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Bankers' pay and the evolving structure of US banking[☆]

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ABSTRACT

We consider the determinants of pay in US banks since 1986 using a new structural model in which banking firms are matched in rank order with management teams of varying talent. We calibrate the model to data from US bank holding companies focussing on labor's share of bank value-added, the level of bankers' pay and its sensitivity to bank performance. We find that three changes in banking regulation have shaped bankers' pay in the last three decades: (1) removal of obstacles to interstate banking set off a process of banking consolidation in the 1990s, (2) deregulation at the end of the 1990's allowing banks to pursue non-interest income has driven a trend toward higher pay and higher incentive pay, (3) tougher regulations following the financial crisis imposing an implicit tax on size and complexity has moderated pay in large banks but in so-doing has allowed smaller banks to take on business outside of standard credit intermediation resulting higher pay in those banks. Taking these structural changes into account we find a tendency over three decades for a decline in labor's share, in line with superstar effects implied by our structural model.

1. Introduction

Compensation practices in banking and in finance more generally have attracted the attention and, often, the critique of policy makers, regulators, and researchers. The very high level of pay to some bankers is seen by some as a form of rent extraction that results from weak corporate governance and declining competition. The high-powered incentives offered to bankers have been identified as an inducement to excessive risk-taking in banking, especially in those banks considered by regulators as too big or too complex to fail.

In this paper we consider what, if anything, is special about bankers' pay? To address this question we study the evolution of pay in US bank holding companies from 1986 to 2019 using a structural model of the banking firm. The model incorporates a strong complementarity between capital provided by shareholders and bankers' talent and their non-contractible effort. In a given year bankers' pay is given as the solution to the second-best problem of maximizing payoff to shareholders subject to the bankers' participation and incentive compatibility constraints. Market equilibrium is found as an assignment model in which managers with

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different levels of talent are matched in rank order with banks of different capital. We set out the main empirical characteristics of the US banking sector in both cross-section and time series focussing on the consolidation of the banking sector and on three characteristics of bankers' pay: labor's share of bank value-added, the level of bankers' pay and its sensitivity to bank performance. In light of the changing structure of banking through mergers, acquisitions, and re-structuring we allow for both bank capital and management talent to evolve over time. We calibrate the structural model that we have introduced to see if it can reproduce the empirical characteristics of compensation that we have found.

We find that three major changes in banking regulation have shaped bankers' pay in the last three decades. First, the removal of obstacles to interstate banking set off a consolidation process that is still on-going. This has allowed banks to operate at a greater scale and has made new technologies viable in regulated commercial banking. Second, since the Gramm, Leach, Bliley Act, the freedom to combine credit intermediation with activities generating non-interest income has driven a trend toward higher pay and higher incentive pay in banks aiming for higher shares of non-interest income. Finally, the mass of tougher regulations brought on by the financial crisis has had the effect of imposing an implicit tax on size and complexity which in turn has moderated the trend toward higher and more sensitive pay in large, complex banks. Indirectly this has given an opening for smaller banks to compete for some of the business outside of standard credit intermediation. But in so-doing, this has resulted in an increase of their pay levels and pay sensitivity. We find some evidence of a decline in average talent in the sector and that the trend toward high average pay has been driven in large part by the increase in managers' options outside banking. Overall, after controlling for the *de facto* regulatory tax on large banks we find a secular trend toward a decline of labor's share brought-on by a continuing process of consolidation in the US banking sector. Finally we find that although pay levels have risen significantly in three decades the premium received over fair pay in our model is rather small.

Our paper has links to the large literature on executive compensation and also to the literature on banking structure and regulation. A survey of the relevant literature is presented in Section 2 of the paper. The branch of the literature that is closest to our analysis is that which explores the *cross section* of compensation within an industry where there is a strong complementarity between the capital or size of the firm and the skill level of key employees of the firm. This literature has emerged out of the seminal contribution of Rosen (1981) which has become known as the economics of superstars where a relatively small skill advantage can give rise to a very large compensation premium. Our own analysis is related particularly to the papers of Autor et al. (2020), Terviö (2008) and Gabaix and Landier (2008). Our contribution is threefold. First, we show that the superstar firm hypothesis is consistent with observed patterns in the US banking sector in the last 30 years. Second, we employ the theory to understand the compensation of skilled employees outside of the top management group, thus providing a possible explanation for pay premia of a wider range of employees. Third, we implement a version of the model that allows explicitly for unobservable effort as well as skill differences and thus delivers implications for pay sensitivity which we find to be consistent with the data.

The paper is organized as follows. Section 2 provides a literature review including particularly papers that will be discussed later in relations to our results. Many readers may choose to read this section after seeing our structural framework. Section 3 sets out explicitly a new theoretical model that will allow us to characterize the effect of the transformation of the US banking sector on managerial compensation. Section 4 explores the comprehensive data that the Federal Reserve collects from federally supervised banking institutions. We use these to document the structural changes to the US banking sector which have followed major changes in banking regulation since 1986. We then ask how these changes have been reflected in bankers' compensation, focusing on three measures— labor's share in banking value-added, the level of average real compensation within a bank and the sensitivity of that compensation to the bank's performance. Then in Section 5 we use the structural model of Section 3 which we calibrate and then see if it is able to replicate the empirical patterns documented in Section 4. In this way we present an internally consistent account of the forces that have shaped compensation practices in US banking. The key step in the calibration relies on estimates of capital share and management share in total employment from census and labor surveys which together in our model set managerial pay sensitivity. Given these, we explore the implications for labor's share, managerial pay levels, and the fraction of bankers' pay that can be attributed to a pay premium not attributable to equilibrium compensation for talent. Section 6 summarizes our results and discusses open questions and possible extensions. An appendix is devoted to derivations of model results, a description of our data, and several extensions of our analysis.

2. Literature review

Ever since the seminal contribution of Jensen and Murphy (1990) there has been a lively debate about the relation of firm performance and managerial incentives. The controversy about rising pay inequality is reviewed by Edmans and Gabaix (2016) in their survey of the theoretical literature on executive compensation since about 1990. They argue that traditional models of shareholder value maximization in the face of moral hazard are not supported by the data and that, for this reason, a number of researchers have concluded that excessive executive compensation is the result of "rent extraction". However, Edmans and Gabaix show that more recent models including assignment models of the level of pay, and static and dynamic moral-hazard models of incentives give new insights into senior executive pay and find more support in the data on CEO compensation implying that practices need not be inefficient.

Philippon and Reshef (2012) study the compensation of human capital in the U.S. finance industry over the last century. Using a variety of indicators, over time and subsectors, they find that financial regulation and deregulation is associated with differences in skill intensity, job complexity, and the level of compensation for finance employees. All three measures were high before 1940 and after 1985, but not in the interim period. Workers in finance earned the same education-adjusted wages as other workers until 1990, but subsequently received a skill adjusted premium which by 2006 reached 50% on average and 250% for top executives. Changes in earnings risk can explain about one half of the increase in the average premium; changes in the size distribution of firms can explain about one fifth of the premium for executives.

Cheng et al. (2020) study compensation of top managers in financial firms using Execucomp. They ask whether compensation practices were misaligned with shareholders' interests as a result of managerial entrenchment and whether this induced financial firms to take excessive risks before the financial crisis of 2008. They argue that in a classical principal–agent setting without entrenchment and with exogenous firm risk, riskier firms may offer higher total pay as compensation for the extra risk in equity stakes borne by risk-averse managers. Using long lags of stock price risk to capture exogenous firm risk, they conclude that differences in compensation are in line with differences in risk. They also show that riskier firms are also more productive and more likely to be held by institutional investors who are most able to influence compensation. Autor et al. (2020) consider the evolution of compensation patterns from the perspective of labor's share of value-added. Using international aggregate data and disaggregated U.S. census data for a variety of industries they find that many of the observed trends in labor's compensation are compatible with the rise of "superstar firms". In their view when globalization or technological changes push sales toward the most productive firms there will be increased product market concentration. These superstar firms make high markups and exhibit a low labor share of value added. They find the predictions of assignment models of industry equilibrium with superstar type firms are supported by data for most industrial sectors. The exception is the financial sector (which in census data includes credit-intermediation, insurance and securities issuance and trading) where they find evidence of a secular rise in labor's share.

The economic theory of superstars was introduced by Rosen (1981). He showed how in an industry where there is a complementarity between capital and the skills of a key worker, a relatively small skill advantage can give rise to a very large compensation premium. This idea was developed in the context of CEO compensation by Terviö (2008) who presents an assignment model of CEOs and firms. The distributions of CEO pay levels and firms' market values are analyzed as the competitive equilibrium of a matching market where talents, as well as CEO positions, are scarce. It is shown how the observed joint distribution of CEO pay and market value can then be used to infer the economic value of underlying ability differences. The variation in CEO pay is found to be mostly due to variation in firm characteristics, whereas implied differences in managerial ability are small and make relatively little difference to shareholder value. He estimates that the value-added of scarce CEO ability within the 1000 largest firms in the US was about $21-25 billion in 2004, of which the CEOs received about $4 billion as ability rents while the rest was capitalized into market values.

Gabaix and Landier (2008) develop a simple equilibrium model of CEO pay. CEOs have different talents and are matched to firms in a competitive assignment model. In market equilibrium, a CEO's pay depends on both the size of his firm and the aggregate firm size. Using results from extreme value theory to calibrate the model, they find a very small dispersion in CEO talent can justify large pay differences. They argue that the sixfold increase of U.S. CEO pay between 1980 and 2003 can be fully attributed to the sixfold increase in market capitalization of large companies during that period.

Our own analysis is related to the papers of Autor et al. (2020), Terviö (2008) and Gabaix and Landier (2008) in that we suppose there is a complementarity between the capital or size of the firm and the skill level of key employees of the firm. Our contribution is threefold. First, we show that the superstar firm hypothesis is consistent with observed patterns in the US banking sector in the last 30 years. Second, we employ the theory to understand the compensation of skilled employees outside of the top management group, thus providing a possible explanation for pay premia of a wider range of employees. Third, we implement a version of the model that allows explicitly for unobservable effort as well as skill differences and thus delivers implications for pay sensitivity which we find to be consistent with the data.

There are other contributions to the literature on skill and compensation that are also related to our paper. Célérier and Vallée (2019) consider the compensation premium in finance using information of French exam performance of top executives as a proxy for talent. Wage returns to talent have been significantly higher and have risen faster since the 1980s in finance than in other sectors. Both wage returns to project size and the elasticity of project size to talent are also higher in this industry. Last, the share of performance pay varies more for talent in finance. These findings are supportive of finance wages reflecting the competitive assignment of talent in an industry that exhibits a high complementarity between talent and scale.

Böhm et al. (2023) consider whether the pay level premium to finance observed in Sweden can be attributed to increased demand for talent or rather by an increase in rents that are shared with finance employees. Their analysis is based on a unique data set which provides the scores of cognitive and non-cognitive abilities of almost all Swedish males taken prior to their entry into employment. They find that finance workers tend to have higher test scores on average than workers in the non-finance sector. However, there has been no significant increase in the relative skill level of finance workers in the period 1990–2017 covered in their study. They argue that the large increase in the pay premium of finance workers observed in that period cannot be attributed to increase in demand for skilled workers. Instead, they find that over this period value-added in the finance sector grew relative to the real sector. They also find that elasticities of pay to firm value-added are at least as high in finance as compared to the real sector and that, therefore, much of the increase in the finance pay premium is attributable to increased rent-sharing. It is worth noting that Böhm et al. are focused on rents defined as the difference between average pay within finance and the average level of pay for non-finance workers with comparable skill. In contrast, our analysis (as well as the studies cited above concerned with super-star effects) focuses primarily on the relation of the distribution of talent within the finance sector and the distribution of pay levels within the finance sector. We will comment further on the Böhm et al. in Section 5.5 after we present our main findings the bankers' pay level. Bandiera et al. (2015) study the matching of firms with managers and the implications of firm type for incentive pay. Using administrative and survey data they study the match between firms and managers. Their data are attractive because they cover manager characteristics, firm characteristics, detailed measures of managerial practices, and outcomes for the firm and the manager. They use an assignment model to illustrate how risk aversion and talent determine how firms select and motivate managers.

Our study is also related to a recent study by Corbae and D'Erasmo (2020) on the concentration of banking in the US. Concentration of insured deposit funding among the top four commercial banks in the U.S. has risen from 15% in 1984 to 44% in 2018, a roughly three-fold increase. Regulation has often been attributed as a factor driving this increase. The Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994 removed many of the restrictions on opening bank branches across state lines. They interpret the Riegle-Neal Act as lowering the cost of expanding a bank's funding base. They build an industry equilibrium model in which banks endogenously climb a funding base ladder. Rising concentration occurs along a transition path between two steady states after branching costs decline.

Our analysis as well as most of the papers reviewed above focus on talent differences (which may be relatively small) as explaining large observed differences of pay level across different firms. There may be alternative possible explanations to observed pay differences that do not rely on the assumption skill differences but rather assume differences in other characteristics of firms. An example might be differences in risk across firm which can give rise to pay differentials as compensation for risk-bearing as argued by Cheng et al. (2020). More generally, a variety of theories of equilibrium efficiency wage may be relevant to understanding some of the aspects of bankers' pay that we explore. See, Katz (1986) for an excellent survey of the early efficiency wage literature. In our view those models that feature differences in costs of monitoring effort could be very relevant. An example is the "shirking" model of Shapiro and Stiglitz (1984) where differences in the ability to monitor employee effort can give rise to differences in pay levels in equilibrium across different market segments even when there are not differences in labor skills across segments and when labor is risk neutral. This feature is central to the theoretical analysis of Axelson and Bond (2015) which is focussed on jobs in finance where the failure of employees to extend sufficient effort can potentially result in enormous losses (eg. in dealer market-making). We will return to this point below in Section 5.6 in discussing how our analysis differs from the pure efficiency wage type of explanations.

3. Analytical framework

3.1. Set-up

We consider an assignment model of banking that will generate implications for labor's share, the level of bankers' compensation and bankers' incentive pay. Following the Lucas (1978) model of the size distribution of firms, we suppose that one of the important inputs is labor with heterogenous, observable skill which we term as 'management' and which in combination with other inputs, in our case capital and labor, will determine the value-added of the firm. Following Rosen (1981) a crucial characteristic of the technology we specify is the complementarity between capital and management, where management may be of different types or qualities which can be ordered in a single dimension which we refer to as "talent". Then we consider a sorting equilibrium that will result in higher types of managers being matched with higher types of firms. Following Terviö (2008) we allow for firms to differ in other characteristics, which will allow the model to make predictions about differences in the level of pay across banks of different types. What is original here is that we furthermore allow managers to choose an unobservable action, thus generating a traditional moral hazard problem. This will generate implications for the managers' compensation contracts that will vary across managers of different skills and across firms of different types.

3.2. Model

Consider a firm whose value-added V is a function of three inputs— capital K, labor L and management M. Management, in turn depends upon management talent, T, which is assumed to be observable, and management action or effort, a, which is assumed to be non-contractible. Value added takes the Cobb–Douglas form,

$$V = (Ta)^{\alpha_m}(K)^{\alpha_k}(L)^{\alpha_l} \tag{1}$$

where $\alpha_m + \alpha_k + \alpha_l = 1$ with $\alpha_m > 0$, $\alpha_k > 0$ and $\alpha_l > 0$. Notice that this specification implies a strong complementarity among capital, managerial skill and managerial effort. Here management talent enters as a Harrod-neutral productivity shift.

Capital is provided by shareholders through a capital market. The opportunity cost of capital is a constant r. Labor is hired in a competitive labor market with a given wage rate, w_l. Management may be a team, but here we assume that it operates as a single decision maker. We assume that a manager with talent T has an outside option given by the function $w_m(T)$. We suppose that the owners of a given capital, K, have been matched with a manager with a given talent, T, and that the two parties will determine a contract that will allocate control rights over the choice of L and will determine the sharing of value-added between the manager and shareholders. In line with standard models of managerial moral hazard we assume that the shareholder is the principal and sets a compensation contract $c(V)$ and that, if accepted, the manager will then hire labor, L, and choose his effort, a. Manager's effort comes at a private cost to the manager which we assume the manager evaluates in monetary terms. In particular we assume that effort cost takes the form ga where $g > 0$ is the constant marginal cost of effort.[2]

This is the standard problem of the form: maximize firm value net of compensation to the manager and to labor subject to the manager's participation and incentive compatibility constraints. The new element introduced here is the way the manager's effort interacts with his talent.[3]

[2] The crucial difference between M and L is that management's action is not contractible; whereas, that of labor is. We also assume that skill of management is heterogenous and that of labor is homogeneous.

[3] Anderson (2023) considers other contracting arrangements including cooperative solutions that can be applied in this framework which result in different levels of firm value and of sharing of surplus between shareholders and management.

We solve this problem under the assumption that the manager's incentive contract is linear, $c(V) = w_0 + w_1 V$, where w_0 and w_1 are constants set by the shareholders. At first sight this might seem to be very restrictive in characterizing a second-best optimal compensation contract. However, it should be kept in mind that in our application we are characterizing the compensation for the whole management team. In that context the bargaining between shareholders and management focusses primarily on determining the bonus pool which then will be allocated among individuals based on compensation practices negotiated within the management team.[4]

In Appendix A.1 it is shown that the second best value of the firm, given K and T is given by,

$$V = \left[\frac{\alpha_m + \alpha_l}{1 + \alpha_l}\right]^{(\alpha_m+\alpha_l)/\alpha_k} \left(\frac{\alpha_m T}{g}\right)^{\alpha_m/\alpha_k} \left(\frac{\alpha_l}{w_l}\right)^{\alpha_l/\alpha_k} K \tag{2}$$

This is proportional to K, increasing in T, and decreasing in g.

Also it is found that the manager's pay sensitivity takes a particularly simple form,

$$w_1 = \frac{\alpha_m + \alpha_l}{1 + \alpha_l} \tag{3}$$

Since $\alpha_m < 1$, $w_1 < 1$. That is, the shareholder would never seek to set income sensitivity of the manager at unity.

The manager's fixed pay is set to just satisfy the manager's participation constraint. Given the results above this can be written as,

$$w_0 = w_m(T) - \left[\frac{\alpha_m + \alpha_l}{1 + \alpha_l}\right]^{1/\alpha_k} \left(\frac{\alpha_m T}{g}\right)^{\alpha_m/\alpha_k} \left(\frac{\alpha_l}{w_l}\right)^{\alpha_l/\alpha_k} K \tag{4}$$

If the outside option, $w_m(T)$ is increasing, then the fixed compensation of the manager may be increasing or decreasing in T. If the outside option is constant for all T, then the fixed compensation is decreasing in T. In that case, it is more likely that more talented managers need to have "skin in the game". As we will see, in a matching equilibrium it is natural that the outside option is increasing in T.

Finally, the compensation of labor is given as,

$$w_l L = \alpha_l \left[\frac{(\alpha_m + \alpha_l)}{1 + \alpha_l}\right]^{1/\alpha_k} \left(\frac{\alpha_m T}{g}\right)^{\alpha_m/\alpha_k} \left(\frac{\alpha_l}{w_l}\right)^{\alpha_l/\alpha_k} K \tag{5}$$

Note that this is decreasing in w_l. That is, under managerial moral hazard in a firm with a manager with given talent T, there is elastic demand for labor paid at the fixed wage w_l.

These closed-form expressions give us the basic building blocks we need to calibrate our model in relation to metrics that interest us — labor's share of value-added, pay level and pay sensitivity.

3.3. Market equilibrium

We now consider the equilibrium in an industry made up of firms that all have the technology introduced in the previous section and which are identical in all respects except that they differ in size. They will compete for managers who are identical in all respects except their talent. We use an assignment model to characterize the industry equilibrium and generate implications for labor's share, the level of bankers' compensation and bankers' incentive pay. As in Terviö (2008), the crucial assumptions for that framework are that each firm requires one manager, firms and managers are each differentiated in one dimension only (size for firms, talent for managers), and that there is a complementarity between size and managerial input. What is original here is that we allow managers to choose an unobservable action, thus generating a traditional moral hazard problem, and that we explicitly consider the choices of the manager of a variable input, labor L, which is obtained in a competitive market with perfectly elastic supply. This will deliver implications for pay sensitivity and also for aggregate (management and fixed wage) labor's share of firm value-added.

