segment contribute most to a bank's risk choices. Hence, the exact transmission channels remain something of a black box to be explored in future research. Another limitation of the analysis is its focus on the second moment of trading income; the Sharpe ratio compares trading income only to its standard deviation. Ignoring higher moments can be problematic if the call option nature of bonus pay entices traders to accept high tail risks, i.e. unlikely yet very negative outcomes. However, we find no significant correlation between the skewness of trading income and the strength of pay incentives.[3] We also collect data on crisis-related write-offs and government bailouts as alternative risk measures. Neither of the two statistics is significantly correlated with the strength of pay incentives.[4]

[1] We regress the *Bonus Share* in bank segments unrelated to trading on *Trading Income*, standardized by *Gross Interest Income*, bank, and time fixed effects. The regression coefficient of *Relative Trading Income* is not significant at the 5% level. If we filter the instrument from any temporal (but not cross-sectional) covariation with trading income, our results remain robust.

[2] Limited liability of shareholders in combination with high bank leverage can rationalize this finding whereby incentive pay aligns employee interests with those of shareholders in pursuit of equity value rather than bank asset value maximization.

[3] We concede that the measurement of the skewness of trading income is noisy as we have only annual data on trading income.

[4] Of all banks with data on trading income and bonus payments only 32 report crisis-related losses or write-offs in their annual statements. Our sample of banks with data on bonus payments covers nine of 10 banks that received public capital injections and 11 of 19 banks that demanded government guarantees in Austria, Germany, or Switzerland.

The discussion of the literature in the next section and the development of the hypotheses in Section 3 are followed by a description of the data in Section 4. Section 5 explores the structure of incentive pay at the employee level and aggregate bank level. Section 6 begins by characterizing the correlation between pay incentives and the level and volatility of trading income. This is followed by instrumental variable regressions about the causal link and an estimation of the marginal effect of incentive pay on the Sharpe ratio of trading income. Section 7 concludes.

2. Literature

The 2007–2008 financial crisis has ignited a political debate about what is often termed "excessive" bank compensation practices. In Europe this has resulted in EU-wide legislation to cap the bonus pay of bank executives (European Parliament, 2013, page 201). A popular referendum in Switzerland has tried to cap the highest executive pay package at 12 times the lowest salary paid out in the same firm (Federal Assembly, 2013).[5] Financial sector pay has become a particular focus of public discontent, because a substantial increase in compensation in the financial industry can be observed in the run-up to the recent crisis (e.g. Philippon and Reshef, 2012, for the U.S. banking industry). Moreover, Bell and Van Reenen (2010) document that about 60% of the increase in pre-crisis extreme wage inequalities in the U.K. was due to the financial sector.

The political debate is related to a broader academic dispute about the determinants of executive pay in general, with two opposing views. A technological explanation in defense of high remuneration focuses on changes in the marginal productivity of corporate leadership in a competitive labor market for executives (Gabaix and Landier, 2006). This view is supported by new cross-sectional evidence of CEO sorting by ability, pay, and firm size in Sweden (Adams et al., 2014). Philippon and Reshef (2012) argue that increased wages in the financial industry may simply reflect changes in the working environment, including an increase in skill intensity, job complexity, and earning risks. Recent theoretical research focuses on the competition for talented workers as a key factor of high salaries in the financial industry (Célérier and Vallée, 2013). Bannier et al. (2013) suggest that bonus payments are increasing with the intensity of competition for managerial talent. Moreover, companies seem to raise their executives' pay after losing executives to other firms (Gao et al., 2013). An opposing view relates executive pay to corporate governance problems and the weakness of shareholder rights. Hakenes and Schnabel (2014) suggest that bailout expectations may induce steeper incentive schemes, whereas bonus schemes become flatter if problems of effort arise. While excessive risk-taking may only manifest itself in the long run, short-run cash payouts can be enormous and performance measures may not properly account for long-term risks. The pay of bank executives in particular seems to have largely overcompensated top managers for what turned out to be disastrous long-run equity returns (Bebchuk et al., 2010; Bhagat and Bolton, 2014).

The issue of optimal incentive pay is particularly relevant for banks because of their high leverage. Given bankruptcy costs or public guarantees for too-big-to-fail banks, even an incentive contract that is optimal from the shareholder perspective (by maximizing the bank equity value) may not maximize a bank's total asset value and thus imply excessive risk-taking from a welfare perspective (Bolton et al., 2014). While higher bank capital requirements appear to be the first-best regulatory intervention (Admati et al., 2010), restrictions on bankers' equity pay component have also been considered as a means of dealing with limited liability externalities (Thanassoulis, 2012; Acharya et al., 2013; Bannier et al., 2013).

Much of the U.S. literature has focused on equity compensation for CEOs and executive board members, which generally implies a strong

[5] The proposition to curb executive pay was rejected by two-thirds of the voters.

Table 1
Summary statistics for employee-level incentives. Reported are summary statistics on employee characteristics and their individual compensation in a given year. The variables are subject to the following cleaning procedures: First, 681,455 observations from service divisions and cross-divisional functions are dropped. Second, 67,860 observations of employees not eligible for a bonus are dropped. Finally, we discard 4,708 observations with base salaries below €24,000. We winsorize the 10 largest and 10 smallest observations of the variables *Age*, *Tenure*, *Base*, and *Bonus*. *Bonus Share* is defined as the ratio of *Bonus* over the sum of *Bonus* and *Base Salary*.

	Obs.	Mean	Std. dev.	Skew.	Q5	Q25	Q50	Q75	Q95
Employee information									
Age	436,826	39.7	9.5	0.07	24	32	40	47	55
Age Missing	521,194	0.16	–	–	–	–	–	–	–
Tenure	494,675	13.7	10.0	0.72	1	5	12	20	34
Tenure Missing	521,194	0.05	–	–	–	–	–	–	–
Base Salary	516,486	61,862	26,372	2.00	31,584	44,440	55,800	72,015	111,809
Bonus	521,194	15,709	47,760	17.91	0	2,014	4,868	13,000	62,422
Total Salary	516,486	77,706	65,669	9.97	33,514	47,005	62,125	85,676	170,877
Bonus Share by country									
Austria	31,673	0.05	0.07	3.25	0	0.01	0.03	0.07	0.19
Germany	372,151	0.12	0.11	2.25	0	0.05	0.08	0.14	0.34
Switzerland	112,662	0.18	0.15	1.16	0	0.06	0.14	0.26	0.47
Bonus Share by bank segment									
Investment Banking	12,343	0.23	0.20	0.92	0	0.08	0.19	0.35	0.63
Treasury/Capital Market	34,977	0.23	0.20	0.94	0	0.07	0.18	0.35	0.64
Asset Management	21,188	0.24	0.16	0.67	0	0.12	0.22	0.33	0.53
Corporate Banking	53,685	0.15	0.11	1.23	0	0.07	0.13	0.21	0.37
Private Banking	75,547	0.19	0.14	1.01	0	0.08	0.15	0.27	0.47
Retail Banking	318,746	0.08	0.07	1.78	0	0.03	0.07	0.11	0.23
Bonus Share by hierarchy level									
Hierarchy Level 1 (Lowest)	42,042	0.05	0.04	1.59	0	0.02	0.05	0.07	0.11
Hierarchy Level 2	123,028	0.06	0.05	1.74	0	0.02	0.06	0.09	0.13
Hierarchy Level 3	117,826	0.09	0.07	2.08	0	0.04	0.08	0.11	0.21
Hierarchy Level 4	130,913	0.14	0.11	1.58	0	0.07	0.12	0.19	0.35
Hierarchy Level 5	78,354	0.23	0.15	0.81	0	0.13	0.21	0.32	0.51
Hierarchy Level 6	23,377	0.33	0.18	0.35	0	0.21	0.31	0.44	0.67
Hierarchy Level 7 (Highest)	946	0.46	0.25	–0.16	0	0.32	0.46	0.65	0.86
All	516,486	0.13	0.12	1.94	0	0.04	0.09	0.16	0.39

alignment of shareholder and executive interests. Bankers' pay outside the U.S. and the U.K., and for lower-ranked employees, rely much more on performance-contingent bonus payments. These may feature pay-off functions of either higher or lower convexity than shareholder equity. In both cases, risk-taking incentives may be larger than is optimal for the maximization of bank asset value. Generally, the public interest should coincide with the objective of bank value maximization if a functioning bank resolution system can avoid public subsidies through effective creditor bail-ins.

Some research has also highlighted the role of governance frictions in a bank's incentive culture. Fahlenbrach (2009) shows that banks with weak corporate governance structures tend to allow contracts with larger pay-for-performance components. Yet, weak governance could also influence the quality of risk management and thus impact bank risk-taking and crisis performance more directly. The nexus between weak bank governance and losses during the financial crisis is examined by Hau and Thum (2009), who find considerably higher write-downs for German banks with less competent boards.

The empirical literature generally confirms a link between performance-contingent pay and corporate risk. DeYoung et al. (2013) find larger systematic and idiosyncratic risk for corporations with more performance-sensitive CEO compensation and Hagendorff and Vallascas (2011) show that they are more likely to engage in risk-inducing mergers. The evidence of correlation may reflect a causal link between incentive pay and risk-taking, or alternatively follow from optimal contracts that stipulate more high-powered incentives in a high-risk environment. Evidence of this correlation is also available for the financial sector: Cheng et al. (2010) show that total executive compensation is positively correlated with pre-crisis subprime market exposure; Chesney et al. (2012) document that the pre-crisis incentive structures of CEOs of U.S. financial institutions significantly affected bank write-downs during the crisis; and Fahlenbrach and Stulz (2011) point out that stronger equity incentives for the CEO before the crisis are (weakly) associated with worse performance during the crisis. At the very least, more high-powered equity incentives for CEOs do not seem to correlate with better management of downside risks.

Most of the literature has focused on CEO and board compensation in U.S. companies. Yet, it is far from clear that most risk choices in the financial sector are made by top executives. Empirical evidence for non-financial industries suggests that non-executive incentives matter for corporate outcomes (Oyer, 1998; Bova et al., 2013; Gill et al., 2013; Larkin, 2014). Non-executive incentives may matter even more in finance, where success is predicated on information asymmetries. Acharya et al. (2014) show that higher non-executive compensation elasticities are associated with higher subsequent bank risk and lower subsequent bank value. Bogaard and Svejnar (2013) examine the link between incentive pay and productivity in a Central-East European bank. They find a positive correlation between differentiated incentive pay and productivity, although the evidence for the quality of sales is mixed. Two special financial functions have received extensive research into the link between incentive pay and risk-taking, namely bank loan officers and fund managers. The introduction of volume-based pay for loan officers is found to be associated with higher output and default rates (Agarwal and Wang, 2009; Agarwal and Ben-David, 2014). Tzioumis and Gee (2013) reveal that nonlinear incentive designs for lower-level employees influence their actions, with adverse effects on organizational efficiency. On the other hand, Cole et al. (forthcoming) point out that loan officers facing high-powered incentives are more likely to outperform statistical credit-scoring models. Empirical evidence on fund performance suggests that higher incentives correlate with riskier investment strategies (Massa and Patgiri, 2009) as well as with superior performance (Agarwal et al., 2009; Massa and Patgiri, 2009).

