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Ronald W. Anderson
Karin Jõeveer

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

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Ronald W. Anderson, Xinhua College of Sun Yat-sen University, CEPR and Department of Finance and the Systemic Risk Centre, London School of Economics

Karin Jõeveer, Tallinn University of Technology, and the Systemic Risk Centre, London School of Economics

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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

*Department of Finance; London School of Economics, Xinhua College of Sun Yat-sen University and CEPR, r.w.anderson@lse.ac.uk. This work is preliminary. Please do not circulate. Comments welcome.

†Department of Finance and Economics, Tallinn University of Technology, karin.joeveer@taltech.ee

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 study compensation practices in US banking over the last three decades using aggregative and firm level data on institutions supervised by the Federal Reserve System. We document the changing structure of the US banking sector and explore the relation of this changing structure to changes in banker compensation. We find a clear pattern of banking consolidation that has resulted in the emergence of very large banking groups. While for much of this period consolidation has coincided with a decline in labor's share of net value-added, this decline was reversed in the ten years from 2000 when many of the largest banks pursued strategies aimed at generating non-interest income. These same banks tend to be the ones with relatively high mean total compensation per banker and which rely upon relatively high powered incentives. We also find evidence of an increase in the last decade of the use of high powered incentives among banks which concentrate on traditional credit intermediation. Using a new, structural model of banking firms where shareholders set compensation contracts for bankers with varying skills and non-contractible effort we find that observed levels of incentives are in line with those that are set by shareholders as part of a second-best optimal compensation contract.

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 many other contributions to the literature on skill and compensation that are also at least indirectly related to our paper. Célérier and Vallée (2019) consider the compensation premium in finance using information of exam performance of top executives. They exploit a special feature of the French higher education system. 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.

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 and 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. In the next section we will discuss how our data and findings on concentration differ from those of Corbae and D'Erasmo.

Our anlysis 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 3.4 in discussing how our analysis differs from the pure efficiency wage type of explanations.

The paper is organized as follows. In Section 2 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 3 we introduce a structural model of the banking which we calibrate to see if it is able to replicate the empirical patterns documented in Section 2, in this way presenting an internally consistent account of the forces that may have shaped compensation practices in US banking. The model postulates a complementarity between capital provided by the bank's shareholders and the skill of the managers engaged by the bank. Manager's effort is supposed to be non-contractible, and shareholders set out a manager's compensation contract which maximizes shareholder return subject to the manager's participation and incentive compatibility constraints. The set of potential managers is supposed to be heterogeneous. Industry equilibrium is studied using a matching model where banks and managers are sorted in rank order of their qualities as reflected in size and talent respectively. Section 4 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 Empirical Characteristics of the US Banking Sector and Banker Pay

In this section we present disaggregated evidence on the evolution of the banking sector in the United States focusing particularly on bankers' pay. After describing our data sources in the next subsection we then look at four different aspects of US banking. First we examine the changing structure of the banking sector and it relation to a series of important developments in banking regulation. Then in Section 2.3 we take up the relation of labor's share in banking to changes in banking competition both overall and within different segments of the banking industry. In the forth subsection we look at the distribution of average total compensation per banker, both in cross section and over time. Finally, we look at the evidence of the sensitivity of bankers' pay in relation to bank performance.

2.1 Data

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 a 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. The model is developed in Anderson (2020) and presented briefly in Section 3.1 below.

Before discussing any result relying on this calibration we continue in this section to see what can be said on the questions posed in the Introduction simply on our panel data on BHCs. The description of the data set are set out in the data appendix Section 5.1.

2.2 US banking sector size and concentration

It is useful to start with some basic measures of size and concentration of the US banking using both the BHC regulatory filings (FRY9c reports) and the domestically-based, licensed banks reporting to the Federal Reserve (call reports). This will tell us something about the process of consolidation through entry and exit that has been underway in the last 40 years. It will also tell us something about a number of changes in reporting requirements that need to be kept in mind when interpreting banking data over time.[1]

Figure 1 presents the evolution of the number of reporting entities in the two data

[1] A very useful reference to regulatory reporting to the Federal Reserve is given in Avraham, Selvaggi and Vickery (2012).

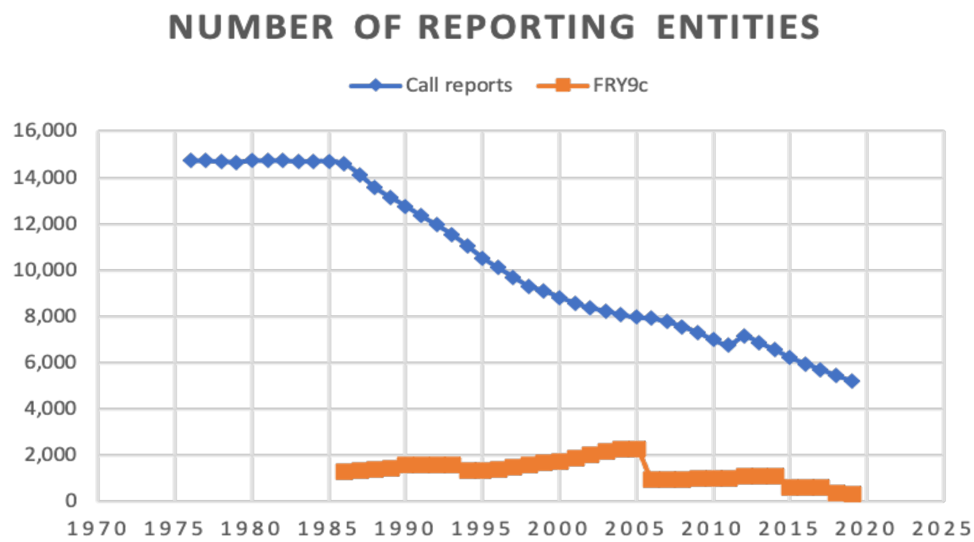

Figure 1: Number of Reporting Entities

sets. The federal call reports 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 began a steady decline in the number of reporting institutions through a mixture of mergers, acquisitions and closures. This continued through the 1990s under the impetus of Riegle-Neal Act of 1994 which largely eliminated existing obstacles to interstate banking. 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 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 BHCs in 2006 (from 2,310 to 986), 2015 (from 1,129 to 653) and 2018 (from 641 to 373). This pattern reflects

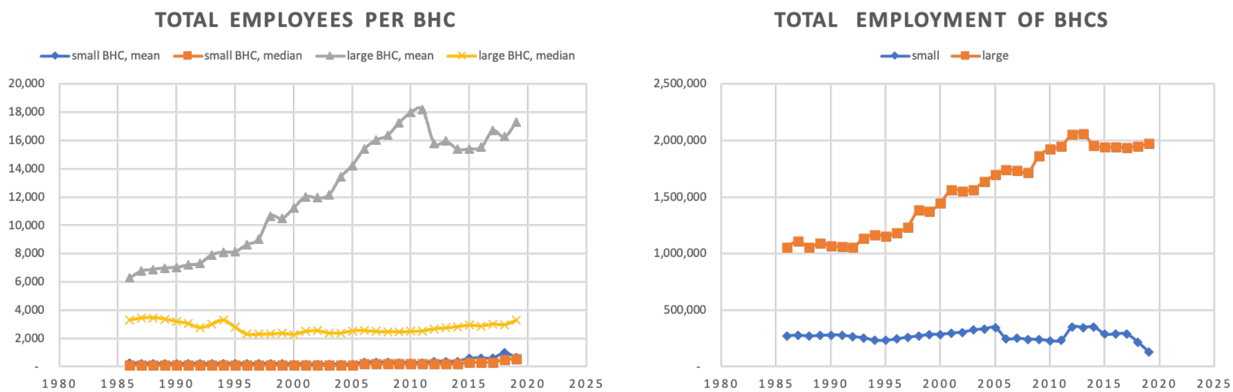

Figure 2: Employment in Banking Groups

the fact that the BHCs are required to file FRY9c reports only if they have total assets greater than a reporting threshold. Furthermore, reporting has 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 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 presents the evolution of the mean and median numbers of group employment, measured in full-time-equivalent employees (FTE) per BHC. We calculate this for small and large BHC's separately where we have considered a bank 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.[2]

Already in 1986 the size distribution of large bank holding companies was skewed, with the mean employment of 6292 FTE as compared to a median of 3306. Subsequently, the distribution became markedly more skewed with the mean employment reaching 18,007 by 2011 while the median had fallen to 2498. In contrast, the small

[2]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 group.

BHCs by total assets have tended to shed employees. In 1986 mean employment was 246 FTEs while the median was 123. By 2005 (the year before the Federal Reserves reporting thresholds were raised) the mean had fallen to 169 while the median was 105.

Overall the banking sector has grown in size as measured by total employment. This is seen in the right panel of Figure 2 which presents the trend of total FTE employment for small and large BHC's reported separately. Between 1986 and 2005 there was a strong increase in total employment in large BHC's (from 1 million FTE in 1986 to 1.7 million in 2005). Over the same period employment among small BHCs rose about 27% from 273 thousand to 346 thousand. Subsequently, total employment grew principally among the large BHC's reaching 2 million in 2012. Total employment growth in BHC's has outpaced that of licensed bank entities. Between 1986 and 2019 employment in reporting BHCs rose by 58%, from 1.33 million to 2.11 million. In contrast, over the same period aggregate employment in call reports went from 1.63 million to 2.07 million, a 26% increase. In sum, more people have entered the banking sector, and generally they have joined large banks.

In addition to banking consolidation, the strong growth of BHCs also reflects the entry into the banking sector of a number of large domestic investment banks as well as US subsidiaries of large foreign banks which were restructured as BHCs during the financial crisis of 2007-08 or through changed regulatory requirements under the Dodd-Frank Act of 2010. It should be noted that some of the employment growth of BHCs has been in subsidiaries providing financial services outside of the licensed banks with insured deposits. Avraham, Selvaggi and Vickery (2012) give some insights into the emergence of large, complex banking groups engaging in activities other than deposit taking and credit intermediation. They study the cross section of the top 50 BHCs by total assets as reported in the FRY9c date for December 2011. For example, JP Morgan Chase & Co, the largest BHC at that date, had a total of 3,391 subsidiaries of which 4 were commercial banks, 2,936 were domestic non-bank subsidiaries and 451 were foreign subsidiaries.

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 was 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. There are limitations associated with this metric. In particular, in the last 40 years many banking institutions have developed alternative funding sources including wholesale funding and securitisation so that banks have been able to expand their business with-

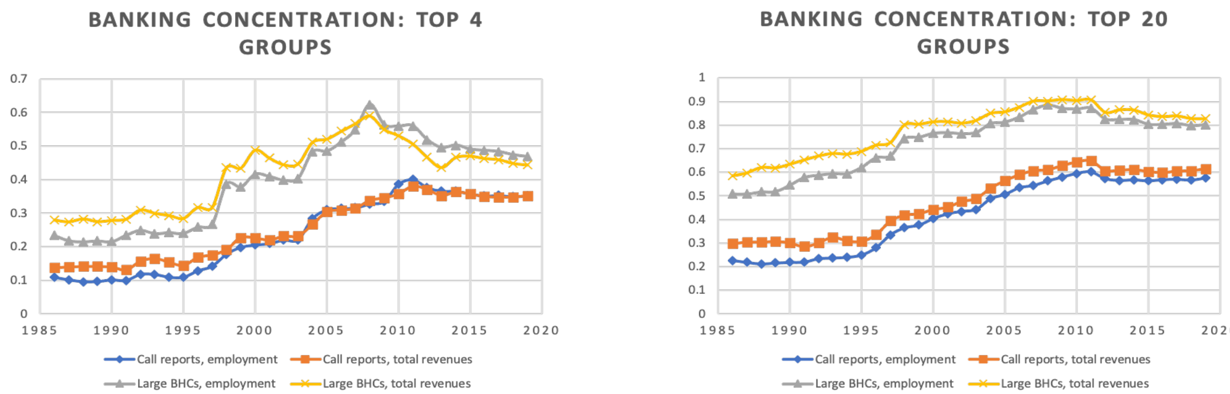

Figure 3: Concentration in Banking

out relying heavily on insured deposits. Furthermore, the process of consolidation has often involved merging two or more commercial banking subsidiaries of a single BHC into a single licensed commercial bank. This increased the size of that surviving unit but may not have affected greatly or at all the size the consolidated position of the BHC. Thus we revisit this issue here by looking at metrics of concentration based on alternative measures of bank size, namely employment and total revenues. And we compute these metrics using both call reports and the FRY9c reports on BHCs, where the latter are restricted to large BHCs which were at the top of group in cases where a BHC hierarchy was used.