A general feature of assignment models is that industry equilibrium is essentially ordinal in character. Firms are ranked in order of size, K. Managers are ranked in order of talent, T. In equilibrium the i'th quantile firm, K_i, is matched with the i'th quantile manager, T_i. As pointed out by Terviö (2008) in equilibrium the compensation of management and shareholders matched in firm i will depend upon their marginal contributions to rents generated relative to those of the firm just below the i'th quantile. This in turn will depend upon the joint distribution of K and T. Equilibrium is characterized by a sorting condition which says that the i'th firm K_i is matched with the i'th quantile manager T_i has no incentive to deviate by matching with some other manager T_j with greater or lesser talent. In our context this can be expressed as follows. Define $G(K,T) = F(K, L(K,T), a(K,T)T) - w_l L(K,T)$, where $F(.)$ is the total revenues net of other costs of the firm. That is, $G(.)$ is the net value-added of the firm producing with capital K matched with manager with talent T who then makes second-best optimal choices of effort $a(K,T)$ and labor $L(K,T)$. The equilibrium sorting condition is,

$$G(K_i, T_i) - w(K_i, T_i) \geq G(K_i, T_j) - w(K_i, T_j) \tag{6}$$

for all i and $j \neq i$ where $w(K_i, T_i)$ is the manager's total compensation in that match. In addition, there are participation constraints for both capital and management. As in the previous section we assume the option for capital outside of the industry gives a constant

[4] The form of compensation contracts to individual managers has been the subject of many contributions to labor economics, notably, Lazear and Rosen (1981), Costrell and Loury (2004) and Benabou and Tirole (2016),

return r. Furthermore, for all managers with measurable talent for the industry considered here we assume the option outside that industry would be a constant w^0. Then the participation constraints are

$$G(K_i, T_i) - w(K_i, T_i) \geq rK_i$$
$$w(K_i, T_i) \geq w^0 \quad (7)$$

This equilibrium can be characterized as described by Terviö (2008). Let $\phi(T)$ be the cumulative distribution of talent. It can as well be expressed by its inverse which can be thought of as the talent profile, $t(i)$, s.t., $\phi(t(i)) = i$. Then consider the sorting condition firm K_i relative to lower quantile $i - \epsilon$. This can be rewritten as

$$\frac{G(K_i, T_i) - G(K_i, T_{i-\epsilon})}{\epsilon} \geq \frac{w(K_i, T_i) - w(K_i, T_{i-\epsilon})}{\epsilon} \quad (8)$$

This holds with equality at the limit $\epsilon \to 0$ so that,

$$w_T(K_i, T_i) = G_T(K_i, T_i)t'(i) \quad (9)$$

where w_T and G_T are partial derivatives and $t'(.)$ is the derivative of the talent profile. Observing that the outside industry option will be binding for the lowest talent manager, $w(K_0, T_0) = w^0$, then the whole compensation profile can be found as,

$$w(K_i, T_i) = w^0 + \int_0^i G_T(K_j, T_j)t'(j)dj \quad (10)$$

Similarly let the cumulative distribution function of capital in the industry be continuous and let the profile $k(.)$ be the inverse of the cumulative distribution function of capital. Let $\pi(K_i, T_i)$ be the equilibrium payoff of the i'th quantile firm. This can be determined either using the adding up condition,

$$\pi(K_i, T_i) + w(K_i, T_i) = G(K_i, T_i) \quad (11)$$

or equivalently as

$$\pi_K(K_i, T_i) = G_K(K_i, T_i)k'(i) \quad (12)$$

and

$$\pi(K_i, T_i) = rK_0 + \int_0^i G_T(K_j, T_j)k'(j)dj \quad (13)$$

This equilibrium can be evaluated in the special case of Cobb–Douglas production function as in Section 3.2. In this case the net value-added of the firm can be developed using Eqs. (A.9) and (A.18) and the net value-added of the firm can be written as,

$$G(K, T) = (1 - \alpha_l w_1)\big[\frac{\alpha_m + \alpha_l}{1 + \alpha_l}\big]^{(\alpha_m+\alpha_l)/\alpha_k}(\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k}(\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k}K \quad (14)$$

Substituting for w_1 using (A.17) the net value-added of the firm can written as,

$$G(K, T) = (\big[\frac{\alpha_m + \alpha_l}{1 + \alpha_l}\big]^{(\alpha_m+\alpha_l)/\alpha_k} - \alpha_l\big[\frac{\alpha_m + \alpha_l}{1 + \alpha_l}\big]^{(1/\alpha_k)})(\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k}(\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k}K \quad (15)$$

This expression is strictly increasing in T and can be inverted to obtain an expression for talent T as a function of firm value-added. We will use this property in Section 5 to calibrate our model using data on US bank holding companies. First, in the next section we introduce the regulatory data that we will use to describe the important characteristics of US bank holding companies over the three decades from 1986.

4. US banking structure and bankers' pay

In this section we present empirical characteristics of the US banking sector that are pertinent to understanding the evolution of bankers' pay in the US since 1986. In particular we summarize that evolution in terms of the three characterizations of pay that have been the focus of the recent literature on managerial compensation, namely: level of pay, incentive pay, and the share of firm value-added surplus accruing to management. We will then use these descriptors in Section 5 in calibrating our structural model of Section 3 in order to see if the observed characteristics are compatible with competitive equilibrium in a banking sector where banks use incentive compatible contracts so as to maximize shareholder value.

There is a large literature on the history of US banking which emphasizes its highly fragmented nature with a very large number of banks and the low level of integration of diverse financial services other than those devoted to credit intermediation. However, since the 1980's a number of regulatory changes eliminated obstacles to branch banking and to interstate banking which has set off a process of consolidation. In Appendix A.2 we survey this literature and also describe in detail the data that we use in our calibration.

One point that emerges from this analysis is that the degree of observed consolidation is dependent on which regulatory data set one uses in the analysis. In the past analysts tended to use data in Call Reports, a data set based on regulatory reporting by federally licensed banks. Often such banks are part of a larger banking group and the consolidated financial position of the group will not be captured in the Call Reports. For this reason we rely on reporting by bank holding companies (BHCs) in the FRY9c reports which do report consolidated data for the group. Over time federal regulators have given strong incentives and in some cases require large banking groups to be structured as BHCs.

In the FRY9c data the main variables of interest for us have been reported on a consistent basis since 1986. However, over time additional variables have been included in the report that have increased considerably the reporting burden for BHCs. One reason for making the reports more complex is that many banks have become more complex. In particular since the passage of the Gramm–Leach–Bliley Act of 1999 the scope grew for banks to generate income in securities origination, trading and sales and well as in insurance underwriting. While some banks actively pursued these activities they tended to be the larger BHCs. Many banks continued to concentrate their activities in traditional credit intermediation and strongly objected to the increased reporting complexity. In response, the Federal Reserve has waived the FRY9c reporting requirement for BHCs with total assets below a reporting threshold, and this threshold has been raised repeatedly— from $150 million of total assets to $500 million in 2006, from $500 million to $1 billion in 2015 and from $1 billion to $3 billion in 2018. This resulted in noticeable drops in numbers of reporting BHCs at those times (see a discussion of this in Appendix A.2). In order to have measures of banking structure on a consistent basis since 1986 we have confined our analysis to banks that have had total assets considerably greater than $3 billion. Specifically we include a BHC only if it is "large" by which we mean it had total real assets (valued in 2002 dollars) of at least $8 billion in at least one year in the sample . A further reporting issue is that a single banking group may be organized as a hierarchy in which one BHC may have a subsidiary which is itself a BHC reporting with FRY9c. In order to avoid double counting within such banking groups, we retain only the BHC at the top of the hierarchy.

As discussed in detail in Appendix A.2 the evolution of US banking structure looks very different when approached at the level of reporting BHCs as compared to analyzing structure using Call Reports. The number of federally licensed banks has declined markedly since the mid-1980s. In contrast, the number of BHCs rose between 1986 and 2005. And after correcting for the change in the reporting threshold in 2006, there was an increase in number of BHCs between 2006 and 2014. (See Fig. A.1). Viewed from another perspective the number of bankers in large BHCs rose from 1 million full-time equivalent employees (FTE) in 1986 to 2 million FTEs in 2019. Over the same period the mean number of FTEs per BHC went from 7000 to 17,000. Finally, under the influence of very active bank consolidation set off by the removal obstacles to interstate banking, there was a marked concentration of activity starting in 1997 which resulted in a dramatic increase in concentration as measured by the 4-firm concentration measured by numbers of employees or by total revenues. However, since the financial crisis banking market concentration has fallen as large investment banks and subsidiaries of large foreign groups joined the fold of US bank holding companies. (See Fig. A.2).

We now consider how bankers' pay has evolved in the US over three decades since 1986 in the light of the consolidation process we have reviewed. The main variables that we will use are set out in Table 1 where we have also reported summary statistics.

As suggested in the literature reviewed in Section 2, this consolidation process may have set off a competition for talent in the light of complementarity between talent and firm capital, the so-called "super-star" effect. Previous literature has raised some doubt about whether the super-star effect operates in the financial sector. In particular Autor et al. (2020) argue that the emergence of superstar firms will coincide with a decline in labor's share for the industry as a whole, something which they say has not occurred in the financial sector as calculated in the US National Product and Income Accounts. The evidence examined by Autor et al. (2020) covers the whole of financial sector which aggregates credit intermediation (including banks and savings and loans associations), insurance, securities and derivatives brokerage, origination, and advisory. In order to focus specifically on the banking sector we have used FRY9c data to measure labor's share of value-added calculated at the consolidated bank holding company level.[5]

The left panel in Fig. 1 reports the evolution the median labor's share of BHC value-added each year over 1986 to 2019. This is calculated separately for large BHCs and small BHCs using the classification introduced above. In contrast with Autor et al. we find a marked decline in labor's share between the late 1980's through 1997. Then between 1998 and 2006 it remained relatively constant, particularly for large BHCs. During the financial crisis of 2007–2008 there was a very sharp increase in labor share. Subsequently, it has fallen steadily so that in 2019 lay eight percentage points below level of 1997.

The decline in labor's share in BHCs between 1986 and 1997 coincides with the first large wave of bank consolidations as seen in the decline in the numbers of licensed banks in Fig. A.1. This was also the period of increased banking market concentration of the top-4 BHC's as seen in the right panel of Fig. A.2. Taken together this is consistent with the hypothesis of superstar banks beginning to emerge in the period when changes in regulation opened the way for a national market for banking services. Then, as discussed above, this process took on a different dimension with the passage the Gramm–Leach–Bliley Act of 1999 which allowed combining retail with wholesale banking and other financial services in new, larger and more complex group structures. It was further shaped by the financial crisis of 2007–2008 and the subsequent strengthening of banking supervision and capital regulation.

The increased complexity of banking groups is reflected earnings from the diverse wholesale banking activities summarized in non-interest income expressed share of a bank's total earnings The right panel of Fig. 1 shows the evolution of the distribution of non-interest income share (*niish*) in large BHCs. The median non-interest share has hardly changed since 1986, hovering in the range of 25 to 28 percent. However, the cross-sectional distribution of niish has grown more right skewed over the sample period. The mean value of niish (blue diamonds) rose from 28 percent in 1986 to 36 percent in 2009 and has declined slightly subsequently. However, in the 90 percentile bank (yellow Xs) the non-interest income share, which was 40 percent in 1986, rose to 65 percent in 2006 and then, following a dip during the financial crisis, continued to rise and stood at 77 percent in 2019. Thus, over three decades the US banking has seen the emergence of a segment of banks whose business model is concentrated on the generation of non-interest income.

[5] Value-added of a bank is calculated as the sum of total compensation (BHCK4135) and net income (BHCK4340). Total labor share is calculated as total compensation (BHCK4135) divided by value-added.

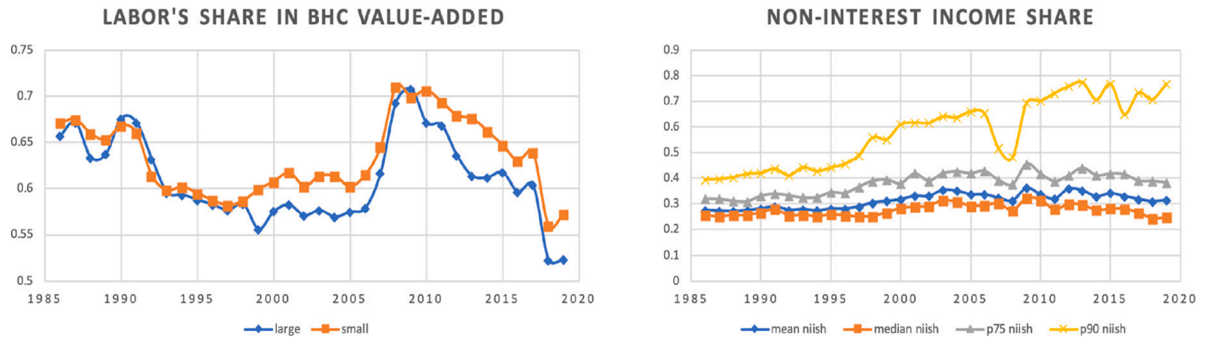

Fig. 1. Median Labor's Share and Non-interest Income: The left panel gives the evolution of median labor share of value-added in bank holding companies (BHCs) reporting to the Federal Reserve. Labor's share of value-added is calculated as the ratio of total pay to the sum of total pay plus net revenues, or bhck4135/(bhck4135+bhck4340). bhck44135 is salaries and employee benefits in the BHC. bhck4340 is net income (loss) in the BHC. The blue-diamond curve reports labor value added for *large* BHCs. The red-square curve reports labor value added for *small* BHCs. *large* BHCs are those that report total real assets of at least 8 billion dollars in at least one year end over 1986–2019. *small* BHCs are all other reporting BHCs. The right panel reports the evolution of net interest income (*niish*) between 1986 and 2019. *niish* is the ratio of non-interest income and the sum of non-interest income and net interest income as reported yearly for *large* BHCs. The blue-diamond curve reports the mean of *niish*. The red-square curve reports the median of *niish*. The gray-triangle curve reports the 75th percentile of *niish*. The yellow-X curve reports the 90th percentile of *niish*. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 1

Summary Statistics of Main Variables: All variables are expressed for a given entity in a given year. As explained in the text we calculate these statistics for *large* BHCs that are at the top of the organization if the BHC is hierarchical. *wage_r* is the mean total real compensation per employee expressed in thousands of 2002 dollars. *dlnwager* is yearly percentage change of average real compensation. *totlabshvalad* is total labor share of value-added. Value-added of a bank is calculated as the sum of total compensation (BHCK4135) and net income (BHCK4340). Total labor share is calculated as total compensation (BHCK4135) divided by value-added. *lntar* is the log of total real assets (thousand 2002 dollars). *niish* is the share of non-interest income in bank's total revenues. *incrperemp* is real revenues (million 2002 dollars) per employee. *atrperemp* is real assets (millions of 2002 dollars) per employee. *dlnincr* is yearly percentage change of total real revenues. *dlnvaladr* is yearly percentage change of real value-added. *tal1* is the model implied talent of the BHCs managers in a given year as explained in the text.

Short name	Description	N	Mean	SD	p25	p50	p75
wage_r	mean pay per banker	4442	58.713	30.601	41.907	50.855	66.990
dlnwager	log change of pay per banker	4154	0.023	0.147	−0.023	0.020	0.064
totlabshvalad	labor share of value-added	4443	0.580	1.340	0.536	0.607	0.682
lntar	log of toral real assets	4443	16.226	1.605	15.286	16.069	17.069
niish	non-interest income share	4443	0.311	0.181	0.200	0.272	0.377
incrperemp	real income per banker	4442	0.281	0.150	0.202	0.243	0.306
atrperemp	total real assets per banker	4442	4.030	2.589	2.535	3.305	4.502
dlnincr	log change of BHC net revenues	4155	0.067	0.181	−0.026	0.053	0.138
dlnvaladr	log change of BHC value-added	4030	0.093	0.314	0.010	0.082	0.173
tal1	benchmark calibrated talent	4356	0.196	0.110	0.122	0.185	0.244

Taking the two panels of Fig. 1 together we have a pattern of a move by BHCs into non-interest income earning activities coinciding with the continuing consolidation of banks into larger entities in the ten years to 2006. This suggests the hypothesis that over this period the stability of labor's share of value reflects a balance between two opposing forces— the trend toward large banks which tended to reduce labor's share and the increased complexity which forced the larger banks to respond by hiring more bankers and, possibly, more skilled bankers. This balance was upset by the arrival of the financial crisis, with the result that labor's share rose sharply especially in large banks.

In order to better capture the combined effects of consolidation and increased complexity of banking business we consider regression analysis of labor share using the log of total real assets (lntar) as a proxy for size, non-interest income share (niish) as a proxy for complexity, and year fixed effects. Table 2 reports the results of multiple regressions of labor share on our size and complexity proxies plus year dummies. The regressions are run for the sample of large BHCs over the period 1986–2019. In both the OLS regression and in the panel regression we find a negative effect of size and a positive and highly significant effect of complexity. Overall these results give robust support for the hypothesis that consolidation has tended to reduce labor share in US banking but that the increased complexity of many banking groups has tended to mitigate this tendency or even have led to an increase in labor share.

We now turn to study pay level, the central focus in much of the literature reviewed in Section 2. Previous empirical work on bankers' pay has focused on senior management and on CEO pay in particular. This focus on top management has been largely driven by the availability of data, in particular as reported in the Execucomp data set. Our data set based on the FRY9c reports

Table 2
Regressions of Total Labor Share: Dependent variable, total labor share of value-added, *totlabshvalad*, winsorized at 1% and 99%. Regressors *lntar*, *niish*. Subsample of *large* BHCs and top of a hierarchical group structure if applicable. *t* statistics in parentheses. Robust standard errors. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	(1) mean(ols)	(2) panel
lntar	−0.00984* (−2.27)	−0.0343 (−1.71)
niish	0.372*** (8.01)	0.524** (3.13)
_cons	0.653*** (9.42)	0.972*** (3.37)
Fixed Effect	year	year, entity
Winsorized	(0.01, 0.99)	(0.01, 0.99)
R-sq	0.053	0.036
Nobs	4443	4443

Table 3
Evolution of Bankers' Pay Level Correlations: Pearson correlation coefficients of real pay per banker (*wage_r*) with log of total assets (*lntar*), real revenues per banker (*incrperemp*), total real assets per banker (*atrperemp*), and non-interest income share (*niish*). Subsample of *large* BHCs and top of a hierarchical group structure if applicable.

period	1986–1994	1995–1999	2000–2010	2011–2019
lntar	0.167	0.3594	0.3559	0.3856
incrperemp	0.8259	0.7856	0.4806	0.657
atrperemp	0.88	0.685	0.3854	0.601
niish	0.2574	0.4549	0.4505	0.4654

Subsample of *large* BHCs

allows us to look at pay levels for a wider set of managers. For us the main measure of bankers' pay level is the average total compensation per banker within a given BHC in a given year, expressed in thousands of 2002 dollars (*wage_r*).

One of the main empirical regularities regarding CEO pay is that it tends to be increasing in the size of the firm. It is not obvious what accounts for this positive correlation. One possible explanation that CEOs are rewarded for creating a larger firm in the hopes of operating at a higher scale and with higher profits in the future. However this explanation is less likely to apply to managers below top management, the focus of our study. In that context, compensation may be linked to productivity. For that reason we examine two standard measures of labor productivity— total revenue per banker (million 2002 dollars per FTE) and total real assets per banker (million 2002 dollars per FTE). Another possible driver of compensation suggested by the massive restructuring of banking in the US since 1986 is the increased complexity of banking. As a proxy for this we employ non-interest income share (*niish*) introduced above.