This study focuses on the incentives of non-executives in two bank functions, treasury/capital markets and investment banking. Considerable regulatory effort is exerted to isolate and limit the risk in these

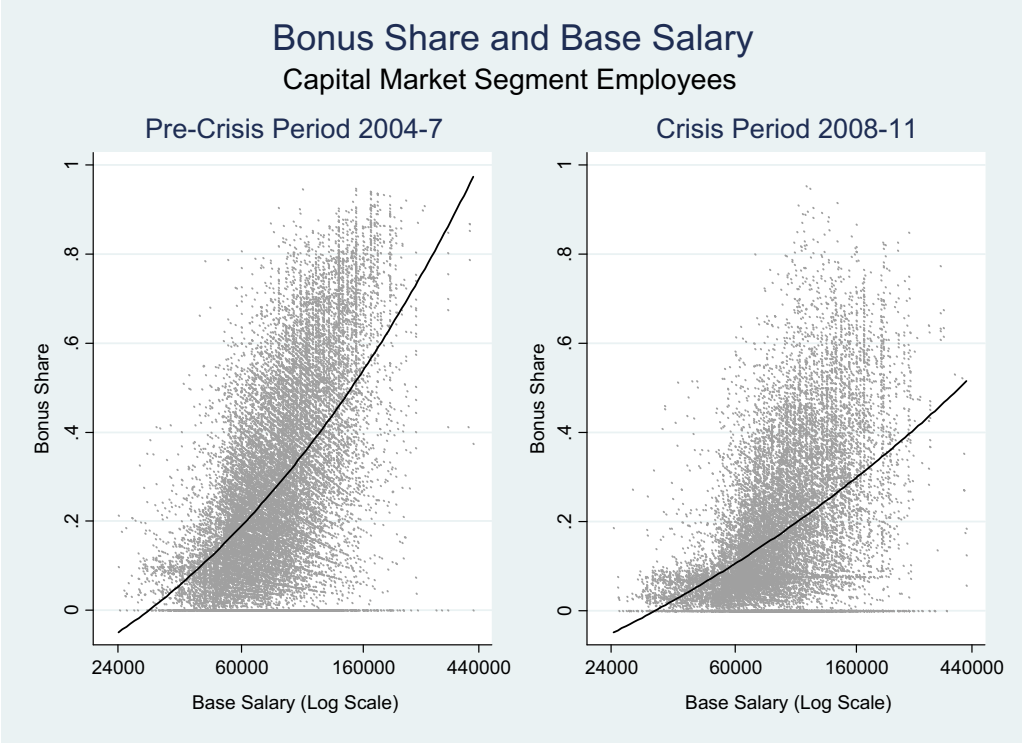

Fig. 1. Plotted is the *Bonus Share* against *Base Salary* (on a log scale) for 47,320 employee-year observations of bank employees in the capital market segments treasury/capital management and investment banking. The graph for the pre-crisis years 2004–2007 uses observations from 116 Austrian, German, and Swiss banks, whereas the graph for the crisis years 2008–2011 is based on 117 banks. The dark lines plot quadratic functions fitted to *Bonus Share* and *Log Base Salary*. Observations with zero *Bonus Share* represent 8.1% and 16.8% for the pre-crisis and crisis period, respectively.

two functions from ordinary deposit-taking activity (e.g. Dodd–Frank-Act, Chapter VII; or EU Regulation No. 648/2012). While the trading profits are on average large, they also feature a high degree of volatility. Recurring large losses by "rogue traders" have invited additional public scrutiny of these bank functions and have also triggered new theoretical work on optimal incentives for bank traders (Bijlsma et al., 2012; Glode and Lowery, 2013).[6] Yet, to our knowledge, there has been no empirical examination of the relationship between non-executive incentives in capital market divisions and trading profits.

3. Hypotheses

In a first step, we explore the existence of a positive relationship between high-powered incentives and the level of bank trading income. High-powered incentives may be required in a trading environment in which work performance is highly dependent on effort levels. Unlike effort, trading income can be measured and serve as a contractible outcome for the incentive contract. We expect to find a positive effect of bonus payments on the average trading income.

Hypothesis 1. Pay incentives and average trading income

a) Bonus payments in the capital market segment correlate positively with higher average trading income.
b) A stronger incentive culture in a bank increases average trading income.

The relationship in Hypothesis 1a) between profitability-contingent incentive pay and trading profitability is certainly influenced by reverse causality. High and highly variable trading income will generally raise the measured bonus payments for almost any option-like incentive contract. We seek to exclude (or at least reduce) such reverse causality in Hypothesis 1b) by instrumenting the *Bonus Share* in the capital market segments with the corresponding *Bonus Share* in the trading-unrelated segments of retail, corporate, and private banking and the relative size of these trading-unrelated segments in the same bank (see Section 6.3). The *Bonus Share* in trading-unrelated bank segments captures the incentive culture of a bank. Any exogenous variation in a bank's incentive culture should simultaneously influence the bonus shares in capital market segments and in other bank divisions.

In a second step, we explore the existence of a positive relationship between high-powered incentives and the volatility of bank trading income.

Hypothesis 2. Pay incentives and volatility of trading income

a) Bonus payments in the capital market segment correlate positively with a higher volatility of trading income.
b) A stronger incentive culture in a bank increases the volatility of trading income.

Optimal contracting in a high-risk trading environment might necessitate higher pay incentives to ensure that employees stay vigilant and curb the risk to the corporation. This explanation is consistent with a positive correlation predicted in Hypothesis 2a). Alternatively, the incentive culture of a bank (proxied by the bank's *Bonus Share* outside the capital market segments) may exogenously influence the pay incentives of traders. High performance-contingent pay could entice traders to increase profitability not (or not only) by higher levels of effort, but also by taking more risky positions, which are, on average, compensated by higher expected returns (see Hypothesis 2b).

[6] For example, the French bank Société Générale lost approximately 4.8 billion through the gambling of one of its traders in 2008. Three years later, the Swiss bank UBS similarly lost approximately CHF 1.7 billion.

Table 2
Incentive pay and trading income before and during the crisis. We report separately for the pre-crisis period (2003–2007) and the crisis period (2008–2011) the individual employee compensation across capital market segments (Panel A) as well as the *Log Period-Average Relative Trading Income*, computed as the natural logarithm of the period-average of *Trading Income* in percent of *Interest Income*, the *Log Standard Deviation (SD) of Relative Trading Income*, and the *Sharpe Ratio of Trading Income* (Panel B). The symbols *, **, and *** represent significance levels of 10%, 5%, and 1% in two-sample t-tests. We use Wilcoxon rank-sum tests to check if variables are distributed the same before and during the crisis (H0) and report the p-values.

Panel A: Employee compensation capital market segments

	Obs.	Mean	Std. dev.	Skew.	Min	Max
Base Salary						
Pre-crisis period	26,046	82,896	32,427	1.62	24,100	418,000
Crisis period	21,274	91,005	39,969	1.61	24,444	418,000
Difference		–8,109***				
Wilcoxon (*p-value*)		0.00				
Bonus						
Pre-crisis period	26,070	68,017	154,617	7.33	0	2,662,500
Crisis period	21,276	34,056	73,279	7.27	0	2,164,453
Difference		33,961***				
Wilcoxon (*p-value*)		0.00				
Bonus Share						
Pre-crisis period	26,046	0.28	0.21	0.71	0	0.95
Crisis period	21,274	0.17	0.17	1.22	0	0.95
Difference		0.11***				
Wilcoxon (*p-value*)		0.00				

Panel B: Trading income

	Obs.	Mean	Std. dev.	Skew.	Min	Max
Log Period-Average Relative Trading Income						
Pre-crisis period	62	0.936	2.404	–0.282	–4.461	5.482
Crisis period	56	0.997	2.392	–0.399	–4.826	4.956
Difference		–0.061				
Wilcoxon (*p-value*)		0.80				
Log SD of Relative Trading Income						
Pre-crisis period	48	0.325	1.764	0.010	–2.760	3.603
Crisis period	40	0.821	1.783	–0.126	–2.612	4.478
Difference		–0.497*				
Wilcoxon (*p-value*)		0.22				
Sharpe Ratio of trading income						
Pre-crisis period	48	1.676	1.768	1.006	–1.213	7.092
Crisis period	40	0.837	1.096	0.571	–1.793	4.297
Difference		0.839***				
Wilcoxon (*p-value*)		0.03				

In a third step, we evaluate the trade-off between trading income and its volatility and explore whether incentives are excessive, in the sense that they tilt investment choices towards more risk and higher expected returns without increasing the total asset value of the bank. In the absence of externalities, value maximization of corporate assets is the socially desirable managerial choice. Let K denote the capital needed to finance a bank's trading infrastructure, which can generate (without leverage) an expected annual trading income $E(\Pi)$ growing at rate g, and a standard deviation of return on investment $\sigma_{\Pi} = SD(\Pi/K)$. The NPV of the trading business follows as

$$V_{\Pi} = \frac{E(\Pi)}{r_0 - g + \rho\frac{\sigma_{\Pi}}{\sigma_M} r_M}, \quad (1)$$

where r_0 and r_M denote the risk-free rate and the market premium, respectively; σ_M represents the standard deviation of market returns; and ρ characterizes the correlation between trading returns and market returns.

Writing the risk equity premium in Eq. (1) in terms of the return variance σ_{Π} illustrates that the NPV of the trading business is proportional to the *Sharpe Ratio* $E(\Pi)/(K\sigma_{\Pi})$ of trading income whenever the growth rate of expected trading income equals the risk-free rate, hence $r_0 - g = 0$. But even if we do not want to assume $r_0 = g$, we can argue that trading operations are special compared to other corporate activities, in the sense that both their expected income $E(\Pi)$ and the volatility of that income $K\sigma_{\Pi}$ are exceptionally large compared to either invested capital or labor costs. According to the U.S. Commerce Department, the average ratio of annual corporate income to total employment compensation for all U.S. firms increased from 14% in 2000 to 23% in 2011.[7] Yet, the banks in our sample generate a median trading income of 119% of total employee compensation in the respective trading division. The variability of trading income relative to total compensation is also extremely volatile across years and banks.[8] Similar to most service sector activities, the physical capital required for trading operations is even more negligible than labor costs. A bank's trading position itself is generally highly leveraged: Under normal pre-crisis conditions, a dealer bank might have financed trading positions mostly with overnight repos with an average haircut of under 2%, thus allowing an effective leverage ratio of at least 50 (Duffie, 2011, page 32).

It is straightforward to show that under conditions of leverage, value maximization for the trading operation becomes equivalent to maximizing the *Sharpe Ratio* if expected trading income, along with the standard deviation σ_{Π}, can be scaled by a leverage factor $L \gg 1$ so that $(r_0 - g)/L \approx 0$. Using $E(\Pi^L) = L \times E(\Pi)$ and $\sigma_{\Pi}^L = L \times \sigma_{\Pi}$, we obtain

$$V_{\Pi} = \frac{E(\Pi)}{\frac{r_0 - g}{L} + \frac{\rho r_M}{\sigma_M}\sigma_{\Pi}} \approx \frac{\sigma_M}{\rho r_M}\frac{E(\Pi)}{\sigma_{\Pi}} = \lambda \frac{E\left(\Pi^L\right)}{SD\left(\Pi^L\right)} = \lambda \ \textit{Sharpe Ratio}, \quad (2)$$

where we define a constant term $\lambda = K\sigma_M/\rho r_M > 0$.

[7] See http://www.politifact.com/corporatewages/.
[8] The trading income relative to total compensation varies from –150% to 1920% for the 10% to the 90% quantile, respectively.

