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# Bankers' Pay and the Evolving Structure of US Banking

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We study the evolution of pay in US bank holding companies since 1986 using a structural model of the banking firm. The model incorporates a strong complementarity between capital provided by shareholders and bankers' talent and its noncontractible effort. Bankers' pay is given as 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 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. We then calibrate the structural model that we have introduced to see if it can reproduce the empirical characteristics 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 which set-off consolidation process that is still on-going., 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 hypothesised 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.

Keywords: executive compensation, banking industry structure, rent extraction, superstar firms, regulation

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# Bankers' Pay and the Evolving Structure of US Banking

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We study the evolution of pay in US bank holding companies since 1986 using a structural model of the banking firm. The model incorporates a strong complementarity between capital provided by shareholders and bankers' talent and its non-contractible effort. Bankers' pay is given as 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 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. We then calibrate the structural model that we have introduced to see if it can reproduce the empirical characteristics 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 which set-off consolidation process that is still on-going., 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 hypothesised 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.

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# 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 has 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 or whether the high level compensation sometimes reported for bankers can be understood as the reasonable outcome within a well-functioning market for talent. For example, high pay on-average may be a premium paid to compensate for risk borne by a banker, and very high pay in a given year may be due to exceptional performance in that year. Alternatively, highly skilled bankers may achieve higher pay because their skills are in high demand by some banks. In particular, this is the prediction of some "super-star" models when there is a complementarity between a worker's skill and the firm's capital and when the size distribution of capital is highly skewed.

We explore these issues by studying the evolution of pay in US bank holding companies since 1986. We set 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. The pay characteristics we focus on are labor's share of bank value-added, the level of an average bankers' real compensation and the sensitivity of that compensation to firm performance. Then in a second step we introduce a structural model of industry equilibrium which we calibrate to the US banking data. The model supposes that the pay package agreed upon between shareholders and management solves the second-best problem of maximizing payoff to shareholders subject to the managers' participation and incentive compatibility constraints. We then characterise market equilibrium as an assignment model in which managers with different levels of talent are matched in rank order with banks of different quality. A crucial feature of the model is that we assume a complementarity between banker talent and shareholder capital. Thus 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 through entry, exit, and mergers. We find that by allowing for three major changes in banking regulation, the model is able to reproduce the main times series and cross-sectional characteristics found in the data for bankers' share of value-added, the level of bankers' pay, and the sensitivity of bankers' pay.

The controversy about the the emergence of 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 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, Hong and Scheinkman (2015) 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 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 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 (1980). 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 among of 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 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, Metzger & Strömberg (2022) 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 skill 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 4.5 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, Hong and Scheinkman (2020). More generally, a variety of theories of equilibrium efficiency wage may be relevant to understanding some of the aspect 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 4.6 in discussing how our analysis differs from the pure efficiency wage type of explanations.

The paper is organized as follows. In Section 2 we set out explicitly the theoretical framework that we use in characterising how the transformation of the US banking sector structure over more than three decades has impacted practices on banks' managerial compensation. In Section 3 we introduce 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 4 we use the structural model of Section 2 which we calibrate and then see if it is able to replicate the empirical patterns documented in Section 3. 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 pay 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 5 summarizes our results and discusses open questions and possible extensions. An appendix is devoted to derivations of model results and a description of our data.

# 2 Analytical Framework

## 2.1 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.

## 2.2 Model

The details of the model are developed in Anderson (2023) which examines the determination of incentive contracts in this framework and explores the implication for incentives of share value maximisation as well as other solutions which allow for alternative allocations of rents between capital owners and managers. Here we briefly give an outline of the model using the functional specification we will use in our calibration.

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 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.[1]

This is the standard problem of the form: maximise 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.[2]

[1]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.

[2]Anderson (2023) considers other contracting arrangements in addition to standard shareholder value

The solution to this problem is developed in the Annex A.1 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. Then the second best value of the firm, given $K$ and $T$ is given by equation (43) which we repeat here.

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

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,

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

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 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." 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,

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

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.

maximization and compares them to the first-best benchmark that maximizes total surplus assuming contractible effort.

## 2.3 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 characterise 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 characterised by a sorting condition which says that the $i$'th firm $K_i$ 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 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

$$\begin{aligned} G(K_i, , T_i) - w(K_i, T_i) &\geq rK_i \\ w(K_i, T_i) &\geq w^0 \end{aligned} \tag{7}$$

This equilibrium can be characterised 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

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

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

$$w_T(K_i, T_i) = G_T(K_i, T_i)t'(i) \tag{9}$$

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,

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

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,

$$\pi(K_i, T_i) + w(K_i, T_i) = G(K_i, T_i) \tag{11}$$

or equivalently as

$$\pi_K(K_i, T_i) = G_K(K_i, T_i)k'(i) \tag{12}$$

and

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

This equilibrium can be evaluated in the special case of Cobb-Douglas production function as in Section 2.2. In this case the net value-added of the firm can be developed using equations (34) and (43) and the net value-added of the firm can be written as,

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

Substituting for $w_1$ using (42) the net value-added of the firm can written as,

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

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 4 to calibrate our model using data on US bank holding companies. First, in the next section we set out important characteristics of US banking over the three decades from 1986.

# 3 Empirical Characteristics of the US Banking Sector and Banker Pay

In this section we present an empirical analysis of the evolution of bankers' pay in the US in the context of broader changes in the structure of US banking.

## 3.1 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 Hanwick, 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 authorised 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, Krosner and Rajan, 1993). This picture began to change in the 1980's through a combination of 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 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 FRY9-c reports. (See Appendix B for a discussion of the FRY9-c data including the definitions of the main variables used in our statistical analysis.)

Figure 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 BHC's 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 Figure 2 which gives the evolution of employment, measured in full-time equivalent employees (FTE) in large bank holding companies since 1986.[3] Total employment in the large BHCs (red squares, measured on the left vertical axis) doubled 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 the Introduction 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 Figure 2 we apply this metric to the sample of large BHC's. 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 found 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 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 inter-state banking opened the door to new entrants in local banking markets. Furthermore,

[3]We consider a BHCbank holding company 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 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 alllow us to construct the hierarchy of the banking groups.

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 pursue different strategies in including pursuing a broad line of financial services or specialising on certain finance products or customer bases.

The consequences of increased banking complexity were explored by Cetorelli, Jacobides and Stern (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 2.2 which will be the basis of our calibration in Section 4. 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 return to this theme below in Section 4.4.

Our study covers the three decades from 1986 to 2019. As shown by Stiroh (2002) one interesting way of dividing up the banking market runs in terms of traditional credit intermediation, as measured by net interest income, as compared to non-interest income. These categories have been reported in the FRY9c data since 1986. For this reason, in our analysis will use the non-interest income share (*niish*) as control for changes in banking structure.

## 3.2 Labor's share

We now turn to bankers' pay and start our discussion by noting that the literature reviewed in the Introduction leaves something of a puzzle. On the one hand, the high pay premia in finance documented by Phillipon and Reshef (2012) might seem to be manifestations of a superstar phenomenon where workers with slightly higher skill are able to gain large premia by joining larger, better capitalized firms. However, as argued by Autor *et al* (2020), this runs up against another implication of the superstar phenomenon which is 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. One piece of evidence they use to justify this is the evolution of labor's share as calculated in the US National Product and Income Accounts. Of the six sectors broad sectors they consider they find a pronounced decline in labor's share in four sectors– manufacturing, retail, wholesale, and services. Those are the sectors they explore further and produce evidence that fit the predictions of the superstar firm hypothesis quite well. Finance is an exception to this pattern. By this measure, they find there was a sharp increase in labor's share during the 1980's which was maintained at high levels until the onset of the financial crisis in 2007. They do not attempt to explain why, on their evidence, finance does not seem to reflect the superstar firm characteristics. This is what we would like to explore in more detail here.

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.[4]

The left panel in Figure 3 reports the evolution the median labor's share of BHC value-added each year over 1986 to 2019. This is calculated separately for large BHC's and small BHC's using the classification we introduced in Subsection 3.1. 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 BHC's 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 Figure 1. This was also the period of increased banking market concentration by the top-4 BHC as seen in the right panel of Figure 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 in the previous subsection 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

[4]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.

subsequent strengthening of banking supervision and capital regulation.

As in the previous subsection we think this complexity is reflected in changes in the share of a bank's total earning generated by traditional credit intermediation compared with earnings from the diverse wholesale banking activities summarised in non-interest income. The right panel of Figure 3 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. The median bank is firmly based on traditional credit intermediation. 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.

Taking the two panels of Figure 3 together we have a pattern of a move by BHCs into non-interest income earning activities coincided 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.

There is no shortage of potential explanations for why large BHCs heavily involved in investment banking, securities markets and other wholesale banking services may have had rising labor's shares as a consequence of the crisis. They may have suffered more trading losses when securities markets collapsed. They may have had to write down intangible assets as they exited businesses that were no longer viable in the post crisis environment. They may have needed to hire additional bankers with new and expensive skills to help reinforce core functions in legal, risk and compliance. However, once the banks had made an adjustment in management practices, the process of consolidation continued as seen Figure 1 and the downward trend of in labor's share resumed as seen in the left panel of Figure 3.

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. There is considerable evidence of non-normality in the data. The simple correlation of labor share with these proxies is low— 0.03 for niish and 0.02 for lntar. This reflects the low cross-sectional dispersion of niish in the early years of the sample, the extremely skewed distribution of size, and fat tails in the distribution of labor share induced by yearly fluctuations of value-added. However, rank correlation of labor share and niish is 0.28 in the pooled sample and rises from 0.26 in 1986 to 0.48 in 2016. In contrast, the rank correlations of labor share and size falls from 0.28 in 1986 to 0.06 in 2016. To deal with suspected problems of non-normality and possible large outliers, we report the results two alternative regressions. First we use OLS where we Winsorize the dependent variable and the size and complexity proxies at the 1% and 99% levels. As an alternative not involving trimming we report median quantile regressions.