The left hand panel of Figure 3 reports the 4-bank concentration ratios for commercial banks and for large BHCs. The patterns are similar both for total employment and for total revenues. The concentration ratios for BHCs are systematically higher than for the commercial banks by about 10 to 15 percentage points. This reflects principally the fact that many banking groups use BHCs as the base for operating multiple commercial banks as well as other non-bank subsidiaries. Furthermore, the level of 4-BHC concentration rose sharply for the ten year prior to 2008 before falling markedly afterward. In this case of 4-BHC employment concentration went from 27% in 1997 to 62% in 2008 on to 47% in 2019. As has been mentioned already, the ten years since the financial crisis in 2007-2008 has seen the entry of large investment banks and subsidiaries of large foreign banks into fold of BHCs. This is reflected in the decline of concentration since 2008. The right panel of Figure 3 reports to evolution of commercial bank and BHC concentration measured using market share of the top-20 institutions. These metrics exhibit a similar pattern of an increase in concentration through 2008 followed by a subsequent decline. However, the changes have been more

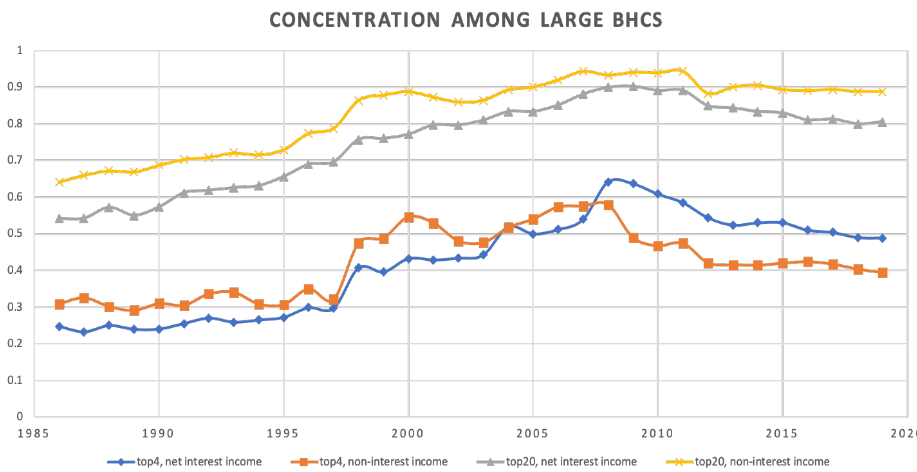

Figure 4: Concentration in Banking Groups: Interest Income vs Non-interest Income

moderate.

These observations made on the basis of the evolution revenues streams suggest that it is too simple to conclude that the process of consolidation in banking has led to 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 has opened the door to entry in local banking markets. Furthermore, the dismantling of barriers separating commercial banking, investment banking, and insurance have blurred the boundaries between formerly distinct market places for different financial services. The FRY9c data report a number of sub-categories of BHC revenues enabling us to assess the degree to which banks have pursued strategies of concentrating their activities in a small number of core activities or, rather, have adopted a highly diversified approach.

As argued 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, which is also reported in the FRY9c data. In Figure 4 we have calculated concentration ratios for these two income categories for large BHCs over the period 1986 to 2019. Interestingly, as measured by top-4 BHCs the patterns are similar for both net interest income and non-interest income and similar in turn to those already noted for employment or total revenues in large BHC's. There was a marked rise from 1986 to 2008 and then an equally marked fall in concentration to 2019. Again, this is hardly the picture of a tight, settled oligopoly. Instead, it seems that following the major swings regulatory environment have given rise to a variety of

Net Interest Income							
1988		1998		2008		2018	
Entity	Share	Entity	Share	Entity	Share	Entity	Share
CITICORP	0.110	CITIGROUP INC.	0.139	CITIGROUP INC.	0.209	JPMORGAN CHASE & CO.	0.135
BANKAMERICA CORPORATION	0.055	BANKAMERICA CORPORATION	0.133	BANK OF AMERICA CORPORATION	0.184	WELLS FARGO & COMPANY	0.124
CHASE MANHATTAN CORPORATION	0.047	BANK ONE CORPORATION	0.069	JPMORGAN CHASE & CO.	0.150	BANK OF AMERICA CORPORATION	0.118
SECURITY PACIFIC CORPORATION	0.038	WELLS FARGO & COMPANY	0.066	WELLS FARGO & COMPANY	0.099	CITIGROUP INC.	0.113
FIRST INTERSTATE BANCORP	0.034	CHASE MANHATTAN CORP	0.063	METLIFE, INC.	0.059	CAPITAL ONE FINANCIAL CORPORATION	0.056
CHEMICAL BANKING CORPORATION	0.033	FIRST UNION CORPORATION	0.054	U.S. BANCORP	0.030	SYNCHRONY FINANCIAL	0.032
MANUFACTURERS HANOVER CORP	0.029	FLEET FINANCIAL GROUP, INC.	0.028	CAPITAL ONE FINANCIAL CORP	0.028	U.S. BANCORP	0.032
WELLS FARGO & COMPANY	0.028	U.S. BANCORP	0.023	SUNTRUST BANKS, INC.	0.018	PNC FINANCIAL SERVICES GROUP, INC., THE	0.024
J.P. MORGAN & CO. INCORPORATED	0.025	SUNTRUST BANKS, INC.	0.022	BB&T CORPORATION	0.016	DISCOVER FINANCIAL SERVICES	0.022
PNC FINANCIAL CORP.	0.018	NATIONAL CITY CORPORATION	0.021	REGIONS FINANCIAL CORPORATION	0.015	AMERICAN EXPRESS COMPANY	0.019
Non-interest Income							
1988		1998		2008		2018	
Entity	Share	Entity	Share	Entity	Share	Entity	Share
CITICORP	0.143	CITIGROUP INC.	0.236	METLIFE, INC.	0.190	JPMORGAN CHASE & CO.	0.132
CHASE MANHATTAN CORPORATION	0.060	BANKAMERICA CORPORATION	0.099	BANK OF AMERICA CORPORATION	0.155	BANK OF AMERICA CORPORATION	0.104
SECURITY PACIFIC CORPORATION	0.050	CHASE MANHATTAN CORP	0.078	JPMORGAN CHASE & CO.	0.146	WELLS FARGO & COMPANY	0.086
MANUFACTURERS HANOVER CORP	0.049	BANK ONE CORPORATION	0.062	WELLS FARGO & COMPANY	0.088	MORGAN STANLEY	0.082
BANKAMERICA CORPORATION	0.049	FIRST UNION CORPORATION	0.050	BANK OF NEW YORK MELLON CORP	0.067	GOLDMAN SACHS GROUP, INC	0.080
BANKERS TRUST NEW YORK CORP	0.044	WELLS FARGO & COMPANY	0.049	STATE STREET CORPORATION	0.044	AMERICAN EXPRESS COMPANY	0.080
J.P. MORGAN & CO. INCORPORATED	0.040	J.P. MORGAN & CO. INC	0.045	U.S. BANCORP	0.042	CITIGROUP INC.	0.065
CHEMICAL BANKING CORPORATION	0.038	BANKERS TRUST CORPORATION	0.029	CAPITAL ONE FINANCIAL CORP	0.037	UNITED SERVICES AUTOMOBILE ASSOC	0.063
FIRST CHICAGO CORPORATION	0.029	MBNA CORPORATION	0.026	FRANKLIN RESOURCES, INC.	0.028	BANK OF NEW YORK MELLON CORP	0.031
FIRST INTERSTATE BANCORP	0.026	FLEET FINANCIAL GROUP, INC.	0.025	PNC FINANCIAL SERVICES GROUP INC	0.019	U.S. BANCORP	0.023

Figure 5: Top 10 Bank Holding Companies

strategic responses among major players who have achieved large scale in at least some lines of business and who then contest among themselves for dominance.

This impression is reinforced if one looks at the changes over time in the make-up of the top-ranked participants, treating net-interest income and non-interest income separately. Figure 5 reports this at 10 year intervals since 1988 for the top 10 institutions. For example, comparing the list of top-10 BHC's ranked by share of net interest income in 2008 and in 2018, we see that four firms, Metlife, SunTrust Banks, BB&T and Regions Financial had disappeared from the list by 2018. The four banks that replaced them were the products of a complex, trial and error process of mergers and acquistions leaving them with different geographic footprints and covering different product lines.[3] Furthermore, while the same four BHC's made up the top-4 rankings

[3]Synchrony Financial emerged through the spin-off of retail banking services by GE Capital and has grown through acquisitions in pet insurance and joint-ventures with the payments company PayPal. PNC Financial Services is the product of merging two large regional commercial banks. It has grown through an aggressive series of acquisitions which, following a difficult time in the financial crisis including a spell in the Troubled Asset Relief Program, continued until it had established a dense market coverage with more than 2000 branches and 9000 ATMs. The history of Discover Financial Services goes back to the 1980's when the nation-wide retailer Sears attempted to create its own financial supermarket based on the Discover credit card by acquiring the securities broker DeanWitter, the real-estate broker and mortgage banker Coldwell Banker and other financial firms. After a disappointing start, Sears spun-off most of these activities in an independent subsidiary which then merged with the investment banking firm Morgan Stanley in 1997. A decade later, Morgan Stanley in turn spun off the consumer banking and credit card conglomerate as an independent company in 2007. Since then it has continued to grow with further acquisitions of credit card businesses and student loan specialists.

by share of net-interest income, collectively they had given up 15.2% of their market share.

During the 1980s and 1990s bank activities generating non-interest income were largely limited to trust, custodial services, advisory and other wealth management services. During this period the changes in the make-up of these activities in the US was a reflection of the consolidation through mergers and acquisitions that were then gaining momentum. This accounts for the departure by 1998 of five of the top-10 as ranked in the 1988 list by non-interest income.[4] With the passage of the Gramm-Leach-Bliley Act of 1999 the scope grew for banks to generate income in securities origination, trading and sales and well as in insurance underwriting. Since then the changing make-up of the top-10 banks judged by non-interest income reflects the entrance of traditional investment banks either on a stand-alone basis (Goldman Sachs, Morgan Stanley) or as part of a merged bank entity (Bank of America which acquired the large securities broker-dealer Merrill-Lynch in 2008). However, it also reflects the mixed experience with operating insurance activities within a bank holding company structure, as reflected by Citigroup's spinning-off its insurance operations in the Travelers Group in 2002 and the insurance giant Metlife's decision to sell off its banking and mortgage servicing units in 2012.