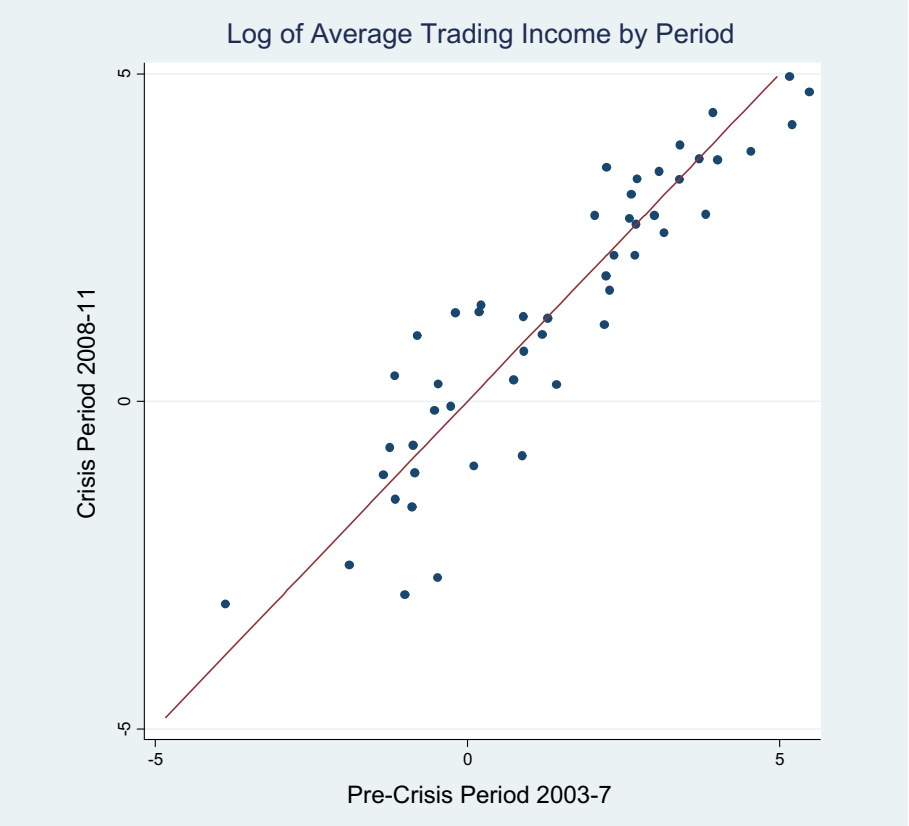

Fig. 2. Plotted are the log of the average (absolute) trading income for each bank in the pre-crisis period 2003–2007 against the corresponding log average (absolute) trading income for the crisis period 2008–2011.

Value maximization of bank assets calls for pay incentives that maximize the *Sharpe Ratio* of trading income. Yet limited liability of shareholders under excessive bank leverage may imply that shareholders seek value maximization of their equity claim rather than total firm assets.[9] As a consequence, bonus incentives may feature a much larger convexity of payoffs than is socially desirable. Provided that the *Sharpe Ratio* is a concave unimodal function of incentive pay, the optimal incentive contract is characterized by a zero marginal effect of incentive pay on the *Sharpe Ratio*.[10] By contrast, a negative (positive) marginal effect of incentive pay on the *Sharpe Ratio* signifies excessive (insufficient) pay incentives from the point of asset value maximization:

Hypothesis 3. Pay incentives and bank asset value maximization

Bonus incentives conflict with bank asset value maximization if the marginal effect of a bonus increase on the *Sharpe Ratio* of trading income is negative.

We highlight that the problem of excessive incentive pay could be related to a bank's ability to socialize the potential costs of such risk-taking. For example, if a bank acquires a too-big-to-fail status and/or private bank resolution fails because of political constraints, bank shareholders should find it optimal to approve larger bonuses to traders because they benefit selectively from the upside of increased risk.[11] The correct bank asset valuation here needs to account for the expected bailout costs as well. Without such too-big-to-fail externalities, asset value maximization is in the shareholder interest. A negative marginal effect of incentive pay on the bank asset value represents excessive bonus pay from the shareholder perspective; and if the marginal effect of incentive pay on the *Sharpe Ratio* is negative, bonus moderation should be in the shareholder interest. We examine the evidence for excessive incentive pay in more detail in Section 6.4.

4. Data

4.1. Compensation data

This paper draws on a large payroll data set from the financial service sectors of Austria, Germany, and Switzerland. The data were collected by a major international pay consulting firm from human resource departments of more than 120 banks in the three countries. The payroll data are directly extracted from the financial services companies' electronic personnel records. Every data submission is reviewed and validated by

[9] Statements by bank CEOs about maximization of return on equity (rather than return on total assets) hint at this conflict of interest.

[10] The *Sharpe Ratio* is a concave function in the bonus share *BS* if the linear combination $E\left(\Pi^L\right)\frac{d}{dBS}SD\left(\Pi^L\right)+SD\left(\Pi^L\right)\frac{d}{dBS}E\left(\Pi^L\right)$ is a decreasing function in bonus share $BS \in [0, 1]$. Intuitively, the marginal trade-off between the first and second moments of trading profits needs to deteriorate as incentive pay gets stronger.

[11] See Bolton et al. (2014). Yet such non-resolvability should not apply to the large majority of banks in our sample. Only 3 of the 67 banks in our sample belong to the group of 28 global systemically important banks (classified by the Financial Stability Board).

Table 3
Summary statistics at the bank level. Reported are bank characteristics separately for the pre-crisis period 2003–2007 and the crisis period 2008–2011. The variables *Assets*, *Trading Income*, *Gross Interest Income*, *Trading Income/Gross Interest Income*, *Gross Interest Income/Assets* and *Net Loans/Assets* are winsorized at the 1% level in each tail. The variables *Relative Trading Income*, *Gross Interest Income/Assets*, and *Net Loans/Assets* are given as percentages. *Employment Non-Capital Market Segments* is the fraction of employees working in the non-capital market segments corporate banking, private banking, and retail banking. *Relative Trading Income* is defined as *Trading Income* as percentages of *Gross Interest Income*. *Log Relative Trading Income* is computed as *Ln* (*Relative Trading Income* +17.92) where the constant 17.92 is chosen to reduce the skewness of the variable computed over both periods (2003–2011) to zero. The standard deviation of *Relative Trading Income* is computed only if the variable has at least three observations. The constant 0.04 reduces the skewness of *Log of Standard Deviation* (*SD*) *of Relative Trading Income*, defined as *Ln* (*SD of Relative Trading Income* + 0.04), to zero. *Sharpe Ratio of Trading Income* is computed as the ratio of *Relative Trading Income* and *SD of Relative Trading Income*. *EW Base Salary* and *HW Base Salary* are standardized by 100,000.

Panel A: Pre-crisis period 2003–2007

	Obs.	Mean	Std. dev.	Skew.	Q5	Q25	Q50	Q75	Q95
Bank characteristics									
Assets (in billion €)	222	147.1	317.1	3.93	1.8	6.4	37.0	148.5	484.2
Log Assets	222	10.4	1.9	0.02	7.5	8.8	10.5	11.9	13.1
Trading Income (in million €)	222	237.7	1163.5	5.86	−40.4	1.0	11.5	74.7	458.0
Gross Interest Income (in million €)	222	5027.6	8704.1	3.24	43.3	246.3	1532.5	5778.5	18,850.3
Relative Trading Income (%)	222	8.2	15.9	2.85	−1.2	0.1	0.9	11.5	39.1
Gross Interest Income/Assets (%)	222	4.0	1.7	1.01	1.7	2.7	3.9	4.7	7.4
Net Loans/Assets (%)	222	40.9	22.0	0.36	5.7	27.0	39.8	54.7	83.7
Employment Non-Cap. Mkt. Segm.	41	0.7	0.3	−0.52	0.3	0.5	0.7	0.9	1.0
Performance characteristics									
Log Relative Trading Income	222	3.14	0.46	0.60	2.81	2.89	2.94	3.38	4.04
Log of SD of Relative Trading Income	48	0.32	1.76	0.10	−2.31	−1.23	0.05	1.83	3.41
Sharpe Ratio of Trading Income	48	1.68	1.77	1.01	−0.58	0.41	1.26	2.76	5.28
Pay in capital market segments									
EW Bonus Share	49	0.277	0.146	0.602	0.077	0.160	0.263	0.358	0.580
EW Base Salary	49	0.881	0.196	0.897	0.613	0.750	0.841	0.984	1.261
HW Bonus Share	49	0.324	0.169	0.401	0.086	0.188	0.295	0.432	0.629
HW Base Salary	49	0.996	0.246	0.821	0.688	0.843	0.951	1.099	1.490
Pay in non-capital market segments									
EW Bonus Share	41	0.164	0.083	0.818	0.048	0.103	0.166	0.215	0.272
EW Base Salary	41	0.740	0.214	0.809	0.462	0.590	0.716	0.853	1.057
HW Bonus Share	41	0.191	0.095	0.701	0.049	0.126	0.193	0.243	0.305
HW Base Salary	41	0.819	0.237	0.714	0.494	0.641	0.838	0.945	1.152

Panel B: Crisis period 2008–2011

	Obs.	Mean	Std. dev.	Skew.	Q5	Q25	Q50	Q75	Q95
Bank characteristics									
Assets (in billion €)	179	163.0	335.2	3.39	2.0	8.4	30.7	158.9	1010.5
Log Assets	179	10.4	1.9	0.04	7.6	9.0	10.3	12.0	13.8
Trading Income (in million €)	179	235.2	1297.6	5.11	−375.0	0.0	4.3	52.0	1209.0
Gross Interest Income (in million €)	179	4799.6	8302.2	3.06	37.1	131.7	995.8	5761.0	20,775.0
Relative Trading Income (%)	179	10.9	27.2	4.43	−7.7	0.0	1.6	11.8	56.6
Gross Interest Income/Assets (%)	179	3.3	1.7	1.29	1.0	2.2	3.1	4.2	6.4
Net Loans/Assets (%)	179	39.4	24.1	0.16	4.2	17.3	38.3	59.7	80.0
Employment Non-Cap. Mkt. Segm.	50	0.8	0.2	−1.07	0.3	0.6	0.8	0.9	1.0
Performance characteristics									
Log Relative Trading Income	179	3.12	0.68	−0.20	2.32	2.89	2.97	3.39	4.31
Log of SD of Relative Trading Income	40	0.82	1.78	−0.13	−2.27	−0.20	0.86	2.34	3.62
Sharpe Ratio of Trading Income	40	0.84	1.10	0.57	−0.52	0.16	0.68	1.55	2.49
Pay in capital market segments									
EW Bonus Share	55	0.199	0.124	0.601	0.035	0.099	0.205	0.277	0.440
EW Base Salary	55	0.954	0.254	1.148	0.656	0.773	0.934	1.015	1.530
HW Bonus Share	55	0.223	0.133	0.504	0.063	0.108	0.233	0.308	0.470
HW Base Salary	55	1.049	0.280	0.929	0.692	0.831	1.032	1.138	1.643
Pay in non-capital market segments									
EW Bonus Share	50	0.135	0.084	0.659	0.032	0.076	0.116	0.197	0.313
EW Base Salary	50	0.798	0.220	0.160	0.434	0.650	0.784	0.953	1.135
HW Bonus Share	50	0.160	0.103	1.023	0.046	0.077	0.140	0.232	0.377
HW Base Salary	50	0.889	0.260	0.305	0.502	0.669	0.874	1.080	1.310

survey analysts and compensation consultants, processed through analysis software for data anomalies, and then double-checked by the banks' and the consultancy's pay compensation specialist.