Table 1 reports the results of multiple regressions of labor share on our size and complexity proxies plus year dummies.[5] In both the OLS regression and in the median regression we find a negative effect of size and a positive effect of complexity with both effects highly significant. 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. The year fixed effects, not reported here, of both the OLS regression with Winsorised covariates and the median quantile regression closely track the yearly sample medians of labor share for large firms as depicted in the left panel of Figure 3.

## 3.3 Bankers' Productivity and Pay Level

We now turn to study pay level, the central focus in much of the literature reviewed in the Introduction, in particular in the analyses of the Gabaix and Landier (2008), Terviö (2008) and Philippon and Reshef (2012). Previous empirical work on bankers' pay has focused on senior management and on CEO pay in particular. This has been largely driven by the availability of data on top management, in particular as reported in the Execucomp data set. Our data set based on the FRY9c reports allows 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,

[5]The regressions are run for the sample of large BHCs over the period 1986-2019. For banking groups with more than one BHC we include only those at the top of the hierarchy. All reported t-statistics are based on robust standard errors

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 is that larger firms attract more talented managers who are able to achieve higher levels of productivity. This is the result obtained in the sorting equilibrium described in Section 2.3 when combined second best contracting as set out in Section 2.2.[6]

It is useful to compare the evolution of our measure of bankers' pay level with 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). Figure 4 presents the evolution of the cross section medians of these three measures for the subsample restricted to large BHCs over the period 1986 to 2019. We have also plotted the median total real assets and non-interest income share, our proxy for the BHC's involvement outside of traditional credit intermediation. We have normalized these series to give them comparable scale by dividing the series by its value in 1986.

Average real compensation per banker (*wage_r*, blue diamond) rose steadily over this period from 40 thousand 2002 dollars in 1986 to 76 thousand in 2019, an increase of 88 percent. Productivity measured as real assets per banker (*atrperemp*, gray triangle) tracks this trend very closely. In contrast revenue per banker (*incperemp*, red square) fluctuates cyclically but is roughly flat over the sample period. Interestingly, the median total real assets per BHC (*at_r*, light blue star) was approximately constant between 1986 and 2001. From 2001 total assets per BHC rose steadily until 2008 and then very sharply to 2019. This reflects the tendency toward consolidation unleashed by the Gramm-Leach-Bliley Act as discussed in Section 3.1. But it also shows the emergence of a push toward very large banks following the banking crisis. These same forces were seen in the non-interest income share (*niish*, yellow X) which rose by 22 per cent between 1999 and 2009. However, this reversed course subsequently and for the median bank returned to 1999 levels by 2019.

This discussion based on trends in the median large bank suggests that the evolution in banker pay levels in the US may reflect changes in banker productivity which has resulted from the consolidation in banking that was described in Section 3.1 and also from the shift in banking away from traditional credit intermediation and toward activities generating non-interest income as described in Section 3.2. 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

[6] For a fuller discussion of this see Anderson (2023)

there is one. Table 2 reports the results.

In columns 1 and 2 of the table we report the regressions of pay level on total assets and year fixed effects but omitting the productivity and banking type measures. In both the least squares regression and the median quantile regression we find a strong positive relation between bankers' pay level and bank size. This is in line with the regularity widely observed in the literature on pay of CEOs and other top level management. 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 both the OLS and the median regressions the coefficient of log real assets is insignificant. In contrast the coefficients of the productivity variables are both positive and highly significant in both regressions. The positive and significant coefficient of real assets per banker is unsurprising given the close relation between this median productivity measure and median real bankers' pay as shown in Figure 4. More striking is the large and highly significant coefficient of revenues per banker. This implies that pay can be quite variable from year to year within a BHC with given assets per banker, suggesting that performance pay may be widespread among large US banks, a possibility we explore explicitly in the next section, 3.4. Finally, the positive and highly significant coefficient on non-interest income share suggests that pay practices can vary widely for different types of banking businesses. In the context of the model introduced in Section 2.2, this can be interpreted as a variation in relative contributions of labor ($L$) whose contribution is contractible and of management with observable talent ($T$) but non-contractible effort ($a$).

## 3.4 Bankers' Incentive Pay

The final aspect of bankers' compensation that we explore in this section is its sensitivity in relation to the performance of the bank. We ask how does bankers' pay vary with performance? How does bankers' pay sensitivity vary across different types of banks? How has it evolved over time as the structure of the US banking has changed? Again we will treat these questions not just for the top echelon of management but rather for all the bankers in the BHC.

Our key variable of interest is the yearly percentage change in mean compensation in a given BHC, specifically *dlnwager*, the log difference of mean total real compensation in a given entity. We study this in relation to two yearly measures of bank performance for a given BHC— the yearly percentage change in total real revenues ($dlnincr$) and the yearly percentage change of real value-added ($dlnvaladr$). While some bankers may have contracts that give incentives linked to narrower measures of performance, a very widespread practice is to set a bank's bonus pool in relation to the bank's overall performance and to set an individual's share of the bonus pool in relation to an individual performance evaluation. Thus average compensation within the bank will naturally be driven by the bank's overall performance.

Our analysis of labor share (Section 3.2) and of pay level (Section 3.3) has produced some evidence that pay practices among big banks may have changed over the 1986-2019 period under the influence of banking consolidation and also changing business models. To gain a preliminary view of this regarding pay sensitivity in Table 3 we report correlations of change in mean compensation with the performance measures for large BHCs for three periods—1987-1999, the first phase of consolidation induced by the removal of obstacles to intra-state and inter-state banking; 2000-2010, the post-Gramm-Leach-Bliley period including the financial crisis; and 2011-2019, the post-Dodd-Frank period. The top two rows use simple correlation coefficients as measures of average compensation sensitivity. For both value-added and total revenue growth these measures of sensitivity were at about 20% or bit below in first and second periods. However, in the post-Dodd-Frank period these sensitivities rose sharply with the sensitivity with respect to revenues standing at 40%. As a precaution against possible distortion due to outliers we also report rank order correlations in rows 3 and 4. Here we find that measured sensitivities are higher with respect to growth of value-added rather than of total revenues. Otherwise as with the simple correlations we find a rise in sensitivity in period 2011-2019.

In light of this evidence of a structural break in pay sensitivity in 2010 we consider regression analysis of the percentage change of average compensation in a firm in relation to firm performance, allowing for a structural break in sensitivity using a *post-2010* dummy. We allow for the intensity of performance incentives across different types of banks by interacting performance with the binary variable *hiniish* which takes on the value 1 for BHC's with non-interest income share of at least 40% in the year. And we also include the double interaction of performance with both *hiniish* and *post-2010*. As in our pay level regressions we confine our attention to large BHCs that are at the top of a BHC hierarchy if there is one.

We present the results of the pay sensitivity regressions based on performance measured as the percentage change of revenues in Panel 1 of Table 4. As previously discussed in light of the apparent non-Gaussian characteristics of the data we focus on the OLS regressions with Winsorized data (column 1) and on the median quantile regressions (column 2). The results are qualitatively similar for these two methods. The change of revenues enters positively and is highly significant. The interaction of hiniish and change of revenues is positive is positive and significant in both regressions. That is, banker pay sensitivity tends to be higher in banks that depend more on non-interest income such as fund management and investment banking. The interaction between post-2010 and revenue growth is also positive and highly significant in the median regression. That is, there is evidence that some banks tended to increase performance pay sensitivity following the financial crisis. The double interaction of revenue performance with hiniish and post-2010 is negative in both regression and highly significant in the median regression. This suggests that the increase in pay sensitivity post-Dodd-Frank was principally a feature of banks focused on traditional credit intermediation.

In order to the combined effect of differences in business model and a possible structural break post-Dodd-Frank in Table 5 we report the sensitivities in the four states of the system implied by the two segments (low niish, high niish) and two periods (1986-2010, 2011-2019). The result for revenue sensitivity are reported in Panel 1 of the table. In the earlier period there was a systematic tendency for pay sensitivities to be higher for the banks with relatively high shares of non-interest income. Subsequently, the estimated sensitivities rose sharply for banks with relatively low shares of non-interest income. In contrast, sensitivities were stable or may have declined in banks with very high shares of non-interest income.

This same pattern prevails if we measure sensitivity to performance measured as a change in value-added. This is seen in Panel 2 of Table 4 where we report the sensitivity regression results using *dlnvaladr* instead of *dlnincr* and in Panel 2 of Table 5 where we report the implied point estimates of sensitivities in the four states. Sensitivities tend to be lower when performance is based on value-added compared to performance based on revenues. That is to be expected given the higher volatility of value-added as compared to revenues. Otherwise, we see the same sharp rise in sensitivity in the latter period for banks which rely less on non-interest income.

The fact that we find in the pre-Dodd/Frank period a tendency for 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 4 where we will discuss in the context of a structural model the implications for US banks of regulatory changes brought on by the financial crisis.

### 3.5 Summary

In this section we have documented the process of banking consolidation that has been underway since the 1980's when regulatory changes eliminated obstacles to bank branching and to interstate banking in the US. This has led to the emergence of a relatively small number of very large banking groups, and this also has coincided with the increase in banking market concentration as measured by the 4-firm concentration ratios. 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.