2.3 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 observation is reproduced here in Figure 6. This depicts the evolution of labor's share as calculated in the US National Product and Income Accounts for six sectors. It documents a pro-

[4]Security Pacific was acquired by Bank of America in 1992. In 1998 First Chicago Corporation merged with Bank One which had been growing fast through a series of acquisitions in the Midwest. Manufacturers Hanover was acquired by Chemical Bank in 1992 which in turn merged with Chase Manhattan Corporation in 1996. Continuing to operate as Chase Manhattan Corp this bank in turn acquired JP Morgan & Co in 2000, changing its name JP Morgan Chase. Then this bank was acquired by Bank One in 2004, but the combined entity has operated under the name JP Morgan Chase subsequently.

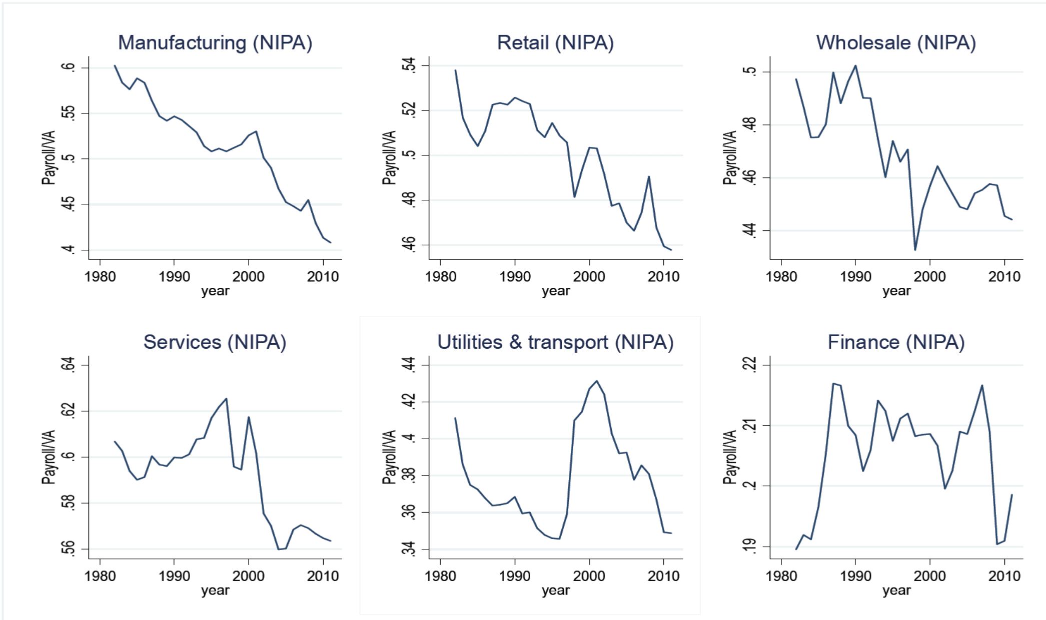

Figure 6: Labor's Share in NIPA (Autor et al, 2020, online appendix)

nounced decline in labor's share in 4 of these 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 their measure, 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.[5]

The left panel in Figure 7 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 2.2. In contrast with Autor *et al* we find a marked decline in labor's share between the late 1980's

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

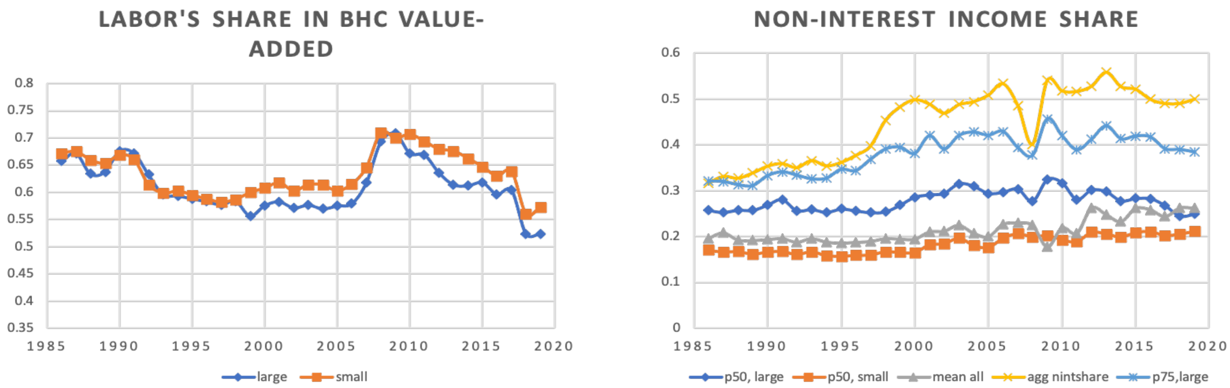

Figure 7: Labor's Share and Non-interest Income

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-20 BHC as seen in the right panel of Figure 3. 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 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 7 shows the evolution of BHC's non-interest income share as captured in five different metrics. As depicted by the median non-interest income share among small BHCs (red squares), the mix of a typical bank's services has hardly changed in the last three decades and is still largely confined to conventional credit intermediation. Among large BHC's the median non-interest income share (dark blue diamonds) increased gradually from 26% to 31% between 1996 and 2009. However, among the large BHC's the distribution of the non-interest income share has become markedly right-skewed as seen in the relatively rapid rise of the 75th percentile (light blue stars) from 34% to 46% over the same period. The move of banking into new products is captured even more dramatically in the share of aggregate banking income derived from non-interest earnings (yellow $\times$'s) which rose from 38% in 1996 to 54% in 2009.

The move by some larger 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 7.

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.

Table 1 reports the results of multiple regressions of labor share on our size and

Table 1: Regressions of Total Labor Share

Panel 1					
	(1)	(2)	(3)	(4)	
	mean (ols)	mean(ols)	median	panel	
lntar	-0.0105	-0.0137**	-0.0135***	-0.0282	
	(-0.44)	(-2.80)	(-11.85)	(-1.50)	
niish	0.497	0.418***	0.309***	0.467**	
	(1.27)	(9.68)	(22.23)	(3.01)	
_cons	0.546	0.701***	0.750***	0.898**	
	(1.68)	(9.04)	(40.40)	(3.28)	
Fixed Effect	year	year	year	year, entity	
Winsorized	no	(0.01, 0.99)	no	(0.01, 0.99)	
R-sq	0.00680	0.0530		0.0326	
Nobs	4443	4443	4443	4443	

Panel 2					
	(1)	(2)	(3)	(4)	(5)
	p10	p25	median	p75	p90
lntar	0.00653***	-0.00249*	-0.0135***	-0.0174***	-0.0201***
	(3.29)	(-2.12)	(-11.85)	(-10.48)	(-9.40)
niish	0.221***	0.269***	0.309***	0.351***	0.414***
	(10.07)	(21.10)	(22.23)	(22.28)	(14.67)
_cons	0.306***	0.526***	0.750***	0.849***	0.962***
	(8.10)	(24.15)	(40.40)	(33.22)	(12.99)
Fixed Effect	year	year	year	year	year
Winsorized	no	no	no	no	no
Nobs	4443	4443	4443	4443	4443

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

t statistics in parentheses, robust standard errors

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

complexity proxies plus year dummies.[6] Panel 1 is devoted to estimates of central tendency of the distribution, using four alternative estimation techniques in an effort to obtain robust conclusions despite the non-normal features of the data just mentioned. In column 1 we present the results of OLS. The coefficient on size is negative and complexity is positive as we hypothesized, but neither is statistically significant. Even when including the yearly fixed effects the overall fit is extremely poor. To deal with this suspected problem of large outliers, in column 2 we report the results of OLS when we Winsorize the dependent variable and the size and complexity proxies at the 1% and 99% levels. Again we find a negative coefficient on size and a positive coefficient on complexity. However, with these trimmed data the results are highly significant, and the overall fit has increased by an order of magnitude. In column 3 we use quantile regressions as an alternative approach to obtaining robust results but without data trimming. This is based on absolute deviations around the median. Again we find a negative effect of size and a positive effect of complexity with both effects highly significant. Finally, in column 4 we use panel regression on Winsorized data and attempt to control for non-observable determinants that would be approximately constant for a given BHC over time but varying in cross-section. Again we find a negative coefficient on size and a positive coefficient on complexity where the latter effect is 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.

In Panel 2 of Table 1 we report labor share quantile regression results for the 10th, 25th, 50th, 75th and 90th percentiles. The coefficients for niish are positive, significant and of a similar magnitude at all the percentiles. This suggests that a uniform increase in banking complexity across banks would tend to displace the whole distribution of labor share to the right. The coefficients on size are negative and significant in all the quantile regression with the exception of that of 10th percentile. One possible interpretation of this is that a expansion of the US banking market (e.g., through an increased popularity of intermediated finance or 'reverse disintermediation') banks generally would be able to automate more processes with a resulting shift of the whole distribution of labor share to the left.

The year fixed effects, not reported here, of the median quantile regression closely track the yearly sample medians of labor share for large firms as depicted in the left

[6] 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

panel of Figure 7. The year fixed effects in the 25th and 75th percentile regressions similarly tracked the movements of the sample median with the notable exception of the crisis year 2007 when the 25th percentile effect fell sharply and the 75th percentile effect rose sharply.

2.4 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). In our data set the main measure of bankers' pay level is the average total compensation per banker within a given BHC in a given year, expressed in thousands of 2002 dollars (wage_r). It is useful to compare the evolution of this 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). The left panel Figure 8 presents the evolution of the cross section medians of these three measures for the subsample restricted to large BHCs. We have normalized these series to give them comparable scale by dividing the series by its value in 1986. The right panel gives the same information for the subsample of small BHCs.

The average total real compensation per banker in large BHCs (blue diamonds) has grown steadily over the 33 years to 2019 where stood at nearly double the 1986 level. The real assets per banker (gray trangles) also improved steadily over the same period for a cumulative increase of more than 100 percentage points. The real revenues per banker ratio (orange squares) has fluctuated over the same period reflecting cyclicality of banks' total revenues but improved strongly in the period since 2014 to stand in 2019 twenty-three per cent higher than in 1986. Turning to the right panel of Figure 8, we see the trend of banker compensation level among small BHCs has followed a similar smooth upward trend as for large BHCs but at slightly slower rate of growth (1.85% versus 1.93%). Similarly there was smooth but more moderate rise in the real asset/banker ratio. The cyclicality of the real revenue/banker ratio has been even larger for small BHCs than for large. For most of the 33 years to 2019 by that measure small BHC banker productivity was worse than in 1986.