A unique feature of the data set is that information on the functional area and hierarchical level is comparable across banks and countries, because the consultancy applies a standardized and globally consistent method to define a large set of specific job positions in the financial services sector. Each of these detailed job positions is uniquely assigned to a specific functional area and hierarchical level. Banks use this standardized algorithm when reporting their personnel records and classify their job positions accordingly. This guarantees that functional areas and hierarchical levels are comparable across different banks in the industry.

The banks surveyed include most of the largest ones. In 2008, for instance, our sample comprises 24 Austrian, 68 German, and 31 Swiss institutions including 17 out of the 20 largest banks in Germany and

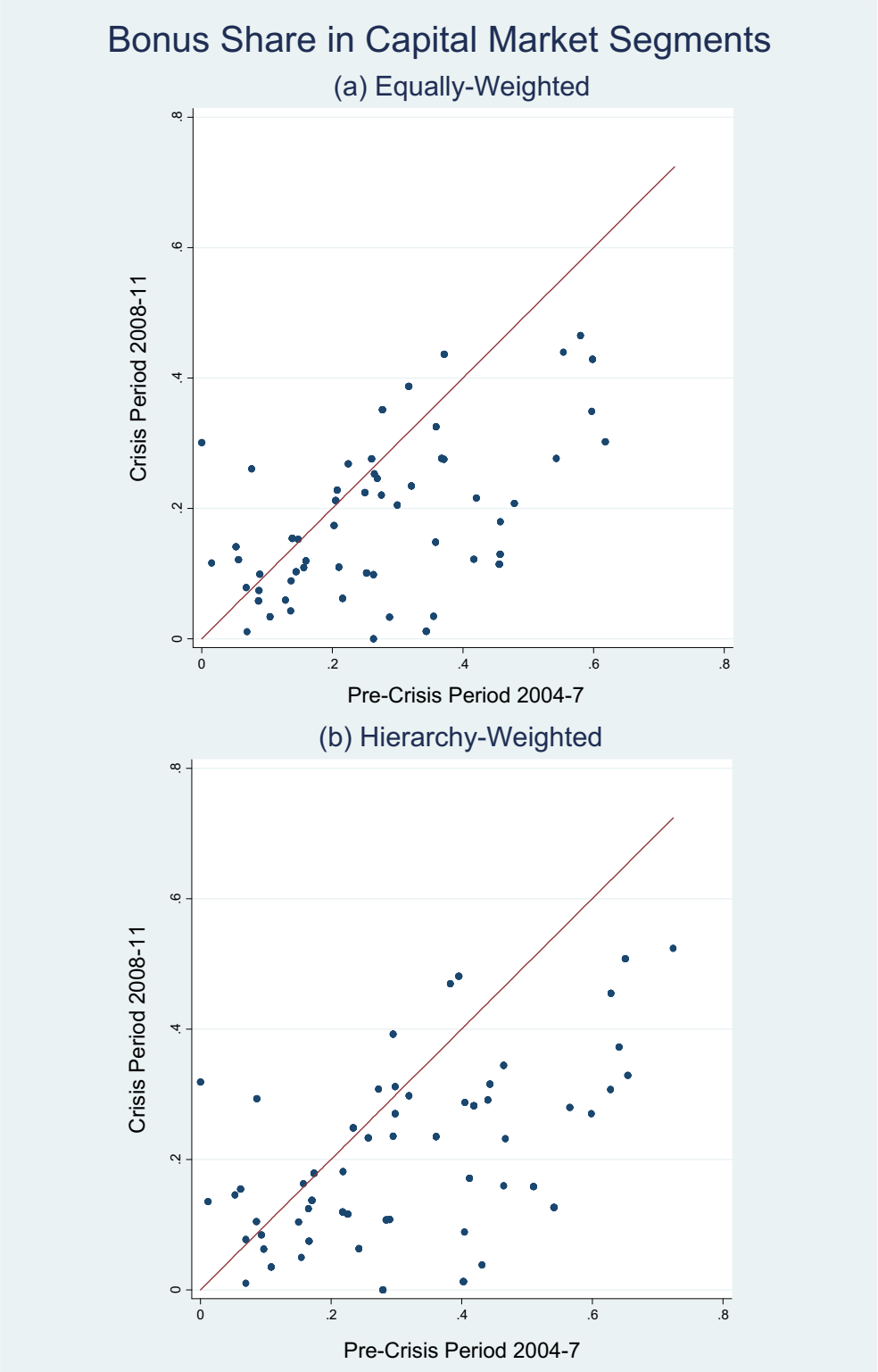

Fig. 3. The (a) *Equally-Weighted* and the (b) *Hierarchy-Weighted Bonus Share* (defined as the ratio of bonus to total compensation) for the capital market segment employees in each bank is plotted (as average) for the pre-crisis period 2004–2007 (x-axis) against the corresponding *Bonus Share* in the crisis period 2008–2011 (y-axis).

six out of the 10 largest banks in Austria and Switzerland. All banks in the sample in 2008 represent approximately 30%, 74%, and 73% of all bank assets in Austria, Germany, and Switzerland, respectively.[12]

The compensation data cover at least 80% of all employees below board level in any bank and record the contractual fixed *Base Salary* as well as the short-term performance-related *Bonus* payment made (paid out) to each employee. The employee data include age, employment tenure, bonus eligibility, hierarchy level, and the bank division in which the employee works. Unfortunately, the data lack a unique

[12] Our analysis observed strict confidentiality requirements; all employee-level data were analyzed only at the premises of the pay consultant in a secured data room.

Table 4
Trading income and incentive pay. In Panel A, we regress the *Log Relative Trading Income* defined as the log of the ratio of *Trading Income* to *Gross Interest Income* on a bank's *Equally-Weighted* (*EW*) *Bonus Share* and *Equally-Weighted* (*EW*) *Base Salary* calculated for all employees in the segments *Treasury/Capital Market* and *Investment Banking*. In Panel B, we regress the same dependent variable on the *Hierarchy-Weighted* (*HW*) *Bonus Share* and the *Hierarchy-Weighted* (*HW*) *Base Salary* calculated for the same capital market segments. The controls are: *Log Assets* = natural logarithm of bank assets; *Net Loans/Assets* = net loans over bank assets, and year fixed effects. Ordinary least squares (OLS) regressions are used in columns (1) and (4). In columns (2) and (5) we weight each bank by the square root of the number of employee-observations used to compute the bank average bonus share (WOLS). Columns (3) and (6) report the results of random effects (RE) panel regressions. All specifications include a constant. Robust standard errors clustered at the bank level are reported in parentheses. The symbols *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively.

Panel A: Trading income and the equally-weighted bonus share

Dep. variable:	Pre-crisis period 2003–2007			Crisis period 2008–2011		
Log Relative Trading Income	OLS	WOLS	RE	OLS	WOLS	RE
	(1)	(2)	(3)	(4)	(5)	(6)
EW Bonus Share	2.374***	2.099***	2.278***	0.476	0.914	0.314
	(0.529)	(0.669)	(0.515)	(0.671)	(0.569)	(0.796)
EW Base Salary	−1.548***	−1.404**	−1.469***	0.744**	0.535*	0.843**
	(0.433)	(0.558)	(0.434)	(0.321)	(0.292)	(0.392)
Log Assets	−0.115***	−0.090***	−0.117***	−0.108***	−0.103***	−0.113***
	(0.025)	(0.032)	(0.025)	(0.024)	(0.027)	(0.027)
Net Loans/Assets	−0.000	−0.001	−0.001	−0.002	−0.002	−0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	222	222	222	179	179	179
Number of banks	49	49	49	55	55	55
R^2	0.382	0.256	0.381	0.342	0.346	0.340

Panel B: Trading income and the hierarchy-weighted bonus share

Dep. variable:	Pre-crisis period 2003–2007			Crisis period 2008–2011		
Log Relative Trading Income	OLS	WOLS	RE	OLS	WOLS	RE
	(1)	(2)	(3)	(4)	(5)	(6)
HW Bonus Share	2.098***	1.978***	2.028***	0.603	0.955*	0.465
	(0.425)	(0.563)	(0.420)	(0.616)	(0.514)	(0.735)
HW Base Salary	−1.280***	−1.115***	−1.236***	0.552*	0.312	0.655*
	(0.304)	(0.389)	(0.310)	(0.289)	(0.262)	(0.353)
Log Assets	−0.113***	−0.084**	−0.116***	−0.110***	−0.103***	−0.116***
	(0.026)	(0.035)	(0.027)	(0.024)	(0.027)	(0.028)
Net Loans/Assets	−0.001	−0.001	−0.001	−0.002	−0.002	−0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	222	222	222	179	179	179
Number of Banks	49	49	49	55	55	55
R^2	0.398	0.269	0.396	0.332	0.336	0.329

employee identifier, which would allow us to track the employees from year to year. Each employee is assigned to one of seven hierarchical levels and into either one of six bank segments (investment banking, treasury/capital markets, asset management, corporate banking, private banking, retail banking) or various bank service functions (e.g. human resources, communication, or IT services).

The original compensation data extend from 2004 to 2011 and cover more than 1.27 million bank employee years. We apply three filters to the raw data. First, we discard 681,455 observations for employees in bank service functions such as IT services, communication, and human resources. Second, a further 67,860 observations were not eligible for bonus payments and are therefore ignored. These restrictions may apply to recently recruited employees in particular. By contrast, employees eligible for bonus payments are retained and their bonus is assumed to be zero if the bonus payment is recorded as missing. Third, we discard 4708 extremely low compensation levels with a base salary below €24,000. These positions correspond to low-paid service functions like contact center employees and are excluded from our analysis. In order to discard data outliers that might be simple reporting errors, we also winsorize the 10 smallest and largest observations for *Age*, *Tenure*, *Base Salary*, and *Bonus*.

Table 1 reports the summary statistics for the retained sample, which covers annual observations (obs.) for Austria (31,673 obs.), Germany (372,151 obs.), and Switzerland (112,662 obs.). Our analysis focuses on the two most critical banking functions from a risk management perspective, namely *investment banking* (12,343 obs.) and *treasury/capital market* (34,977 obs.). We refer to these as the capital market segments; they generate a bank's trading income. By contrast, the banks' asset management segments (21,188 obs.) manage client accounts. Other bank segments of lesser importance for a bank's risk management are corporate banking (53,685 obs.), private banking (75,547 obs.), and retail banking (318,746 obs.); all three feature weaker incentive pay structures.

The yearly *Total Salary* is defined as the sum of *Base Salary* and (cash) *Bonus*. A simple proxy for the strength of incentive pay is the *Bonus Share*, defined as the ratio between the (end of the year) *Bonus* and the yearly *Total Salary*. The average *Bonus Share* increases from 5% for the lowest *Hierarchy Level 1* to 46% for the highest *Hierarchy Level 7*.

The *Bonus Share* varies considerably across bank segments. In retail banking, the bonus payment accounts for only 8% of the total salary, whereas the *Bonus Share* is 15% in corporate banking, 19% in private banking, and reaches an average of 23%, 23%, and 24% in the segments investment banking, treasury/capital markets, and asset management, respectively. We also note that the standard deviation of the *Bonus Share* is the highest at 20% in the investment banking and treasury/capital market segments.