In considering the implication of these structural changes for banker pay we first examined the evolution of labor's share in banking value-added. We document a decline in bankers' value-added share between the late 1980's and 1997 which is consistent with the hypothesis of a superstar phenomenon in banking that had been facilitated by banking deregulation which paved the way for a national market in banking. In the decade that followed which saw the changing nature of banking through the integration of investment banking and related financial services into BHC structures, the labor share was relatively stable. Then as the financial crisis unfolded it rose very sharply reaching levels in 2009 that were comparable to those seen two decades earlier. Then in the decade to 2019 bankers share of value-added declined steadily. In a regression analysis of disaggregated BHC data we find support for the hypothesis that consolidation in banking has tended to reduce labor's share in banks which have maintained a relatively constant business model. However, this tendency may have been counter-balanced by increased complexity of some business groups.

We then studied the evolution of the level of bankers pay as measured by the average total real compensation per banker in a given BHC and in a given year. We document the near doubling of banker's pay between 1986 and 2019 as measured by the median of the distribution of average compensation across BHC's in a given year. We also find that this distribution is right skewed and has become more so over the last three decades. That is, the highest paying banks pay an average compensation that is much greater than the median bank while the low-paying banks pay something not much below the median. We use regression analysis to explore the factors that may account for these patterns. We find that average banker pay varies positively with two measures of banker productivity (revenues per banker and assets per banker) and also positively with the share of non-interest income in the bank. Controlling for these factors, there is no significant association with the size of the bank as measured by total assets.

Finally we have explored the incentives provided by compensation practices in US banks by studying the sensitivity of average pay in a bank to changes in bank performance. Specifically we use regression analysis that relates the year-to-year percentage change in the average real compensation in a BHC to the year-to-year percentage change in performance measured either by real income or real value-added. In light of the evidence that the bank's share of non-interest income does impact its pay levels, we allow for sensitivity to differ for banks that obtain more than forty percent of their income in the form of non-interest income. Furthermore based on preliminary evidence of changing pay sensitivity over time we allow for a structural break in 2010, the date of the passage of the Dodd/Frank act. We find clear evidence that in the pre-Dodd/Frank period pay sensitivity was significantly higher among the banks with high share of non-interest income. Surprisingly we find that in the post-Dodd/Frank period there was a rise in pay sensitivity in banks with a relatively low share of non-interest income.

Given these empirical characterisations of the US banking sector, we now return the question posed in the Introduction— what, if anything, is special about bankers' pay? Or stated otherwise, are bank pay practices the reasonable outcome within a well-functioning market for talent? To do this we use the structural model introduced in Section 2 which we will calibrate and then see if it can reproduce the patterns documented here.

# 4 Calibration

In Section 3 we used firm level data to explore the relation of the structure of the US banking sector to banker pay as reflected in the share of value-added accruing to bankers, the level of banker compensation and its sensitivity to bank performance. The results provide support for the view that the consolidation of banking into large, more complex banks has led to much higher and more performance sensitive pay for the average banker. Furthermore, we have argued that once you control for the increased complexity of some banks, there has been overall a tendency labor's share of value-added to fall over time, in line with the hypothesis of a super-star firm effect.

In this section we take the analysis further by calibrating the structural model introduced in Section 2 to see if the empirical patterns we have reported above are consistent with an equilibrium model based on second-best contracting by profit maximizing shareholders.

## 4.1 Calibrating pay sensitivity

We start by calibrating pay sensitivity which in the model introduced in Section 2 takes a particularly simple form.

The solution of optimal pay sensitivity for *management*, was given in equation (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 Annex 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 (34), 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 maximisation was found in (32) 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,

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

The FRY9c data does not provide direct reporting of a break-down of total between categories of employees in a particular BHC. However, recent work by Eisfeldt, Falato and Xiaolan (2020) based on the NBER-CES data set finds that across a wide variety of US manufacturing firms the proportion of skilled labor in the total firm labor force is approximately 30%. We will use this in our benchmark calibration. Thus we are left with $\alpha_m/(1-\alpha_k) = 0.3$. Furthermore a number of studies applying Cobb-Douglas production functions have regularly found $\alpha_k$ in the neighborhood of 0.3 which Eisfeldt *et al* also use. Examining yearly median shareholders' share of value added in our sample we find it fluctuates between 0.25 and 0.4 . Thus we adopt $\alpha_k = 0.3$ in our benchmark calibration, implying $\alpha_m = 0.21$ and $\alpha_l = 0.49$.

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

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

Since the pay sensitivity of fixed wage labor is zero we find the implied sensitivity of total compensation per FTE is given is $w^{tot} = 0.3 \times 0.47 = 0.141$.

These benchmark calibrated sensitivities can be compared to the estimates of pay sensitivity as reported in Section 3.4. Our calibrated sensitivity of 0.141 is close to the estimated sensitivity of 0.119 as reported in Table 5 for the OLS regression based on revenue sensitivity using winsorized data. This estimate pertains to banks with relatively low shares of non-interest income which represent about 90% of our sample. For firm's with high shares of non-interest income the point estimate in that regression was 0.226. As is clear from equation (21) the calibrated sensitivity is itself quite sensitive to variations of $\alpha_m$, $\alpha_l$, and $\alpha_k$. For example, if $\alpha_m = 0.32$, $\alpha_l = 0.48$, and $\alpha_k = 0.2$ the resulting calibrated sensitivity is 0.216 which is very close to the estimated sensitivity obtained in Table 5.

## 4.2 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 2.3 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,

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

(see, details in Section 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 $\alpha_m$,$\alpha_l$, and $\alpha_k$ are identical, 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 2.3. Then the value-added of the $i$'th percentile bank is,

$$G(K_i, T_i) = C(\alpha_m, \alpha_l, \alpha_k, g, w_l) T_i^{\alpha_m/\alpha_k} K_i \tag{24}$$

This is increasing in $T_i$ and $K_i$, proportional to $K_i$ and convex (concave) in $T_i$ for $\alpha_m > \alpha_k$ ($\alpha_m < \alpha_k$ ). $C(.)$ is decreasing in $g$ and $w_l$ .

We can find observable proxies for firm size within the FRY9-c data set that allow us calibrate $k(.)$, the profile of $K_i$. Total assets and total shareholder capital are likely candidates and produce profiles that are qualitatively very similar (see, Figure 5). We use total real shareholder capital here.

In firm value-added is observable in the FRY9c data. We can use relation (24) to find an expression for talent in terms of value-added and size. Specifically, we obtain,

$$T_i = c^* \times (Y_i/K_i)^{(\alpha_k/\alpha_m)} \tag{25}$$

where $c^*$ is constant positive scaling factor which we normalize to 1. $Y_i$ is the measured value-added of bank $i$ in a given year and $K_i$ is total shareholder capital.

What are the properties of talent implied by this relation? Given the right skewed distributions of bank capital found in Figure 5 we may suspect that the model implied talent would be similarly right-skewed. This is indeed the case. Figure 6 presents kernal estimates of the implied talent distributions for large BHCs for 1986-2016 at ten year intervals. Specifically we have used *tal1*, the implied talent obtained by using equation (25) with size measured as real shareholder equity with share parameters set as in the benchmark case discussed above, $\alpha_k = 0.3$ and $\alpha_m = 0.21$. This is calculated for large BHC's, and we have Winsorized the result at 1% and 99%. In all years the resulting distribution is right-skewed. What is notable is that is 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 Figure 7 where we have plotted realized talent against log real assets at 10 year intervals from 1986. These yearly cross sections exhibit a positive relation between talent and size for 1986, 1996 and 2006. However, by 2016 there is a slight negative slope to the talent/log size relation. And it is notable that in all four years depicted here 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.[7]. More generally, these relation 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 resulted in a wide range of performance results that are reflected in our estimates of managerial talent.

## 4.3 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 $T_i$ calibrated under our benchmark parameters can serve as proxy for the productivity variables used in pay level regressions presented in Section 3.3 and thus may account for variations in the level bankers' pay.

We consider regressions of average total real compensation where model implied talent (*tal1*) replaces the productivity variables used in regressions reported in Table 2. Otherwise, we include the proxy for size (*lntar*) and the banks' core business (*niish*) as in that table. The results are reported in Table 6. Columns 1 and 2 report results for set of all large BHCs at the top of a group hierarchy if there is one. The results are similar for the OLS regression (column1) and the median regression (column 2). The coefficients of size (*lntar*), non-interest income share (*niish*), and model implied talent (*tal1 w01*) are positive and highly significant. Comparing these regressions with those given in Table 2, it is notable that *lntar* enters positively in the regression with model implied talent whereas it did not in the regression using the productivity variables.

[7] In 2016 one of the outliers was Silicon Valley Bank.

Furthermore, the R-square in the regressions with implied talent are markedly lower than in the regressions using productivity measures. One possible explanation is suggested by Figure 4 where it was shown that the cross-sectional median productivity, measured by real assets per employee, does a good job of tracking median pay level. Thus using assets per banker in descriptive regression in Table 2 resulted in a relatively good fit in the disaggregated sample. This effect was not fully captured by our implied talent measure. Consequently, in the regressions using implied talent, total assets per bank emerges as significant, but overall the goodness of fit is lower.

The descriptive results in Section 3 have provided considerable evidence of important differences in the conditions of banks that are concentrated on traditional credit intermediation versus larger banks with a big presence in non-interest income generating activities. In light of this we also run our pay level regressions separately on BHCs grouped by whether or not the non-interest income share exceeds 40 percent. In Table 6 the results for the *hiniish* group are given in columns 3 and 4, and those for low *niish* BHCs are in columns 5 and 6. In the OLS regression for *hiniish* banks the coefficients of size, non-interest income share and talent are all positive and highly significant. In the median regression the coefficients on those variables are positive and significant for size and *niish*. In these regressions the coefficients on size and *niish* are roughly twice the size of those in the pooled regressions. In effect, a given increase in *niish* or log total assets has a much bigger impact of pay level in banks that already have a significant presence in fund management, investment banking or in other non-interest income activities. For low-*niish* firms in columns 5 and 6 the coefficients for size and talent are positive and significant whereas the coefficients on niish are negative. This gives some indication that for traditional banks with little presence in non-interest income generating activities a marginal move in that direction does not translate into higher pay for bankers unless the bank also increases size and the management shows some performance improvement which translates into increased implied talent.