It is interesting as well to look beyond central tendency and see how the whole distribution of the level of bankers' compensation has evolved since 1986. Figure 9 plots the 10th, 25th, 50th, 75th and 90th percentiles of the yearly distributions of average real (2002 dollars) compensation per banker for large BHCs (left panel) and for small BHCs (right panel). Focussing on the large BHCs, what is very striking

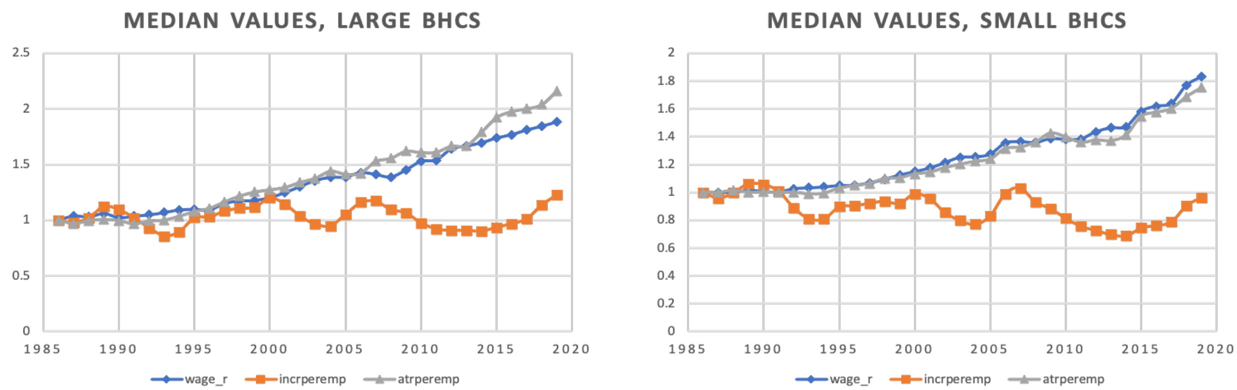

Figure 8: Total Compensation per FTE and Productivity per FTE

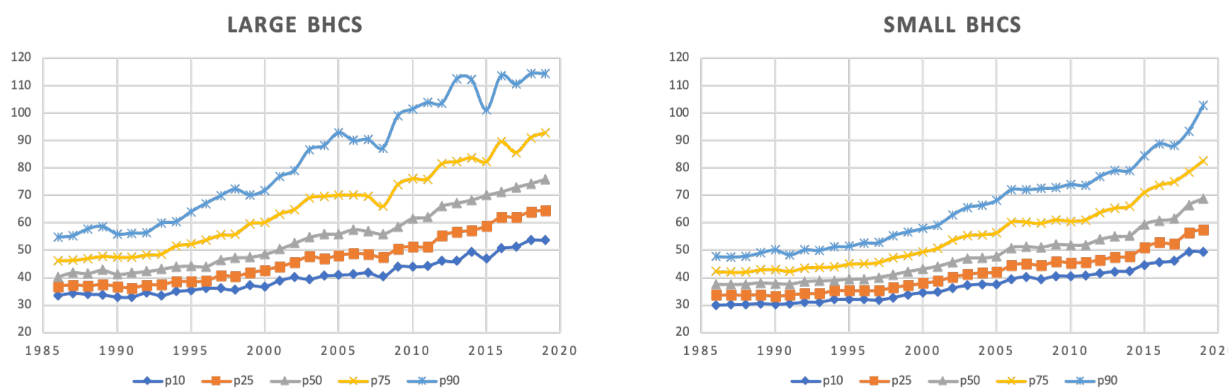

Figure 9: Distributions of Average Bankers' Pay

in this figure is the very strong and steady rise in real banker compensation at the 90th percentile of the distribution. Among these high-paying banks, the total annual compensation per banker rose from $60,000 in 1994 to $112,000 in 2013, an annual growth rate 3.3%. This compares to a more moderate growth rate of average real banker compensation of 2.2% for the 50th percentile large BHC or 1.5% for the 10th percentile BHC. Overall this was a shift to the right and an increase in right-skewness of the annual distribution of bankers pay. Among the small BHCs the change in average compensation per banker has been similar but more moderate. The growth rates of total compensation have been 1.5 %, 1.8% and 2.3 % for the 10th percentile, 50th percentile and 90th percentile small BHCs. What is striking however is that while growth in average compensation at the 90th percentile moderated post-2013 for the large BHCs it accelerated for the small BHCs.

The discussion in this section has suggested that the evolution in banker pay levels

Table 2: Bankers' Pay Level Regressions

Panel 1

	(1) mean(ols)	(2) mean(ols)	(3) median	(4) panel
incrperemp	37.91*	44.67***	43.49***	65.24***
	(2.30)	(8.68)	(9.75)	(5.98)
atrperemp	5.824***	3.312***	4.475***	1.018
	(7.36)	(11.22)	(16.48)	(1.60)
niish	66.22***	46.00***	51.69***	14.64*
	(12.63)	(21.65)	(30.14)	(2.24)
lntar	-0.667	0.0407	0.0458	-2.678*
	(-1.68)	(0.19)	(0.41)	(-2.55)
_cons	9.232*	9.100**	4.919***	58.41***
	(2.06)	(3.09)	(4.16)	(4.08)
Fixed Effects	year	year	year	year , entity
Winsorized	no	(0.01, 0.99)	no	(0.01, 0.99)
R-sq	0.671	0.683		0.687
Nobs	4442	4442	4442	4442

Panel 2

	(1) p10	(2) p25	(3) median	(4) p75	(5) p90
incrperemp	1.304	18.39***	43.49***	70.14***	112.4***
	(0.28)	(3.30)	(9.75)	(13.82)	(7.99)
atrperemp	2.533***	3.069***	4.475***	6.046***	6.047***
	(7.94)	(9.89)	(16.48)	(14.93)	(9.49)
niish	27.84***	37.16***	51.69***	60.78***	87.49***
	(13.16)	(23.50)	(30.14)	(28.12)	(16.94)
lntar	2.005***	1.214***	0.0458	-0.878***	-2.817***
	(17.21)	(10.27)	(0.41)	(-7.84)	(-9.30)
_cons	-11.30***	-3.790*	4.919***	10.19***	29.41***
	(-6.93)	(-2.54)	(4.16)	(7.54)	(8.58)
Fixed Effect	year	year	year	year	year
Winsorized	no	no	no	no	no
Nobs	4443	4443	4443	4443	4443

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

t statistics in parentheses, robust standard errors

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

in the US may reflect changes in banker productivity which has resulted from the consolidation in banking that was described in Section 2.2 and also from the shift in banking away from traditional credit intermediation and toward activities generating non-interest income as described in Section 2.3. To assess the sensitivity of bankers' pay level to these factors we again use regressions based on the data set restricted to large BHCs which are at the top of a banking group hierarchy if there is one. As before, to deal with possible outliers and non-Gaussian characteristics of the data, we employ a variety of regression techniques. Table 2 reports the results.

Panel 1 is devoted to estimates of central tendency of the distribution of mean banker compensation. OLS regression results with untrimmed data are reported in column 1. The coefficients on the two productivity proxies and also the non-interest income share are all positive and are statistically significant. The coefficient on bank size is negative but insignificant. In column 2 we report the OLS results based when the dependent variables and regressors are Winsorized at 1% and 99%. Column 3 give results of quantile regressions based on medians regressed on untrimmed variables. In both cases the results are similar to column 1. Estimated coefficients on revenues per banker, real assets per banker and the bank's non-interest income share are all positive and statistically significant. The coefficient of size is insignificant. Finally in column 4 the results panel regression with BHC entity fixed-effects are reported. In this case the coefficient on total assets per banker is insignificant and the coefficients on non-interest income share is positive and marginally significant and that of size is negative and marginally significant. The coefficient on revenue per banker is highly significant and relatively large. Given that this productivity measure is highly cyclical, it suggest a sensitivity of pay to the bank earnings for broad range of bankers within the entity.

Panel 2 presents quantile regression results based on 10th, 25th, 50th, 75th and 90th percentiles. the coefficients on the two productivity variables are positive and increase systematically from the lower quantile regression to higher quantile regression. With a single exception they are all highly significant. This suggests that an improvement in bankers' productivity translates into higher banker average compensation, especially for relatively high-paying banks. Similarly, the coefficients on niish are positive and highly significant. This suggests that a general move into investment banking, trading and fund management is associated with an increase of average compensation in the bank. The coefficients on bank size are positive and significant for the 10th and 25th percentile regressions but negative and significant for the 75th and 90th percentile regressions.

These results can be interpreted in the context of the restructuring of US banking in the first decade of the 21st century which resulted in bigger banks many which diversified into investment banking, trading and other activities outside traditional credit intermediation. The move into investment banking, fund management and trading tended to raise average bankers' pay within the bank. However, for banks with pay levels near the top of the pay distribution this tendency may have been reduced or even reversed if the size of the bank size increased significantly.

2.5 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 risky is bankers' pay, generally? 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? As discussed in the Introduction 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.

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

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

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 with the labor's share and pay level regressions we report results for four alternative methods. As previously discussed in light of the apparent non-Gaussian characteristics of the data we focus on the OLS regressions with Winsorized data and on the median quantile regression in columns 2 and 3 respectively. The results are qualitatively similar these two methods The change of revenues enters positively, the interaction of hiniish and change of revenues is positive as it the interaction between post-2010 and revenue. The double interaction of revenue performance with hiniish and post-2010 is negative. The sensitivity with respect to revenues and its interaction with hiniish are significant in both. The interaction of revenue and the post-2010 indicator is significant in the median regression.

While point estimates differ considerably across the four regression methods, in fact, their implications are qualitatively similar. This is seen in Panel 1 of Table 5 where we have reported the implied sensitivities in the four states of the system implied by the two segments (low niish, high niish) and two periods (1986-2010, 2011-2019). In the

Table 4: Bankers' Pay Sensitivity Regressions

Panel 1: Revenue Performance

	(1)	(2)	(3)	(4)
	mean(ols)	mean(ols)	median	panel
dlnincr	0.201*	0.119***	0.0692***	0.151***
	(2.53)	(5.12)	(6.22)	(6.33)
hiniish3×dlnincr	-0.0133	0.107*	0.133***	0.0985*
	(-0.06)	(2.36)	(5.30)	(2.11)
post_2010×dlnincr	0.115	0.0760	0.126***	0.0848
	(0.98)	(1.62)	(5.58)	(1.74)
hiniish3×post_2010×dlnincr	-0.0968	-0.0973	-0.204***	-0.141
	(-0.43)	(-1.14)	(-5.25)	(-1.62)
_cons	0.0159	0.0154	0.00975	0.00599
	(1.39)	(1.90)	(1.25)	(0.68)
Fixed Effects	year	year	year	year , entity
Winsorized	no	(0.01, 0.99)	no	(0.01, 0.99)
R-sq	0.0711	0.0634		0.0716
Nobs	4154	4154	4154	4154

Panel 2: Value-added Performance

	(1)	(2)	(3)	(4)
	mean(ols)	mean(ols)	median	panel
dlnvaladr	0.0886	0.0456***	0.0169***	0.0516***
	(1.89)	(3.52)	(3.74)	(3.86)
hiniish3×dlnvaladr	-0.0163	0.0413	0.0111	0.0410
	(-0.29)	(1.55)	(1.35)	(1.30)
post_2010×dlnvaladr	0.0279	0.0494	0.0420***	0.0450
	(0.44)	(1.94)	(4.86)	(1.52)
hiniish3×post_2010×.dlnvaladr	-0.0182	-0.0351	0.00549	-0.0359
	(-0.24)	(-0.73)	(0.18)	(-0.69)
_cons	0.0366**	0.0293***	0.0137	0.0219*
	(3.05)	(3.46)	(1.78)	(2.41)
Fixed Effects	year	year	year	year , entity
Winsorized	no	(0.01, 0.99)	no	(0.01, 0.99)
R-sq	0.0455	0.0461		0.0496
Nobs	4029	4029	4029	4029

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

t statistics in parentheses, robust standard errors

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

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. 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 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 3 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.

2.6 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

Table 5: Point Estimates of Pay Sensitivity

Panel 1: Revenue Performance

Method	(1) OLS		(2) Winsorized		(3) Median		(4) Panel	
Share of Non-interest Income	Low	High	Low	High	Low	High	Low	High
1987-2010	20.1%	18.8%	11.9%	22.6%	6.9%	20.2%	15.1%	25.0%
2011-2019	31.6%	20.6%	19.5	20.5%	19.5%	12.4%	23.6%	19.3%

Panel 2: Value-added Performance

Share of Non-interest Income	Low	High	Low	High	Low	High	Low	High
1987-2010	8.9%	7.2%	4.6%	8.7%	1.7%	2.8%	5.2%	9.3%
2011-2019	11.6%	8.2%	9.5%	10.1%	5.9%	7.6%	9.7%	10.2%

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

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 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 half 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.