Unlike in the U.S., granting stock options to middle and senior bank management is not generally practiced in Austria, Germany, or Switzerland. Moreover, the majority of banks in the three countries are not market-listed, which prevents the use of stock options. However, some of the larger listed Swiss banks pay out part of their bonuses in bank shares at a discount. Such stock grants are not part of our *Bonus*

Table 5
Trading income volatility and incentive pay. In Panel A, we regress the *Log Standard Deviation* (*SD*) *of the Relative Trading Income* defined as the log of the standard deviation of the ratio of *Trading Income* to *Gross Interest Income* on a bank's *Equally-Weighted* (*EW*) *Bonus Share* and *Equally-Weighted* (*EW*) *Base Salary* calculated for all employees in the segments *Treasury/Capital Market* and *Investment Banking*. In Panel B, we regress the same dependent variable on the *Hierarchy-Weighted* (*HW*) *Bonus Share* and the *Hierarchy-Weighted* (*HW*) *Base Salary* calculated for the same capital market segments. The controls are: *Log Assets* = natural logarithm of bank assets; *Net Loans/Assets* = net loans over bank assets. Ordinary least squares (OLS) regressions are used in columns (1) and (3). In columns (2) and (4) we weight each bank by the square root of the number of employee-observations used to compute the bank average bonus share (WOLS). All specifications include a constant. Robust standard errors are reported in parentheses. The symbols *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively.

Panel A: Volatility of trading income and the equally-weighted bonus share

Dep. variable:	Pre-crisis period 2003–2007		Crisis period 2008–2011	
Log SD of Relative Trading Income	OLS	WOLS	OLS	WOLS
	(1)	(2)	(3)	(4)
EW Bonus Share	12.580***	10.022***	1.356	2.794
	(2.429)	(2.981)	(2.667)	(1.923)
EW Base Salary	−8.541***	−5.720**	3.311*	3.121*
	(2.061)	(2.730)	(1.650)	(1.581)
Log Assets	−0.285**	−0.089	0.252**	0.301**
	(0.122)	(0.134)	(0.124)	(0.116)
Net Loans/Assets	−0.005	−0.018*	−0.023**	−0.023**
	(0.010)	(0.011)	(0.010)	(0.011)
Observations (= number of banks)	48	48	40	40
R^2	0.366	0.275	0.360	0.434

Panel B: Volatility of trading income and the hierarchy-weighted bonus share

Dep. variable:	Pre-crisis period 2003–2007		Crisis period 2008–2011	
Log SD of Relative Trading Income	OLS	WOLS	OLS	WOLS
	(1)	(2)	(3)	(4)
HW Bonus Share	10.583***	9.145***	2.413	3.059*
	(1.975)	(2.457)	(2.192)	(1.671)
HW Base Salary	−6.386***	−4.309**	1.789	1.865
	(1.604)	(2.041)	(1.444)	(1.475)
Log Assets	−0.252*	−0.058	0.282**	0.321**
	(0.127)	(0.134)	(0.123)	(0.127)
Net Loans/Assets	−0.008	−0.020*	−0.021**	−0.020*
	(0.010)	(0.011)	(0.011)	(0.012)
Observations (= number of banks)	48	48	40	40
R^2	0.360	0.296	0.322	0.388

statistics, which are defined as the annual, short-term, performance-related cash component paid out. We ignore additional equity-based incentives as less than 1% of employees are entitled to pay in the form of equity shares.

During the 2007–2008 financial crisis, banks faced considerable public criticism about their incentive systems. Large bonus payments in particular came under political attack. Fig. 1 plots the *Bonus Share* for all 47,320 employee-year observations in the two capital market segment investment banking and treasury/capital markets as a function of the *Base Salary* on a log scale. Observations for the pre-crisis years 2004–2007 are plotted in the left-hand graph and crisis (or post-crisis) observations in the right-hand graph. Two observations follow directly from visual inspection. First, the dispersion of the *Bonus Share* along with the average bonus share increases (almost linearly) in the (log) *Base Salary*. Second, two quadratic functions fitted to pre-crisis and crisis observations, respectively, show a roughly 40% lower slope for the latter period. The *Bonus Share* diminishes for all bank employees in the capital market segments in similar proportions, which amounts to a much larger total salary loss for employees with a high base salary. The 2007–2008 financial crisis brought about a substantial adjustment of incentive pay in the capital market segments of banking.

Table 2, Panel A, reports aggregate statistics for capital market segments and tests for differences between the pre-crisis years 2004–2007 and the crisis years 2008–2011. The average *Base Salary* increased by €8109 or 10%, whereas the average *Bonus* decreased by €33,961 or 50%. These changes are statistically highly significant and justify a separate analysis of the nexus between incentive pay and risk-taking focused on the pre-crisis period. It is interesting to highlight that the substantial decrease in the *Bonus Share* did not occur against a decrease in trading income. Table 2, Panel B, compares the (log of the) average trading income for the pre-crisis period with the crisis years and Fig. 2 provides the corresponding graphical representation. Average trading income did not decrease in spite of the drastic reduction in *Bonus Share*. This suggests that the incentive pay moderation in investment banking and treasury/capital market segments occurred mostly under external political pressure. In the following section, we discuss the trading income data in more detail.

4.2. Bank trading income and its volatility

In this paper we focus on *Trading Income* as a function of a bank's incentive pay structure. The capital market activity of a bank provides numerous trade-offs between risk and return—hence trading income and its variability amount to a proxy of bank risk-taking in financial markets. Our initial bank sample is extracted from Bankscope and includes all reporting Austrian, German, and Swiss banks with total assets above 300 million in the year 2008. The Bankscope sample covers a slightly larger period than our payroll data set and also includes the year 2003. The sample overlap comprises 67 banks that report compensation data and annual trading income for at least one year in 2003–2011. Table 3 provides the summary statistics on this bank sample separately for the pre-crisis years 2003–2007 and the crisis years 2008–2011. Over both periods combined, sample size totals 401 bank years. The bank size ranges from approximately €400 million for the smallest bank to more

Table 6
Trading income and instrumented incentive pay. We estimate a two-stage regression with *Log Relative Trading Income* as the dependent variable and in which the *Equally-Weighted* (*EW*) *Bonus Share* is instrumented in a first stage regression (Panel A) by the equally-weighted bonus share in *Retail Banking*, *Private Banking* and *Corporate Banking* of the same bank (= *EW Bonus Share Other Segm.*), and the share of the total number of employees in these segments relative to total employment (= *Employment Other Segm.*). Panel B reports the second stage regression. We use the same control variables as before: *Log Assets* = natural logarithm of bank assets; *Net Loans/Assets* = net loans over bank assets; and year fixed effects. Two-stage least squares (2SLS) regressions are used in columns (1) and (3). In columns (2) and (4) we weight each bank by the square root of the number of employee-observations used to compute the bank average bonus share (W2SLS). All specifications include a constant. Robust standard errors clustered at the bank level are reported in parentheses. The symbols *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively. The last row of Panel B reports the p-value for the null hypothesis that all instruments are valid.

Panel A: First stage regression for EW bonus share

Dep. variable:	Pre-crisis period 2003–2007		Crisis period 2008–2011	
EW Bonus Share	2SLS	W2SLS	2SLS	W2SLS
	(1)	(2)	(3)	(4)
EW Bonus Share Other Segm.	0.657***	0.788***	0.804***	0.967***
	(0.154)	(0.172)	(0.158)	(0.182)
Employment Other Segm.	0.118***	0.150***	0.100**	0.107**
	(0.043)	(0.048)	(0.038)	(0.041)
EW Base Salary	0.449***	0.387***	0.254***	0.216***
	(0.065)	(0.097)	(0.040)	(0.053)
Log Assets	0.015**	0.016***	0.007	0.008
	(0.006)	(0.006)	(0.004)	(0.005)
Net Loans/Assets	−0.001	−0.000	0.000	0.000
	(0.001)	(0.001)	(0.000)	(0.001)
Year FE	Yes	Yes	Yes	Yes
Observations	185	185	163	163
Number of Banks	41	41	50	50
R^2	0.773	0.700	0.685	0.633
F-Test (H_0: all coeff. = 0)	30.46	18.21	32.17	29.89
F-Test (H_0: IV coeff. = 0), weak ID	9.11	10.58	15.79	19.14
SY weak ID test critical values (10%/15%/20% maximal size)	19.93/11.59/8.75			

Panel B: Second stage with instruments for EW bonus share

Dep. variable:	Pre-crisis period 2003–2007		Crisis period 2008–2011	
Log Relative Trading Income	2SLS	W2SLS	2SLS	W2SLS
	(1)	(2)	(3)	(4)
EW Bonus Share (instrumented)	2.956**	3.964**	0.821	1.386*
	(1.487)	(1.468)	(1.093)	(0.836)
EW Base Salary	−1.572	−2.258**	0.620	0.343
	(1.003)	(1.107)	(0.499)	(0.401)
Log Assets	−0.120***	−0.118***	−0.106***	−0.106***
	(0.030)	(0.041)	(0.025)	(0.028)
Net Loans/Assets	0.004**	0.003	−0.002	−0.001
	(0.002)	(0.003)	(0.002)	(0.002)
Year FE	Yes	Yes	Yes	Yes
Observations	185	185	163	163
Number of banks	41	41	50	50
R^2	0.323	0.144	0.345	0.360
Overident. test (*p-value*)	0.294	0.126	0.709	0.346

than €1.0 trillion for the largest, with an average size of €147 billion in bank assets over the pre-crisis period.[13]

Trading income can be expected to increase in the scale of the financial market activity of a bank. We use the *Gross Interest Income* as denominator for *Trading Income*.[14] In the absence of any own account trading, *Trading Income* as a percentage of *Gross Interest Income* should be zero. *Trading Income* is, on average, positive for the 222 (179) bank-year observations in the pre-crisis (crisis) period, and represents on average 8.2% (10.9%) of *Gross Interest Income*. *Relative Trading Income* is highly volatile, with a standard deviation of 15.9% and 27.2% for the pre-crisis and crisis period, respectively. It is highly positively skewed, which suggests that a logarithmic transformation should offer better small-sample properties in a linear model that relates relative trading profits to pay incentives. We therefore define the dependent variable *Log Relative Trading Income* as the (natural) log of (*Relative Trading Income* + d), where the parameter $d = 17.92$ is chosen to reduce the skewness of the relative income ratio computed over the full sample period to zero.[15]

Table 2, Panel B, reports the test statistics for a comparison of *Log Period-Average Relative Trading Income* across the pre-crisis and crisis period. The 56 observations of the crisis period suggest a slightly higher average log trading income at 0.997 compared to 0.936 for 62 observations in the pre-crisis period, but the difference is statistically insignificant.

The volatility of *Trading Income* relative to *Gross Interest Income* is calculated as the standard deviation of *Relative Trading Income* over the pre-crisis period (2003–2007) and the crisis period (2008–2011), respectively. Any value computed on the basis of fewer than three observations is set to missing. Positive skewness of the standard deviation of relative trading income again suggests a logarithmic transformation.

[13] Reported extreme asset values here are rounded in order not to disclose the identity of the banks in our sample.

[14] The banks in our sample follow different accounting standards, which make total bank assets a problematic denominator for comparison. The income-orientated normalization based on gross interest income should be a better procedure for scaling *Trading Income* and is applied in other recent studies (Moshirian et al., 2011).