An important question is whether our model provides an account for the very strong upward trend in bankers' pay level over the three decades from 1986. One answer is given in Figure 8. There we have plotted median real pay level in the cross-sections of large BHC's along with the time fixed effects from the pay level regressions reported here.[8]

[8]The results for medians of the *wager* are given in blue, round dots. The year fixed effects of the OLS regression with productivity variables (Table 2 ) are plotted with red, diamonds. Those of the pooled OLS regression with implied talent (Table 6 column 1) are plotted with gray triangles. And those of the *hiniish* subsample are plotted with yellow, squares. All the results have been normalised by dividing by the 1986 median real pay level in the relevant sample.

The path of the cross-sectional median pay levels documents the strong, three-decade upward trend in bankers' pay in relatively large BHC's. In 2019 the average banker in the median BHC received total compensation in 2002 dollars that was 86 percent higher than in 1986. The plot of the fixed effects from the regressions including productivity variables follows similar smooth uptrend accounts for roughly half of the observed pay increase. This implies that the remaining half of the increase is accounted for by the covariates of that regression: size, *niish*, income per banker, and assets per banker. The plot of the pooled regression using implied talent tracks that of the sample medians. This implies that covariates in the model do not capture much of the upward trend in bankers' pay. However, when restricted to *hiniish* firms the plot of fixed effects in the regression using model based talent lies below the plot of median bankers' pay level. In most years it is also below the trend line implied by year fixed effects in the pay level regression using productivity variables. From 1986 to about 2000 the trend in hiniish, implied talent regression was roughly flat, implying that the upward trend of pay was largely explained by three factors: size, non-interest income share, and banker talent. However, after 2000 the trend of the year effects in the *hiniish* subsample is positive but with a slope that is less than that of the observed median pay levels. This suggests that increases in size, *niish*, and talent continued to be drivers of the level of bankers' pay among banks which were already strongly oriented to non-interest income generating activities. This pattern is consistent with the idea embodied in our model that the removal of barriers to banking consolidation and freedom to integrate some elements of investment banking into a banking group gave effective incentives to match better larger firms with more talented management.

So far in this section we have captured the heterogeneity of business models among large BHCs in two ways. First, in our pay level regressions we have included non-interest income share, *niish*, as a covariate along with size and talent as implied by the model as discussed in section 4.2. The results were given Table 6 columns 1 and 2. Then in addition we ran this model on two different subsamples depending upon whether the BHC's *niish* was greater than 40 percent or not. The results were given in columns 3-6 in the table. In both cases the implied talent was based on the benchmark share parameters $\alpha_k$ and $\alpha_m$ which implied a pay sensitivity of 0.14. This sensitivity was roughly midway between the point estimates of sensitivity found in Table 5 for BHCs with relatively low *niish* and those with high *niish*.

To further introduce heterogeneity of firm structure we also consider calibrating implied talent with share parameters for high and low non-interest income shares separately. Specifically, we consider $\alpha_k = 0.3$ and $\alpha_m = 0.175$ which implies an overall sensitivity of $w^{tot} = 0.1148$. This we associate with BHCs with $niish \leq 0.4$ and the result is an implied management talent, $tal1l$. Alternatively, we set $\alpha_k = 0.2$ and $\alpha_m = 0.32$ which implies an overall sensitivity of $w^{tot} = 0.2162$ and which we associated with BHCs with $niish > 0.4$. This leads to a calibrated talent measure those firms of $tal1h$.

The wage level regression results obtained with these talent measures are reported in Table 9 in Annex A.3.2. They are quite close to those we obtained in Table 6 columns 3-6. They yield the same pattern of sign and significance for the coefficients of size, non-interest income share, and talent for both the *hiniish* and *lowniish* subsamples. Furthermore, the time fixed effects are very close to those in the regressions with benchmark talent. In particular, for the *hiniish* firms they imply a similar time trend as found in Figure 8 for the *hiniish* subsample. Beyond this it is interesting to use these alternative calibrated management talent measures to see how the talent distributions have evolved over time. The results are given in Figure 9 where the left panel describes the cross sectional distributions of $tal1h$ for the *hiniish* firms and the right panel gives the cross sectional distributions of $tal1l$ for the low *niish* firms.

There are differences between the two. In 1986 for high *niish* BHCs talent was tightly grouped around a pronounced mode and if anything the distribution was left skewed. In comparison the low *niish* talent distribution was more disperse and was right-skewed in that year. What is similar with the two measures is that the distributions have shifted to the left over time. One possible explanation of this is high talent management from traditional credit intermediation banks has gravitated to larger banks greater emphasis on non-interest income generation. And talent within banks with a presence in non-interest income generation may have been gravitating toward competitor banks with greater size or other attractive attributes. This may have resulted in a dilution of talent in some high *niish* banks. Also some of movement of talent could have been outside of regulated banking and into other finance areas such as venture capital and private equity. We will develop this point in Sections 4.4 and 4.5.

## 4.4 Calibrating labor's share

In Section 3.2 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 to 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 Figure 10. This plots the median value of the cross section of $tal1$ in our sample of large BHCs.[9]. In line with Figure 9 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 Section 3.1 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. [10] Here we explore how to introduce these changes in the calibration of our model.

Recall that in our model talent is given by equation (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 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 and total shareholder equity experienced a sharp drop in the crisis that has not fully recovered subsequently. 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

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

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

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 characterised 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 Figure 10 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 Figure 3. 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 Figure 3. 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.

## 4.5 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 equation (10) of Section 2.3. 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 realised pay and the outside option. This is the *total rent*. The difference between the total 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 Figure 11 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 realised 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 Figure 11. 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 Figure 4 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 Figure 3. 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 Figures 6 and 9. However, as seen in Figure 8 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 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 Figure 11.

This sharp rise in the implied outside option is not as surprising as it first might seem to some readers. 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* (2022) 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 hypothesising 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 organisational 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.

While these additonal 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.

### 4.6 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 far from clear that changes in risk aversion are able account 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-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 incentivised 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 succss, 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 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 hypothesise 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 Figure 4 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 Figure 12 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. 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. Finally while one might hypothesise as above an increase over time in the amount of assets at risk in high risk activities, this would not imply seem to imply anything in particular about the evolution of cross sectional distribution of average compensation across firms other than an increase the central tendency.

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 stylised way. Bankers in the high risk task are incentivised 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.

# 5 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 is to use a structural model to give an internally consistent account of bankers' pay both in cross-section and time series. We do 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 given 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 characterisation 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 hypothesised 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.

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Table 1: Regressions of Total Labor Share

| | (1) mean(ols) | (2) median |
|---|---|---|
| lntar | -0.0137** | -0.0135*** |
| | (-2.80) | (-11.85) |
| niish | 0.418*** | 0.309*** |
| | (9.68) | (22.23) |
| _cons | 0.701*** | 0.750*** |
| | (9.04) | (40.40) |
| Fixed Effect | year | year |
| Winsorized | (0.01, 0.99) | no |
| R-sq , Pseudo R-sq | 0.0530 | 0.0327 |
| Nobs | 4443 | 4443 |

Subsample of *large* BHCs ,
top of a hierarchical group structure if applicable.
$t$ statistics in parentheses, robust standard errors
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2: Bankers' Pay Level Regressions

| | (1) mean(ols) | (2) median | (3) mean(ols) | (4) median |
|---|---|---|---|---|
| lntar | 4.517*** | 3.762*** | 0.0407 | 0.0458 |
| | (23.25) | (32.51) | (0.19) | (0.41) |
| incrperemp | | | 44.67*** | 43.49*** |
| | | | (8.68) | (9.75) |
| atrperemp | | | 3.312*** | 4.475*** |
| | | | (11.22) | (16.48) |
| niish | | | 46.00*** | 51.69*** |
| | | | (21.65) | (30.14) |
| _cons | -28.60*** | -17.43*** | 9.100** | 4.919*** |
| | (-9.09) | (-9.06) | (3.09) | (4.16) |
| Fixed Effects | year | year | year | year |
| Winsorized | (0.01, 0.99) | no | (0.01, 0.99) | no |
| R-sq , Pseudo R-sq | 0.394 | 0.462 | 0.683 | 0.261 |
| Nobs | 4442 | 4442 | 4442 | 4442 |

Subsample of *large* BHCs, top of a hierarchical group structure if applicable.
$t$ statistics in parentheses, robust standard errors
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Bankers' Pay Sensitivity

| | Correlation of dlnwager | | |
|---|---|---|---|
| | 1987-1999 | 2000-2010 | 2011-2019 |
| dlnvaladr | 0.2 | 0.1709 | 0.2781 |
| dlnincr | 0.2064 | 0.1933 | 0.4004 |
| | **Rank order correlation of dlnwager** | | |
| | 1987-1999 | 2000-2010 | 2011-2019 |
| dlnvaladr | 0.1865 | 0.181 | 0.2941 |
| dlnincr | 0.1142 | 0.0868 | 0.2057 |

Table 4: Bankers' Pay Sensitivity Regressions

| Panel 1: Revenue Performance | | |
|---|---|---|
| | (1) | (2) |
| | mean(ols) | median |
| dlnincr | 0.119*** | 0.0692*** |
| | (5.12) | (6.22) |
| hiniish×dlnincr | 0.107* | 0.133*** |
| | (2.36) | (5.30) |
| post_2010×dlnincr | 0.0760 | 0.126*** |
| | (1.62) | (5.58) |
| hiniish×post_2010×dlnincr | -0.0973 | -0.204*** |
| | (-1.14) | (-5.25) |
| _cons | 0.0154 | 0.00975 |
| | (1.90) | (1.25) |
| Fixed Effects | year | year |
| Winsorized | (0.01, 0.99) | no |
| R-sq , Pseudo R-sq | 0.0634 | 0.036 |
| Nobs | 4154 | 4154 |

| Panel 2: Value-added Performance | | |
|---|---|---|
| | (1) | (2) |
| | mean(ols) | median |
| dlnvaladr | 0.0456*** | 0.0169*** |
| | (3.52) | (3.74) |
| hiniish×dlnvaladr | 0.0413 | 0.0111 |
| | (1.55) | (1.35) |
| post_2010×dlnvaladr | 0.0494 | 0.0420*** |
| | (1.94) | (4.86) |
| hiniish×post_2010×dlnvaladr | -0.0351 | 0.00549 |
| | (-0.73) | (0.18) |
| _cons | 0.0293*** | 0.0137 |
| | (3.46) | (1.78) |
| Fixed Effects | year | year |
| Winsorized | (0.01, 0.99) | no |
| R-sq , Pseudo R-sq | 0.0461 | 0.023 |
| Nobs | 4029 | 4029 |

Subsample of *large* BHCs, top of a hierarchical group structure if applicable.