3 Calibration

In Section 2 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 using a structural model of the banking firm which we calibrate and then see if the logic of the model is capable of replicating the empirical patterns we have reported above.

3.1 Model

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. The details of the model are developed in Anderson (2021) 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.

Consider a firm whose value-added is a function of three inputs— capital K, labor

L and management M. Following Lucas (1978) firm value takes the Cobb-Douglas form,

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

which exhibits constant returns to scale in M, K and L. That is, $\alpha_m + \alpha_k + \alpha_l = 1$ with $\alpha_m > 0$, $\alpha_k > 0$ and $\alpha_l > 0$. 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. Note that the production function (1) implies a complementarity between management and capital. Management may be a team, but here we assume that it operates as a single decision maker. The manager's contribution to firm value will depend upon his talent, T, and his action, a, which may be thought of as effort. Furthermore, we assume that

$$M = Ta \tag{2}$$

so that there is a complementarity of effort with talent and capital. Under these assumptions firm value can be written as,

$$V = (Ta/\alpha_m)^{\alpha_m}(K/\alpha_k)^{\alpha_k}(L/\alpha_l)^{\alpha_l} \tag{3}$$

The manager's effort is unobservable by people other than himself. We assume that the manager's talent is observable and 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.[7]

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

[7] 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.

effort interacts with his talent.[8]

The solution to this problem is developed in the Annex 5.2 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 (45) which we repeat here.

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

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,

$$w_1 = \frac{\alpha_m + \alpha_l}{1 + \alpha_l} \tag{5}$$

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,

$$w_0 = w_m(T) - \Big[\frac{\alpha_m + \alpha_l}{1 + \alpha_l}\Big]^{1/\alpha_k} \Big(\frac{\alpha_m T}{g}\Big)^{\alpha_m/\alpha_k} \Big(\frac{\alpha_l}{w_l}\Big)^{\alpha_l/\alpha_k} K \tag{6}$$

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,

$$w_l L = \alpha_l \Big[\frac{(\alpha_m + \alpha_l)}{1 + \alpha_l}\Big]^{1/\alpha_k} \Big(\frac{\alpha_m T}{g}\Big)^{\alpha_m/\alpha_k} \Big(\frac{\alpha_l}{w_l}\Big)^{\alpha_l/\alpha_k} K \tag{7}$$

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

[8] Anderson (2021) considers other contracting arrangements in addition to standard shareholder value maximization and compares them to the first-best benchmark that maximizes total surplus assuming contractible effort.

level and pay sensitivity.

3.2 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,

$$G(K_i, T_i) - w(K_i, T_i) \geq G(K_i, T_j) - w(K_i, T_j) \tag{8}$$

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

$$\begin{aligned} G(K_i, , T_i) - w(K_i, T_i) &\geq rK_i \\ w(K_i, T_i) &\geq w^0 \end{aligned} \tag{9}$$

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

$$\frac{G(K_i, T_i) - G(K_i, T_{i-\epsilon})}{\epsilon} \geq \frac{w(K_i, T_i) - w(K_i, T_{i-\epsilon})}{\epsilon} \tag{10}$$

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

$$w_T(K_i, T_i) = G_T(K_i, T_i)t'(i) \tag{11}$$

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,

$$w(K_i, T_i) = w^0 + \int_0^i G_T(K_j, T_j)t'(j)dj \tag{12}$$

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,

$$\pi(K_i, T_i) + w(K_i, T_i) = G(K_i, T_i) \tag{13}$$

or equivalently as

$$\pi_K(K_i, T_i) = G_K(K_i, T_i)k'(i) \tag{14}$$

and

$$\pi(K_i, T_i) = rK_0 + \int_0^i G_T(K_j, T_j)k'(j)dj \tag{15}$$

This equilibrium can be evaluated in the special case of Cobb-Douglas production function as in Section 3.1. In this case the net value-added of the firm can be developed using equations (36) and (45) and the net value-added of the firm can be written as,

$$G(K,T) = (1-\alpha_l w_1)\big[\frac{\alpha_m+\alpha_l}{1+\alpha_l}\big]^{(\alpha_m+\alpha_l)/\alpha_k}(\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k}(\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k}K \tag{16}$$

Substituting for w_1 using (44) the net value-added of the firm can written as,

$$G(K,T) = (\big[\frac{\alpha_m+\alpha_l}{1+\alpha_l}\big]^{(\alpha_m+\alpha_l)/\alpha_k} - \alpha_l\big[\frac{\alpha_m+\alpha_l}{1+\alpha_l}\big]^{(1/\alpha_k)})(\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k}(\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k}K \tag{17}$$

3.3 Calibrating the Model

In this section we discuss the calibration of the model of industry equilibrium developed above to US bank holding data as reported in Section 2.1. Firm value-added given in (17) can be written as,

$$G(K,T) = C(\alpha_m,\alpha_l,\alpha_k,g,w_l)T^{\alpha_m/\alpha_k}K \tag{18}$$

where,

$$C(\alpha_m,\alpha_l,\alpha_k,g,w_l) = (\big[\frac{\alpha_m+\alpha_l}{1+\alpha_l}\big]^{(\alpha_m+\alpha_l)/\alpha_k} - \alpha_l\big[\frac{\alpha_m+\alpha_l}{1+\alpha_l}\big]^{(1/\alpha_k)})(\frac{\alpha_m}{g})^{\alpha_m/\alpha_k}(\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} \tag{19}$$

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 (19) is strictly positive. Within the industry assume that α_m,α_l, and α_k are identical, all firms face the same rate for labor, w_l, and that the marginal cost of effort, g is identical for all managers. Then the value-added of the i'th percentile firm is,

$$G(K_i,T_i) = C(\alpha_m,\alpha_l,\alpha_k,g,w_l)T_i^{\alpha_m/\alpha_k}K_i \tag{20}$$

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 11). We use total real shareholder capital here.

While we treat talent, T_i, as observable to the shareholders and the managers, in fact there is no information on this that is contained in the FRY9-c data set.[9] Therefore,

[9]In the US there are some aggregative measures of educational attainment and other qualifications as

we proceed indirectly to infer the talent profile, $t(.)$ implied by the data. Our strategy is to use observations of value-added as characterized by G(.,.) in relation (20).

As explained above $G(.,.)$ represents value-added of the bank in a given period. This is measurable in FRY9-c data using a items reported in the bank holding company income statements. Our measure of total value-added of a bank in a year is the sum of net income (bhck4340) and total employee compensation (bhck4135). One complication in our analysis is that the FRY9-c data reports the total compensation of all employees in the bank holding company and does not give any break-down across different types of employees. One useful feature of these data is that banks are required to report numbers of employees (expressed in full-time equivalents). This allows us to measure the average total compensation (including wages, bonuses, stock awards, and benefits) per employee. As in Section 2, we refer to this as the bank's *wage* in a given year. This is a key variable in our analysis, and it is one of the advantages of the US bank regulatory data as compared to standard financial statements of non-bank firms where normal accounting standards to not result in reports of numbers of employees in a systematic way.

3.3.1 Calibrating pay sensitivity

With these data features in view, we proceed as follows. It is useful to start with calibrating pay sensitivity which, in our model, takes a particularly simple form. The sensitivity of *wage* will depend upon the relative amounts of pay to labor and to management. Under the second best contract management makes a labor choice that results in total pay for labor given by (36), which we repeat here,

$$L = \frac{\alpha_l w_1}{w_l} V \tag{21}$$

In our model the contribution of management toward value-added the product of effort and talent, $M = aT$. This is skill-adjusted measure of contribution of manager's effort. In our context is is natural to consider that the manager's effort is measured in the same natural 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 payroll in FTE's (bhck4150) is a proxy for $a + L$. The second-best choice

well as compensation data that are available in a variety of BLS and Census reports. We use some of these data to supplement the FRY9-c data in some steps in our calibration as described below.

of a under shareholder-value maximisation was found in (34) as

$$a = \frac{\alpha_m w_1}{g} V \tag{22}$$

Thus,

$$\frac{a}{L} = \frac{\alpha_m}{\alpha_l} \frac{w_l}{g} \tag{23}$$

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.[10] Thus we assume $w_l = g$ which implies,

$$\frac{a}{L} = \frac{\alpha_m}{\alpha_l} \tag{24}$$

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

$$\frac{a}{a+L} = \frac{\alpha_m}{\alpha_m + \alpha_l} = \frac{\alpha_m}{1 - \alpha_k} \tag{25}$$

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 CD production functions have regularly found α_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 (5), the expression for equilibrium compensation sensitivity of management, we find,

$$w_1 = \frac{\alpha_m + \alpha_l}{1 + \alpha_l} = \frac{0.7}{1 + 0.49} \approx 0.47 \tag{26}$$

Since the pay sensitivity of fixed wage labor is zero we find the implied sensitivity of total compensation per FTE is given is $w^{tot} = 0.3 \times 0.47 = 0.141$. This can be compared to the estimates of pay sensitivity as reported in Section 2.5. Our calibrated sensitivity of 0.141 is close to the estimated sensitivity of 0.119 as reported in Table

[10]We recognise that this might be debatable if we find that our managers in equilibrium work many more time units than fixed wage workers. We will check this in our calibration and also robustness of findings to a possible premium in the effort costs of managers.

Table 6: Calibrated Pay Sensitivity

α_k	$\alpha_m/(\alpha_l+\alpha_m)$	$\alpha_l+\alpha_m$	α_l	α_m	w_1	w^{tot}
0.2	0.2	0.8	0.64	0.16	0.488	0.098
0.2	0.3	0.8	0.56	0.24	0.513	0.154
0.2	0.4	0.8	0.48	0.32	0.541	0.216
0.3	0.2	0.7	0.56	0.14	0.449	0.090
0.3	0.3	0.7	0.49	0.21	0.470	0.141
0.3	0.4	0.7	0.42	0.28	0.493	0.197
0.4	0.2	0.6	0.48	0.12	0.405	0.081
0.4	0.3	0.6	0.42	0.18	0.423	0.127
0.4	0.4	0.6	0.36	0.24	0.441	0.176

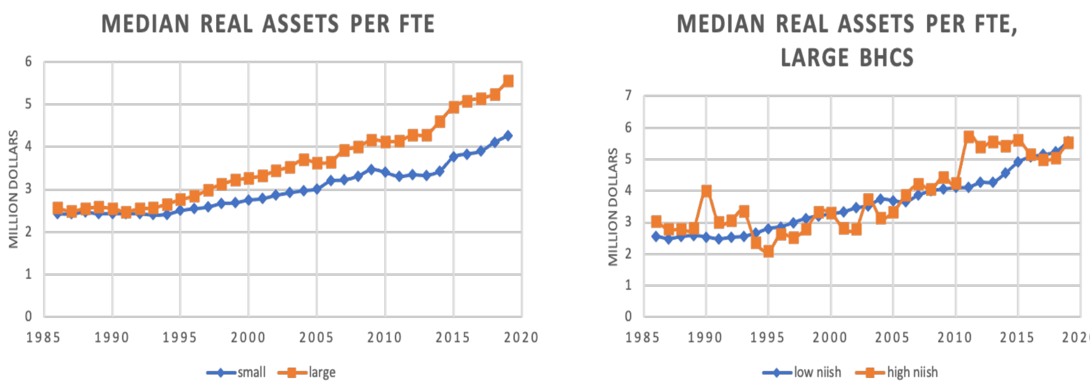

Figure 10: Assets Per Employee

5 for the OLS regression based on 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 (26) the calibrated sensitivity is itself quite sensitive to variations of α_m, α_l, and α_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 Table 5.