Table 3 reports the correlation between the mean real compensation per banker in a given BHC (*wage r*,), with that BHCs size (*lntar*), revenue per banker (*incperemp*), assets per banker (*atrperemp*), and complexity (*niish*) over 4 periods with breaks corresponding to the regulatory changes described above.[6] It is notable that pay level correlations with productivity variables are greater than correlations of pay level and bank size. Also, there was a clear increase in correlation with complexity following the implementation of the Interstate Banking Act in 1994. This discussion suggests that the evolution in banker pay levels in the US may reflect changes both in banker productivity which has resulted from the consolidation in banking that was described and also from the shift in banking away from traditional credit intermediation and toward activities generating non-interest income.

To assess the effect of these factors on the level of bankers' pay we again use regressions based on the data set restricted to large BHCs which are at the top of a banking group hierarchy if there is one. Table 4 reports the results.

In columns 1 and 2 of the table we report the regressions of pay level on log of total assets and year fixed effects but omitting the productivity and banking type measures. In the least squares regression we find a strong positive relation between bankers' pay level and bank size; whereas, in the panel regression we find a negative but insignificant size effect. When we run the regressions including our productivity measures and our proxy for type of bank business model (columns 3 and 4), the pure size effect disappears. In contrast the coefficients of the productivity variables are both positive and significant in both the OLS and panel regressions. The proxy for complexity (*niish*) enters positively in both regressions and is highly significant in the OLS regression. The fact that it is insignificant in the regression with entity fixed effects may be attributable to business type changing slowly in any given reporting

[6] Interstate Banking Act of 1994, Gramm–Leach–Bliley Act in 1999, and Dodd–Frank Act in 2010.

Table 4

Bankers' Pay Level Regressions: Dependent variable, real pay per banker (*wage_r*). Regressors, log of total assets (*lntar*), real revenues per banker (*incrperemp*), total real assets per banker (*atrperemp*), non-interest income share (*niish*) and year fixed effects. Subsample of *large* BHCs and top of a hierarchical group structure if applicable. *t* statistics in parentheses. Robust standard errors. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Columns 1 and 3, year fixed-effects . Columns 2 and 4, year and entity fixed effects.

	(1) mean(ols)	(2) panel	(3) mean(ols)	(4) panel
lntar	5.303*** (13.24)	−3.075 (−0.88)	−0.667 (−1.68)	−4.141 (−1.80)
incrperemp			37.91* (2.30)	60.22* (2.42)
atrperemp			5.824*** (7.36)	4.115*** (3.38)
niish			66.22*** (12.63)	15.19 (1.43)
_cons	−41.18*** (−6.47)	88.38 (1.73)	9.232* (2.06)	71.91** (2.61)
Fixed Effects	year	year, entity	year	year, entity
Winsorized	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)
R-sq	0.254	0.346	0.671	0.631
Nobs	4442	4442	4442	4442

Table 5

Bankers' Pay Sensitivity: This reports the Pearson correlation coefficients of the yearly log change in bankers' pay (*dlnwager*) with the yearly log change of BHC net real income (*dlnincr*). Column 1 reports correlations over the full sample period. Column 2 reports correlations for 1987–1994. Column 3 reports correlations for 1995–1999. Column 4 reports correlations for 2000–2019. Column 5 reports correlations for 2011–2019. The first row includes all *large* BHCs. The second row includes *large* BHCs reporting low levels of non-interest income (*niish* < *0.4*). The third row includes *large* BHCs reporting high levels of non-interest income (*niish* > *0.4*).

period	(1) 1987–2019	(2) 1987–1994	(3) 1995–1999	(4) 2000–2010	(5) 2011–2019
all niish	0.233	0.050	0.420	0.174	0.395
niish < 0.4	0.251	0.163	0.341	0.152	0.417
niish > 0.4	0.187	−0.184	0.714	0.231	0.259

BHC and at the same time assets and revenues gravitating toward BHCs concentrating on fund management, investment banking and market making.

The final aspect of bankers' compensation that we explore in this section is its sensitivity in relation to the performance of the bank. Our key variable of interest is the yearly percentage change in mean compensation in a given BHC, specifically *dlnwager*. Broadly speaking this may be thought of as the size of the change of the bonus pool. We study this in relation to the yearly percentage change in total real revenues (*dlnincr*).

Table 5 reports this correlation for the data set of all large BHC's over the whole period covered and also for subsamples. The first row reports this correlation for the set of all large BHC's. For the full sample,1987–2019, the sensitivity of the bonus pool was 23 percent. Prior to the Interstate Banking Act, it was noticeably lower– only 5 percent. Once the consolidation process and the move toward non-interest income generation gained momentum the pay sensitivity was higher. In the second and third rows of the Table we report sensitivities separately for banks focused on traditional intermediation (*niish* < *0.4*) and banks pursuing high levels of non-interest income (*niish* > *0.4*).

The fact that we find in the pre-Dodd–Frank period that pay sensitivity is higher in banks with relatively high non-interest income is probably in line with what most analysts of US banking would expect. However, the sharp rise in the post-Dodd/Frank period for banks with relatively low non-interest income is more surprising. We will return to this issue in Section 5 where we will use our structural model to characterize the implications for US banks of regulatory changes brought on by the financial crisis.

5. Calibration

In this section we see whether the structural model of Section 3 is able to reproduce the principal empirical regularities we have reported in Section 4. In any given year we suppose that the banking sector is in an equilibrium where a bank of a particular size is matched in rank order with a management team of a given talent. Pay for the management team is that set out in the second best contract between shareholders and management. In our benchmark calibration we assume all banks have the same technology so that differences in pay and returns to shareholders in the cross-section of banks are determined by the distributions of bank size and management talent. Changes in pay and shareholder returns are determined by changes in the distributions of bank scale and of talent, which reflect the changes in banking structure and technical change in the economy more broadly. In extensions we make allowances for some limited changes in technology to capture the possible changes in bank complexity.

5.1. Calibrating pay sensitivity

We start by calibrating pay sensitivity which in the model introduced in Section 3 takes a particularly simple form. The solution of optimal pay sensitivity for *management*, was given in Eq. (3) which states $w_1 = (\alpha_m + \alpha_l)/(1 + \alpha_l)$. The sensitivity of average pay to *all* bankers (management and labor combined) will depend upon the relative amounts of pay to labor and to management. In Appendix A.1 it is shown that under the second best contract management makes a labor choice that results in a total amount of labor given by (A.9), which we repeat here,

$$L = \frac{\alpha_l w_1}{w_l} V \tag{16}$$

In our model the contribution of management toward value-added is the product of effort and talent, $M = aT$. This is a skill-adjusted measure of the contribution of manager's effort. In our context it is natural to consider that the manager's effort is measured in the same units as those of fixed wage labor, such as hours worked per period. In our bank regulatory data these are FTE work-years. As a consequence we assume bank's total workforce in FTE's (bhck4150) is a proxy for $a + L$. The second-best choice of a under shareholder-value maximization was found in (A.7) as

$$a = \frac{\alpha_m w_1}{g} V \tag{17}$$

Thus,

$$\frac{a}{L} = \frac{\alpha_m}{\alpha_l} \frac{w_l}{g} \tag{18}$$

We suppose that leisure time for a skilled banker is as valuable as leisure time for a fixed-wage banker and that fixed-wage bankers work just to the point where they are indifferent between a marginal unit of work or leisure. Thus we assume $w_l = g$ which implies,

$$\frac{a}{L} = \frac{\alpha_m}{\alpha_l} \tag{19}$$

With this the fraction of managerial labor in total labor is,

$$\frac{a}{a+L} = \frac{\alpha_m}{\alpha_m + \alpha_l} = \frac{\alpha_m}{1 - \alpha_k} \tag{20}$$

Based on these relations, the starting point of our calibration is to set the values of α_k and α_m. Recent research on aggregate production functions find estimates of capital's share in the range of 0.25 to 0.4 (see, Barkai, 2020; Rognlie, 2015). We adopt $\alpha_k = 0.3$ in our benchmark calibration.

The literature on aggregate production functions typically considers a homogeneous labor input, whereas our model splits the workforce into homogeneous labor and management teams with heterogenous talent. The distinguishing feature of management is that its compensation contains an element of incentive pay. While there is an extensive literature on incentive pay of top management, research on incentive pay for employees below the C-suite is extremely limited, largely for want of publicly available data. A recent exception is the study of Eisfeldt et al. (2022) which builds on the NBER-CES data set to provide estimates of stock-based compensation for skilled labor in manufacturing firms. They document a rise in stock-base compensation over recent decades. They estimate that the high-skill share of labor income rises from about 1/3 to 2/3 over the five decades from the 1960's.

The management literature on compensation documents the wide variety of types of incentive pay that are in use. These range from bonus payments (in cash or kind) based on firm and/or individual performance metrics, fixed pay raises, as well as awards of stock or stock options. Some publicly disseminated reports of compensation consultants give some information about the extent of use of pay incentives in the financial sector. For example in its annual financial survey of financial sector compensation eFinancial.com reported that in 2023 typical bonuses ranged from 42,000 USD for a level 1 analyst to 308,000 USD for a director. The same report states that overall average bonus constituted 42.5 percent of a bankers' total compensation.[7]

In light of these observations we can fix the values of share parameters for our benchmark calibration and see what that implies for pay sensitivity.[8] In particular, we set the benchmark management share of total bank labor as $\alpha_m/(1 - \alpha_k) = 0.3$. Given $\alpha_k = 0.3$, this implies $\alpha_m = 0.21$ and $\alpha_l = 0.49$. This seems reasonable. For example, if mean management pay is 3 times the level of fixed wage labor, it would mean that management share of total compensation would be (.21*3/(.21*3 +.49) = 0.5625, which is within the (1/3, 2/3) range found by Eisfeldt et al. Assuming a lower total pay multiple for managers versus labor would lower management share of total compensation but it would still be within that target range.

With these results we can find the implied sensitivity of aggregate compensation per FTE. Using Eq. (3), the expression for equilibrium compensation sensitivity of management, we find,

$$w_1 = \frac{\alpha_m + \alpha_l}{1 + \alpha_l} = \frac{0.7}{1 + 0.49} \approx 0.47 \tag{21}$$

[7] Z. Toulon, "Banking bonuses: The Situation in 2024, www.efinancialcareers.com downloaded 1/6/2025.

[8] See a further discussion of calibration of the firm's technology in Appendix A.4.1 and especially Table A.2 which gives the correspondence of firm technologies to pay sensitivities.

Since the pay sensitivity of fixed wage labor is zero we find the implied sensitivity of total compensation per FTE is given as $w^{tot} = 0.3 \times 0.47 = 0.141$. This is slightly less than the correlation between yearly percentages changes of bankers' pay and bank value-added which was 0.174 as reported in Section 4 for the middle of our sample (2000–2010) and including all large BHCs. In that section we found evidence that pay sensitivity differs between banks with low shares of non-interest income and those with high shares of non-interest income. In light of this we consider alternative combinations of parameters of our model. For banks with $niish < 0.4$, we consider $\alpha_k = 0.3$ and $\alpha_m = 0.175$ which implies $w^{tot} = 0.1148$. For banks with $niish > 0.4$ we set $\alpha_k = 0.2$ and $\alpha_m = 0.32$ which implies $w^{tot} = 0.2162$. These sensitivities are relatively close to the empirical sensitivities found in Table 5 for mid-sample (2000–2010) for $niish < 0.4$ and $niish > 0.4$ respectively.

5.2. Calibrating model implied talent

In our model managerial talent is assumed to be known to shareholders; however, it is not directly measured in our data set. So we use our model to find talent implied by the model and observable variables. In Section 3.3 firm value-added under the second-best contract is given by (15). This can be written as,

$$G(K,T) = C(\alpha_m, \alpha_l, \alpha_k, g, w_l) T^{\alpha_m/\alpha_k} K \tag{22}$$

where,

$$C(\alpha_m, \alpha_l, \alpha_k, g, w_l) = \left(\left[\frac{\alpha_m + \alpha_l}{1+\alpha_l}\right]^{(\alpha_m+\alpha_l)/\alpha_k} - \alpha_l \left[\frac{\alpha_m + \alpha_l}{1+\alpha_l}\right]^{(1/\alpha_k)}\right)\left(\frac{\alpha_m}{g}\right)^{\alpha_m/\alpha_k}\left(\frac{\alpha_l}{w_l}\right)^{\alpha_l/\alpha_k} \tag{23}$$

(see, details in Appendix A.1). For $0 < \alpha_m < 1$, $0 < \alpha_l < 1$, $0 < \alpha_k < 1$ and $\alpha_m + \alpha_l + \alpha_k = 1$ the first term in parentheses on the RHS of (23) is strictly positive.

For now we assume that for all large BHCs the parameters α_m, α_l, and α_k are identical across banks, that all banks face the same rate for labor, w_l, and that the marginal cost of effort, g, is identical for all managers. Furthermore, we assume that in each year, banks are arranged in matching equilibrium as described in Section 3.3. Then the value-added of the i'th percentile bank is,

$$G(K_{it}, T_{it}) = C(\alpha_m, \alpha_l, \alpha_k, g, w_l) T_{it}^{\alpha_m/\alpha_k} K_{it} \tag{24}$$

This is increasing in T_{it} and K_{it}, proportional to K_{it} and convex (concave) in T_{it} for $\alpha_m > \alpha_k$ ($\alpha_m < \alpha_k$). $C(.)$ is decreasing in g and w_l.[9]

Note that here we allow for the capital of the i'th firm and the talent of the i'th manager to vary with time. That is, the *distribution* of bank sizes is allowed to change over time reflecting the entry, exit and consolidation of bank holding companies. And the distribution of management team talent is also allowed to vary, reflecting the entry and exit of bankers with varying skill sets and evolution of management organizations.

We can find observable proxies for firm size within the FRY9c data set that allow us calibrate $k(.)$, the profiles of K_{it}. Total assets and total shareholder capital are likely candidates and produce profiles that are qualitatively very similar (see, Fig. 2). We use total real shareholder capital here.

We can use relation (24) to find an expression for talent in terms of value-added and size. Specifically, we obtain,

$$T_{it} = c^* \times (Y_{it}/K_{it})^{(\alpha_k/\alpha_m)} \tag{25}$$

where c^* is constant positive scaling factor which we normalize to 1. Y_{it} is the measured value-added of bank i in a given year t and K_{it} is total shareholder capital in year t.

What are the properties of talent implied by this relation? Given the right skewed distributions of bank capital found in Fig. 2 we may suspect that the model implied talent would be similarly right-skewed. This is indeed the case. Fig. 3 presents kernal estimates of the implied talent distributions for large BHCs over our sample period 1986–2019 divided into four sub-periods: 1986–1994, the run-up to the Interstate Banking Act;1995–1999, ending with the Gramm–Leach–Bliley Act;2000–2010, the period of emergence of very large, complex banks and ending with the financial crisis; and 2011–2019, the post-Dodd–Frank period. These use *tal1*, the implied talent obtained by using Eq. (25) with the benchmark parameters, $\alpha_k = 0.3$ and $\alpha_m = 0.21$. This is calculated for large BHCs, and we have Winsorized the result at 1% and 99%. In each period the resulting distribution is right-skewed. What is notable is that it has become progressively more so over time. This is support for the view that, in step with the process of consolidation of banking, there has been a process of sorting out bankers of varying talent. The result would suggest that over time the data should conform increasingly to the matching of talent and size predicted by the superstar firm hypothesis.

A further insight into the distribution of talent is given in Fig. 4 where we have plotted realized talent against log real assets in the four sub-periods related to regulatory changes. These cross sections exhibit a distinct positive relation between talent and size for the first three periods. However, in the post-Dodd–Frank period there is an essentially zero slope to the talent/log size relation. And it is notable that in all four periods some of the banks with the highest levels of measured talent were medium sized banks and that the largest banks were far from having the highest levels of model implied talent. Inspection of the outliers reveals that often the somewhat smaller banks with high implied talent had high levels of trust business and appeared to specialize in private banking.[10]

[9] In Appendix A.4.2 we extend the analysis to allow for g and w_l to be time varying.

[10] In post-Dodd–Frank period Silicon Valley Bank produced some of the outliers.

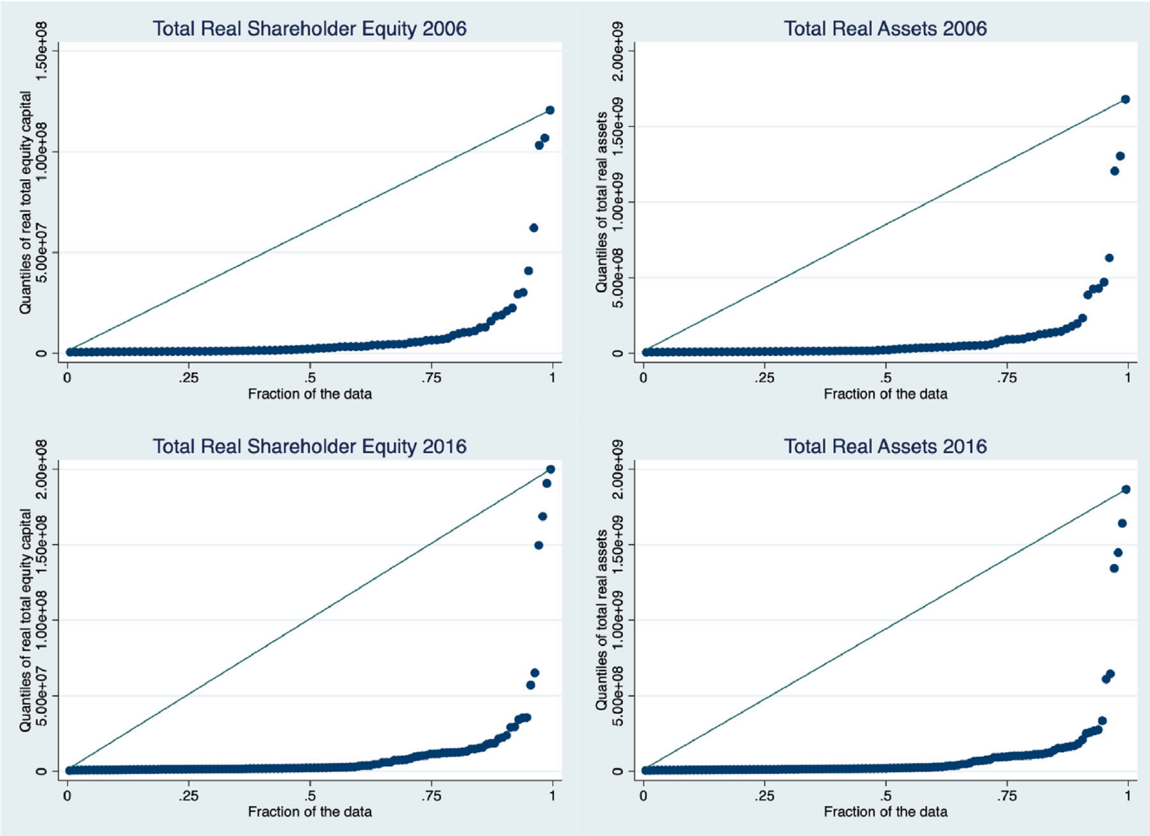

Fig. 2. Bank Size Profiles: The graphs report the quantiles of two measure of the size of *large* BHCs at two dates. The left panels give the percentiles of total equity capital. The right panels give the percentiles of total real assets. The top panels report size percentiles for 2006. The bottom panels report size percentiles for 2016.

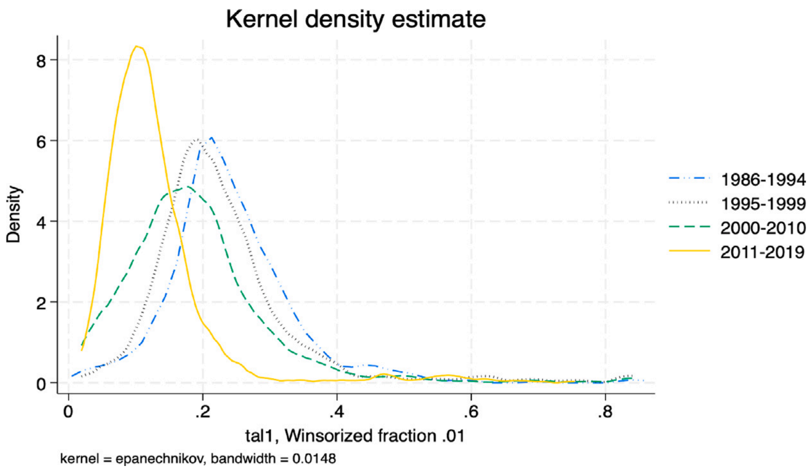

Fig. 3. Banker Talent Distributions: This graphic presents the evolution of the distributions of implied manager talent under our benchmark calibration (*tal1*) of *large* BHCs for four subsamples between 1986 and 2019. The blue-dash–dot–dot curve is 1986–1994. The gray-dot curve is 1995–1999. The green-dash curve is 2000–2010. The yellow-solid curve is 2011–2019. The modes of the distributions moved to the left successively from 2.2 (1986–1994) to 1.9 (1995–1999) to 1.8 (2000–2010) to 1.6 (2011–2019). The underlying values of *tal1* have been winsorized at the 1% and 99% levels.