$t$ statistics in parentheses, robust standard errors

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Point Estimates of Pay Sensitivity

Panel 1: Revenue Performance

| Method | (1) OLS | | (2) Median | |
|---|---|---|---|---|
| Share of Non-interest Income | Low | High | Low | High |
| 1987-2010 | 11.9% | 22.6% | 6.9% | 20.2% |
| 2011-2019 | 19.5% | 20.5% | 19.5% | 12.4% |

Panel 2: Value-added Performance

| Share of Non-interest Income | Low | High | Low | High |
|---|---|---|---|---|
| 1987-2010 | 4.6% | 8.7% | 1.7% | 2.8% |
| 2011-2019 | 9.5% | 10.1% | 5.9% | 7.6% |

Subsample of *large* BHCs, top of an hierarchical group structure if applicable.

Table 6: Pay Level Regressions with Implied Talent

| | (1) OLS pooled | (2) median pooled | (3) OLS hiniish | (4) median hiniish | (5) OLS low niish | (6) median low niish |
|---|---|---|---|---|---|---|
| lntar | 2.605*** | 2.573*** | 6.693*** | 5.464*** | 2.414*** | 2.422*** |
| | (14.19) | (18.87) | (14.82) | (20.55) | (12.96) | (17.05) |
| niish | 30.47*** | 27.99*** | 53.20*** | 69.80*** | -19.52*** | -7.697** |
| | (12.80) | (15.02) | (12.41) | (10.37) | (-4.96) | (-2.96) |
| tal1_w01 | 18.14*** | 9.965*** | 18.39** | 5.517 | 24.82*** | 20.10*** |
| | (4.84) | (4.64) | (3.24) | (1.07) | (5.38) | (9.69) |
| _cons | -11.63*** | -9.503*** | -83.20*** | -72.82*** | 1.906 | -0.577 |
| | (-4.11) | (-4.44) | (-9.80) | (-13.91) | (0.69) | (-0.28) |
| Fixed Effects | year | year | year | year | year | year |
| Winsorized | (0.01, 0.99) | | (0.01, 0.99) | | (0.01, 0.99) | |
| R-sq , Pseudo R-sq | 0.482 | 0.301 | 0.473 | 0.250 | 0.412 | 0.284 |
| Nobs | 4355 | 4355 | 908 | 908 | 3447 | 3447 |

$t$ statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

# Figures

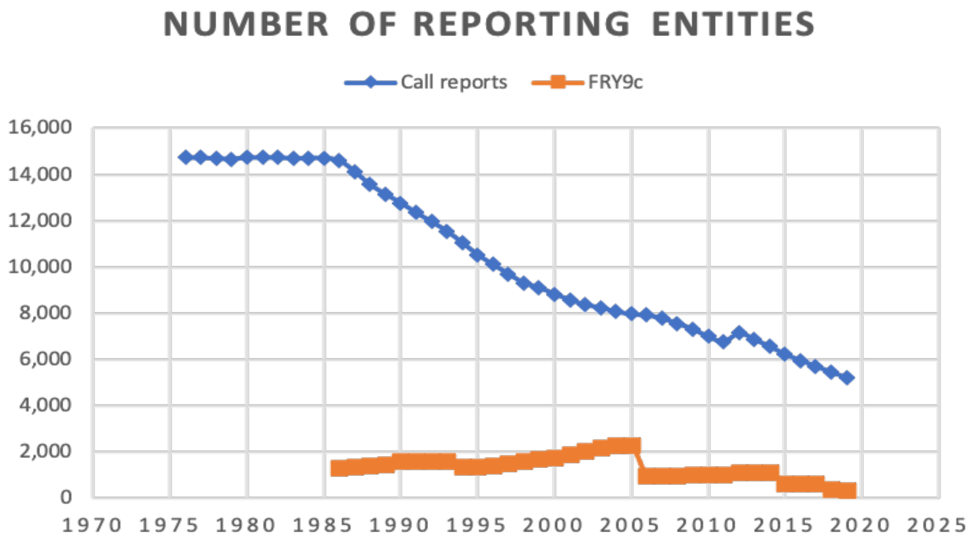
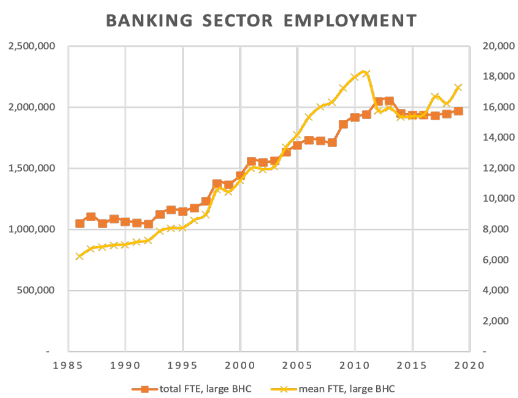



Figure 1: Number of Reporting Entities



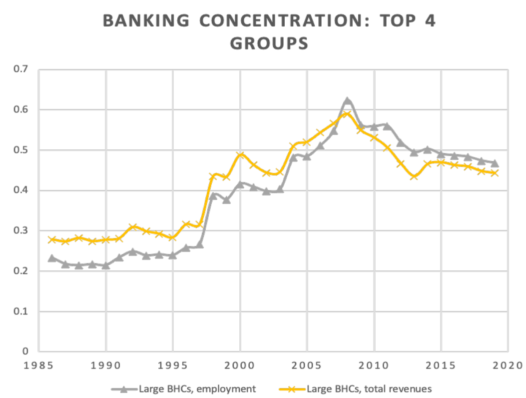
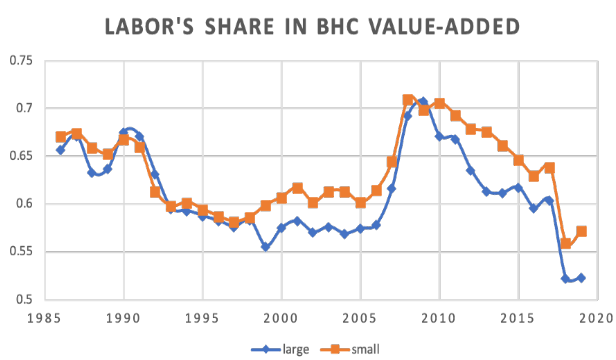