[15] Robustness checks are provided in the Web Appendix using alternatively the raw data or a simple log transformation with $d = 0$.

Fig. 4. The components of (a) the *Log Relative Trading Income* and (b) the *Log Standard Deviation (SD) of Relative Trading Income* that are unexplained by the control variables are plotted against the predicted (instrumented) *Equally-Weighted (EW) Bonus Share* (in the *Investment Banking* and *Treasury/Capital Market* segments) of each bank. The residual plots represent the 2SLS regression of Table 6, Panel B, column (1) and Table 7, Panel B, column (1), respectively.

We thus define the *Log Standard Deviation (SD) of Relative Trading Income* as the natural logarithm of (standard deviation of *Relative Trading Income* $+ d$), where a parameter $d = 0.04$ implies zero skewness.

While a higher trading income is desirable from a shareholder perspective, its volatility is clearly undesirable if the corresponding return contains a systematic component. How much systematic risk is embodied in the banks' trading income is difficult to measure because trading income for most banks is reported only at an annual frequency. We can nevertheless report a pooled estimate of 0.404 (0.530) for the correlation between annual relative trading income returns and the German (European) benchmark index DAX (EURO STOXX 50). Both point estimates are statistically significantly different from zero and support the assumption that trading income embodies a significant systematic risk component for which shareholders will demand a higher expected return.

5. Incentive pay structures

5.1. Incentive pay at the bank and bank segment level

Most of the empirical literature on bank risk-taking is based on compensation data from board members or CEOs because of the corresponding reporting requirements. Yet in practice, most material risk-taking decisions are likely to be taken at a lower level of the bank hierarchy. The data from compensation surveys used in this paper allow for a much broader measurement of incentive pay using base pay and bonus pay data from all bank hierarchy levels. Our objective is to aggregate the employee data to a sensible measure of risk-taking incentives at the bank level.

The most straightforward approach consists of defining an *Equally-Weighted (EW) Bonus Share* and an *Equally-Weighted (EW) Base Salary*

Table 7
Trading income volatility and instrumented incentive pay. We estimate a two-stage regression with the *Log Standard Deviation* (*SD*) *of Relative Trading Income* as the dependent variable and in which the *Equally-Weighted* (*EW*) *Bonus Share* is instrumented in a first-stage regression (Panel A) by the equally-weighted bonus share in *Retail Banking*, *Private Banking* and *Corporate Banking* of the same bank (= *EW Bonus Share Other Segm.*), and the share of total number of employees in these segments relative to total employment (= *Employment Other Segm.*). Panel B reports the second-stage regression. We use the same control variables as before: *Log Assets* = natural logarithm of bank assets; *Net Loans/Assets* = net loans over bank assets. Two-stage least squares (2SLS) regressions are used in columns (1) and (3). In columns (2) and (4) we weight each bank by the square root of the number of employee-observations used to compute the bank average bonus share (W2SLS). All specifications include a constant. Robust standard errors are reported in parentheses. The symbols *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively. The last row of Panel B reports the p-value for the null hypothesis that all instruments are valid.

Panel A: First stage regression for EW bonus share

Dep. variable:	Pre-crisis period 2003–2007		Crisis period 2008–2011	
EW Bonus Share	2SLS	W2SLS	2SLS	W2SLS
	(1)	(2)	(3)	(4)
EW Bonus Share Other Segm.	0.669***	0.768***	0.710***	0.976***
	(0.150)	(0.166)	(0.194)	(0.241)
Employment Other Segm.	0.122***	0.149***	(0.101**)	0.111**
	(0.043)	(0.047)	(0.047)	(0.050)
EW Base Salary	0.443***	0.387***	0.337***	0.252**
	(0.066)	(0.097)	(0.081)	(0.093)
Log Assets	0.015**	0.016***	0.002	0.006
	(0.006)	(0.005)	(0.006)	(0.007)
Net Loans/Assets	−0.001	−0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Observations (= number of banks)	41	41	37	37
R^2	0.768	0.700	0.624	0.595
F-Test (H_0: all coeff. = 0)	46.88	31.67	15.62	17.96
F-Test (H_0: IV coeff. = 0), weak ID	10.07	10.71	8.66	10.73
SY weak ID test critical values (10%/15%20% maximal size)	19.93/11.59/8.75			

Panel B: Second stage with instruments for EW bonus share

Dep. variable:	Pre-crisis period 2003–2007		Crisis period 2008–2011	
Log SD of Relative Trading Income	2SLS	W2SLS	2SLS	W2SLS
	(1)	(2)	(3)	(4)
EW Bonus Share (instrumented)	10.542*	12.051**	1.200	0.794
	(6.228)	(5.874)	(5.858)	(3.962)
EW Base Salary	−7.255*	−6.908*	3.135	3.075
	(3.991)	(4.175)	(3.179)	(2.145)
Log Assets	−0.261*	−0.108	0.203*	0.219**
	(0.139)	(0.160)	(0.114)	(0.108)
Net Loans/Assets	−0.003	−0.016	−0.021**	−0.023**
	(0.014)	(0.016)	(0.009)	(0.010)
Observations (= number of banks)	41	41	37	37
R^2	0.306	0.248	0.342	0.364
Overident. Test (*p-value*)	0.329	0.670	0.281	0.152

as

$$EW\ \ Bonus\ \ Share(b,T) = \frac{1}{N_{b,T}} \sum_{i \in E(b,T)} Bonus\ \ Share(i) \qquad (3)$$
$$EW\ \ Base\ \ Salary(b,T) = \frac{1}{N_{b,T}} \sum_{i \in E(b,T)} Base\ \ Salary(i),$$

respectively. The terms *Bonus Share*(i) and *Base Salary*(i) denote a survey observation i from the set $E(b,T)$ of all $N_{b,T}$ bank employee observations in the *Investment Banking* and *Treasury/Capital Market* segments of bank b sampled during one of the two periods T, which represent the four pre-crisis years 2004–2007 and the four (post-)crisis years 2008–2011. The year-to-year variation in the bank-level bonus share may reflect less the strength of the (ex-ante) incentive system than the favorable realization of bank profits. Defining the bank-level bonus share as the time average over the four consecutive years reduces this reverse causality from bank profitability to the measured bonus share.

A second measure of the bank-level risk incentives may account for the fact that the influence on risk-taking decisions may increase with the hierarchy level (H) of an employee. If we are willing to assume that his/her relative influence on bank risk-taking is proportional to the average hierarchy-specific total salary, we can define hierarchy weights $w(H,T)$ accordingly. For the aggregate weight sum

$$W_{b,T} = \sum_{i \in E(b,T)} w(H(i),T) \qquad (4)$$

of all employee observations in the *Investment Banking* and *Treasury/Capital Market* segments of bank b in period T, we can define the *Hierarchy-Weighted* (*HW*) *Bonus Share* and the *Hierarchy-Weighted* (*HW*) *Base Salary* as

$$HW\ \ Bonus\ \ Share(b,T) = \frac{1}{W_{b,T}} \sum_{i \in E(b,T)} w(H(i),T) \times Bonus\ \ Share(i)$$
$$HW\ \ Base\ \ Salary(b,T) = \frac{1}{W_{b,T}} \sum_{i \in E(b,T)} w(H(i),T) \times Base\ \ Salary(i), \qquad (5)$$

Table 8
Sharpe Ratio of trading income and optimal pay incentives. We estimate a two-stage regression with the *Sharpe Ratio of Trading Income* as the dependent variable and in which the *Equally-Weighted* (*EW*) *Bonus Share* is instrumented in a first-stage regression (Panel A) by the equally-weighted bonus share in *Retail Banking*, *Private Banking* and *Corporate Banking* of the same bank (= *EW Bonus Share Other Segm.*). Panel B reports the second-stage regression. We use the same control variables as before: *Log Assets* = natural logarithm of bank assets; *Net Loans/Assets* = net loans over bank assets. Two-stage least squares (2SLS) regressions are used in columns (1) and (4). In columns (2) and (5) we weight each bank by the square root of the number of employee-observations used to compute the bank average bonus share (W2SLS). Columns (3) and (6) in Panel B show the coefficients of ordinary least squares (OLS) regressions (*EW Bonus Share* is not instrumented). All specifications include a constant. Robust standard errors are reported in parentheses. The symbols *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively.

Panel A: First stage regression for EW bonus share

Dep. variable:	Pre-crisis period 2003–2007		Crisis period 2008–2011	
EW Bonus Share	2SLS	W2SLS	2SLS	W2SLS
	(1)	(2)	(3)	(4)
EW Bonus Share Other Segm.	0.149***	0.497***	0.573**	0.189***
	(0.136)	(0.148)	(0.236)	(0.296)
EW Base Salary	0.470***	0.439***	0.348***	0.275***
	(0.068)	(0.121)	(0.086)	(0.107)
Log Assets	0.015**	0.020***	0.002	0.008
	(0.007)	(0.007)	(0.006)	(0.008)
Net Loans/Assets	−0.001	−0.000	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Observations (= number of banks)	41	41	37	37
R^2	0.718	0.577	0.576	0.524
F-Test (H_0: all coeff. = 0)	34.98	19.25	18.70	19.33
F-Test (H_0: IV coeff. = 0), weak ID	9.50	11.31	5.89	7.64
SY weak ID test critical values (10%/15%/20% maximal size)	16.38/8.96/6.66			

Panel B: Second stage with instruments for EW bonus share

Dep. variable:	Pre-crisis period 2003–2007			Crisis period 2008–2011		
Sharpe Ratio of Trading Income	2SLS	W2SLS	OLS	2SLS	W2SLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
EW Bonus Share (instrumented)	−19.679*	−13.562*	−2.942	8.521*	4.613**	2.973**
	(10.564)	(7.734)	(4.260)	(4.472)	(2.242)	(1.382)
EW Base Salary	11.018*	7.209	1.539	−3.977	−2.125*	−1.438
	(6.168)	(4.821)	(2.654)	(2.497)	(1.181)	(1.177)
Log Assets	−0.065	−0.093	−0.236**	−0.217***	−0.221***	−0.249***
	(0.186)	(0.176)	(0.102)	(0.070)	(0.046)	(0.062)
Net Loans/Assets	−0.027	−0.005	−0.009	−0.004	−0.005	−0.003
	(0.023)	(0.02)	(0.017)	(0.008)	(0.008)	(0.007)
Observations (= number of banks)	41	41	41	37	37	37
R^2	−0.314	−0.216	0.092	0.098	0.320	0.239

respectively.[16] These latter definitions put more weight on the *Bonus Share* of employees at higher levels of responsibility.[17] The underlying assumption here is that the marginal influence on risk choices corresponds to the total salary of the bank employee, which increases in the hierarchical level. The following regressions use the (*EW* or *HW*) *Bonus Shares* averaged over the pre-crisis period 2004–2007 and the crisis period 2008–2011 as the main variables of interest. As dependent variables we use either the annual (relative) trading income or the volatility of trading income computed as its standard deviation within the two periods. To enlarge the sample by one year, we add information about trading income in 2003.