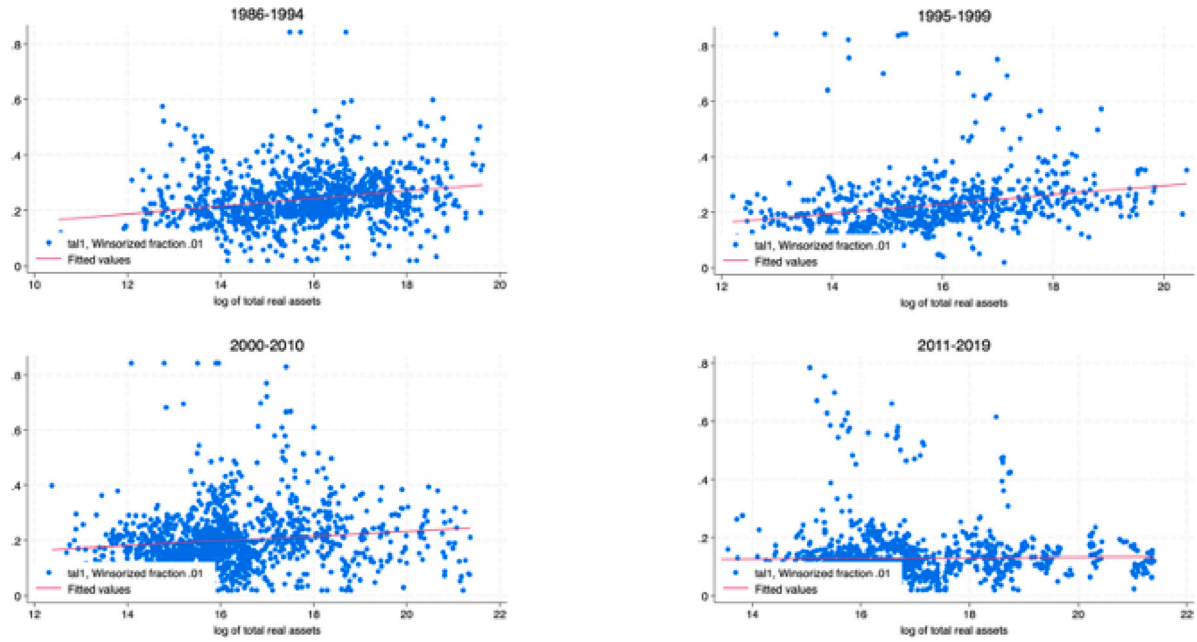

Fig. 4. Banker Talent Profiles: This graphic presents two-scatter plots of implied manager talent under our benchmark calibration (*tal1*) and log or real assets for four subsamples between 1986 and 2019. This is based on the set of *large* BHCs. The underlying values of *tal1* have been winsorized at the 1% and 99% levels.

More generally, these relations suggest that the combined forces of concentration, the opportunity to merge credit intermediation and non-interest income generating activities, and re-regulation following the financial crisis led banking groups to adopt a diversity of strategies. And these diverse strategies give rise to a wide range of performance results that are reflected in our estimates of managerial talent.

5.3. Calibrating pay level

Next we use our structural model to shed light on the *level* of managers' compensation. In particular we explore the extent to which variations in T_{it} calibrated under our benchmark parameters can serve as a proxy for the productivity variables used in pay level regressions presented in Section 4 and thus may account for variations in the level bankers' pay. The results are reported in Table 6.

Column 1 presents the results of the OLS regression of *wage_r* on bank size, $niish$, $tal1$ (our benchmark implied talent variable) and year dummies. This covers the entire period of 1986–2019 and all large BHCs. The coefficients of $lntar$ and $niish$ are positive and significant. The model implied talent measure enters positively and is significant. The R-square is 0.386 which is less than 0.671, the fit obtained in the pay level regression with productivity variables, Table 4, Column 3. Overall this regression suggests that the empirical talent measure constructed using the calibrate structural model does serve as a decent proxy for the ex-post productivity measures we used to characterize bankers' pay level.

Column 3 of Table 6 reports the OLS regression results based on the subset of observations for $niish < 0.4$ banks. In this regression we use the talent proxy $tall$ based on model parameters calibrated to the lower pay sensitivity observed in low non-interest income banks. This talent proxy enters positively and is highly significant.

Column 5 reports the OLS regression for the subset of BHCs with $niish > 0.4$ and uses the model implied talent measure $talh$ which is based on the model parameter calibrated to relatively higher pay sensitivity. Size, $niish$ and talent all enter positively. While size and $niish$ are highly significant, the talent proxy is not.

We have run the pay level regression with talent also using panel regression with entity fixed effects. The results are reported in Table 6 Columns 2, 4 and 6. The patterns of signs of coefficients are very similar as those in the OLS regression. However, with one exception, the coefficient estimates are insignificant. In effect, for a given BHC the observed changes in bank capital, business models and management structure have not been great enough to bring about major changes in bankers' pay. How can this be squared with the major consolidation of the US banking sector as discussed in Section 4? This suggests that the major drivers of changes in pay levels have been felt by relatively few, often new, highly capitalized banks that have adopted the holding company structure and adopted complex management structures. (See also the Appendix A.3.)

In order to gain further insight on how changes in US banking structure have impacted bankers' pay, it is useful to look at the evolution of the *distribution* of talent over the three decades from 1986. Fig. 5 is a plot of the percentiles of talent ($tal1$) of the set

Table 6

Bankers' Pay Level and Talent: This table reports regressions of real pay per banker (*wage_r*) on bank size (*lntar*), non-interest income share of net revenues (*niish*), year fixed effects, and model calibrated talent winsorized at 1% and 99% . Columns 1 and 2 report regressions with talent based on our benchmark calibration (*tal1*) includes all *large* BHCs. Column 3 and 4 report regressions for the subset of BHCs reporting low levels of non-interest income and use the talent measure calibrated to that subsample (*tal1l*). Columns 5 and 6 report regressions for the subset of BHCs reporting high levels of non-interest income and use the talent measure calibrated to that subsample (*tal1h*). Columns 1, 3 and 5 include year fixed effects. Columns 2, 4, and 6 include both year fixed effects and entity fixed effects. t statistics in parentheses. Robust standard errors. * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

	(1) wage_r OLS pooled	(2) wage_r panel pooled	(3) wage_r OLS $niish < 0.4$	(4) wage_r panel $niish < 0.4$	(5) wage_r OLS $niish > 0.4$	(6) wage_r panel $niish > 0.4$
lntar	2.658*** (9.13)	−0.730 (−0.35)	2.088*** (7.96)	0.449 (0.30)	8.195*** (10.32)	2.128 (0.52)
niish	52.09*** (11.02)	18.19 (1.91)	−16.81*** (−3.92)	21.37 (1.65)	113.1*** (11.73)	21.01 (1.16)
tal_w01	15.69* (2.48)	8.252 (1.25)				
tall_w01			27.78*** (4.32)	6.952 (1.04)		
talh_w01					15.16 (1.25)	44.78* (2.54)
_cons	−17.94*** (−3.82)	46.32 (1.41)	7.016 (1.60)	27.53 (1.14)	−140.9*** (−8.23)	−23.16 (−0.31)
Fixed Effects	year	year, entity	year	year, entity	year	year, entity
Winsorized	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)
R-sq	0.386	0.434	0.312	0.586	0.411	0.421
Nobs	4355	4355	3447	3447	908	908

of large BHCs. Starting from 1986 there was a moderate decline of 25th percentile and 50th percentile of the talent distribution but less so for the 75th and 90th percentiles. That is, the distribution was becoming increasingly right skewed as already seen for the four sample subsets depicted in the talent distributions plotted in Fig. 3. This is consistent with the view that in the consolidation of the banking sector more talented banking teams were gravitating toward better capitalized banks. This continued until 2006 at which point there was a sharp drop during the financial crisis, with the biggest drop in model implied talent at the 90th percentile. Then from 2010 until 2019 there was some recovery of talent measured at the 25th and 50th percentiles but at the 75th and 90th percentiles the talent trend has been flat. Recalling that talent implied by our model is driven in large part by bank value-added, this is very consistent with the widespread view that the financial crisis was felt most by some bankers taking high risk which produced good results for a time but very poor results when stressed.

In light of the regulatory response to the financial crisis which targeted large, complex banks it is interesting to see if there was a permanent change in the determinants of pay level. We explore this by reconsidering our pay level regressions for two sub-periods: 1986–2006, prior to the onset of the financial crisis, and 2011–2019, the aftermath of Dodd–Frank. The results are reported in Table 7.

What is striking is that the pre-crisis results for complex banks ($niish > 0.4$) in Table 7, Column 3 are in line with the results for the full sample (Table 6, Column 5). In particular size, $niish$ and talent all enter positively. However, in the post-crisis subsample the results have changed. The coefficient on $niish$ is much higher than in the pre-crisis period. And the coefficient of talent is *negative*. One possible interpretation of this is to say that tougher, post-crisis regulation pushed the larger, more complex banks to build up their management devoted to risk management and dealing with regulatory affairs. This required a different and expensive skill set that did not translate into talent as measured by our model implied talent which was driven by the bank's value-added performance. We return to this argument in Section 5.4 where we discussion what the calibrated model can say about labor's share of value-added.

Another way of asking whether the transformation of the banking sector through the creation of larger, more complex banks has driven changes in bankers' pay is to ask how much of the observed rise of bankers' pay can be accounted for by our calibrated model? One answer to that question is given in Fig. 6. There we have compared the year fixed effects from our pay level regression using productivity variables with the pay level regressions using talent and also with a regression using year fixed effects only. The figure reports the results for these regressions on the segment of our large BHCs with business models oriented toward generating non-interest income ($niish > 0.4$).

The solid line gives results of the pure year effect regression. It documents the strong upward trend in average bankers' pay with average pay per banker in 2019 exceeding the 1986 level by 60 thousand 2002 dollars. In the regression of pay using bank size, non-interest income share, and the productivity proxies ($incperemp$ and $atarperemp$), the year fixed effects (dot–dash line) follow more moderate upward trend which reaches about 16 thousand 2002 dollars by 2019. That is, the explanatory variables in that regression can account for 44 thousand of the 60 thousand dollars of average bankers' pay increase since 1986.

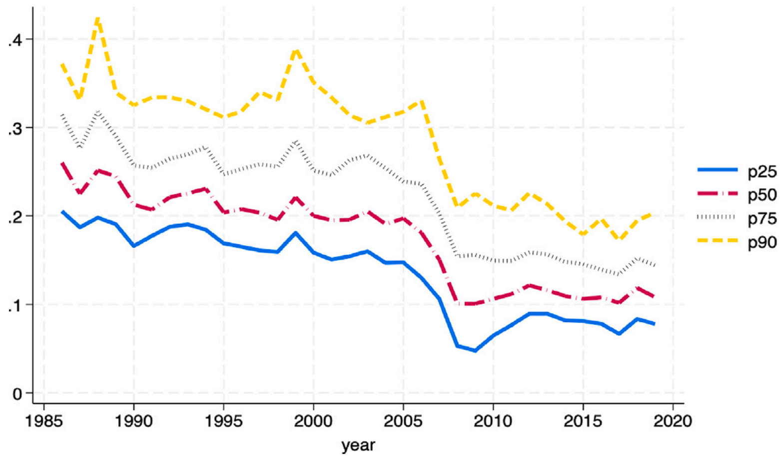

Fig. 5. Percentiles of Talent, tal1: This graphic presents the evolution of the cross-sectional distributions of implied manager talent under our benchmark calibration (*tal1*) between 1986 and 2019. The blue-solid curve gives the 25th percentile. The red-dash–dot curve gives the 50th percentile. The gray-dot curve gives the 75th percentile. The yellow-dash curve gives the 90th percentile. This based on the sample of *large* BHCs. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 7
Bankers' Pay Level Regressions with Talent by Sub-period: This table reports bankers pay level regressions using calibrated talent for two subperiods. Columns 1–3 report results for the period before the onset of the financial crisis (1986–2006). Columns 4–6 report results for the post-Dodd–Frank period (2011–2019). Columns 1 and 4 report results based on all reporting *large* BHCs and use the benchmark calibrated talent (*tal1*). Columns 2 and 5 report results based on the *large* BHCs reporting low levels of non-interest income and use *tal1l*. Columns 3 and 6 report results based on the *large* BHCs reporting high levels of non-interest income and use *tal1h*. Model calibrated talent winsorized at 1% and 99% *t* statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$. Robust standard errors.

	(1)	(2)	(3)	(4)	(5)	(6)
	wage_r	wage_r	wage_r	wage_r	wage_r	wage_r
Period	1986–2006	1986–2006	1986–2006	2011–2019	2011–2019	2011–2019
Segment	pooled	$niish < 0.4$	$niish > 0.4$	pooled	$niish < 0.4$	$niish > 0.4$
lntar	2.132***	1.663***	7.927***	5.035***	3.486***	8.002***
	(8.02)	(6.05)	(10.89)	(5.85)	(4.80)	(4.18)
niish	35.96***	−14.23***	100.9***	60.96***	−19.24*	121.5***
	(8.04)	(−3.34)	(9.61)	(6.07)	(−2.04)	(6.71)
tal1_w01	22.61***			14.23		
	(3.85)			(0.71)		
tal1l_w01		29.58***			64.28*	
		(5.15)			(2.53)	
tal1h_w01			20.31			−26.68
			(1.87)			(−0.84)
_cons	−7.030	12.69**	−133.3***	−35.33*	5.216	−113.2**
	(−1.61)	(2.65)	(−8.82)	(−2.57)	(0.45)	(−2.72)
Fixed Effects	year	year	year	year	year	year
Winsorized	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)
R-sq	0.271	0.126	0.415	0.282	0.089	0.259
Nobs	2887	2368	519	1087	810	277

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The time effects of the regression including bank size and non-interest income but where our model-based talent measure replaces the productivity proxies is given in the dashed line. Between 1986 and 1997 the time effects of that regression hover close to zero. That is, talent, size and business model account for most of the rise in average bankers' pay in that period. Following this, the time effects in the regression with talent declines until 2000. Then subsequently the time effects of the talent based regression rise in an upward trend in parallel with the pure time effects. What can account for this? An in-the-model explanation would be that the rise of the fixed effect after 2000 reflects an increase of the outside option for bankers. We do not think that this is at all implausible.

One needs only to look at the rapid rise since 2000 in private equity, venture capital and quantitative fund management to see concrete, attractive opportunities in finance outside the banking sector.

Before turning to ask what insight our calibrated model has for labor's share and the superstar firm effect, we note that our framework can be extended to study other questions regarding bankers' pay level. We do this in the Annex, Appendix A.4.2, A.4.3, and A.4.4.

In Appendix A.4.2 we allow for the value of the leisure, g, to vary yearly within our sample. We set $g_t = w_{lt}$ year by year and solve the model to obtain $tal1tv$, the model implied value of talent consistent with that changing opportunity cost of working. When we regress $wage\_r$ on firm size, $niish$ and $tal1tv$, we find results that are qualitatively very similar to those obtained using ***tal1*** in the OLS regression for the pooled sample in Table 6, column 1. When we compare the time fixed effects from the regression using $tal1tv$ with those from the regression using $tal1$, we find they are very close to one-another. This implies that that not much of the time trend in bankers' pay can be attributed to the increases over time of the cost of leisure as reflected in the labor force participation rate. See Appendix A.4.2 for details.

So far our calibration of bankers' pay level has focused on the average pay to all employees of a given BHC in a given year, as this can be directly calculated using the FRY9c data. However, our structural model distinguishes between fixed-wage labor and management which receives a combination of salary and incentive pay. It is reasonable to ask what have been the evolutions of those two categories of bankers' pay and whether changes in the distribution of management talent explain them. This done is in Appendix A.4.3 where we give a break-down of total compensation (BHCK4135) into total wages paid to labor and total compensation (wage plus incentive pay) to management. There we estimate the evolution of labor wages using an index constructed from the CES series of normal weekly wages of non-supervisory full-time employees. The resulting break-down shows that the evolution of fixed wage labor contribution to bank value-added shows a very regular secular decline between 1986 and 2019. In contrast the management share remained relatively constant from 1986 to 1999 then rose regularly in the post-Gramm–Leach–Bliley era. These results are similar to the findings reported in Eisfeldt et al. (2022) who compared share of labor value-added measured as salary versus pay including salary plus stock-based compensation. Thus we see that a similar pattern emerges when we distinguish fixed-wage pay with pay including incentive pay generally. We also explore the determinants of management pay using regression analysis both when productivity variables are included and when they are replaced using model-implied talent.

Finally, in Appendix A.4.4 we ask how pay for bankers below the C-suite compare with top management of the BHCs included in our data set. We study top management pay in the subset of the BHCs that are covered by Execucomp. We focus total compensation (*tdc1*) which includes salary, stock-based compensation as well as other forms of incentive pay. We consider both the mean tdc1 of all executives reported by Execucomp and the tdc1 of the CEO alone. We regress these alternative pay level measures on bank size, complexity and banker productivity variables to highlight similarities and differences in pay at different levels of the management structure. The overall finding is that the determinants of pay differ for top managers compared to lower-level managers. For top-level managers, and especially, CEO firm size is the single most important predictor of pay level. For managers at lower levels, productivity measures and bank complexity are the important determinants of manager pay and have strong positive effects. See Appendix A.4.4 for details.

5.4. Calibrating labor's share

In Section 4 we documented a secular decline of labor share of value-added in US banking over 1986–1997 which coincided with a period of rapid bank consolidation. This was consistent with the Superstar firm hypothesis applied to US commercial banking. Subsequently, labor share stayed relatively constant between 1998 and 2006 which coincided with the entry of a number of commercial banks into investment banking and fund management. Banks' labor share rose sharply from 2007 to 2010 but has fallen since 2011. We have argued that the course of labor's share could be understood as reflecting a process of consolidation that is still on-going but as modified by changes in the nature of banks' business as well as the increased regulatory burden imposed on larger and more complex banks. Here we return to these themes and consider how this can be reflected in the model we have used in our calibration of bankers' pay levels and sensitivity.

A key feature of the model is the introduction bankers with heterogeneous talent allocated across banks of different sizes and different business models. The evolution of $tal1$, the talent implied by our model under our benchmark calibration, is given in the left panel of Fig. 7. This plots the median value of the cross section of $tal1$ in our sample of large BHCs.[11]. This shows a slow downward trend from 1986 to 2006 followed by a sharp drop in the financial crisis 2007–2009 and then a flat trend subsequently.

What could have accounted for the structural drop in model implied talent since 2007? As we have seen, to some extent model-implied talent captures some of trends in banker productivity. But total real assets per banker have risen almost continuously in the whole sample period covered with no sign of structural break in 2007–2020. Similarly real bank revenues per banker have shown cyclical variation but overall have been flat since 1986.

As discussed in Appendix A.3 Correa and Goldberg (2022) have documented the effects of a series of changes in the regulation of large banks have been introduced progressively in the decade following the financial crisis.[12] It is interesting to consider how to these changes can be reflected in the calibration of our structural model.

Recall that in our model talent is given by Eq. (25). It is an increasing function of the ratio of value-added to bank size, where that latter has been proxied by either total assets or total shareholder equity. Thus talent is increasing in the summation of the ratio

[11] This is given for the pooled sample (blue dots), the high $niish$ subsample (red squares) and the low $niish$ subsample (gray diamonds).