Figure 2: Size and Concentration of Bank Holding Companies



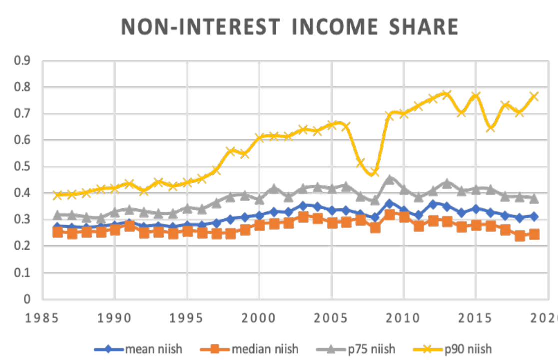




Figure 3: Labor's Share and Non-interest Income

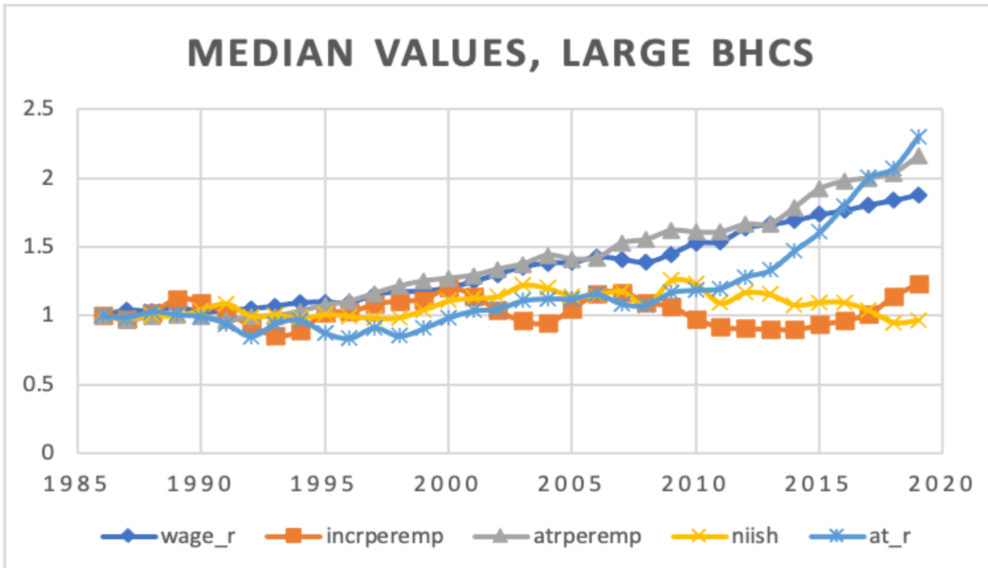



Figure 4: Total Compensation per FTE and Productivity per FTE

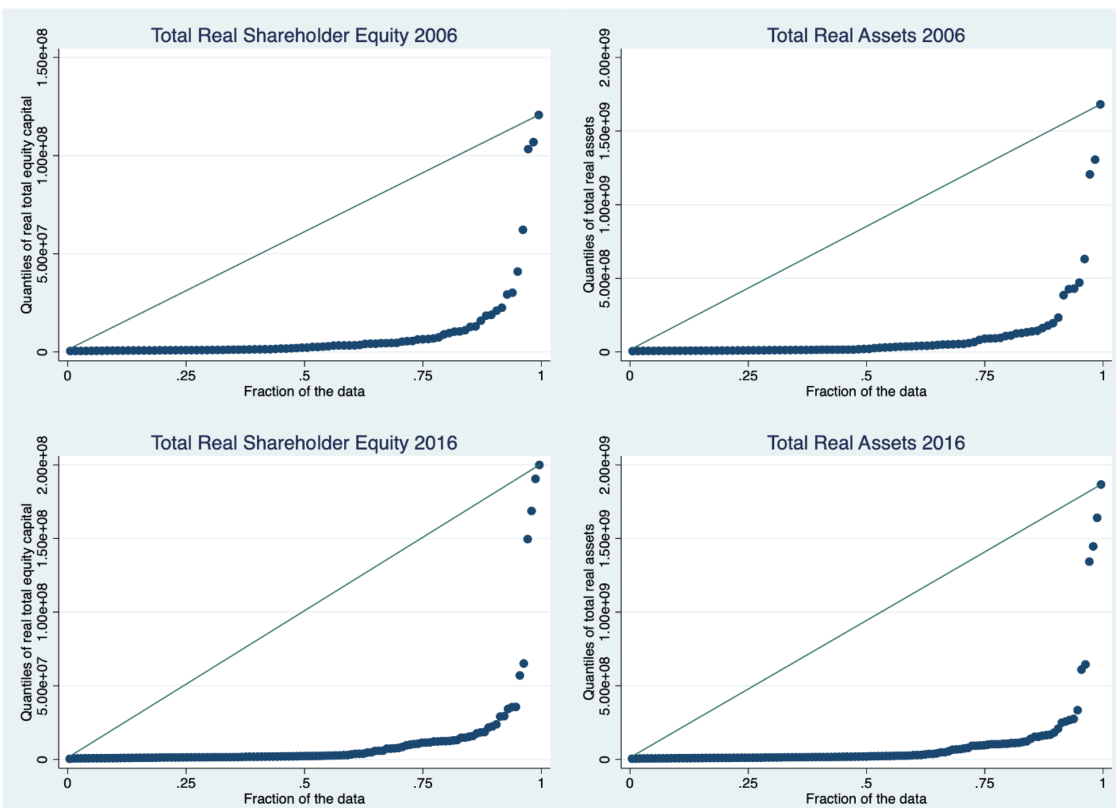



Figure 5: Bank Size Profiles

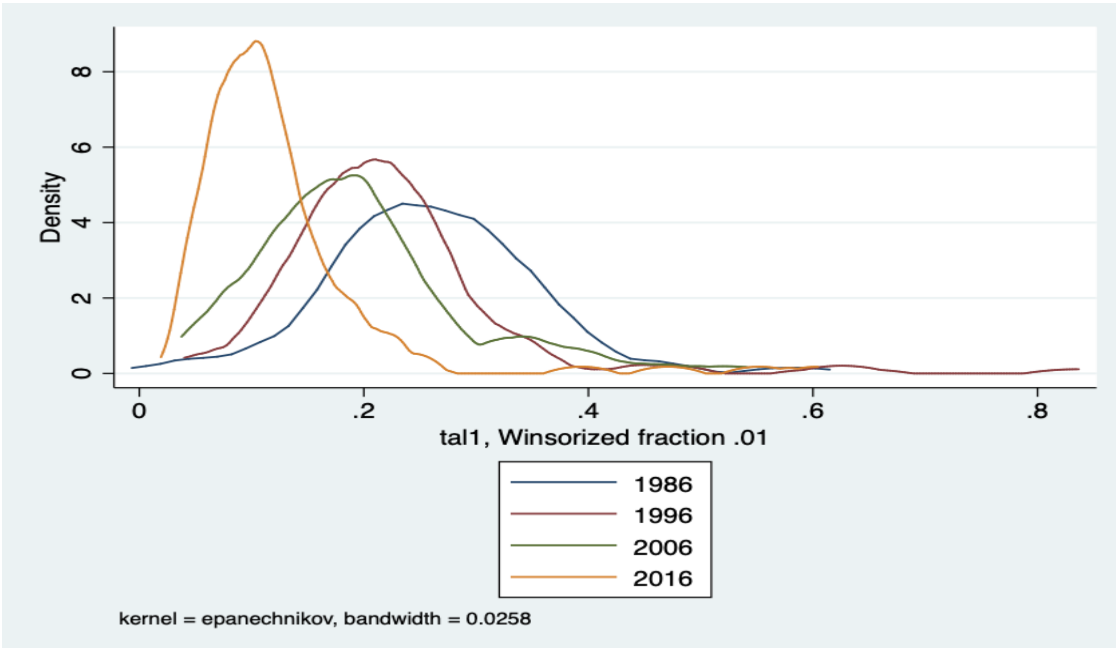



Figure 6: Implied Talent Distributions

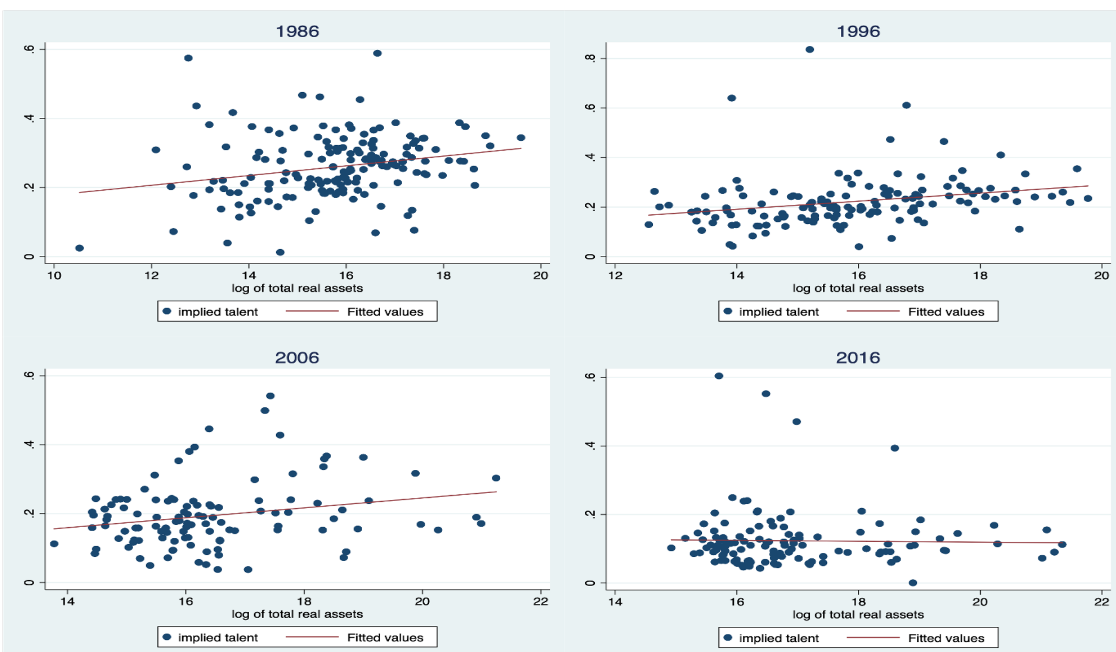



Figure 7: Talent Size Profiles

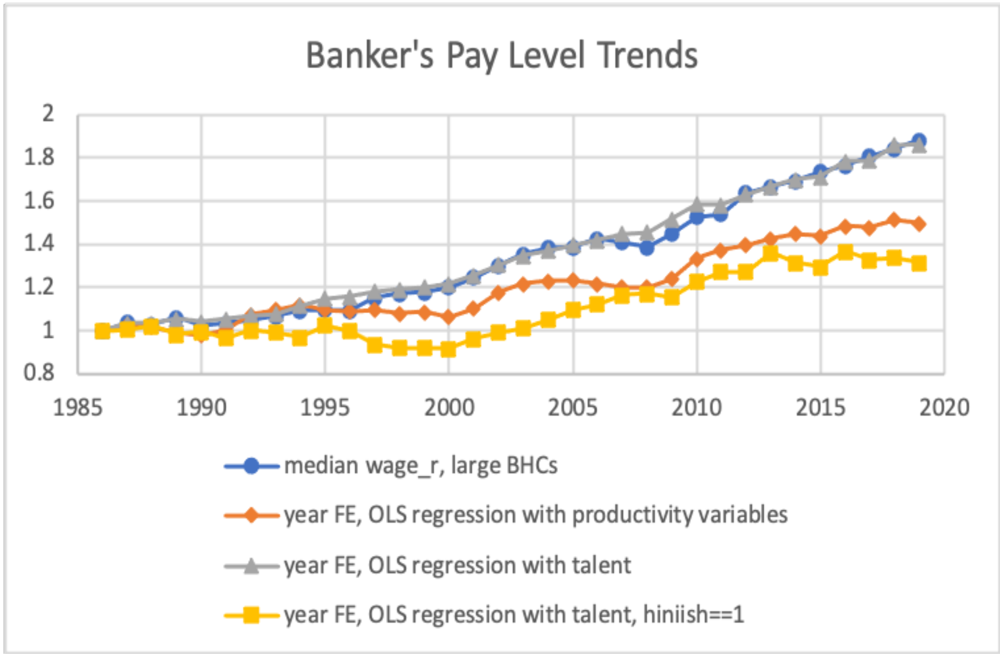



Figure 8: Pay Level Trend and Regression Year Fixed Effects

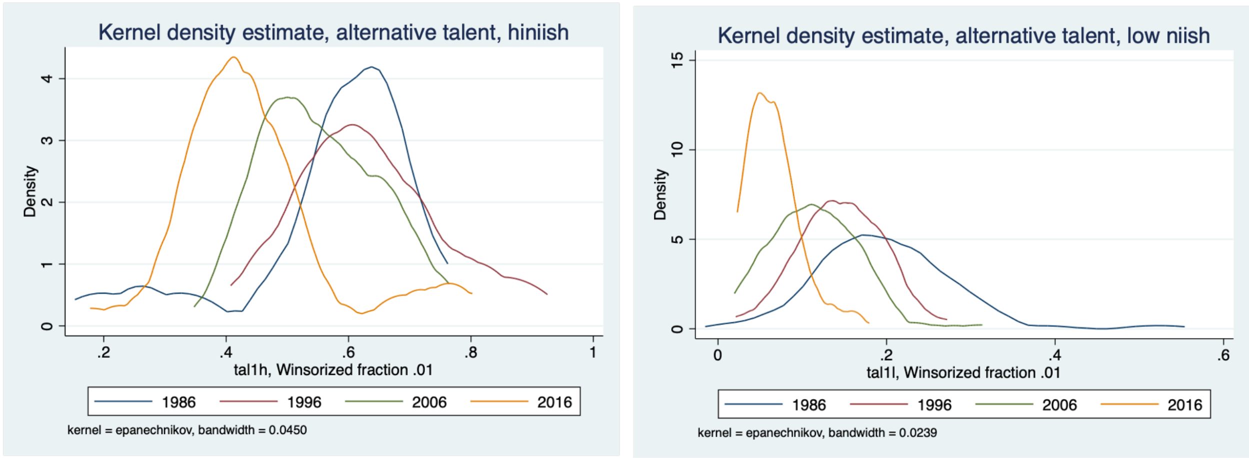



Figure 9: Implied Talent Distributions, hi and low niish

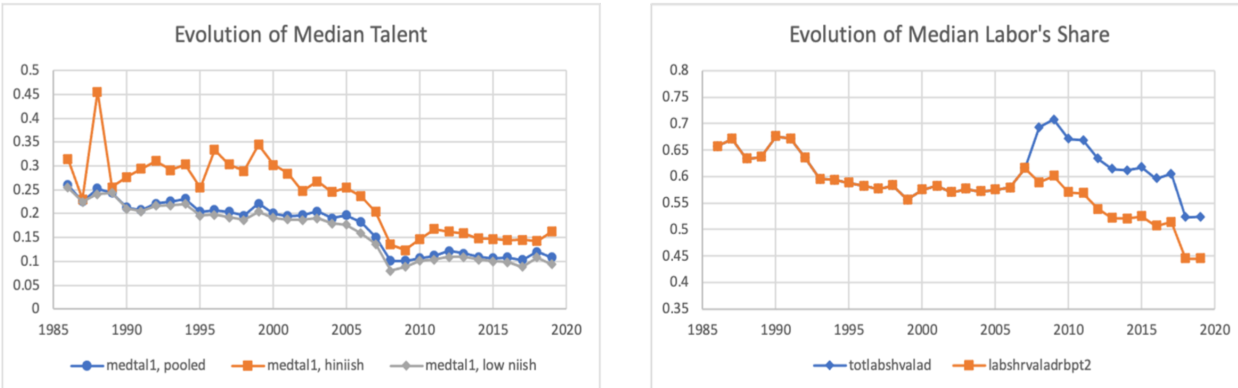



Figure 10: Implied Talent and Labor's Share: Large BHCs

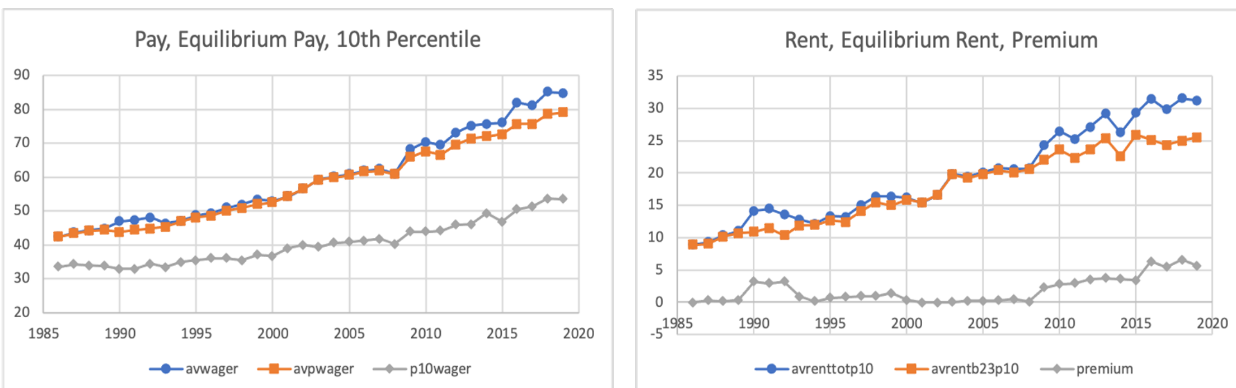



Figure 11: Total Rent, Equlibrium Rent and Bankers' Premium: Large BHCs

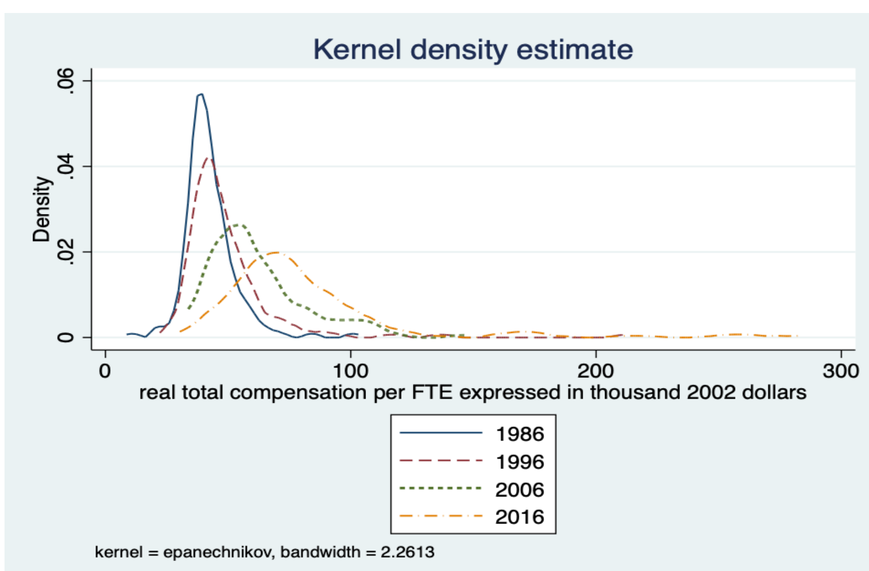



Figure 12: Distributions of Average Bankers' Pay

# A Appendices

## A.1 Model Details

In this subsection we present solutions to the second best optimal contract for a given firm as used in Subsection 2.2. Under the functional specification introduced there principal's problem is,

$$Max_{\{c(.),L,a\}} a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l} - c(a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l}) - w_l L \tag{26}$$

subject to the participation constraint,

$$c(a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l}) - ga \geq w_m(T) \tag{27}$$

and the incentive compatibility restriction,

$$\frac{d\left(c(a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l})\right)}{da} = g \tag{28}$$

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

$$c(V) = w_0 + w_1 V \tag{29}$$

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

$$Max_{\{a,L\}} w_1 a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l} - ga - w_l L \tag{30}$$

The first-order condition for $a$ is,

$$\alpha_m w_1 a^{\alpha_m - 1} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l} - g = 0 \tag{31}$$

which implies,

$$a = \frac{\alpha_m w_1}{g} V \tag{32}$$

The first order condition for $L$,

$$\alpha_l w_1 a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l - 1} - w_l = 0 \tag{33}$$

which implies,

$$L = \frac{\alpha_l w_1}{w_l} V \tag{34}$$