Fig. 3 is a graphical representation of the bonus share in *Investment Banking* and *Treasury/Capital Market* segments for 57 banks, with pre-crisis values on the x-axis and crisis values on the y-axis. The *Equally-Weighted* (*EW*) and *Hierarchy-Weighted* (*HW*) *Bonus Shares* are depicted in Fig. 3(a) and (b), respectively. Bank-level *Bonus Shares* are predominantly below the 45-degree line for both measures of the bonus share, reflecting the decreased *Bonus Shares* during the crisis period at the bank level. Yet we find considerable persistence of the bank-level bonus share across both periods with a time correlation of 0.55 (*EW Bonus Share*) and 0.57 (*HW Bonus Share*). Also notable is the wide dispersion of the bank-level *Bonus Share*, which ranges from almost zero to a maximum above 60%. The correlation between the *Equally-Weighted* and *Hierarchy-Weighted Bonus Share* is very high at 0.97.

Since most of the literature has focused on CEO or board incentives, it is interesting to measure the correlation between the CEO or management board bonus share and the *Equally-Weighted* or *Hierarchy-Weighted Bank Bonus Share*. We use hand-collected data to calculate the average bonus share for a total of 24 bank CEOs and 29 management boards. The correlation of the bonus share of the management board with the *Equally-Weighted* and the *Hierarchy-Weighted Bonus Share* at the bank level is 0.47 and 0.50, respectively. For the CEO bonus share, this correlation drops to only 0.37 and 0.43 for the *Equally-Weighted* and *Hierarchy-Weighted Bonus Share* at the bank level, respectively. Hence, measuring incentive pay exclusively at the level of the management board or CEO does not proxy bank-level risk incentives very well.

6. Incentive pay and trading income

6.1. Trading income levels

In a first step, we explore the relationship between incentive pay and the average profitability of a bank's trading operation. The dependent variable is the *Relative Trading Income*, defined as the logarithmic

[16] Alternatively, we compute the *EW Bonus Share* for hierarchy levels 1–4 and hierarchy levels 5–7 separately. In a second step, we regress *Relative Trading Income* and its standard deviation on both variables simultaneously. The results are shown in the Web Appendix.

[17] Note that the highest hierarchy level measured in the data is populated by senior group manager positions, i.e. the hierarchy level just below board members. Board members themselves are not covered. Our focus on the lower hierarchy levels distinguishes this paper from other studies on pay incentives.

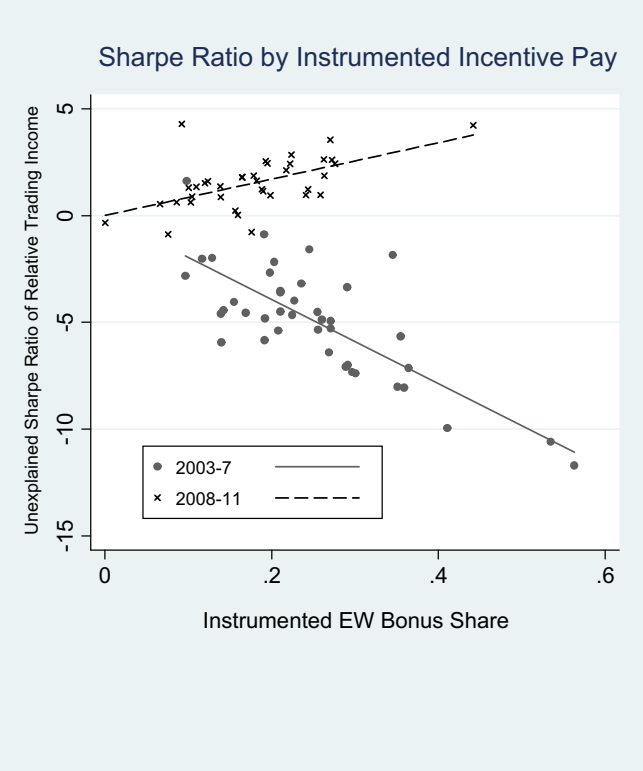

Fig. 5. The component of the Sharpe Ratios that is unexplained by the control variables is plotted against the instrumented *EW Bonus Share* of each bank, as estimated by the IV regression in Table 8. The slopes of the solid and dashed lines equal the correlations between instrumented bonus share and the unexplained component of the Sharpe Ratios in the pre-crisis and crisis period, respectively.

transformation of the ratio of annual *Trading Income* and *Gross Interest Income* in the same year. The independent variables are the bank-level *Bonus Share* and the *Base Salary*. Additional control variables are bank size, measured by *Log Assets*, and the *Net Loans/Asset* ratio as a control for bank structure. Robust standard errors are clustered at the bank level.

Table 4, Panel A, reports the regression results for the *Equally-Weighted* (*EW*) *Bonus Share* and the *Equally-Weighted* (*EW*) *Base Salary* and Panel B reports the corresponding hierarchy-weighted (*HW*) pay statistics. Columns (1) to (3) in Table 4 focus on the pre-crisis period 2003–2007, while columns (4) to (6) use the observations from the crisis years 2008–2011. The observations for the pre-crisis and the crisis period originate from 49 and 55 banks, respectively. The total number of individual banks over both periods is 67.[18] As the bank-level *Bonus Share* and *Base Salary* might be measured more precisely for banks with a large number of survey observations, we also use weighted ordinary least squares (WOLS) with bank weights equal to the square root of the number of bank observations in a bank's capital market division in any period.[19] This also amounts to giving more weight to large banks with more employees in their capital market divisions.

For the pre-crisis period 2003–2007, the OLS regression in Table 4, Panel A, column (1) shows a positive and statistically significant coefficient of 2.374 for the *EW Bonus Share* and a negative coefficient of –1.548 for the *EW Base Salary*. The correlation between the *Relative Trading Income* and the *Bonus Share* is economically significant: A one-standard deviation increase in the *EW Bonus Share* (=0.146) is associated with an increase in *Relative Trading Income* by roughly three-fourths of one standard deviation.[20] The WOLS-specification in column (2) shows a very similar coefficient of 2.098, which is also statistically significant—suggesting that the positive correlation between trading profits and pay incentives is as pronounced among larger banks.

The negative coefficient for the *EW Base Salary* in the pre-crisis period suggests a substitution effect between higher bonus pay and the base salary of employees. In other words, banks tend to provide a lower base salary if their employees can expect a larger year-end bonus. During the crisis period, the compression of the *EW Bonus Share* appears to have been compensated with higher base salaries, which explains the sign change of the coefficient in columns (4) to (6). The coefficient for *Log Assets* in column (1) is statistically significantly negative with a value of –0.115. A bank size increase by one standard deviation (=1.9) reduces the *Relative Trading Income* by almost 50% of one standard deviation. Thus, *Relative Trading Income* features decreasing economies of scale. Qualitatively similar evidence based on actual trading data is provided by Hau (2001) in a study of own-account trading by German bank dealers. This finding mirrors a negative correlation between fund size and fund performance found in some mutual fund research (Chen et al., 2004).

The random effects specification in column (3) produces very similar point estimates for the coefficients. The Web Appendix reports a regression specification that collapses the time-dimension within each sample period and computes the period-averages of the *Relative Trading Income* and all independent variables for each bank. The regression coefficient for the *EW Bonus Share* in the pre-crisis period remains robust at 2.728 and statistically significant at the 1%-level.

The regression results for the crisis period 2008–2011 reported in columns (4) to (6) show statistically weaker results for a positive relationship between *Relative Trading Income* and the *Equally-Weighted Bonus Share*. A weaker link may be due to much tighter risk controls during the crisis or diminished pay incentives documented in Section 5. We also repeat the OLS regressions in the full sample (2003–2011). The coefficient of *EW Bonus Share* decreases to 0.907 but remains statistically significant with a p-value of 0.023.

Table 4, Panel B, repeats the regressions in Panel A for the *Hierarchy-Weighted* (*HW*) *Bonus Share* and *Hierarchy-Weighted* (*HW*) *Base Salary*. The standard deviation of the *HW Bonus Share* is at 0.17 for the period 2003–2007 and approximately 16% higher than the standard deviation of the *EW Bonus Share*, which implies that the smaller coefficient of 2.098 in column (1) indicates the same level of economic significance. Overall, the equally-weighted and hierarchy-weighted incentive measures give very similar results. This is not surprising, considering their high correlation.

6.2. Variability of trading income

High performance-contingent pay could entice traders to increase profitability not (or not only) by higher levels of effort, but also by taking more risky positions, which are, on average, compensated by higher expected returns. Therefore, we examine the correlation between incentive pay for the *Log SD of Relative Trading Income*. At this stage we do not propose a causal interpretation: More risk-taking might increase the volatility of trading income, but the reverse causality of higher volatility affecting the average *Bonus Share* is also plausible. Without valid instruments for the *Bonus Share*, this section is limited to reporting conditional correlations.

Table 5, Panel A, reports the regression results for the *Equally-Weighted Bonus Share* and Panel B reports the *Hierarchy-Weighted Bonus Share*. As we only compute the dependent variable *Log SD of Relative Trading Income* for a given bank and period if the bank reports its trading income in at least three years, the number of banks in the regression sample drops from 49 in Table 4 to 48 in Table 5 in the pre-

[18] For some banks we only have data in either the pre-crisis or the crisis period.

[19] The count of employees varies across banks between roughly 10 and over 4000. By using the square root of the number of bank observations we avoid excessive weights for banks with many survey observations.

[20] In the pre-crisis period, the standard deviations of *EW Bonus Share* and of (Log) *Relative Trading Income* are 0.146 and 0.46, respectively. Hence: 2.374·0.146/0.46 = 0.75.

crisis period and from 55 to 40 in the crisis period. For the pre-crisis data, columns (1) and (2) in Panel A feature the OLS and WOLS regressions with robust standard errors, respectively. The coefficient for the *EW Bonus Share* is statistically significant at the 1% level in both specifications. The OLS coefficient of 12.580 implies that an increase in the *EW Bonus Share* by one standard deviation (=0.146) increases the *Log SD of Relative Trading Income* by roughly one standard deviation.[21] The *Bonus Share* therefore correlates economically even more strongly with the second moment of trading profitability than with the first. Results for the crisis period 2008–2011 imply much lower point estimates for the *EW Bonus Share* effect for both the OLS and WOLS specification.

In Table 5, Panel B, the *EW Bonus Share* and *EW Base Salary* are replaced by the corresponding hierarchy-weighted measures. The coefficients for the pre-crisis period in columns (1) and (2) are again approximately four times as large as those for the crisis sample in columns (3) and (4). The statistical significance of the coefficient for the *Bonus Share* is very similar irrespective of whether we aggregate the employee bonus shares with equal or hierarchy weights.

6.3. Instrumental variable regression

Performance-contingent incentive contracts for employees should generally imply that trading income influences the *Bonus Share* as well as its variability. By averaging the *Bonus Share* over multiple years for both the equally-weighted and hierarchy-weighted measure, we are able to greatly attenuate this reverse causality, but it is unlikely to be eliminated. A better means of establishing a causal effect between pay incentives and risk-taking is to take an instrumental variable approach, where we seek variables *Z* correlated with the *Bonus Share* and the expected (or average) trading income in a period, but uncorrelated with the regression residuals.

A first instrument consists of the bonus share in other bank segments unrelated to bank trading (*EW Bonus Share Other Segments*). A bank might have a general "bonus culture" that extends to all segments of the bank business. In this case the bonus share in *Retail Banking*, *Private Banking* and *Corporate Banking* should be correlated with the bonus share in the *Treasury/Capital Market* and *Investment Banking* segments as shown in Table 6, Panel A. Evidence that a bank's history might determine its bonus culture is provided by Fields and Fraser (1999), who document that the entry of U.S. commercial banks into investment banking in the late 1980s did not lead to an adjustment of pay-performance sensitivities to a level common among investment banks, but continued to resemble the bonus culture observed in commercial banking.