Table 6 gives the model implied pay sensitivities for alternative choices of calibration parameters. It is seen that holding α_k constant, increasing management share of employment tends to increase overall pay sensitivity. Holding management share of employment constant increasing α_k tends to decrease overall 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 2.

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 α_k, a lower α_l and higher α_m. That is, they employed greater leverage and hired relatively more bankers with higher education or other qualifications useful banking beyond conventional credit intermediation.

In fact, this argument can be checked within the FRY9c data set. Figure 10 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 2. 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 2.2. 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 5. 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 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 α_m and decreasing α_l on the part of the follower BHCs. On the other hand the bank groups that had previously built up their activities in investment banking, trading and fund management either maintained their mix of business or may have cut back. That is they maintained a constant α_m and α_l or, possibly, reduced α_m while increasing α_l.

3.3.2 Calibrating pay level

Next we try to use our structural model to shed light on the *level* of managers' compensation which has been the focus of the studies summarised in the Introduction. In

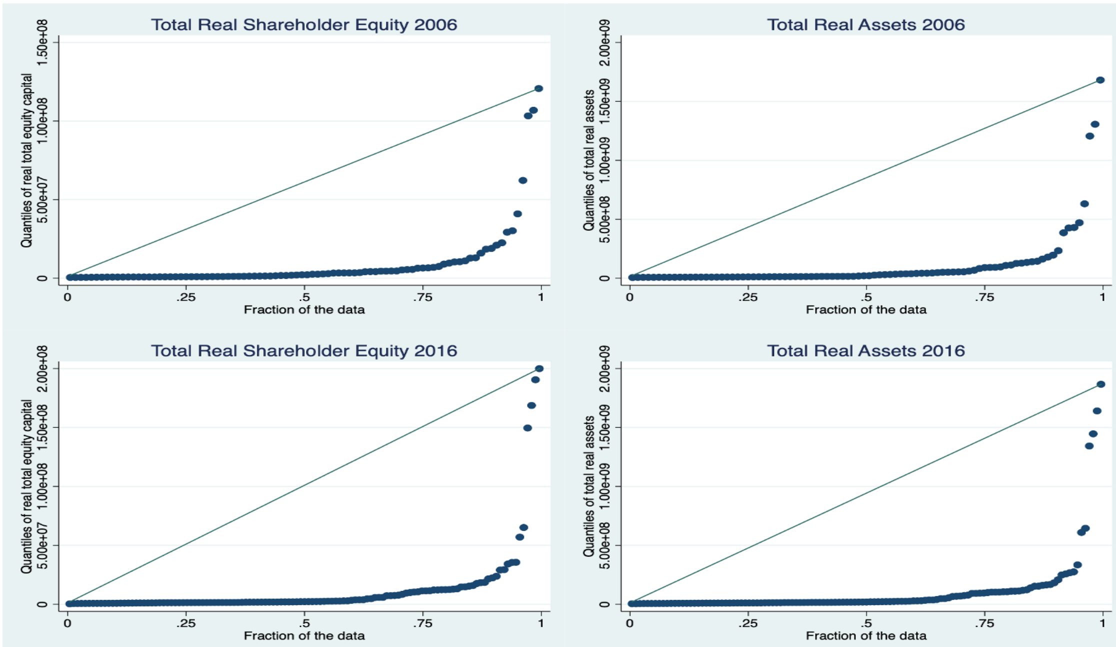

Figure 11: Bank Size Profiles

particular we explore the extent to which variations in *talent* may account for variations in the level bankers' pay. To do so we first consider the calculation of talent implied by the observed size distribution of banks our data set. Using relation (20) combined with our assumption that share parameters and marginal costs w_l and g are identical for all banks in our sample, we can solve for the implied talent of firm i as,

$$T_i = c^* \times (Y_i/K_i)^{(\alpha_k/\alpha_m)} \tag{27}$$

where c^* is constant positive scaling factor which we normalize to 1 and Y_i is the measured value-added of bank i in a given year. We employ two alternative proxies for firm size, K_i — total shareholder capital (bhck3210) and total assets (bhck2170), both expressed in real terms. The size profiles of each for 2006 and 2016 are depicted in the Figure 11. It is seen that by either measure the cross sectional distribution of BHC size is extremely right-skewed — there is a mass of bank with similar size and a very few extremely large banks. From equation (27) we may suspect that the model implied talent would be similarly right-skewed.

This is indeed the case. Figure 12 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 (27) with size measured as real

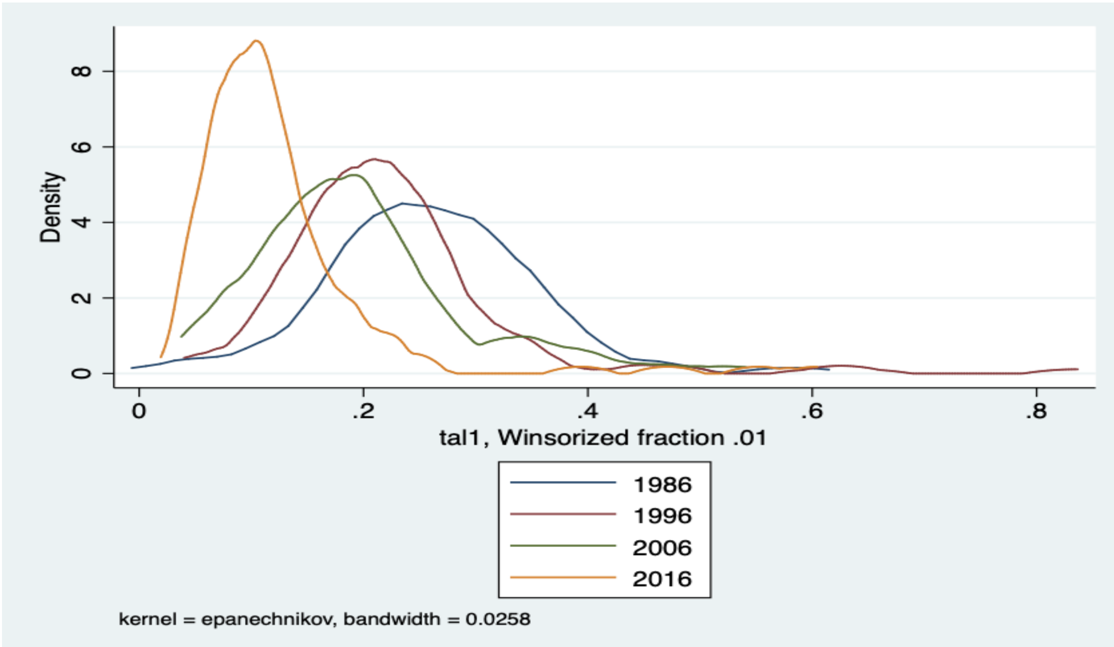

Figure 12: Kernal Estimates of Implied Talent Distributions

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 semi-log regression of winsorized $tal1$ on the log of real assets plus year fixed effects supports this view. The coefficient of $lntar$ is positive with a robust t-statistic of 11, suggesting a convex relation between talent and size. Furthermore, the time fixed effects exhibit a clear down-trend suggesting that available talent is being concentrated in a smaller number of banks. Another insight into the distribution of talent is given in Figure 13 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 comparatively smaller banks and that the largest banks were far from having the highest levels of model

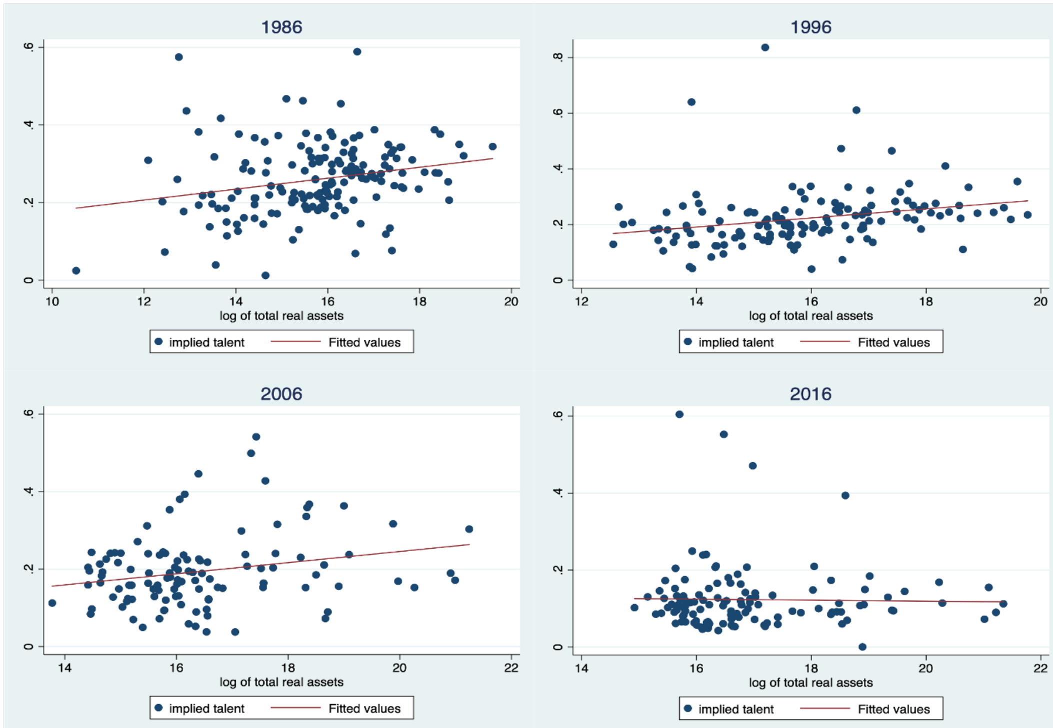

Figure 13: Talent and Size

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.

Given this background we now return to the question of the determinants of bankers' pay level we first examined in Section 2.4. We consider regressions of average total real compensation where model implied talent replaces the productivity variables as reported in Table 2. We include the proxy for size (*lntar*) and the banks' core business (*niish*) as in that table. In light of the evidence we have seen of banks changing core activities we include an interaction of *niish* with model implied talent. As above, we have Winsorized talent at the 1% and 99% levels. We also include year fixed effects which serves to control for cyclical fluctuations and also changes in capital regulations that are common across BHCs. We confine our attention to robust regression techniques. Here we report OLS regressions using Winsorized values of real total compensation per banker as the dependent variable.[11]

[11] In results not reported here we also used median quantile regressions. The results were qualitatively very close to those reported here. Also the in-sample predictions of compensation level were very highly correlated with those of the regression we report here.

Table 7: Bankers Pay Level Regressions with Implied Talent

	(tal1) mean(ols)	(tal2) mean(ols)	(tal3) mean(ols)	(tal4) mean(ols)	(tal5) mean(ols)
lntar	2.845***	2.893***	3.032***	2.692***	3.254***
	(16.69)	(16.91)	(17.63)	(15.78)	(19.18)
niish	15.59***	21.32***	13.15***	-38.97**	-39.48***
	(4.62)	(7.87)	(4.22)	(-2.81)	(-5.81)
tal1_w01	-13.58*				
	(-2.22)				
c.niish×c.tal1_w01	63.32***				
	(5.60)				
tal2_w01		-15.17			
		(-1.77)			
c.niish×c.tal2_w01		70.59***			
		(5.02)			
tal3_w01			-29.96***		
			(-4.48)		
c.niish×c.tal3_w01			90.50***		
			(8.00)		
tal4_w01				-20.66**	
				(-2.73)	
c.niish×c.tal4_w01				97.54***	
				(5.24)	
tal5_w01					-22.52***
					(-5.37)
c.niish×c.tal5_w01					109.0***
					(14.30)
_cons	-7.769**	-9.630***	-8.402***	6.024	-2.051
	(-2.91)	(-3.76)	(-3.32)	(1.04)	(-0.81)
Fixed Effects	year	year	year	year	year
Winsorized	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)	(0.01, 0.99)
R-sq	0.495	0.495	0.502	0.492	0.525
Nobs	4355	4355	4355	4355	4355

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

The results of the pay level regressions obtained using the benchmark measure of implied talent, $tal1$, are reported in column 1 of Table 7. Both the log of real assets and the non-interest income share enter positively and are highly significant. The coefficient of talent is negative; however, that of talent inter-acted with *niish* positive and large. The implication is that for firms with non-interest income share greater than $13.58/63.32 = 0.214$ there is a positive association between talent and pay level. The year fixed effects (not reported here) show a clear upward over the entire period 1986-2019 similar to the pattern for yearly median bankers pay in Figure 8.