Using (32) and (34), firm value can be written as,

$$V = (w_1)^{\alpha_m+\alpha_l} (\frac{\alpha_m}{g})^{\alpha_m} T^{\alpha_m} K^{\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l} V^{\alpha_m+\alpha_l} \tag{35}$$

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, $w_1$,

$$V = w_1^{(\alpha_m+\alpha_l)/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \tag{36}$$

Turning to the determination of the compensation contract offered the manager we use (36) and (34) to express the shareholders' problem as,

$$Max_{(w_0,w_1)} (1 - w_1 - \alpha_l w_1) w_1^{(\alpha_m+\alpha_l)/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K - w_0 \tag{37}$$

subject to

$$w_0 + w_1 w_1^{(\alpha_m+\alpha_l)/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \geq w_m(T) \tag{38}$$

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,

$$Max_{(w_0,w_1)} (w_1^{(\alpha_m+\alpha_l)/\alpha_k} - (1+\alpha_l) w_1^{1/\alpha_k}) (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K - w_0 \tag{39}$$

subject to,

$$w_0 + w_1^{1/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \geq w_m(T) \tag{40}$$

Note that since $\alpha_m + \alpha_l < 1$ and $1/\alpha_k > 1$ the maximand in (39) 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.[11] In that case, the

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

optimal incentive rate $w_1$ can be found by maximizing,

$$(w_1^{(\alpha_m+\alpha_l)/\alpha_k} - (1+\alpha_l)w_1^{1/\alpha_k}) \tag{41}$$

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,

$$w_1 = \frac{\alpha_m + \alpha_l}{1+\alpha_l} \tag{42}$$

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 (36) and $K$, the second best optimal value of the firm is,

$$V = [\frac{\alpha_m + \alpha_l}{1+\alpha_l}]^{(\alpha_m+\alpha_l)/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \tag{43}$$

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

Using (42) and still assuming the manager's wealth constraint is not binding, the value of the manager's fixed compensation is,

$$\begin{aligned} w_0 &= w_m(T) - w_1^{1/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \\ &= w_m(T) - [\frac{\alpha_m + \alpha_l}{1+\alpha_l}]^{1/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \end{aligned} \tag{44}$$

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 needs to have "skin in the game."