[12] See also, Dudley (2013, 2014), Danthine (2017), Greenwood et al. (2017).

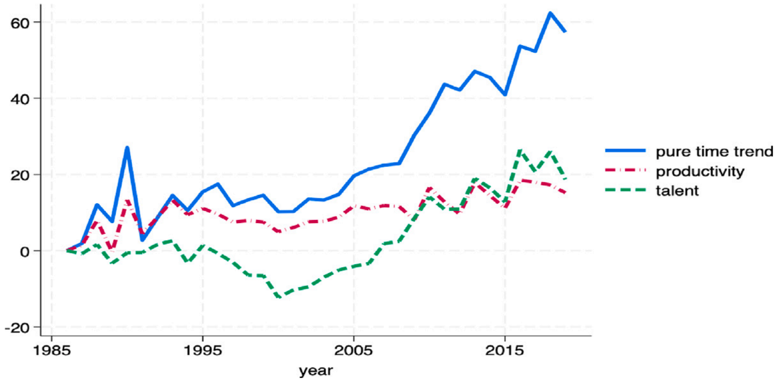

Fig. 6. Year FEs of $wage\_r$ regressions: This graphic compares the evolution of time-fixed effects in regressions of mean total banker pay ($wager\_r$) on alternative sets of regressors. The blue-solid curve depicts the pure yearly fixed effect regression. The red-dash–dot curve includes log of total assets (*lntar*), real revenues per banker (*incrperemp*), total real assets per banker (*atrperemp*), non-interest income share (*niish*) and year fixed effects. The green-dash curve includes log of total assets (*lntar*), non-interest income share (*niish*), talent (*tal1*) and year fixed effects. The regressions are done on the subset of *large* BHCs oriented toward production of non-interest income ($niish > 0.4$). Fixed effects are expressed in thousands of 2002 dollars and are normalized to 0 in 1986. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

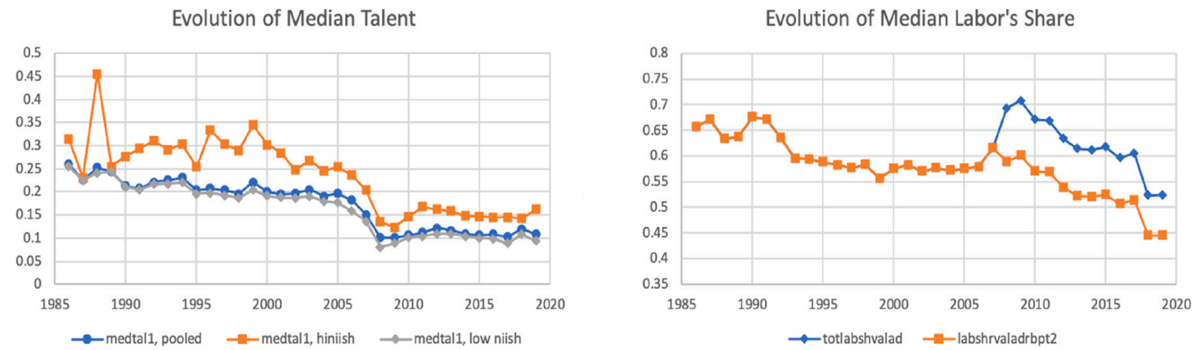

Fig. 7. Implied Talent and Labor's Share in *large* BHCs: The left panel reports the evolution from 1986 to 2019 of median talent in the set of *large* BHCs. The blue-circles curve plots median talent (*tal1*) based on our benchmark calibration. The red-squares curve plots talent (*tal1h*) for the calibration for high *niish* BHCs. The gray-diamonds curve plots talent (*tal1l*) for the calibration for low *niish* BHCs. The right panel contrasts the evolution of two alternative measures of labor's share of value-added depending upon whether or not BHCs were subjected to a pigovian tax implied by increased regulatory scrutiny as discussed in the text. The red-square curve gives the evolution of median labor's share of value-added calculated as the ratio of bankers' pay to total net revenues calculated *before* application of a 15 percent pigovian tax starting in 2008. The blue-diamond curve gives the evolution of median labor's share of value-added calculated as the ratio of bankers' pay to total net revenues calculated *after* application of a 15 percent pigovian tax starting in 2008. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

of banker pay to capital and of the gross return on capital. In the data the ratio of banker pay to total assets has followed a secular upward trend that was not disrupted by the crisis. However, BHC returns on capital experienced a sharp drop in the crisis that was not fully recovered by 2019. The decline in earnings during the crisis can be attributed in part to cyclical factors such as fire sales, write-downs of assets and legal costs. But what can account for the prolonged period of low earnings once the worst of the crisis was past? The most obvious answer is the increase in costs brought on by heightened capital and liquidity requirements, increased reporting requirements including living wills, more bank conduct abuse litigation, and stricter bank supervision. This broad-based re-regulation of banking has been characterized by Jeremy Stein (2013) as a *de facto* pigovian tax on large banks whose business practices imply systemic risk for the whole financial sector and the economy generally (see, also Greenwood et al., 2017).

A pigovian tax can be introduced in our model very naturally as an implicit value-added tax on large banks. Unlike most VATs this tax is paid in-kind rather than as a monetary levy. It involves occupying the time of skilled bankers in activities such as compliance, improving accounting and reporting systems to meet regulatory standards, and developing new models for risk assessment. These activities may do very little to increase bank earnings. Hence they do not translate into implied talent in our model which takes the perspective of constrained shareholder value maximization.

To illustrate the implications of this insight, we have examined the consequences of introducing an implicit VAT of 15 percent commencing in 2008 the year of the Lehmann Brothers collapse. Under this assumption we calculate for each large BHC labor's share expressed as a fraction of pre-tax value-added. The right panel of Fig. 7 depicts the evolution of median labor's share for large BHCs expressed both relative to reported value-added (blue diamonds) and relative to implicit pre-tax value added (orange squares). Labor's share relative to observed value-added reflects a structural break with the crisis as shown previously in the left panel of Fig. 1. In contrast, labor's share of before-tax value-added shows a steady decline commencing in 2009. In effect, the crisis disrupted the balance between the force of banking concentration and that of bank's increased emphasis on investment banking and other activities not involved in conventional credit intermediation. This continuing decline in bankers' share of before-tax value-added from 2009 onward is very similar to the behavior of median of large BHCs non-interest income share depicted in the right panel of Fig. 1. In effect, we see the continuing superstar firm effect implemented through the continuing consolidation of the banking sector and the associated sorting of banks and bankers with diverse talents.

5.5. Managerial rents

As discussed in the Introduction, part of the controversy about observations of high pay among some bankers is whether this represents a rent extracted by bankers as a result of weak governance by shareholders. In this section we see what our calibrated model can say on the subject.

The model we have developed supposes that in each year managers of varying talent are paired with banks of varying quality through a matching mechanism. A proposed match is consummated when the bank's shareholders propose to a manager a compensation contract which maximizes shareholder payoff subject to meeting the manager's participation and incentive compatibility constraints. The match will result in the sharing between shareholders and management of a surplus (or rent) created by the complementarity between the bank's quality and the management talent. In equilibrium the bank with i'th percentile quality is matched with the manager with i'th percentile talent. The result is that for the least talented manager the equilibrium pay just matches his option outside the banking sector. The managers more talented in banking will receive a surplus over the outside option that is an increasing function of their talent. They receive this not because their shareholders are weak but because shareholders need to at least match a potential offer from a bank with a slightly lower quality. This was captured in the pay-talent profile given in Eq. (10) of Section 3.3. Our empirical implementation of this relation was given in the wage level regressions reported in Table 6.

In this context we can distinguish two measures of surplus. One is the difference between equilibrium fair value pay and the outside option which is the fair value pay of the least talented banker. We refer to this as the *equilibrium rent*. The alternative is the difference between the realized pay and the outside option. This is the *total rent*. The difference between the total rent and equilibrium rent (or, equivalently, between the observed pay and fair value pay) may be thought of as the *banker's pay premium*. These relations can be summarized as, *total rent = equilibrium rent +banker's premium*. Or in more explicit notation, $wage(T_i, K_i) - predwage(T_0, K_0) = [predwage(T_i, K_i) - predwage(T_0, K_0)] + [wage(T_i, K_i) - predwage(T_i, K_i)]$, where $wage(T, K)$ is observed total compensation of manager with talent T matched with firm with capital K and $predwage(T, K)$ is the corresponding model predicted compensation.

We implement this decomposition using our calibrated model under the assumptions that our measure of talent is based on the benchmark parameters. The fair value estimate of pay are obtained as the predictions based on the model estimates in column 1 of Table 6. Furthermore, we set the yearly outside option at the 10th percentile of the yearly distribution of *wage_r*. Total rent is calculated as realized *wage_r* less the yearly outside option. Equilibrium rent is calculated as the model predicted *wage_r* less the outside option.

The left panel of Fig. 8 shows the evolution of the yearly values of mean pay, mean equilibrium pay and 10th percentile of pay of large BHCs, all expressed in thousand 2002 dollars. All three series have clear positive trends over 1986–2019 sample period. Equilibrium pay closely tracks realized pay over most of the period, but after 2009 mean realized pay rises somewhat faster than equilibrium pay. The result is that over the sample period mean pay and mean equilibrium pay roughly double from about 42 thousand 2002 dollars to 83 thousand 2002 dollars. The 10th percentile of pay also follows a positive trend the period rising from about 33 thousand 2002 dollars to about 53 thousand 2002 dollars.

The implication of this for rents is seen in the right panel of Fig. 8. There we have plotted the yearly mean values of rents and premia expressed in thousands of 2002 dollars. Between 1986 and 2008 mean equilibrium rents were at times somewhat below the mean of realized rents but generally followed a very similar upward trend rising from about 10 thousand 2002 dollars in 1986 to slightly over 20 thousand dollars in 2008. The result was that the calculated pay premium was positive but rarely exceeded one thousand dollars in this period. Then from 2009 the mean total rents rose faster than mean model implied rents with the result that the pay premium rose to exceed 5 thousand dollars. Still overall, most of the rise in observed rents are explained by the rise in equilibrium rents implemented in the benchmark calibration of our model.

What could have accounted for this pattern? Referring to the calibrated pay level regression in Table 6, the trend of equilibrium rent is driven partially by the model covariates: total assets, non-interest income share, and managerial talent. As depicted in Fig. 9 total real assets per BHC tended increase over the sample period and at an increased pace after 2010. The non-interest income share also rose over the sample period as seen in Fig. 1. So these two factors tended to increase equilibrium rents. They were offset to some degree by the decline in calibrated managerial talent as depicted in Fig. 7. However, as seen in Fig. 10 the year fixed effects from the benchmark pay level regression closely tracked the growth in management pay throughout the sample period. They account for about 35 thousand 2002 dollars of the 41 thousand dollar increase of mean total pay between 1986 and 2019. Thus the combined effect of changes in total assets, increased non-interest income share, and changes in talent account for about 6 thousand 2002 dollars. In the logic of the model, the fixed effects serve to capture changes in the managers' option outside the banking sector

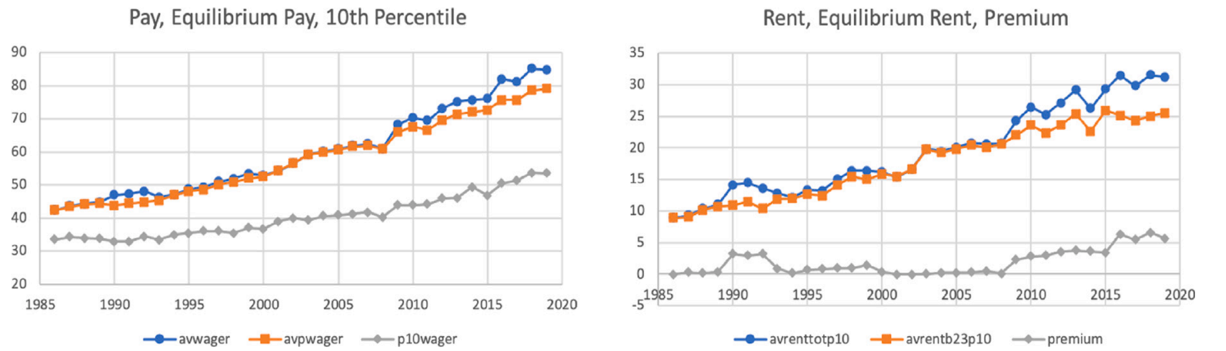

Fig. 8. Total Rent, Equilibrium Rent and Bankers' Premium: The left panel compares the evolution from 1986 to 2019 of three measures of bankers' pay in the set of *large* BHCs measured in tens of thousands of 2002 dollars. The blue-circles curve gives the mean pay (*avwager*). The red-square curve depicts the mean of the predicted bankers' pay obtained from the regression of *wager_r* on total assets (*lntar*), non-interest income share (*niish*), talent (*tal1*) and year fixed effects. The gray-diamond curve plots the 10th percentile of bankers pay in the sample. This is the assumed level of the bankers' option outside the banking sector used as a reference in the calculated bankers' rents. The right panel expresses the information of the left panel in terms of rents. the blue-square curve gives the mean total rent calculated as the difference between the average banker pay and the bankers' outside option. That is, the blue-circles minus the gray diamonds of the left hand panel. The red-square curve gives the equilibrium rent calculated as the difference between mean fair pay as predicted by the our structural model and the bankers' outside option. That is, the red-squares minus the gray-diamonds in the left hand panel. The gray diamond curve plots the bankers' premium calculated as the difference between the mean total rent and the mean fair pay. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

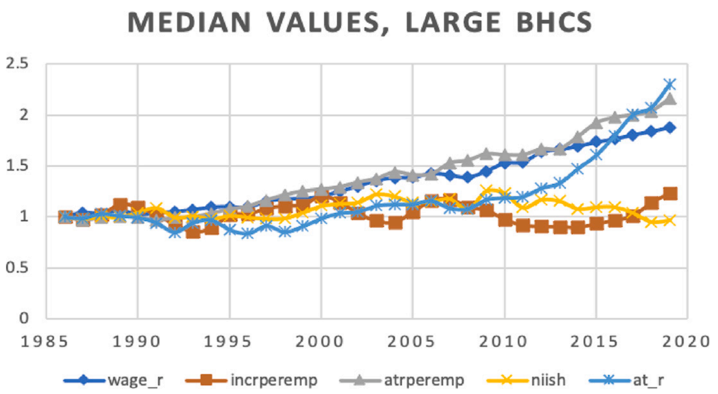

Fig. 9. Total Compensation per FTE and Productivity per FTE: This graphic compares the evolutions values of total real pay per banker (*wager_r*) and measures of productivity (revenues per banker (*incrperemp*) and real assets per banker (*atrperemp*)), noninterest income share (*niish*), and total bank assets (*at_r*). All variables are measured at medians of the yearly medians within in the sample of *large* BHCs.

which fixes the equilibrium pay of the least talented manager. And this results in the modest level of bankers' premium reported in the left panel of Fig. 8.

Again, as discussed in Section 5.3 we find evidence that points to a sharp rise in the implied outside option for bankers. Over the period covered, the nature of banker work has been changed considerably by changes in information technology so that people with tech skills may move relatively freely between banking and many other sectors which have also adopted more advanced technologies. Furthermore, the best outside options for bankers might still lie in finance but outside of regulated banking. Especially since the financial crisis there have been many well-documented movements of human capital among banks, private equity, fund management and fintech.

It should be noted that our interpretation of the data is not at all in conflict with the findings of Böhm et al. (2023) who have argued that the rise in the observed pay premium in finance can be accounted for not by rising talent in finance but rather by the sharing with workers of the rise in relative value-added in the finance sector. Indeed, by hypothesizing a complementarity between banker talent and bank capital our model gives an explanation for the source of the rise of finance value-added. What is different in the two analyses is that we have argued that the competition for talent among banks of different amounts of financial and organizational capital has been the driver of the sharing of surplus. Instead, Böhm et al. consider alternative origins of surplus sharing either because of risk aversion and deferred compensation or because of social connections posing barriers to entry into finance jobs.

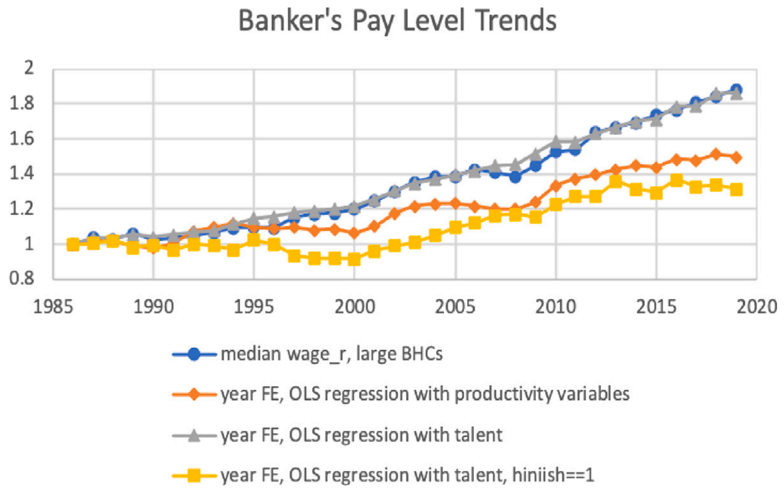

Fig. 10. Pay Level Trend and Regression Year Fixed Effects: The graphic presents the evolution between 1986 and 2019 of median bankers pay (wage_r) depicted by the blue-circles curve as compared to the yearly FEs from alternative regressions. The red diamond curve gives year FEs of the regression on firm size (*lnatr*), productivity (revenues per banker (*incrperemp*) and real assets per banker (*atrperemp*)), and noninterest income share (*niish*). The gray-triangle curve gives year FEs of the regression on firm size (*lnatr*), noninterest income share (*niish*), and talent (*tal1*). The yellow-squares curve gives year FEs of the regression on firm size (*lnatr*), noninterest income share (*niish*), and talent (*tal1h*) restricted to the subsample of BHCs with *niish*> 0.4. Pay levels and fixed effects are normalized to 1 in 1986. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

While these additional factors might be present, our analysis shows they are not necessary to account for the distribution of finance pay either in cross-section or over time. Most of the movements in banker's pay level have been reproduced with a model of a competitive equilibrium among banks with shareholders maximizing shareholder payoff by offering pay contracts that are able to compete for bankers with varying degrees of talent. On balance, the estimated banker's premium above this equilibrium outcome is relatively small.

5.6. Discussion of results and alternative explanations

In the introduction we suggested that there are alternative theoretical explanations that could account for some of empirical patterns that we have documented here. One argument that has been put forward is that high pay for bank managers may be a compensation for risk. In our view risk aversion of bank managers may contribute to the level of bank pay. However, it seems to us that it is not clear that changes in risk aversion can account simultaneously for the changes in pay levels, pay sensitivity, and the changes in labor's share of surplus. This is what we have attempted here using a model that does not allow explicitly for risk aversion. In particular, pay sensitivities we have found for bank management are relatively low compared to the sensitivities that are found in for top bank management. Furthermore, we have found some evidence that in the ten years following the financial crisis pay sensitivities declined in banks oriented toward investment banking, fund management and wholesale banking, while at the same time real pay levels have risen sharply.

In our view this argument applies also to efficiency wage models that rely on differences in risk in different segments of the market. For example, the Shapiro and Stiglitz (1984) model is one where homogeneous firms with a risky technology require equally talented workers to extend costly effort. The outcome is binary, either success or failure, with the probability of success being increasing in effort. Effort is not observable, and thus there is moral hazard. To induce effort there is a penalty for failure. The equilibrium involves a labor contract with a high wage for employed workers in the firm with the penalty being that in case of failure they lose their job and become unemployed receiving unemployment insurance which is lower than the offered wage. The market is segmented with unemployed labor who are willing and able to work for the firm but who are not hired. Incumbent workers are incentivized to extend effort by their high wage and the prospect of a spell of low-pay unemployment if they fail.