These results were based the benchmark choices of α_m and α_k which, as we have seen above, give rise a prediction of pay volatility that comes close to the estimated pay volatility for banks with relatively little non-interest income. We also consider other calculations of implied talent using a range of alternative values of α_m and α_k. We first consider two alternative sets of parameters, one giving low implied pay sensitivity and another giving high implied pay sensitivity and calculate corresponding two implied talent values for each BHC in each year. The low pay sensitivity case sets $\alpha_k = 0.4$ and $\alpha_m = 0.18$. The resulting talent variable is $tal2$. The high pay sensitivity case sets $\alpha_k = 0.1$ and $\alpha_m = 0.36$. The resulting talent variable is $tal4$. Then to capture possible changes in the bank business models over time we interpolate using observed values of *niish* trimmed to lie in the range of $[0.1, 0.7]$ which are the approximate 10th and 90th percentiles of *niish* respectively. Specifically, $tal3$ is result of interpolating between $tal2$ and $tal1$, and $tal5$ is the result of interpolating between $tal1$ and $tal4$.

The results of pay level regressions based on these alternative implied talent variables are reported in columns 2-5 of Table 7. The results are qualitatively close to those obtained with the benchmark measure of talent. Log assets enters positively. Talent enters negatively but with a large positive coefficient when interacted with *niish*. The implication is that for non-interest income shares above about 25% talent has a positive impact on earnings. Also the year fixed effects exhibit a clear upward trend over the whole period covered. Finally, we have compared the in-sample predictions of compensation levels obtained using the 5 implied talent measures. The pairwise correlations among them are all extremely high— 0.977 and above. And the year by year mean predicted compensation levels are virtually identical. Thus for the rest of this subsection we will be focussing on the the results based on the benchmark talent, $tal1$.

It should be noted that the year fixed effects obtained in the pay level regressions reported in Table 7 can be an interesting in-the-model interpretation in terms of outside option of the managers. Referring to equation (12) which gives the equilibrium pay profile of management, we see that the pay level of the least talented manager equals the outside option w^0. The projections of the pay level regressions reported in Table 7 give our estimates of the yearly equilibrium pay profiles. The year-to-year changes of the predicted pay of the least talented managers will be driven by the year fixed effects and the changes in the lower bound of the yearly talent profiles. Thus the fact that the year fixed effects in the pay level regressions displayed a clear and strong upward secular trend between 1986 and 2019 suggests bankers' outside option has increased over that period. We will develop this point in Section 3.3.4 where we discuss the implications of our results for estimates of managerial rent extraction.

3.3.3 Calibrating labor's share

Finally, we explore the implications of the calibrated model for labor's share of value-added. In Section 2.3 we argued that following the removal of regulatory impediments to intra-state branching and inter-state banking a process of bank consolidation began which coincided with a secular decline in labor's share banking sector value-added between 1986 and 1997. This was depicted in the left panel of Figure 7 and was consistent with a Superstar firm hypothesis applied to US commercial banking. Subsequently, this secular trend was disrupted, first by a period of stable labor share between 1998 and 2006 and then with a sharp increase in labor's share between 2007 and 2010. In that section we argued that the relative stability of labor's share coincided with the entry of a number of commercial banks into investment banking and fund management which ultimately was officially tolerated with the passage of the Gramm-Leach-Bliley act. We documented these changes with changes in the share of non-interest income among larger banks and in changes in some indicators of banker productivity, notably a rise in the total real assets per banker. In that section we noted the rise in labor's share at the end of the decade could be understood through a combination of the cyclical shock to banks' earnings in the financial crisis and regulatory actions that followed.

Here we return to these themes and consider how this can be reflected in the model we have used to calibrate bankers' pay levels and sensitivity. The key feature of the model is the introduction bankers with heterogeneous talent which we hypothesise has been allocated across different types of banking activities (as captured by non-interest income share, $niish$ or the binary variable $niish3$) and across banks of different sizes (as captured by total real assets in the BHC, $lntar$). To understand the evolution of talent over time we run median quantile regressions where we control for bank's size using $lntar$, for the bank's business using $niish2$ and for the interaction of these two controls. We run these regressions for all five of the implied talent proxies ($tal1$,..., $tal5$). The results of these regressions are reported in Table 8.

Table 8: Bankers Talent Regressions

	(tal1) median	(tal2) median	(tal3) median	(tal4) median	(tal5) median
lntar	0.00885***	0.00543***	0.00278***	0.00637***	0.0359***
	(11.41)	(11.06)	(4.60)	(11.07)	(27.20)
hiniish3	0.440***	0.304***	0.267***	0.274***	0.916***
	(11.25)	(12.20)	(9.41)	(9.81)	(14.55)
hiniish3×lntar	-0.0214***	-0.0148***	-0.0145***	-0.0130***	-0.0387***
	(-10.43)	(-11.74)	(-9.83)	(-8.46)	(-11.15)
_cons	0.106***	0.0287***	0.172***	0.661***	-0.184***
	(8.15)	(3.32)	(15.40)	(65.94)	(-8.11)
Fixed Effects	year	year	year	year	year
Nobs	4356	4356	4356	4356	4356

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

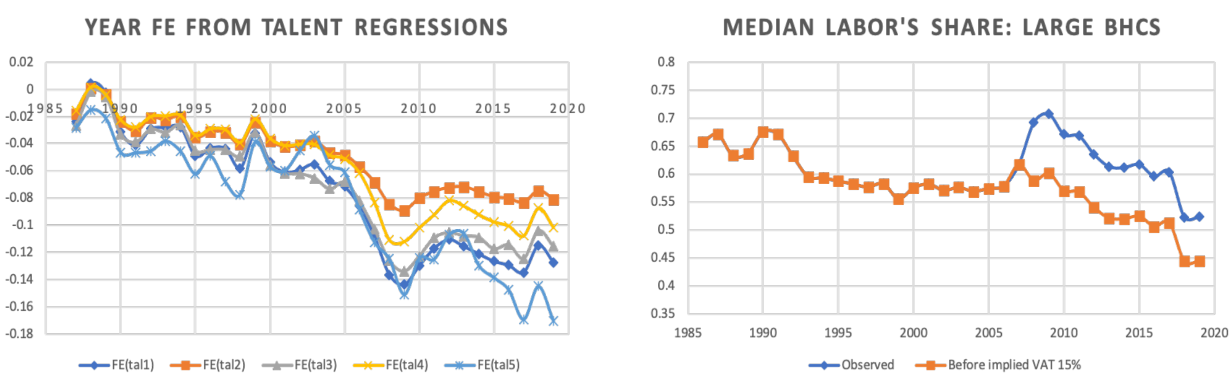

Figure 14: Implied Talent and Labor's Share: Large BHCs

The results of these regressions are qualitatively very similar for all the alternative implied talent measures. Firm size and the high non-interest income dummy both enter positively and are highly significant. The interaction term of these two variables is negative and significant. This sheds light on the pattern we noted in discussing bankers' pay levels. Some large BHCs below the top-tier by size pay relatively high total average compensation. Here we see that at least some of that high pay is a reflection of relatively high talent levels, as measured in our model.

However, the most important result of these talent regressions is given in the year fixed effects which we have plotted in the left panel of Figure 14. It depicts a sharp structural break in implied talent coinciding with the onset of the financial crisis in 2007. By all five talent measures there was a sharp fall in model implied talent that has not recovered subsequently.

What could have accounted for this structural drop in model implied talent? 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.

Recall that in our model talent is given by equation (27). 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 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 regulations, increased reporting requirements, 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 14 depicts the evolution of median labor's share for large BHCs expressed both relative to reported value-added and relative to implicit pre-tax value added. Labor's share relative to observed value-added reflects a structural break with the crisis as shown previously in the left panel of Figure 7. 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 7. 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.

3.3.4 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 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 matched 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 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

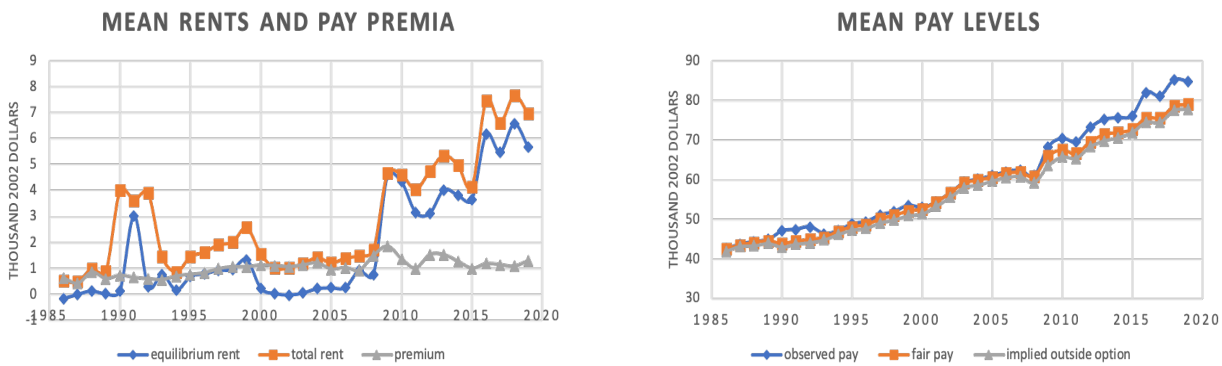

Figure 15: Median Premia Over Average Banker Fair Compensation

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 (12) of Section 3.2. Our empirical implementation of this relation was given in the wage level regressions reported in Table 7.

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. This is *equilibrium surplus*. The alternative is the difference between the realised pay and the outside option. This is the *total surplus*. The difference between the total and equilibrium surplus (or, equivalently, between the observed pay and fair value pay) may be thought of as the *banker's pay premium*.

We implement this decomposition using our calibrated model under the assumptions that our measure of talent is based on the benchmark parameters and that value-added is taken as pre-pigovian tax of 15 percent. Furthermore, we calculate the outside option as the estimated expected pay from the wage equation based on pre-tax talent evaluated at the 10'th percentile of the year's talent distribution with all other explanatory values as observed for the BHC in that year. In this way we construct for each BHC/year pair an observation of equilibrium surplus, total surplus and banker's premium.

In the left panel of Figure 15 we have plotted the yearly mean value of surpluses and premia expressed in thousands of 2002 dollars. It is seen that estimated equilibrium surplus lies slightly below total surplus, implying a real average premium of approximate \$800 per banker in 1986 and rising slowly to stand at slightly over \$1000 per banker in 2019.

Over this same period while the average estimated banker's premium was relatively constant, both total surplus and equilibrium surplus rose, and the rise was particularly sharp over the ten years from 2009. What could have accounted for this? In the right panel of Figure 15 we have plotted the yearly mean values of observed pay, fair pay as estimated by our pay level regression, and the implied outside option as estimated by our pay level regression evaluated at the estimated lower bound of yearly talent. It is clear that most of the rise of estimated fair pay is driven by rise of the outside option. Over the sample period the model implied outside option rose \$36,000 in real terms. This reflects the pure time effects captured by the year fixed effects and accounts for \$31,000 of the rise. The remaining \$5000 of the rise reflects changes in bank size (log total assets), changes in the mix of bank business (share of non-interest income) and the change in the bankers' talent profile.