Continuing under the assumption that the manager's wealth constraint is not binding and combining (34), (42), and (43) the amount of labor employed at fixed wage $w_l$

can be written,

$$L = \frac{\alpha_l w_1}{w_l} V$$
$$L = w_1 \frac{\alpha_l}{w_l} V$$
$$L = \frac{\alpha_m + \alpha_l}{1 + \alpha_l} \frac{\alpha_l}{w_l} V$$
$$L = \frac{\alpha_m + \alpha_l}{1 + \alpha_l} \frac{\alpha_l}{w_l} [\frac{\alpha_m + \alpha_l}{1 + \alpha_l}]^{(\alpha_m + \alpha_l)/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K$$
$$L = \frac{\alpha_l}{w_l} [\frac{\alpha_m + \alpha_l}{1 + \alpha_l}]^{1/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \tag{45}$$

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

$$w_l L = \alpha_l [\frac{(\alpha_m + \alpha_l)}{1 + \alpha_l}]^{1/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \tag{46}$$

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 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 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 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 will be shown, 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, Falato, and Xiaolan, 2020). 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 incentivised to expend unobservable effort. This was introduced in Section 2.2 and is explored more extensively in Anderson (2023).

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). We have provided summary descriptions of the data used in Tables and Figures reported in the text in Table 7. Details of our calculations used to calculate some of these variables are given in the text at the point the variables are first employed.

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). Information 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 7: Summary of Variables Used

| Short Name | Description | Source | Series |
|---|---|---|---|
| at | total assets, thousand dollars | FRY9c | bhck2170 |
| at_r | total real assets , thousand 2002 dollars | authors calculation | |
| atrperemp | real assets (millions of 2002 dollars) per employee | authors calculation | |
| dlnincr | yearly percentage change of total real revenues | authors calculation | |
| dlnvaladr | yearly percentage change of real value-added | authors calculation | |
| dlnwager | yearly percentage change of average real compensation | authors calculation | |
| entity | entity code | FRY9c | rssd9001 |
| eq_r | real total equity capital in thousands of 2002 dollars | authors calculation | |
| FTE | number of FTE employees | FRY9c | bhck4150 |
| hiniish3 | binary variable equals 1 if niish at least 0.4 | authors calculation | |
| inc | net income (loss) in thousand dolllars | FRY9c | bhck4340 |
| incrperemp | real revenues (million 2002 dollars) per employee | authors calculation | |
| infindx | CPI price index (December 2002=1.0) | FRED | |
| lntar | log of total real assets (thousand 2002 dollars) | authors calculation | |
| niish | share of non-interest income in bank's total | authors calculation | |
| tal1 | implied talent (benchmark) | authors calculation | |
| tal2 | alternative implied talent (low pay sensitivity) | authors calculation | |
| tal3 | niish adjusted implied talent (low pay sensitivity) | authors calculation | |
| tal4 | alternative implied talent (high pay sensitivity) | authors calculation | |
| tal5 | niish adjusted model implied (high pay sensitivity) | authors calculation | |
| totlabshvalad | total labor share of value-added | authors calculation | |
| valad_r | real value-added in thousands of 2002 dollars | authors calculation | |
| wage | salaries and employee benefits (thousand dollars) | FRY9c | bhck4135 |
| wage_r | real total compensation per FTE in thousand 2002 dollars | authors calculation | |
| year | year of report (December) | FRY9c | |

## A.3 Calibration extensions and robustness

### A.3.1 Calibrating pay sensitivity

In Section 4.1 we discussed the relation of sensitivity of pay implied by the second-best pay contract and the share parameters ($\alpha_k$, $\alpha_m$,and $\alpha_l$) that capture the bank technology. Table 8 gives the relationship between technology and pay sensitivity. It is seen that holding $\alpha_k$ constant, increasing management share of employment tends to increase managerial pay sensitivity, $w_1$. Holding management share of employment constant increasing $\alpha_k$ 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 3.

For example we can give a possible account of the patterns of pay sensitivity reported in Panel 1 of Table 5. There we saw that between 1987 and 2010 pay sensitivity was higher for banks with a higher 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. Or they may even have dropped. A within-the-model explanation would be that in the earlier period the high-*niish* banks had a lower $\alpha_k$, a lower $\alpha_l$ and higher $\alpha_m$. That is, they employed greater leverage and hired relatively more bankers with higher education or other qualifications useful banking beyond conventional credit intermediation.

In fact, this argument can be checked within the FRY9c data set. Figure 13 shows the evolution of median real assets per banker between 1986 and 2019. The left panel plots this for large and small BHC as we described in Section 3.3. 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 Section 3.1. 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, that is, the data set used in the estimates in Table 4. We plot real assets per banker for both low *niish* firms and high. 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

Table 8: Calibrated Pay Sensitivity

| $\alpha_k$ | $\alpha_m/(\alpha_l + \alpha_m)$ | $\alpha_l + \alpha_m$ | $\alpha_l$ | $\alpha_m$ | $w_1$ | $w^{tot}$ |
|---|---|---|---|---|---|---|
| 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 |

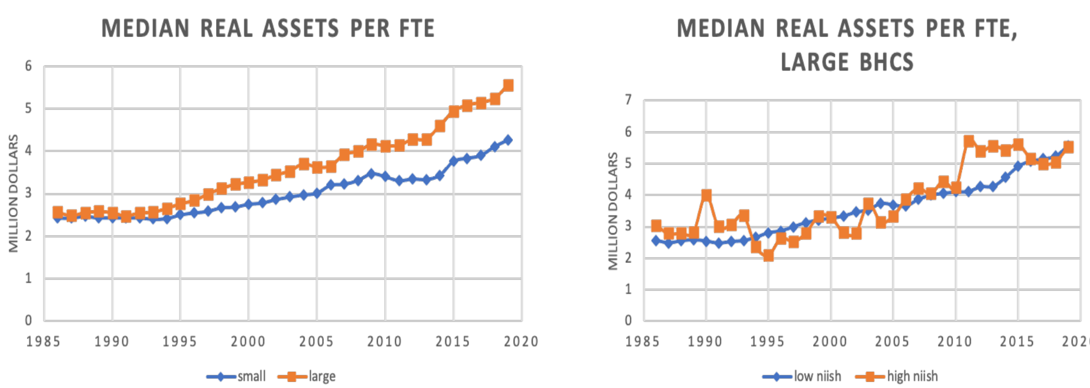



Figure 13: Assets Per Employee

sophisticated banks, 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 $\alpha_m$ and decreasing $\alpha_l$ 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 $\alpha_m$ and $\alpha_l$ or, possibly, reduced $\alpha_m$ while increasing $\alpha_l$.

### A.3.2 Alternative pay level regressions

Table 9: Pay Level Regressions with Alternatiive Implied Talents

| | (1) OLS pooled | (2) median pooled | (3) OLS hiniish | (4) median hiniish | (5) OLS low niish | (6) median low niish |
|---|---|---|---|---|---|---|
| lntar | 2.460*** | 2.457*** | 6.556*** | 5.450*** | 2.403*** | 2.428*** |
| | (13.33) | (18.56) | (14.40) | (20.28) | (12.92) | (17.19) |
| niish | 19.43*** | 16.82*** | 55.55*** | 72.67*** | -18.73*** | -7.783** |
| | (6.25) | (7.88) | (13.40) | (11.21) | (-4.78) | (-3.01) |
| tal1alt_w01 | 20.39*** | 18.28*** | | | | |
| | (8.11) | (9.30) | | | | |
| tal1h_w01 | | | 14.83* | 2.771 | | |
| | | | (2.42) | (0.61) | | |
| tal1l_w01 | | | | | 26.31*** | 22.85*** |
| | | | | | (4.84) | (10.42) |
| _cons | -6.242* | -5.608** | -85.16*** | -73.49*** | 3.037 | 0.0512 |
| | (-2.25) | (-2.73) | (-9.54) | (-13.30) | (1.12) | (0.03) |
| Fixed Effects | year | year | year | year | year | year |
| Winsorized | (0.01, 0.99) | | (0.01, 0.99) | | (0.01, 0.99) | |
| R-sq , Pseudo R-sq | 0.488 | 0.307 | 0.469 | 0.250 | 0.411 | 0.284 |
| Nobs | 4355 | 4355 | 908 | 908 | 3447 | 3447 |

$t$ statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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