Axelson and Bond (2015) employ a similar argument to that of Shapiro and Stiglitz but in a model that is arguably closer to the conditions found in banking. Identical banks can hire bankers with identical skills. They can assign them either a high-risk task or a low-risk task. In either task there may be either success or failure. In the high-risk task the bank's capital is at risk. If there is success, the bank receives a gross return equal to capital plus profit but in the case of failure the committed capital is lost and the bank has a zero gross return. In the low risk task, the bank commits no capital. In the case of success the bank makes a positive gross profit; in the case of failure the return is zero. Bankers assigned to either task make a continuous effort choice that is unobservable. Axelson and Bond show that when assets at risk are sufficiently large the equilibrium involves zero payoff in the case of failure, a positive success bonus in the low risk task that just matches the bankers' participation constraint and a large success bonus in the high risk task. This high risk bonus implies that the bankers' participation constraint is exceeded and that it just satisfies

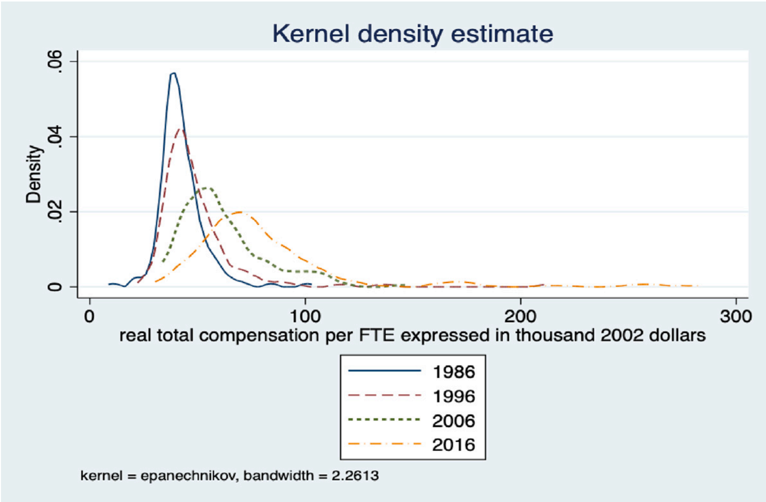

Fig. 11. Distributions of Average Bankers' Pay: This graphic presents the cross sectional distributions of wage_r for the sample of large BHCs at four years within the sample period.

the incentive compatibility constraint. The conclusion is that identical bankers receive different wages for different tasks, and this persists in equilibrium.

From our perspective if we want to use this framework to explain the evolution of pay in US banking we would need to hypothesize a trend toward an increase in size of the capital at risk in big banks. At the aggregate level this works well. We have seen this already in Fig. 9 where we reported the evolution of median value of real assets per banker and median real compensation per banker. A similar pattern is found for mean assets per banker and mean compensation per banker. It is clear that the central tendency of bankers' pay level tracks closely that of assets per banker.

However, as reported in Fig. 11 the annual cross sectional distribution of pay level per banker has a large dispersion which has increased over time. The distribution is also right skewed and has become more so over time. These patterns fit well with our framework and can be interpreted as the reflection of a continuing concentration capital and talent. What does the analysis of Axelson and Bond say about the distribution of compensation across firms? The analysis is based on a competitive equilibrium where all firms make zero expected profits. The mix of high and low risk activities may differ across firms, but there is no incentive for firms to adjust their product mix. Nor is there any prediction about the shape of the cross-sectional distribution of average compensation.

The fact that Axelson and Bond may not have produced clear predictions for the higher moments of the distribution of average compensation across banks is not surprising given that this was not an issue they focused on. Similarly they have not taken up the issue of the evolution of labor's share, which is central to our interests. Regarding pay sensitivity, the Axelson and Bond model does give a coherent account of high-powered incentives in investment banking, albeit in a stylized way. Bankers in the high risk task are incentivized by the promise of a big bonus and therefore extend a higher level of effort as a result. But they face the prospect that their effort will be wasted in the case of failure. This is stark but arguably can be viewed as an explanation of the high sensitivity that we have found in the banks heavily involved in investment banking, trading and fund management.

6. Conclusion

We have attempted to answer the broad question set out in the Introduction— what, if anything, is special about bankers' pay— by studying the evolution of pay in US bank holding companies since 1986. Our aim was to use a structural model to give an internally consistent account of bankers' pay both in cross-section and time series. We did this in three steps.

First we introduce a model of the banking firm where value-added will depend upon the bank capital supplied by shareholders, the talent of the bank managers and the effort extended by management. Important characteristics of the model are that (1) there is a strong complementarity between capital, talent and effort and (2) that while management talent is contractible management effort is not. We suppose that the pay package that has been agreed between shareholders and management solves the second-best problem of maximizing payoff to shareholders subject to the managers' participation and incentive compatibility constraints. Firms and management teams are assumed to be heterogenous. Market equilibrium is found as an assignment model in which managers with different levels of talent are matched in rank order with banks of different capital. Given the strong complementarity of capital with talent and effort, the model gives rise to a super-star firm effect, that is, a tendency for "winner takes almost all". This matching is repeated year by year, thus accommodating changes in the sets of managers and bank holding companies. Implicitly the annual matching involves costly search, and given the exogenous changes in the sets of banks and managers, the market is not likely to converge to a long-run steady-state.

With this model in view we then set out the main empirical characteristics in both cross-section and time series where the basic unit of observation is a given bank holding company in a given year. First we document the process of consolidation that has taken part in US banking in the three decades from 1986 through a process of mergers, acquisitions, entry and exit. Then we set out pay characteristics of US bank holding companies. We focus on three characteristics that have been featured in the managerial compensation literature — labor's share of bank value-added, the level of an average bankers' real compensation and the sensitivity of that compensation to firm performance. We study these in relation to other aspects of the bank, notably, its size and its mix of banking businesses.

Then in a third step we attempt to give an internally consistent account of how the observed behavior came to pass. We do this by calibrating the structural model that we have introduced to see if it can reproduce the empirical characteristics that we have found. An important feature of our model is the moral hazard created by the non-contractibility of management effort, as this gives rise to a relatively simple characterization of pay sensitivity which we can calibrate with data reported in the literature.

We find that three major changes in banking regulation have been important in shaping bankers' pay in the last three decades. First, the removal of obstacles to interstate banking has created a strong incentive for consolidation which is perceptible over the whole three decades we cover. Second, the Gramm, Leach, Bliley Act which opened the way to combining credit intermediation with investment banking, securities trading and fund management appears to have driven a trend toward higher pay and higher incentive pay in banks aiming for higher shares of non-interest income. Finally, the mass of tougher regulations brought on by the financial crisis and enabled by the Dodd–Frank Act has had the effect of imposing an implicit tax on size and complexity which in turn has moderated the trend toward higher and more sensitive pay in large, complex banks. Indirectly this has given an opening for smaller banks to compete for some of the business outside of standard credit intermediation. But in so-doing, this has resulted in an increase of their pay levels and pay sensitivity. We find some evidence of a decline in average talent in the sector and that the trend toward high average pay has been driven in large part by the increase in managers' options outside banking. Overall, after controlling for the hypothesized pigovian tax on large banks we find a secular trend toward a decline of labor's share brought-on by a continuing process of consolidation in the US banking sector. Finally we find that although pay levels have risen significantly in three decades the premium received over fair pay in our model is rather small.

The broader view that emerges from our analysis is that the forces of consolidation, regulatory change, and evolving technology are likely still at work in reshaping US banking structure and banker compensation. The framework we have developed here could be used to understand developments after 2019 when our data set ends. For example, the mini-crisis which emerged with the collapse of Silicon Valley Bank could be characterized by changes in the *de facto* regulatory tax in two steps. First, the tax was lowered in 2018 when the threshold size was raised for systemically important banks required to do regulatory stress tests. Then later the tax was raised following the collapse of SVB in 2023 through heightened supervision, the addition of more and qualitatively different stress tests, and increasing the stress test participation from 23 banks in 2023 to 32 in 2024. In a similar vein, the model could be used in simulating other possible changes to the banking system. An example might be the introduction of central bank digital currency. Another might be increased use of AI in credit risk assessment which is captured as a reduction of the outside option for management.

CRediT authorship contribution statement

Ronald W. Anderson: Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Karin Jõeveer:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendices

A.1. Model details

In this subsection we present solutions to the second best optimal contract for a given firm as used in Section 3.2. Under the functional specification introduced there, the principal's problem is,

$$Max_{\{c(.),L,a\}} a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l} - c(a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l}) - w_l L \tag{A.1}$$

subject to the participation constraint,

$$c(a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l}) - ga \geq w_m(T) \tag{A.2}$$

and the incentive compatibility restriction,

$$\frac{d\,(c(a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l}))}{da} = g \tag{A.3}$$

A modeling choice that will lead to a variety of explicit solutions is to assume that compensation contracts that are linear. We assume this here.

$$c(V) = w_0 + w_1 V \tag{A.4}$$

where w_0 and w_1 are constants set by the shareholders.

Working recursively, given w_0 and w_1, the manager solves the problem

$$Max_{\{a,L\}} w_1 a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l} - ga - w_l L \tag{A.5}$$

The first-order condition for a is,

$$\alpha_m w_1 a^{\alpha_m - 1} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l} - g = 0 \tag{A.6}$$

which implies,

$$a = \frac{\alpha_m w_1}{g} V \tag{A.7}$$

The first order condition for L is,

$$\alpha_l w_1 a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l - 1} - w_l = 0 \tag{A.8}$$

which implies,

$$L = \frac{\alpha_l w_1}{w_l} V \tag{A.9}$$

Using (A.7) and (A.9), firm value can be written as,

$$V = (w_1)^{\alpha_m + \alpha_l} (\frac{\alpha_m}{g})^{\alpha_m} T^{\alpha_m} K^{\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l} V^{\alpha_m + \alpha_l} \tag{A.10}$$

Using $\alpha_m + \alpha_l = 1 - \alpha_k$ and solving for V yields an expression for firm value as a function of the incentive pay sensitivity, w_1,

$$V = w_1^{(\alpha_m + \alpha_l)/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \tag{A.11}$$

Turning to the determination of the compensation contract offered the manager we use (A.9) and (A.11) to express the shareholders' problem as,

$$Max_{(w_0, w_1)} (1 - w_1 - \alpha_l w_1) w_1^{(\alpha_m + \alpha_l)/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K - w_0 \tag{A.12}$$

subject to

$$w_0 + w_1 w_1^{(\alpha_m + \alpha_l)/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \geq w_m(T) \tag{A.13}$$

Since $w_1 w_1^{(\alpha_m + \alpha_l)/\alpha_k} = w_1^{1 + (\alpha_m + \alpha_l)/\alpha_k} = w_1^{1/\alpha_k}$, the shareholders' problem becomes,

$$Max_{(w_0, w_1)} (w_1^{(\alpha_m + \alpha_l)/\alpha_k} - (1 + \alpha_l) w_1^{1/\alpha_k}) (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K - w_0 \tag{A.14}$$

subject to,

$$w_0 + w_1^{1/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \geq w_m(T) \tag{A.15}$$

Note that since $\alpha_m + \alpha_l < 1$ and $1/\alpha_k > 1$ the maximand in (A.14) is concave in w_1 and increasing at $w_1 = 0$. Thus the shareholders will wish to give the manager a strictly positive incentive component to compensation. Furthermore the maximand is strictly decreasing in w_0. Thus the shareholders will wish to give the lowest possible fixed component of compensation that is compatible with the manager's participation constraint. This could be negative for relatively high w_1. That is, the shareholders may propose a contract that requires the manager to have "skin in the game". We suppose that the manager has sufficient wealth to agree this.[13] In that case, the optimal incentive rate w_1 can be found by maximizing,

$$(w_1^{(\alpha_m + \alpha_l)/\alpha_k} - (1 + \alpha_l) w_1^{1/\alpha_k}) \tag{A.16}$$

The first order conditions is,

$$\frac{\alpha_m + \alpha_l}{\alpha_k} w_1^{((\alpha_m + \alpha_l)/\alpha_k - 1)} = \frac{1}{\alpha_k} (1 + \alpha_l) w_1^{1/\alpha_k - 1}$$

which implies,

$$w_1 = \frac{\alpha_m + \alpha_l}{1 + \alpha_l} \tag{A.17}$$

[13] Anderson (2023) explores the complications arising when the manager is wealth constrained.

This is the shareholders' optimal choice of the incentive pay sensitivity when the manager's wealth constraint is not binding. Note that since $\alpha_m < 1$, $w_1 < 1$. That is, even the manager's wealth constraint is not binding, the shareholder would never seek set income sensitivity of the manager at unity. Using the expression for firm value produced by the manager given the incentive contract (A.11) and K, the second best optimal value of the firm is,

$$V = \left[\frac{\alpha_m + \alpha_l}{1+\alpha_l}\right]^{(\alpha_m+\alpha_l)/\alpha_k} \left(\frac{\alpha_m T}{g}\right)^{\alpha_m/\alpha_k} \left(\frac{\alpha_l}{w_l}\right)^{\alpha_l/\alpha_k} K \tag{A.18}$$

This is proportional to K, increasing in T, and decreasing in g.

Using (A.17) and still assuming the manager's wealth constraint is not binding, the value of the manager's fixed compensation is,

$$\begin{aligned} w_0 &= w_m(T) - w_1^{1/\alpha_k} \left(\frac{\alpha_m T}{g}\right)^{\alpha_m/\alpha_k} \left(\frac{\alpha_l}{w_l}\right)^{\alpha_l/\alpha_k} K \\ &= w_m(T) - \left[\frac{\alpha_m + \alpha_l}{1+\alpha_l}\right]^{1/\alpha_k} \left(\frac{\alpha_m T}{g}\right)^{\alpha_m/\alpha_k} \left(\frac{\alpha_l}{w_l}\right)^{\alpha_l/\alpha_k} K \end{aligned} \tag{A.19}$$

For a firm with a manager with a given talent, T, the manager's fixed pay is decreasing in K. If the outside option, $w_m(T)$ is increasing, then the fixed compensation of the manager may be increasing or decreasing in T. Stated otherwise, if 'talent' is specific to this industry so that the outside option is constant in T, then the fixed compensation is decreasing in T. In that case, it is more likely that more talented managers need to have "skin in the game".

Continuing under the assumption that the manager's wealth constraint is not binding and combining (A.9), (A.17), and (A.18) the amount of labor employed at fixed wage w_l can be written,

$$\begin{aligned} L &= \frac{\alpha_l w_1}{w_l} V \\ L &= w_1 \frac{\alpha_l}{w_l} V \\ L &= \frac{\alpha_m + \alpha_l}{1+\alpha_l} \frac{\alpha_l}{w_l} V \\ L &= \frac{\alpha_m + \alpha_l}{1+\alpha_l} \frac{\alpha_l}{w_l} \left[\frac{\alpha_m + \alpha_l}{1+\alpha_l}\right]^{(\alpha_m+\alpha_l)/\alpha_k} \left(\frac{\alpha_m T}{g}\right)^{\alpha_m/\alpha_k} \left(\frac{\alpha_l}{w_l}\right)^{\alpha_l/\alpha_k} K \\ L &= \frac{\alpha_l}{w_l} \left[\frac{\alpha_m + \alpha_l}{1+\alpha_l}\right]^{1/\alpha_k} \left(\frac{\alpha_m T}{g}\right)^{\alpha_m/\alpha_k} \left(\frac{\alpha_l}{w_l}\right)^{\alpha_l/\alpha_k} K \end{aligned} \tag{A.20}$$

The total compensation to labor with unmeasured skill and paid at rate w_l is,

$$w_l L = \alpha_l \left[\frac{(\alpha_m + \alpha_l)}{1+\alpha_l}\right]^{1/\alpha_k} \left(\frac{\alpha_m T}{g}\right)^{\alpha_m/\alpha_k} \left(\frac{\alpha_l}{w_l}\right)^{\alpha_l/\alpha_k} K \tag{A.21}$$

Note that this is decreasing in w_l. That is, under managerial moral hazard in a firm with a manager with given talent T, there is elastic demand for labor paid at the fixed wage w_l.

That is, for a manager with a given talent, it is more likely that he would be asked to commit some of his wealth to join a very large firm. However, it may be that larger firms attract more talented managers, suggesting that the outside option to working with a very large firm would be working for another large firm of slightly smaller K. In that case, the outside option is likely to be increasing in T and effect on the balance of fixed and incentive pay in the manager's contract of greater talent is ambiguous. It is likely to depend upon the joint distribution of managerial talent and firm size as seen in models of the *superstars* (e.g., Terviö, 2008 or Gabaix and Landier, 2008).

A.2. Data appendix

Our main data come from the financial reports required by the Federal Reserve of all bank holding companies (BHCs) operating banks licensed in the United States and supervised within the Federal Reserve System. Based on financial reports consolidated at the bank holding company level this provides information from detailed balance sheets, income statements and cash flow statements on a consistent basis, for many variables going back to 1986. These are obtained from the FRY9c filings that are required quarterly with some further details being reported in the December filing. We use the December filings to construct our annual data set.

The FRY9c data are particularly attractive for studies of banking industry structure for a number of reasons. First is that the structure of banking has changed considerably in the last 40 years driven in large part by major changes in law and in regulations. In particular, the removal of a variety of obstacles to intra-state branching and inter-state banking have given rise to major consolidation of banking through an active process of mergers and acquisitions as well as new entry that has continued to the present. This would be very difficult to trace using financial reporting at the legal entity level (e.g., call reports required of insured depository institutions) or at the establishment level (e.g., industry data of the US Census). With the holding company consolidated reports we have a consistent picture of the major financial results over time even though the banking group may be restructured over a number of years, e.g., with acquisitions of banks or other financial companies that are then gradually integrated in new legal entities assembled from various pieces of the group.

A second advantage of the FRY9c data is that it covers a variety of variables not typically included in balance sheets and income statements. This includes details on various derivative positions and on different categories securities issues that enter into the

Table A.1
Summary Statistics of Main Variables: All variables are expressed for a given entity in a given year. As explained in the text we calculate these statistics for *large* BHCs that are at the top of the organization if the BHC is hierarchical. *wage_r* is the mean total real compensation per employee expressed in thousands of 2002 dollars. *dlnwager* is yearly percentage change of average real compensation. *totlabshvalad* is total labor share of value-added. Value-added of a bank is calculated as the sum of total compensation (BHCK4135) and net income (BHCK4340). Total labor share is calculated as total compensation (BHCK4135) divided by value-added. *lntar* is the log of total real assets (thousand 2002 dollars). *niish* is the share of non-interest income in bank's total revenues. *incrperemp* is real revenues (million 2002 dollars) per employee. *atrperemp* is real assets (millions of 2002 dollars) per employee. *dlnincr* is yearly percentage change of total real revenues. *dlnvaladr* is yearly percentage change of real value-added. *tal*1 is the model implied talent of the BHCs managers in a given year as explained in the text.

Short name	Description	N	Mean	SD	p25	p50	p75
wage_r	mean pay per banker	4442	58.713	30.601	41.907	50.855	66.990
dlnwager	log change of pay per banker	4154	0.023	0.147	−0.023	0.020	0.064
totlabshvalad	labor share of value-added	4443	0.580	1.340	0.536	0.607	0.682
lntar	log of toral real assets	4443	16.226	1.605	15.286	16.069	17.069
niish	non-interest income share	4443	0.311	0.181	0.200	0.272	0.377
incrperemp	real income per banker	4442	0.281	0.150	0.202	0.243	0.306
atrperemp	total real assets per banker	4442	4.030	2.589	2.535	3.305	4.502
dlnincr	log change of BHC net revenues	4155	0.067	0.181	−0.026	0.053	0.138
dlnvaladr	log change of BHC value-added	4030	0.093	0.314	0.010	0.082	0.173
tal1	benchmark calibrated talent	4356	0.196	0.110	0.122	0.185	0.244

calculation of regulatory capital. The most important for our purposes is that banks are required to report total work force measured as full-time equivalents (FTE's) employed by all the entities of the BHC. This in combination with reported total compensation expense of the BHC (including wages, bonuses, stock awards, retirement contributions and other benefits) allows us to construct mean total compensation per employee within the group. This is difficult to do for non-bank firms where reports of employment are typically not mandatory and are reported inconsistently or not at all by different firms. As shown in the text this allows us to infer something about the distribution of compensation within the bank. In this way we will learn something about both the level of compensation and the incentives given to employees who are relatively senior, but below top management. Thus we can deal with different questions than those of analysts who confine their attention to Execucomp data which covers only the CEO and a handful of other senior executives.