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 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.

A further insight into our estimates of the equilibrium fair banker's pay and associated rents can be seen by looking at the expected rent for BHCs sorted by type banking business and by banker skill. In Figure 16 we plot the estimated equilibrium rents (in thousands of 2002 dollars) for deciles of $niish$ and $tal1$ at ten year intervals from 1986. In all four years depicted, the rent profile for the most talented managers (represented by the 90th percentile of $tal1$ in the year) is negative in BHCs with low levels of non-interest income and steeply rising in the BHC's non-interest income share. That is, there is a persistent strong incentive for talented managers to match up with BHCs with an established presence in investment banking, fund management or other areas outside of traditional credit intermediation. It is also notable that the peak rents (for the 90th percentile niish and 90th percentile talent) were fairly constant at about \$2300 in 1986 and 1996. Then they rose sharply to reach almost \$6000 in 2006 before falling back to \$3000 in 2016.

Perhaps the main take-away from this section is that the estimated banker's premium is relative small. Most of the movements in banker's pay level have been reproduced with a model of a competitive equilibrium among banks with shareholders

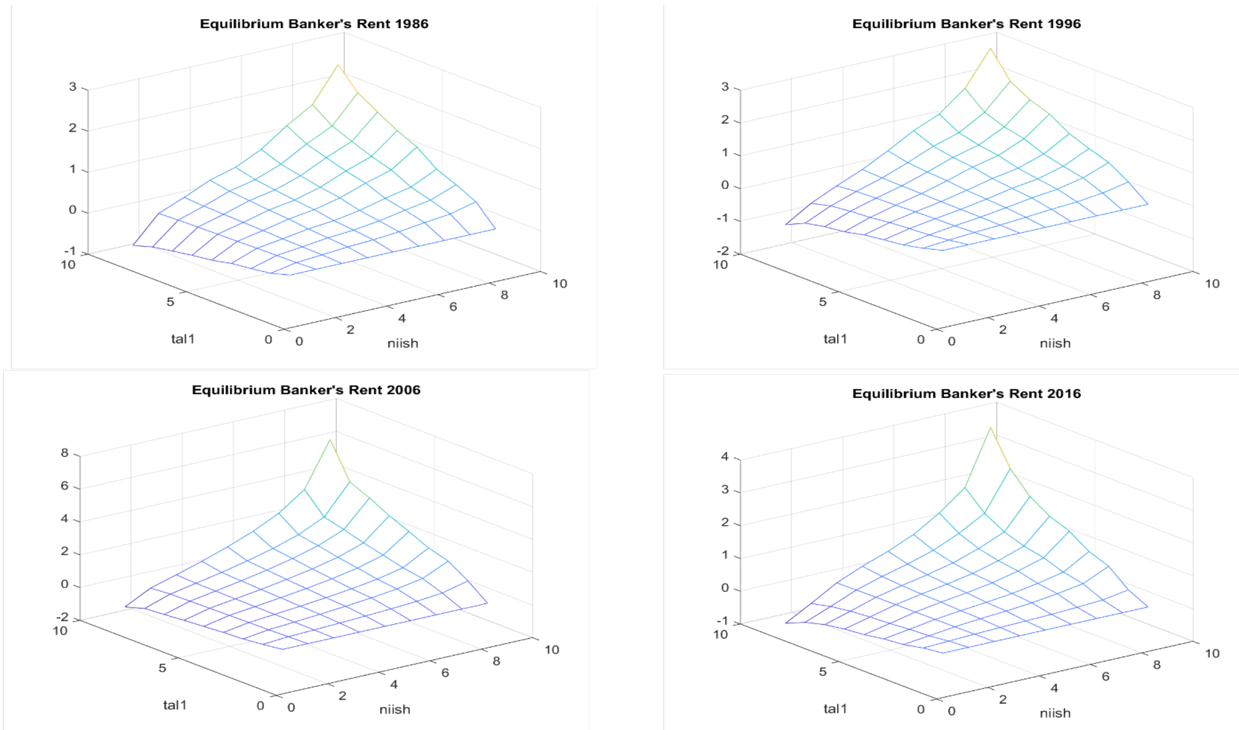

Figure 16: Equilibrim Rents

maximizing shareholder payoff by offering pay contracts that are able to compete for bankers with varying degrees of talent.

3.4 Discussion of results and alternative explanations

We close this section with a discussion of the calibration of structural model that we have put forward as a coherent explanation of the empirical patterns of US bankers' pay that were presented in Section 2.

Our model is a competitive assignment model in which banks of varying sizes contract each year with a management teams with varying levels of talent. Once matched, a bank's management team fixes the amount of labor hired and also the amount of management effort. An important characteristic of the model is that there is a complementarity between the size of the assets of the bank, the talent of the management team, and the amount of effort they extend. Consequently a bank that is slightly larger than its next smaller competitor will engage a management team that is somewhat superior to this smaller rival, and in turn its management extends effort which is higher than the next lower competitor. The net result is that a small difference in talent can be associated with a very large difference in management pay. Bank assets may change from year to year reflecting, for example, the consolidation process that we described in Section 2.2. Furthermore the set of management teams may change with entry of new bankers with new talents and the exit other bankers with their own talents. As a result the cross-sectional distributions of bankers' talent and of compensation level will vary considerably over time.

However as was seen in Figure 11 there is a tendancy for banks size profiles in any given year to reflect a skewed distribution with a large number of relatively small banks and long tail of very large banks. Similarly there tends to be a skewed distribution bankers' pay with large group of bankers with similar level of compensation and then a small tail with considerably higher total compensation. The net result is that it looks something like a segmented market with some bankers going to high-paying banks to manage very large amount of assets while the rest go to smaller banks and manage smaller amounts of assets.

In the introduction we suggested that there are alternative theoretical explanations that could account for some of empirical patterns that we have documented here. In particular efficiency wage models offer explanations of market segmentation even when labor is homogeneous. 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 laborers 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 8 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 9 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. 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.

4 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. We have done this in two steps. First we 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 those that 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 second step we attempt to given an internally consistent account of how the observed behavior came to pass. We do this by setting out a structural model of equilibrium in the US banking market which we then calibrate and see if it can reproduce the characteristics that we had found earlier. The model we use is in some respects standard. 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. 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 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 a massive process of entry, exit, mergers, and structuring that has taken place in US banking in the last three decades. 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.

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. Overall, we find that 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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5 Appendix

5.1 Data Appendix

Our main data is derived from the quarterly reports of bank holding companies reporting 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 9. 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 9: 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	

5.2 Model Details

In this subsection we present solutions to the second best optimal contract for a given firm as used in Subsection 3.1. Under the functional specification introduced there principal's problem is,

$$Max_{\{c(.),L,a\}} a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l} - c(a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l}) - w_l L \tag{28}$$

subject to the participation constraint,

$$c(a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l}) - ga \geq w_m(T) \tag{29}$$

and the incentive compatibility restriction,

$$\frac{d\left(c(a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l})\right)}{da} = g \tag{30}$$

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.[12] Thus,

$$c(V) = w_0 + w_1 V \tag{31}$$

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

$$Max_{\{a,L\}} w_1 a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l} - ga - w_l L \tag{32}$$

The first-order condition for a is,

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

which implies,

$$a = \frac{\alpha_m w_1}{g} V \tag{34}$$

The first order condition for L,

$$\alpha_l w_1 a^{\alpha_m} T^{\alpha_m} K^{\alpha_k} L^{\alpha_l - 1} - w_l = 0 \tag{35}$$

[12] Anderson (2021) explores the restrictiveness of that assumption.

which implies,

$$L = \frac{\alpha_l w_1}{w_l} V \tag{36}$$

Using (34) and (36), firm value can be written as,

$$V = (w_1)^{\alpha_m+\alpha_l}(\frac{\alpha_m}{g})^{\alpha_m} T^{\alpha_m} K^{\alpha_k}(\frac{\alpha_l}{w_l})^{\alpha_l} V^{\alpha_m+\alpha_l} \tag{37}$$

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,

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

Turning to the determination of the compensation contract offered the manager we use (38) and (36) to express the shareholders' problem as,

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

subject to

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

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,

$$Max_{(w_0,w_1)}(w_1^{(\alpha_m+\alpha_l)/\alpha_k} - (1+\alpha_l) w_1^{1/\alpha_k})(\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k}(\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K - w_0 \tag{41}$$

subject to,

$$w_0 + w_1^{1/\alpha_k}(\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k}(\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \geq w_m(T) \tag{42}$$

Note that since $\alpha_m + \alpha_l < 1$ and $1/\alpha_k > 1$ the maximand in (41) is concave in w_1 and increasing at $w_1 = 0$. Thus the shareholders will wish to give the manager a strictly positive incentive component to compensation. Furthermore the maximand is strictly decreasing in w_0. Thus the shareholders will wish to give the lowest possible fixed component of compensation that is compatible with the manager's participation constraint. This could be negative for relatively high w_1. That is, the shareholders may propose a contract that requires the manager to have "skin in the game." We suppose that the manager has sufficient wealth to agree this.[13] In that case, the

[13] Anderson (2021) explores the complications arising when the manager is wealth constrained.

optimal incentive rate w_1 can be found by maximizing,

$$(w_1^{(\alpha_m+\alpha_l)/\alpha_k} - (1+\alpha_l)w_1^{1/\alpha_k}) \tag{43}$$

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,

$$w_1 = \frac{\alpha_m+\alpha_l}{1+\alpha_l} \tag{44}$$

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

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

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

Using (44) and still assuming the manager's wealth constraint is not binding, the value of the manager's fixed compensation is,

$$\begin{aligned} w_0 &= w_m(T) - w_1^{1/\alpha_k}(\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k}(\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k}K \\ &= w_m(T) - [\frac{\alpha_m+\alpha_l}{1+\alpha_l}]^{1/\alpha_k}(\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k}(\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k}K \end{aligned} \tag{46}$$

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 (36), (44), and (45) the amount of labor employed at fixed wage w_l

can be written,

$$
\begin{aligned}
L &= \frac{\alpha_l w_1}{w_l} V \\
L &= w_1 \frac{\alpha_l}{w_l} V \\
L &= \frac{\alpha_m + \alpha_l}{1+\alpha_l} \frac{\alpha_l}{w_l} V \\
L &= \frac{\alpha_m + \alpha_l}{1+\alpha_l} \frac{\alpha_l}{w_l} \Big[\frac{\alpha_m + \alpha_l}{1+\alpha_l}\Big]^{(\alpha_m+\alpha_l)/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \\
L &= \frac{\alpha_l}{w_l} \Big[\frac{\alpha_m + \alpha_l}{1+\alpha_l}\Big]^{1/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \qquad (47)
\end{aligned}
$$

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

$$
w_l L = \alpha_l \Big[\frac{(\alpha_m + \alpha_l)}{1+\alpha_l}\Big]^{1/\alpha_k} (\frac{\alpha_m T}{g})^{\alpha_m/\alpha_k} (\frac{\alpha_l}{w_l})^{\alpha_l/\alpha_k} K \qquad (48)
$$

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)).

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Economic and Social Research Council

The London School of Economics and Political Science
Houghton Street
London WC2A 2AE
United Kingdom

tel: +44 (0)20 7405 7686
systemicrisk.ac.uk
src@lse.ac.uk

Systemic Risk Centre