A second instrument relates to bank structure and governance: If employment in the bank segments unrelated to trading and investment banking is large relative to the capital market segment, then corporate boards might focus more on the non-trading divisions and the capital market division might face less supervision from the executive board and fewer constraints on its bonus share (Fahlenbrach, 2009). We therefore define *Employment Other Segments* as the employment share of non-trading divisions relative to total bank employment.

The first-stage regression, which explains the *EW Bonus Share* as a function of these two instruments and the other control variables, is reported in Table 6, Panel A. As not all banks have data on the two instruments, the number of banks decreases from 49 in Table 4 to 41 in Table 6 for the pre-crisis period and from 55 to 50 in the crisis period. Robust standard errors are clustered at the bank level.

Both instruments feature a high correlation with the *EW Bonus Share* in the pre-crisis period and in the crisis period in columns (1) to (2) and (3) to (4), respectively. Ceteris paribus, an increase in the *EW Bonus Share Other Segments* by one standard deviation (=0.083) in column (1) increases the *EW Bonus Share* in the *Treasury/Capital Market* and *Investment Banking* segments by 20% relative to its mean. An increase in the *Employment Other Segments* by one standard deviation (=0.27) increases the *EW Bonus Share* by 12% relative to its mean. The conditional correlation between *Employment Other Segments* and the *EW Bonus Share* is therefore significantly positive. The F-statistics for the excluded instruments show values of 9.11 and 10.58, which suggests sufficiently strong instruments.

Table 6, Panel B presents the regression results using the instrumented *EW Bonus Share*. For the pre-crisis period, Panel B, column (1) shows a statistically significant point estimate of 2.956 compared to 2.374 for the corresponding OLS coefficient in Table 4, Panel A, column (1). The higher 2SLS coefficients for the *EW Bonus Share* suggest that reverse causality biases the OLS coefficients downwards. This could be the case if high trading profits tend to increase the average *EW Base Salary* in the capital market segment over the four-year measurement period and thereby increase the denominator of the *EW Bonus Share*.

The 2SLS estimates suggest an economically large effect of higher pay incentives on average trading income. An increase of *EW Bonus Share* by one standard deviation (=0.146) implies an increase in the (log) ratio of trading income relative to interest income by 0.9 standard deviations during the pre-crisis period. The economic effect is even larger (with a coefficient of 3.964) for the weighted 2SLS (W2SLS) regression in column (2), which puts more emphasis on the observations of large banks. As the *EW Bonus Share* is instrumented by two variables simultaneously, we also test the overidentification restriction. The last row in Panel B reports the p-values for the null hypothesis that the instruments are valid. All specifications pass the test. Fig. 4(a) illustrates in a scatter plot the positive relationship between the instrumented *EW Bonus Share* and the unexplained component of the *Log Relative Trading Income* after accounting for the other regressors for the pre-crisis years 2003–2007.

We can also use the instruments to repeat the regressions for trading income volatility. Results for the corresponding 2SLS regressions with robust standard errors are reported in Table 7. Compared to Table 5, the analysis drops seven banks in the pre-crisis period and three banks in the crisis period because of missing data on the instruments. Panel A provides the first-stage regressions, whereas Panel B reports the 2SLS estimates for the instrumented *EW Bonus Share*. Except for column (3), the F-statistics for the excluded instruments are above 10 and indicate strong instruments.

The 2SLS estimate of 10.542 for the *EW Bonus Share* coefficient in Table 7, Panel B, column (1), is a bit smaller than in Table 5, Panel A, column (1), but the economic effect remains large. An increase of *EW Bonus Share* by one standard deviation (=0.146) increases the *Log Volatility of Relative Trading Income* by 0.9 standard deviations. The standard error of the coefficient for *EW Bonus Share* increases in the 2SLS regression, but the coefficient remains statistically significant at the 10% level. If we put more weight on bigger banks with a large number of survey observations (column (2)), the coefficient of *EW Bonus Share* becomes statistically significant at the 5% level and suggests a strong causal effect of higher incentive pay on the volatility of trading income. The 2SLS point estimates obtained for the crisis period (2008–2011) in columns (3) and (4) are smaller than for the pre-crisis period and not statistically significant. We also note that the over-identification test cannot reject the null hypothesis of valid instruments in any specification.

Overall, we find evidence that banks with a general "incentive culture" proxied by the *Bonus Share* in other (non-capital market) segments feature economically and statistically higher volatility in their trading income in the pre-crisis period. Fig. 4(b) illustrates the positive relationship between instrumented *EW Bonus Share* and the unexplained component of the *Log Volatility of Relative Trading Income* after accounting for the other regressors. The lower number of points in Fig. 4(b) compared to Fig. 4(a) comes from the fact that the analysis

[21] In the pre-crisis period, the sample standard deviations of *EW Bonus Share* and of *Log SD of Relative Trading Income* are 0.146 and 1.76, respectively. Hence: 12.580·0.146/1.76 = 1.04.

in Table 6 uses annual data whereas Table 7 is based on period-averages.[22]

6.4. The Sharpe Ratio of trading income

The instrumental variable regressions in the previous section suggest that a higher *Bonus Share* increases both the level and volatility of *Relative Trading Income*. But how can we evaluate the trade-off between higher income and higher risk? An incentive pay system should be optimal from a firm-value perspective if it maximizes the (risk-adjusted) present value of future trading income. As we argued in Section 3, NPV maximization under self-financing trading strategies amounts to maximizing the Sharpe Ratio of trading income.

While optimal incentive contracts should maximize the *Sharpe Ratio of Trading Income*, it is an empirical issue if marginal incentive pay indeed maximizes the *Sharpe Ratio* and therefore total firm value. The first-order condition implies that the change with respect to the instrumented *Bonus Share* $\left(\widehat{BS(T)}\right)$ has slope zero for both periods ($T = 2003–2007, 2008–2011$):

$$E\left[\frac{d\,Sharpe\,Ratio}{d\,\widehat{BS(T)}}|X\right] = 0. \quad (6)$$

At the optimum, and conditional on the control variables X, the coefficient of the (instrumented) *Bonus Share* should be zero—implying that neither an increase nor a decrease of the *Bonus Share* allows for a (locally) larger *Sharpe Ratio*.

We calculate the *Sharpe Ratio* as the ratio of the period-average *Relative Trading Income* and its standard deviation for each bank and each of the two periods 2003–2007 (pre-crisis) and 2008–2011 (crisis). The *Sharpe Ratio* is then regressed on the *EW Bonus Share* and the other exogenous control variables *EW Base Salary*, *Log Assets*, and *Net Loans/Assets*. As instruments for the *EW Bonus Share* we use a bank's *EW Bonus Share Other Segments*.[23]

Table 8, Panel A reports the first stage of the instrumental variables regressions. The F-statistics of 9.50 and 11.31 for *EW Bonus Share Other Segments* in columns (1) and (2) suggest that the instrument is reasonably strong for the pre-crisis sample. In the crisis sample used in columns (3) and (4), the (Kleibergen-Paap Wald rk) F-statistics for the excluded instrument are weaker at 5.89 and 7.64, respectively. By comparison, the critical value for the Stock and Yogo (2005) weak instrument test based on a maximal size of 15% is given by 8.96 for a 5% significance level. At the threshold size of 15%, we can reject the weak instrument hypothesis only for the pre-crisis period.

In Table 8, Panel B, columns (1) and (2), the IV coefficients of –19.679 and –13.562 for *EW Bonus Share* are negative, which implies that banks with a culture of large *Bonus Shares* obtain a lower *Sharpe Ratio* of trading income. This is indicative of excessive incentive pay that is not in line with firm value maximization. But we note that the coefficients are estimated with a relative large error and are significant only at the 10% level.

The 2SLS coefficients in columns (4) and (5) are positive at 8.521 and 4.613 and significant at the 10% and 5% level, respectively. The positive coefficients imply that the greatly reduced pay incentive system of the crisis period reversed the negative slope of the *Sharpe Ratio* with respect to higher bonus shares. In column (6), we use the same regression sample as in columns (4) and (5) but estimate the coefficients without instrumenting *EW Bonus Share*. Again the coefficient between the *Sharpe Ratio* and *EW Bonus Share* is statistically significant at the 5% level. The positive and significant estimates suggest that investment bankers and traders are underincentivized during the crisis period.

The results of Table 8 are summarized graphically in the residual plots in Fig. 5. The solid line traces out the marginal effect of the instrumented *EW Bonus Share* on the variation in the *Sharpe Ratio* for the pre-crisis period that is unexplained by the control variables. The negative slope indicates that local variations of the bonus share are associated with a decreasing *Sharpe Ratio*, suggesting that bonus incentives were too strong in 2003 to 2007. For the crisis period (2008–2011), the corresponding slope depicted by the dashed line is positive, now indicating that pay incentives were too weak from the viewpoint of asset value maximization. Overall, comparing the absolute slopes before and during the crisis suggests that the bonus moderation during the crisis has removed excessive pre-crisis incentive pay.

7. Conclusion

Empirical research on bank risk-taking is often constrained by the lack of appropriate compensation data to measure bankers' incentive pay. This paper draws on a large new data set on bank compensation in Austria, Germany, and Switzerland and extracts the performance-related bonus payments in the critical bank segments of investment banking and treasury/capital market management.

We contribute to a better understanding of bank pay incentives in four ways: First, we document a substantial reduction in incentive pay that occurred in 2008–2011 relative to much larger bonus shares in 2004–2007. At 40% the reduction in the *Bonus Share* (bonus relative to total compensation) was particularly strong in the investment banking and treasury/capital market segments. This substantial reduction occurred despite the fact that the overall trading income in our bank sample did not decrease in the crisis period. Second, trading income and its volatility are positively correlated with incentive pay. These correlations are observable for the entire sample period, but are particularly significant (both statistically and economically) in the pre-crisis period. Third, we pursue an instrumental variable approach to explore a possible causal relationship between the strength of pay incentives and bank risk-taking. We use the bonus share in bank segments unrelated to the capital market activity, like retail banking, corporate banking, and private banking, as instruments to capture the "bonus culture" of a bank. We find that a higher instrumented bonus share in capital markets causes both a higher *Relative Trading Income* and a higher *Log Standard Deviation (SD) of Relative Trading Income*.

Fourth, we ask if the observed incentive pay maximizes the Sharpe ratio of trading returns and, thereby, the NPV of bank trading. This requires the marginal effect of the (instrumented) *Bonus Share* on the *Sharpe Ratio* to be zero. Instrumented incentive pay shows a negative and weakly significant effect on the *Sharpe Ratio* of trading returns for the pre-crisis period, which becomes positive and significant for the later crisis period. Therefore, bonus payments seem too high before and too low during the crisis. The drastic reduction in incentive pay in the crisis period appears to have reduced the marginal effect of incentive pay on the *Sharpe Ratio*—possibly producing an overadjustment. We highlight that this last result is obtained only at a modest level of statistical significance. Future empirical work needs to combine the microeconomic measures of incentives proposed in this paper with corresponding micro data on the banks' speculative trading portfolios.

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[22] In Tables 5 and 7, the dependent variable *Log SD of Relative Trading Income* is computed per bank and period. The control variables are averaged by bank and period.

[23] If we also include *Employment Other Segments* as a second instrument, the overidentification test is not passed. Therefore, we use *EW Bonus Share Other Segments* as the only instrument.

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Appendix A. Supplementary data

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