Of course to understand compensation practices, we would be interested in knowing more about the characteristics of the work force with each bank. This might allow us to directly construct metrics of skill levels. Unfortunately, such information is not included in the FRY9c data. Consequently, we turn to information about compensation and education that are contained from the reports of the US Census and from surveys conducted by the US Bureau of Labor Statistics and Bureau of Economic Analysis (for an overview see Eisfeldt et al., 2022). Since these data do not have entity identifiers which can be mapped directly into FRY9c data, we instead use these labor characteristics data in calibrating the structural model of the determination of value-added within a firm run by shareholders who enter into second-best optimal compensation contracts with skilled employees who must be incentivized to expend unobservable effort.

The data on US bank holding companies is derived from the December reports to the US Federal Reserve using the FRY9c form. The documentation, reporting forms and instructions as well as the historical quarterly data set are maintained by the Federal Reserve Bank of Chicago and can be accessed through their portal, https://www.chicagofed.org/banking/financial-institution-reports/bhc-data . Most of these data can be accessed as well through the Bank Regulatory data set maintained by Wharton Research Data Services (WRDS).

In addition to the bank holding company data we have also used some aggregative statistics based on Call Reports, that is, reports of licensed commercial banks and thrift institutions that are federally supervised and guaranteed through the Federal Deposit Insurance Corporation (FDIC). Periodic reports on these data as well historical data can be obtained from the Federal Financial Institutions Examinations Council (FFIEC) Central Data Repository's Public Data Distribution website.

Nominal variables were converted to constant 2002 dollars using the Consumer Price Index (December average) as reported by the Federal Reserve Economic Data (FRED) set managed by the Federal Reserve bank of Saint Louis. Table A.1 presents the summary statistics of the main variables used in the analysis in the text.

A.3. Structure of the US banking

Historically the US has long stood out among the world's developed market oriented economies by the highly fragmented nature of its banking sector with a very large number of banking institutions and the low level of integration of diverse financial services other than those devoted to credit intermediation (see Goldberg and Hanweck, 1991. In part this was the consequence of the expansion of the US state by state in the 19th and first half of the 20th centuries in which new banks were created through new bank charters authorized by state regulators (see, Mengle, 1990). The other formative factor of this pattern was the response to the banking crisis of the 1930's that gave rise to the strict separation of investment banking and commercial banking activities by the Glass Steagall Act of 1933 (see, Kroszner and Rajan, 1994. This picture began to change in the 1980's through a combination

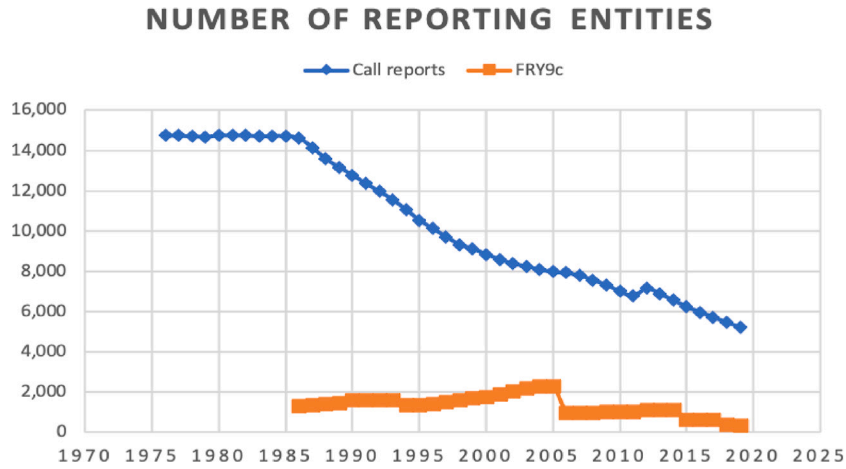

Fig. A.1. Number of Reporting Entities: This graphic gives the evolutions of the numbers of banks or bank holding companies reporting at year end to federal banking authorities in the US. The blue-diamond curve plots the number of federally licensed banks filing call reports (Reports of Condition and Income) at year end. The red-square curve gives the evolution of the number of bank holding companies (BHCs) making FRY9c filings. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

of the development of bank holding companies and liberalization of state regulations which opened the door to branching, first intra-state and subsequently interstate (Mengle, 1990). This liberalization process was effectively completed by Federal legislation in the Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994 which eliminated most remaining restrictions on opening bank branches across state lines (see, Corbae and D'Erasmo, 2020). These developments had a tangible impact on the structure of US banking. Corbae and D'Esrasmo document this using Call Reports, a data set based on regulatory reporting by federally licensed banks. To focus on the banking entities that have emerged from this process we rely on reporting by bank holding companies (BHCs) in the FRY9c reports. (See Appendix A.2 for a discussion of the FRY9c data including the definitions of the main variables used in our statistical analysis.)

Fig. A.1 presents the evolution of the number of reporting entities in the two data sets. The federal call reports (blue diamonds) in their current form commenced in 1976. During the second half of the 1970's the number of reporting banks was relatively constant at about 14,000 federally insured depository institutions (banks and savings and loan institutions). Then in the mid-1980's, after the changes facilitating the formation of federally supervised bank holding companies, there began a steady decline in the number of federally licenced banks through a mixture of mergers, acquisitions and closures. This continued through the 1990s under the impetus of Riegle-Neal Act of 1994. The yearly steady drop of licenced banks has continued largely to the present with exception of the period after the banking crisis of 2007–08 when a number of formerly non-bank financial institutions acquired banking licences.

The pattern presented by the consolidated bank holding companies captured by the FRY9c data (red squares) is very different. First, there are many fewer reporting bank holding companies than federally licensed depository institutions– roughly in a ratio of 10 to 1 in 1986 when FRY9c reporting began. In part this can be attributed to the fact that at times some licensed banks have operated outside of BHCs structures. Furthermore, it reflects double counting when a licensed bank has a subsidiary which is itself a licensed bank. Assets and revenues within the subsidiary would be reflected in both the call report of the senior firm and in the call report of the subsidiary. This is a major draw-back to using call reports in a cross-sectional analysis of the banking system.

Second, the number of BHCs usually does not fluctuate very much from year to year, but there have been noticeable drops in the number of reporting BHCs in 2006 (from 2,310 to 986), 2015 (from 1,129 to 653) and 2018 (from 641 to 373). This pattern reflects the fact that the BHCs are required to file FRY9c reports only if they have total assets greater than a reporting threshold. Furthermore, reporting requirements have become increasingly complex since 2000, and this gave rise to demands of smaller BHCs for relief from the reporting burden. As a result the reporting thresholds have been raised repeatedly— from $150 million of total assets to $500 million in 2006, from $500 million to $1 billion in 2015 and from $1 billion to $3 billion in 2018. This coincides with the noticeable drops in numbers of reporting BHCs at those times.

The process of bank consolidation has led to the emergence a relatively small number of very large banking groups. This is seen in the left hand side of Fig. A.2 which gives the evolution of employment, measured in full-time equivalent employees (FTE) in large bank holding companies since 1986.[14] Total employment in the large BHCs (red squares, measured on the left vertical axis) doubled

[14] We consider a BHC to be "large" if it had total real assets (valued in 2002 dollars) of at least $8 billion in at least one year in the sample and "small" otherwise. The reason for making this distinction is that in this way the subsample of large BHCs will avoid selection bias problems induced by the changes in reporting thresholds. A further reporting issue is that a single banking group may be organized as a hierarchy in which one BHC may have a subsidiary which is itself a BHC with total assets that are above the threshold for FRY9c reporting. In order to avoid double counting within such banking groups, we retain only the BHC at the top of the hierarchy. Fortunately, detailed reporting in the FRY9c data allow us to construct the hierarchy of the banking groups.

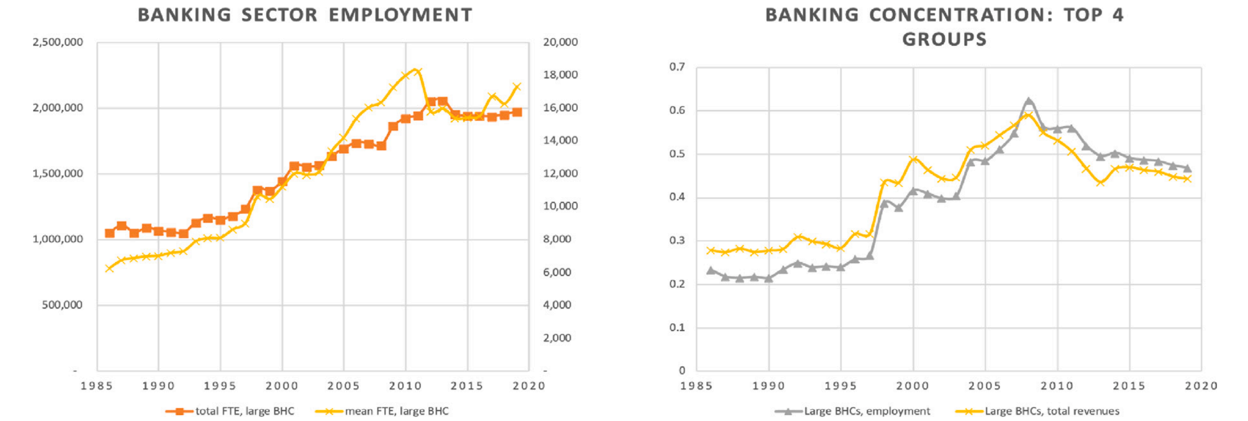

Fig. A.2. Size and Concentration of Bank Holding Companies: This graphic depicts the evolution of the size and concentration of the federally regulated banking system. It is restricted to the subsample of *large* BHCs. The left panel reports the size of the banking sector as measured by the total number of bankers employed (expressed in yearly full time equivalents) in large BHCs (left side vertical axis) and by mean number of bankers (in yearly FTE) in a BHC (right size vertical axis). The right panel reports banking concentration as measured by the 4-firm concentration ratios. The gray-diamond curve reports the proportion of total employment (number of FTEs) in the top-4 *large* BHCs. The yellow-X curve reports the proportion of total revenues in the top-4 *large* BHCs.

from 1 million FTEs in 1986 to 2 million in 2012. This coincided with creation of much larger banks on average as measured by the mean employment per large BHC (yellow X's, measured on the right vertical access) which went from 7000 FTE to 16,000 FTE. Subsequently, the push for consolidation has slowed with both total employment and average BHC size remaining relatively flat through 2019.

The consolidation of the US banking sector between 1986 and 2019 may have had important implications for the competitive environment in banking. As seen in Section 4 this issue was studied by Corbae and D'Erasmo (2020). They reported a sharp rise in US banking concentration measured as the 4-bank concentration ratio of insured deposits among commercial banks filing federal call reports. In the right panel of Fig. A.2 we apply this metric to the sample of large BHCs. Measuring size by employment (gray diamonds) the top-four concentration ratio was relatively constant at about 23 percent between 1986 and 1997, then rose sharply for ten years reaching a high of 62 percent in 2008. Subsequently, concentration has fallen back to less than 50 percent by 2015. A similar pattern is found for the top-four concentration based on total BHC revenues as seen in the figure (yellow X's).

A four-firm concentration is just one, rather crude, indicator of market competition, and the rise in concentration through 2008 does not necessarily mean that there has been an increase in market power accruing to the banks. Indeed, this view is undermined by the simple fact that the removal of restrictions to intra-state branching and interstate banking opened the door to new entrants in local banking markets. Furthermore, the dismantling of barriers separating commercial banking, investment banking, and insurance blurred the boundaries between formerly distinct market places for different financial services. This created the opportunity to use different strategies including offering a broad line of financial services or by specializing on certain finance products or customer bases. It also opened the door to using technologies which were made possible by advances in IT.

The consequences of increased banking complexity were explored by Cetorelli et al. (2017) using regulatory filings to track changes in BHC structure as reflected in numbers of subsidiaries, their geographic dispersion and the numbers of types of businesses as reflected in 4 digit industrial codes over the period 1992–2006. They document a general negative relation between bank complexity and performance where the latter is measured by either ROE or Tobin's Q. They argue that this is consistent with the view that increased complexity and larger firms can increase the importance of agency problems where bankers' payoffs are not aligned with those of shareholders. This is an effect that is integrated in the structural model of Section 3.2 which will be the basis of our calibration in Section 5. Correa and Goldberg (2022) also use diverse regulatory measures of structural complexity in a data set that covers the decade following the crisis of 2007/2008, They document a differential effect of regulatory measures depending upon bank size and complexity. Overall their analysis provides evidence of the increased costs of regulatory compliance in the post-crisis period. We discuss this theme in Section 5.4.

Our study covers the three decades from 1986 to 2019. As shown by Stiroh (2004, 2006) one interesting way of dividing up the banking market into segments is in terms of net interest income (traditional credit intermediation) and non-interest income. These categories have been reported in the FRY9c data since 1986. For this reason, in our analysis we will use the non-interest income share (*niish*) as a control for changes in banking structure.

A.4. Calibration extensions and robustness

A.4.1. Calibrating pay sensitivity

In Section 5.1 we discussed the relation of sensitivity of pay implied by the second-best pay contract and the share parameters (α_k, α_m, and α_l) that capture the bank technology. Table A.2 gives the relationship between technology and pay sensitivity. It is seen

Table A.2
Calibrated Pay Sensitivity: This table shows the relation of value-added parameters of capital α_k, labor α_l and management α_m to the pay sensitivity implied by the structural model of Section 3.2. Columns 1 and 2 give a possible calibration choice of capital share and the ratio of management share to combined labor and management shares. Column 3 gives the implied combined value of labor share and management share. Columns 4 and 5 give the implied share of labor and management. w_1 is the second-best best pay sensitivity to management. w^{tot} is the implied sensitivity to labor and management overall.

1	2	3	4	5	6	7
α_k	$\alpha_m/(\alpha_l+\alpha_m)$	$\alpha_l+\alpha_m$	α_l	α_m	w_1	w^{tot}
0.2	0.20	0.8	0.640	0.160	0.488	0.098
0.2	0.25	0.8	0.600	0.200	0.500	0.125
0.2	0.30	0.8	0.560	0.240	0.513	0.154
0.2	0.35	0.8	0.520	0.280	0.526	0.184
0.2	0.40	0.8	0.480	0.320	0.541	0.216
0.2	0.45	0.8	0.440	0.360	0.556	0.250
0.3	0.20	0.7	0.560	0.140	0.449	0.090
0.3	0.25	0.7	0.525	0.175	0.459	0.115
0.3	0.30	0.7	0.490	0.210	0.470	0.141
0.3	0.35	0.7	0.455	0.245	0.481	0.168
0.3	0.40	0.7	0.420	0.280	0.493	0.197
0.3	0.45	0.7	0.385	0.315	0.505	0.227

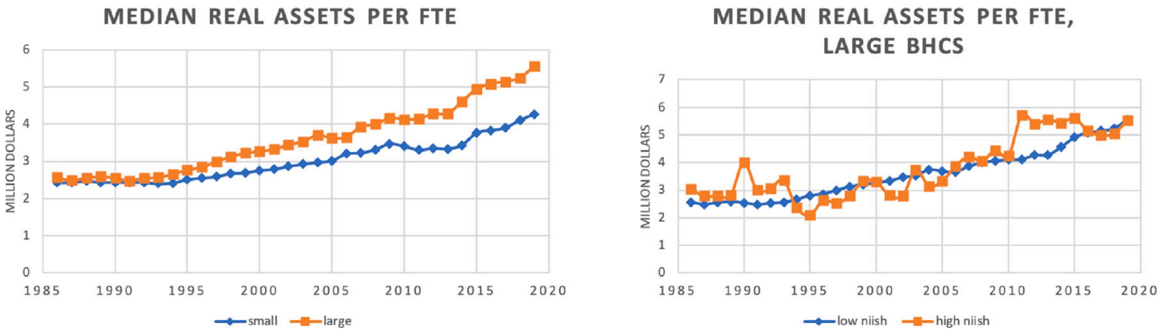

Fig. A.3. Assets Per Employee: The graphic depicts the evolution productivity as measured by the ratio of total BHC assets (in constant 2002 dollars) to the number of bankers in the BHC (as measured by yearly FTE). The left panel compares the medians of this measure for *small* BHCs and *large* BHCs. The right panel reports medians of this measure among *large* BHCs for two subsets –those with low levels of non-interest income (*niish*< 0.4) shown with blue-diamonds and those with high levels of non-interest income (*niish*> 0.4) shown with red-squares. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

that holding α_k constant, increasing management share of employment tends to increase managerial pay sensitivity, w_1. Holding management share of employment constant, increasing α_k tends to decrease managerial pay sensitivity. The table can be helpful in thinking about possible explanations within the logic of the model we have elaborated for the empirical patterns documented in Section 4.

For example we can give a possible account of the patterns of pay sensitivity reported in Table 5. There it was seen that between the mid-1990's and 2010 pay sensitivity was higher for banks with a high share of non-interest income (*niish*), that is, the banks concentrating in investment banking, global markets, and fund management. Then from 2011 onward, estimated pay sensitivity increased sharply for banks with moderate or lower shares of non-interest income, while sensitivity among the banks with high shares of non-interest income stayed at about the same levels as in the earlier period. A within-the-model explanation would be that in the earlier period the high-*niish* banks had a lower α_k, a lower α_l and higher α_m. That is, they employed greater leverage and hired relatively more bankers with higher education or other qualifications useful banking beyond conventional credit intermediation. Then following the financial crisis and the passage of Dodd–Frank, the very large banks with a big presence in investment banking began to cut back on their leverage. This gave an opening for some smaller banks to move into some of those investment banking activities.

In fact, this argument can be checked within the FRY9c data set. Fig. A.3 shows the evolution of median real assets per banker between 1986 and 2019. By this measure large BHCs began to steadily increase their operating leverage as the process of consolidation gained momentum in the 1990's as we have documented in Appendix A.3. In contrast, small BHCs began similar process of increasing leverage but at a much slower pace. In the right panel of this figure we confine our attention to the large BHCs. We plot real assets per banker for both low *niish* firms ($niish < 0.4$) and high ($niish > 0.4$). We see that both categories followed a similar path in increasing leverage between 1996 and 2010. Then there was a sharp increase in 2011 for high *niish* firms after which the curve flattened. In contrast the BHCs with lower non-interest income share continued to increase slowly and steadily their operating leverage. If this process reflected smaller, follower banks imitating the practices of the larger, more sophisticated banks,

Table A.3
Bankers' Pay Level With Time Varying Value of Leisure: Dependent variable, real pay per banker (*wage_r*). Regressors, log of total assets (*lntar*), real revenues per banker (*incrperemp*), total real assets per banker (*atrperemp*), non-interest income share (*niish*), benchmark calibrated talent (*tal1*), talent based on time varying cost of leisure (*tal1tv*) and year fixed effects. Subsample of *large* BHCs and top of a hierarchical group structure if applicable. Model calibrated talent winsorized at 1% and 99%. t statistics in parentheses. Robust standard errors. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	(1) wage_r	(2) wage_r	(3) wage_r	(4) wage_r
lntar		1.059***	2.649***	2.685***
		(5.41)	(15.67)	(15.86)
niish		37.26***	28.53***	28.02***
		(15.29)	(11.93)	(11.43)
incrperemp		24.35***		
		(4.09)		
atrperemp		2.526***		
		(7.76)		
tal1_w01			19.53***	
			(5.20)	
tal1tv_w01				0.0345***
				(5.17)
_cons	42.60***	2.596	−12.17***	−11.60***
	(55.93)	(0.99)	(−4.64)	(−4.46)
Fixed Effects	year	year	year	year
Winsorized	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)
R-sq	0.305	0.646	0.488	0.488
Nobs	4442	4442	4355	4355

this would have involved hiring bankers with the technical skills necessary to manage effectively more assets per banker. That is, it would have meant increasing α_m and decreasing α_l on the part of the follower BHCs. On the other hand the bank groups that had previously built up their activities in investment banking, trading and fund management either maintained their mix of business or may have cut back. That is they maintained a constant α_m and α_l or, possibly, reduced α_m while increasing α_l.

A.4.2. Pay level regressions with time-varying leisure value

Next we consider the possibility discussed in Section 5.2 that the cost of effort parameter g may be time-varying. Allowing for this alters the calculation of model implied talent through the change in the expression for $C(.)$ given by Eq. (23). As in that section, we assume the value of leisure is equal for management and labor with observable effort and set $g_t = w_{lt}$. Then the leading term in the expression for value added becomes,

$$C(\alpha_m, \alpha_l, \alpha_k, g_t) = ([\frac{\alpha_m + \alpha_l}{1+\alpha_l}]^{(\alpha_m+\alpha_l)/\alpha_k} - \alpha_l [\frac{\alpha_m + \alpha_l}{1+\alpha_l}]^{(1/\alpha_k)})(\frac{\alpha_m}{g_t})^{\alpha_m/\alpha_k}(\frac{\alpha_l}{g_t})^{\alpha_l/\alpha_k} \tag{A.22}$$

We use the BLS statistics on civilian labor for participation rates broken down by year, age, sex and race.[15] For most segments of the data there is secular decline of labor force participation rates between 2002 and 2022 and projected to continue through 2032 (with a notable exception for women, aged 25–54, between 2012 and 2022). For our calibration we use the figures for men aged 25–54 which strikes us as the 'modal' category for bank managers who participate significantly in BHC bonus or other incentive schemes characterized as by 'management' in our model. For this category the annual average rate of decline of the participation rate was 0.161 percent. We assume a common trend of increase in g_t also of 0.161 percent. Using the resulting series of g_t in Eq. (A.22), we then invert the value-added equation (analogous to Eq. (22)) which gives us an expression for time-varying talent which is analogous to Eq. (25) except that $c*$ is replaced by a more complicated expression which varies with t. This is the variable *tal1tv* which we use in the alternative pay level regressions reported in Table A.3.

The results for the pooled sample of large BHCs are given in column 4 of Table A.3 These are qualitatively very similar to those obtained using *tal1* in the OLS regression for the pooled sample in Table 6, column 1. In particular they have the same pattern of sign. And in the regression with time varying leisure cost regression the coefficient is now highly significant; whereas it was not in the regressions based on constant leisure cost.

To see how allowing for time-varying cost of leisure affects the predicted trend of bankers' pay level we compare the year fixed effects from the regression with *tal1tv* with those of wage regressions with year fixed effects only, with year effects with controls including productivity measures, and with year effects including *tal1* given in Table A.3 columns 1, 2 and 3 respectively. The results are depicted in Fig. A.4 where we have plotted the model predicted levels of bankers' real pay based on pooled mean values of

[15] Available at https://data.bls.gov/

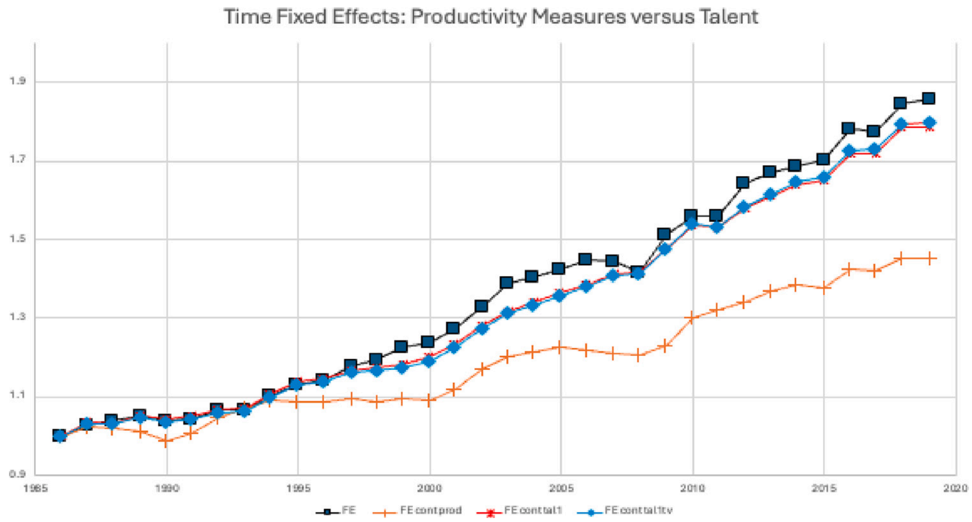

Fig. A.4. Time Fixed Effect Trends Under Alternative Wage Level Regressions: This graphic plots the year FEs (normalized at 1 in 1986) from the four regressions reported in Table A.3. The FEs of the pure time effects regression (Column 1 of Table A.3) are depicted by the dark blue-square curve. The FEs of the regression including productivity variables (Column 2) are depicted by the red-+ curve. The FEs of the regression with talent calibrated with constant cost of leisure (Column 3 of Table A.3) are depicted by the dark red-∗ curve. The FEs of the regression with talent calibrated with time varying cost of leisure (Column 4 of Table A.3) are depicted by the light blue-diamond curve. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

regression controls in the pooled large BHC sample. These projections have been normalized to 1 in 1986. Time trends based on *tal1tv* are very similar to those of *tal1*, implying that not much of the time trend in bankers' pay can be attributed to the increases over time of the cost of leisure (as reflected in general trends of labor force participation rates). And the plots of the projected time trends of pay based on model implied talent are very close to the basic time trend of mean real pay levels in among large BHCs. Overall, this tends to reinforce the interpretation of the time trend given in the body of the paper, namely, that this trend reflects a strong increase in bankers' option to work in private banking, hedge funds, venture capital or other roles outside of banking.

A.4.3. Manager pay versus labor pay

In Section 5 we provided an account of the evolution of bankers' pay between 1986 and 2019 using the structural model of Section 3. We explored the determinants of bankers' pay measured by the mean pay to bankers in a given bank holding company in a given year. Since our model distinguishes between fixed-wage labor and management which receives a combination of salary and incentive pay, it is reasonable to ask what have been the evolutions of those two components of bankers pay considered separately.

Since the BHC data does not report this directly, in this section we provide an answer by extending our calibration using available aggregate labor market data on trends to separate out compensation to labor and to management as formulated in our model. In particular we suppose that the pay rate for homogeneous labor evolved over time at the same rate as observed on average in the US for non-supervisory, full-time employees as reported for December in the NBER-CES data set.

Specifically, we start the calculation by setting labor's pay rate, w_l, in 1986 as the mean of the 10th percentile of *wage_r* over 1986–1990. This was 30.63 (thousands of 2002 dollars). For years 1987 and later we extrapolate using the CES index and then expressing it in 2002 dollars by deflating using the Consumer Price Index (CPI). Then the total pay to non-management labor in a given BHC is calculated assuming the total headcount in the bank holding company is split 0.7 labor and 0.3 management. Total pay to labor is 0.7 X total headcount X non-management pay per worker or *nonmgmtcompces=0.7X bhck4150 X 30.63*X*pay_CES_indx_r*. Total compensation to management is calculated as *mgmt_compces = (bhck4135/infindx)-nonmgmtcompces*. And mean compensation per manager is calculated as, *wagermgm = mgmt_compces /(.3 X bhck4150)*

Fig. A.5 gives a plot of the evolution of share of value-added broken down between labor and management using the calibration based on CES reports of non-management pay trends. The solid line reports the median total (labor+management) compensation share of value-added in large BHCs as reported in Fig. 1. The evolution of fixed wage labor contribution to value added is given by the red-diamond curve. It shows a very regular secular decline from 33 percent in 1986 to 15 percent in 2019. This can be viewed as a measure of the super-star effect brought about by the consolidation in the US banking sector. The management share of value-added (green-squares) remained relatively constant from 1986 to 1999. Then it rose regularly in the post-Gramm–Leach–Bliley era. In the post-Dodd–Frank period the management share again remained relatively constant. These results are similar to the findings reported in Eisfeldt et al. (2022) in their comparison of labor's share without share based pay versus with share based pay. It tends to reinforce the view that the emergence opportunities for growth of larger, complex banking were pursued by compensation practices based on relatively more performance pay.

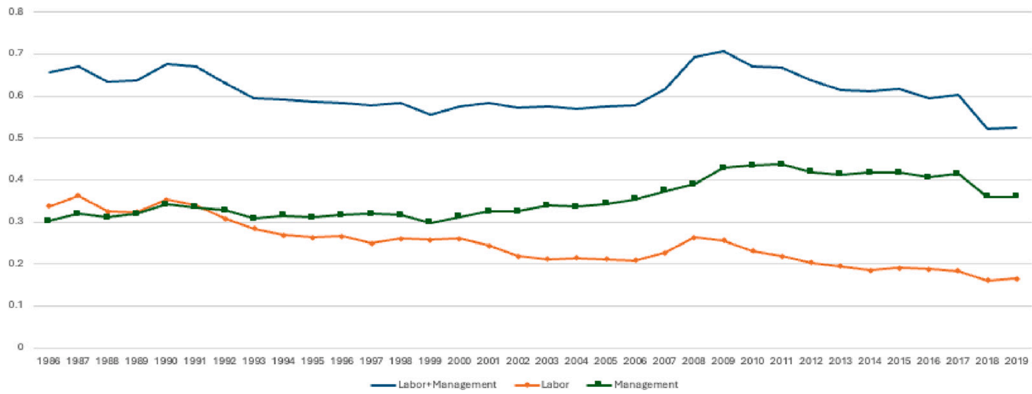

Fig. A.5. Management and Labor Shares of Value-added: This graphic plots the median share of value-added broken down between labor and management using the calibration based on reported earnings of full-time, non-supervisory employees. The share of management and labor combined as reported for total real pay per banker (*wage_r*) is depicted in the dark blue-solid curve. The labor share is based on a trend of calibrated labor total real pay calibrated using reported pay-trends estimated from the NBER-CES data set and is depicted in the red-diamond curve. The calibrated share of management is obtained by finding the difference of total BHC banker compensation and our estimated pay to labor. The implied management share of value-added is shown in the green-square curve. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table A.4
Managers' Pay Level Regressions: Dependent variable, calibrated real pay per manager in the BHC (*wagermgm*). Regressors, log of total assets (*lntar*), real revenues per banker (*incrperemp*), total real assets per banker (*atrperemp*), non-interest income share (*niish*), benchmark calibrated talent (*tal1*), and year fixed effects. Subsample of *large* BHCs and top of a hierarchical group structure if applicable. Model calibrated talent winsorized at 1% and 99%. *t* statistics in parentheses. Robust standard errors. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	(1) wagermgm	(2) wagermgm	(3) wagermgm
lntar	16.146***	0.831	8.217***
	19.18	(0.98)	(11.19)
incrperemp		79.436***	
		(3.54)	
atrperemp		13.396***	
		(10.42)	
niish		185.948***	141.563***
		(16.56)	(12.46)
tal1_w01			77.819***
			(4.36)
cons	−183.885***	−50.282***	−118.259***
	(−13.61)	(−4.54)	(−10.84)
Fixed Effects	year	year	year
Winsorized	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)
R-sq	0.317	0.645	0.432
Nobs	4442	4442	4355

Our calibrated break-down of banker pay into pay to labor and pay to management can be used to assess the determinants of pay focusing specifically on difference of management pay over time and in cross section. This is seen in the pay level regressions reported in Table A.4. Column 1 of the table reports the regression on bank size and year fixed effects. The coefficient of size is positive and highly significant. In column 2 we consider the regression also includes manager productivity variables and non-interest income. The coefficients income per employee and assets per employee are both positive and highly significant, as is the coefficient for *niish*. However, now the pure size effect is no longer significant. This was the pattern found in Table 4 where overall pay level was measured as the mean compensation of all bankers in the BHC inclusive of both labor and management. In column 3 we consider the manager pay level regressed on size, *niish*, model implied talent *tal1*, but omitting the productivity proxies. The coefficients of size, complexity and talent all are positive and highly significant. The R-square is 0.432, less than in the regression including productivity dummies, suggesting that our model implied talent measure captures some, but not all, of the explanatory of the productivity proxies. This is similar to the pattern found in Table 6.

Finally, we have considered alternative versions of the calibration needed to distinguish pay to labor and pay to management. For the extrapolation of labor's pay level over the period 1987–2019 we have replaced the NBER-CES index with one constructed using BLS measures of unskilled, male employees in manufacturing firms reported for Q4. The results hardly differed from those reported in Fig. A.5 and Table A.4. We have also done an alternative calibration where the value of the level of labor's pay in 1986

Table A.5
Pay Level Regressions with Productivity by Banker Type: Dependent variables are calibrated real pay per manager in the BHC (*wagermgm*), mean real total compensation to Execucomp reported executives (*meantdc1r*), and total real compensation to CEO (*totalceotdc1r*). Regressors are log of total assets (*lntar*), real revenues per banker (*incrperemp*), total real assets per banker (*atrperemp*), non-interest income share (*niish*), and year fixed effects. Subsample of *large* BHCs, top of a hierarchical group structure if applicable, and reporting in Execucomp. *t* statistics in parentheses. Robust standard errors. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	(1) wagermgm	(2) meantdc1r	(3) totalceotdc1r
lntar	−3.573**	1432.5***	3031.2***
	(−2.62)	(16.88)	(9.96)
incrperemp	18.31	2208.0*	10202.4***
	(0.55)	(2.37)	(3.54)
atrperemp	22.10***	−10.21	−463.1**
	(10.26)	(−0.19)	(−2.93)
niish	274.1***	2808.5***	2564.8**
	(14.97)	(6.70)	(2.60)
_cons	−36.42	−23987.1***	−50381.5***
	(−1.95)	(−17.17)	(−9.96)
Fixed Effects	year	year	year
R-sq	0.621	0.474	0.280
Nobs	2047	2047	1912

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

was taken as the mean *wager_r* instead of the average of the 10th percentile. In the time-plot of shares of value-added the *levels* change compared to Fig. A.5, with labor's share being higher and management's share being lower. But the *evolutions* are the same: labor's share tending to fall throughout the three decades to 2019 and managements' share being relatively constant up to 1999 after which it rose steadily to 2019.

A.4.4. Bankers' pay and top executive pay

In this paper we have focussed on pay and incentives for bank managers below the top level management. The regulatory data for bank holding companies (FRY9c data) are particularly attractive because they give us information on compensation for all bank employees and include a measure of the entire work force of the whole bank holding company, information that is not systematically reported for non-bank firms. In this way we broke new ground that gives insights beyond what can be gained from the many studies that have focused on CEO's or a handful of top executives. However, having done this, it is natural to ask how do pay practices for management below top level compare with those of the banks' senior executives?

In this subsection we shed some light on this question by looking at the top executive pay in the BHCs for which Compustat data is available. In particular we merge our FRY9c data with the Compustat data set using the linking tables initiated by the Federal Reserve Bank of New York and further developed by WRDS. This covers data starting in 1992 whereas our main data set starts in 1986. Also some BHCs are not covered by Compustat, possibly because they are not listed entities. Another issue is that within Compustat the executives who make up top management are not necessarily consistent across firms. CEO's are reported most regularly. Other executives may be reported with a variety of titles, and some have no titles at all.

To deal with this we calculate two measures of top executive pay. Our measure of all the top executives is *meantdc1r*, the mean real total pay in the year of a BHCs' executives covered in Execucomp. And *totalceotdc1r* is total pay to the CEO (or CEOs if more than one is reported in the year). Both are expressed in thousands of 2002 dollars.[16]

In Table A.5 we compare the determinants of pay across different categories of management. In column 1 we report results for pay of lower level management, *wagermgm*, as discussed in Appendix A.4.3. Column 2 reports results for the mean total pay of Compustat reported managers (*meantdc1r*). Column 3 gives the results for CEO pay (*totalceotdc1r*). The regressors are size (*lntar*), productivity (*incrperemp* and *atrperemp*) and complexity (*niish*). Note the samples are constrained to the subset of BHCs covered by Compustat and that not all covered firms report results for a CEO.

The results highlight some clear differences in the determinants of pay at different levels of the organization. The coefficient of firm size (lntar) is positive and highly significant for senior management (columns 2 and 3); whereas it is negative for lower level management (column 1). For lower level management pay the productivity vari- ables are both positive and that of assets per employee is highly significant. This is in line with the overall bankers pay level results reported in Table 4. In contrast, the coefficient

[16] Total pay is measured as the Execucomp variable TDC1 (Salary + Bonus + Other Annual + Restricted Stock Grants + LTIP Payouts + All Other + Value of Option Grants). We also have used TDC2 (Salary + Bonus + Other Annual + Restricted Stock Grants + LTIP Payouts + All Other + Value of Options Exercised) and find very similar results.

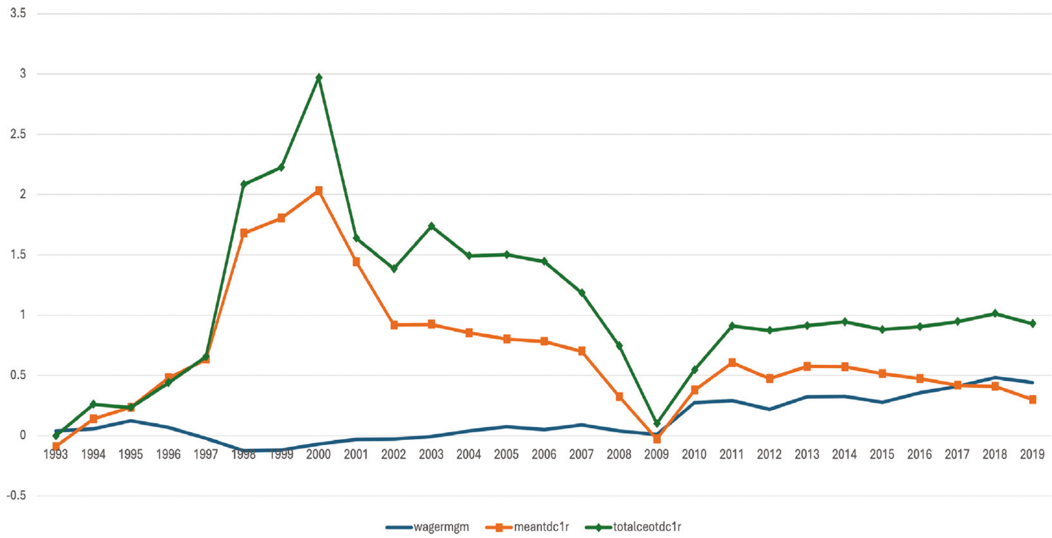

Fig. A.6. Time Fixed Effects of Manager Pay: This graphic plots the time fixed effects of the regressions reported in Table A.5 and expressed as a ratio of FE to median pay level of that management type over 1993–2019. The FEs of lower level management are plotted in the blue-solid curve. Those of the average compensation of Execucomp reported managers is plotted with red-squares. The CEO fixed effects are plotted with green-diamonds. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

of assets per employee (atrperemp) is negative in the top management regressions. However, the effect of bank complexity is similar for both top management and lower level management: the coefficient of niish is positive and significant in all three regressions.

Another aspect of the difference in pay practice between top management and lower level management is illustrated in Fig. A.6 where we have plotted the time fixed effects from the regressions reported in Table A.5, expressed as a ratio of FE to median pay level over 1993–2019. The solid blue line depicts the time fixed effects from the pay level regression of lower level management (*wagermgm*). It follows a slow upward trend over most periods starting from 1998. This is similar to the time FEs found for average pay level in the BHC (*wage_r*) as depicted in Fig. A.4. In contrast, the time trends for top management and for CEOs in particular were radically different. As seen in the FE plots for top executive average (*meantdc1r*) and for CEOs (*totalceotdc1r*) there was an explosion of top management pay in the 1990s which topped out in 2000 following the passage of the Gramm/Leach/Bliley Act. This was followed by a clear moderation of pay and then a dramatic collapse to 2009 following the worst of the financial crisis. In the post-Dodd–Frank period the FEs of top management were flat, suggesting top executive pay was driven largely by bank size and bank complexity.

Data availability

Data will be made available on request.

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