Is Capping Executive Bonuses Useful?

Kentaro Asai¹

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Abstract

This paper develops a theoretical framework to study the impact of bonus caps on risk taking. In the model, labor market price adjustments can offset the direct effects of bonus caps. In particular, bonus caps are only effective when bank executives’ mobility is curtailed. Furthermore, irrespective of the degree of labor market mobility, bonus caps simultaneously reduce risk shifting (bank executives taking on too much risk because of limited liability), but aggravate underinvestment (bank executives foregoing risky but productive projects). Therefore, the welfare effects of bonus caps critically depend on initial condition including the relative importance of the risk shifting versus underinvestment in a given region.

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I. INTRODUCTION

Shareholders have limited liability, which means that they have a limited downside to their investment, but receive all the gains from an increase in the company’s value. Therefore, they have an incentive to transfer wealth from creditors to themselves by choosing risky projects that do not create value for the firm. In practice, they outsource investment decisions to executive managers while aligning the incentives of these managers with their own interests using incentive contracts. As a result, these managers, on behalf of shareholders, can engage in risk shifting, that is, investing in risky projects with negative net present values. Although the debt market partly corrects risk shifting by adjusting credit spreads, this adjustment is not perfect because insured creditors are not incentivised to monitor credit risks (Demirgüç-Kunt and Kane, 2002).

Based upon this premise, it has been argued that bank executives’ risk shifting has played an important role in the global financial crisis (Boyd and Hakenes, 2014). In the aftermath of the crisis, regulators, particularly in the European Union (EU), have proposed various measures to restrict risk shifting by bank executives, including the bonus cap. For example, EU regulators have capped bonuses at 100 percent of salary in general, with the provision to increase it to 200 percent of salary with the approval of at least 65 percent of the firm’s shareholders (or 75 percent in the absence of a quorum).

However, bonus caps remain controversial. In particular, there have been legal disputes among regulators (the United Kingdom (UK) sued the EU in September 2013), while academics have raised concerns. First, if the restrictions on variable pay, such as the ratio cap on fixed to variable remuneration, make bank managers move abroad to avoid the regulation, banks may respond to the ensuing shortage of qualified managers by increasing their base pay (International Monetary Fund, 2014; Murphy, 2013). This increase in base pay can raise the manager’s expected payoff from a risky project, because it raises the compensation floor for the manager (that is the compensation received when a risky project yields a low return). Therefore, it can undo the effect of the cap because it can increase the attractiveness of undertaking a risky project. Thus, labor market adjustments, i.e. the increase in base pay for keeping bank executives from escaping to unregulated jurisdictions, can offset the impact of the policy.

Second, a bonus cap can potentially reduce good risk taking, excessively discouraging investment into risky projects with positive net present values. Since the bonus cap only matters for payoffs associated with high returns, it reduces the expected payoff from a risky investment
with a high expected return more than that with a low expected return. Therefore, the policy can yield underinvestment, i.e. not investing in a risky project with a positive net present value, and cause efficiency losses.

Thus, the effect of a bonus cap on risk shifting is mixed if the labor market adjusts, while its impact on efficiency is ambiguous due to the increase in underinvestment. These concerns motivate us to consider the following questions: (i) to what extent can a bonus cap affect risk shifting and underinvestment and (ii) how much of the impact of a bonus cap is offset by labor market adjustments? To address these questions, we first model the investment decisions of bank executives; then, we calibrate the model by matching the theoretical predictions with observed data; and finally, we use the estimated model to simulate the impact of bonus caps while allowing for labor market adjustments.

Our model predicts that bonus capping reduces risk taking for all levels of profitability, although it is less effective for unprofitable projects. This suggests that the policy can aggravate underinvestment while having only a limited impact on the prevention of risk shifting. In line with this hypothesis, a numerical simulation suggests that bonus caps substantially increase underinvestment while they are only useful in the absence of labor market adjustments. Our analysis suggests that regulatory efforts to eliminate labor market adjustments, such as setting caps on all the sectors bank executives may move to, strengthen the effect of bonus capping on risk shifting to some extent, but they never resolve an increase in underinvestment.

The rest of this paper is structured as follows. Section 2 reviews related literature. Section 3 describes the model of investment decisions by bankers. Section 4 characterizes the behavior of a regional representative bank. Section 5 calibrates the model. Section 6 simulates the impact of a bonus cap on risk shifting and underinvestment. Section 7 discusses policy implications.

II. LITERATURE REVIEW

To the best of our knowledge, no empirical studies directly measure the impact of a bonus cap, because only a few years have passed since the regulatory reforms following the Global Financial Crisis were put in place. Moreover, although the previous empirical compensation literature, such as International Monetary Fund (2014), suggests that performance-linked compensation in the form of options tends to be associated with more risk, their implications
for other forms of bonus instruments are mixed (Table 1). Therefore, these papers do not allow to derive straightforward predictions on the impact of bonus capping. Lastly, the data do not distinguish the effect on risk shifting from the effect on risk taking, nor do they reveal the effect on underinvestment. Reduction in the observed risk measure may or may not correspond to a decrease in risk shifting or an increase in underinvestment. Without knowing the changes in these metrics, it is difficult to measure the welfare impact of reform. All of this motivates us to estimate the impact of bonus capping structurally.

Structural studies most relevant to our paper focus on the implication of bonus caps in individual countries. They include Dittmann, Maug, and Zhang (2011) and Llense (2010), both of which calibrate how firms in US and France would react to different types of pay restrictions. Both studies find that bonus caps only have a moderate impact on shareholder value due to adjustments in labor markets. Our work complements these papers in the sense that we assess the implications for other regions.

Our approach is parsimonious relative to these papers, because we only need easily observable data at the region, country, and bank levels in order to simulate policies for a variety of objects. This also enables us to conduct international analyses, which have seldom been done before. On the other hand, the downside of this approach is over-simplification. Our approach only focuses on the sensitivity of variable pay with respect to performance in the spirit of Gollier, Koehl, and Rochet (1997), so we do not evaluate the regulations of different bonus instruments (cash, equity, options, etc.).

III. Model

Shareholders with limited liability align the interests of bank executives with their incentives by incentive contracts. Therefore, incentive contracts have to induce the compensation schedule that resembles the payoff schedule of shareholders with limited liability, which is flat up to a certain performance threshold and positively associated with the performance of a bank thereafter. As a result, executive compensation is the convex function of a bank’s performance. In this section, we examine the incentives for risk taking by bank executives under convex compensation schedules and how they are altered by a bonus cap.

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1See International Monetary Fund (2014) for a comprehensive cross-country assessment of the effect of different types of executive compensation on bank risk taking.
A. Investment decision

First, we characterize the investment decision by bank executives. The performance threshold is the benchmark against which the banker’s performance is measured. It may be zero profit, the risk free rate, the previous year’s performance, or the performance of rivals, etc. We denote it by $\theta$. Let $\beta$ be the incentive parameter that specifies the amount by which his/her compensation increases based on his/her performance above the performance threshold.

There are two periods ($t = 0, 1$). At $t = 0$, the banker receives the fixed salary $w_0$ and the opportunity of investing in a risky project. At $t = 1$, he/she receives the bonus that is linked to performance. The banker’s performance is measured by the realized return of his/her portfolio. The risky project yields a return of $x$ at $t = 1$. But, the banker does not know this at $t = 0$. Instead, he/she has a belief about the risky project’s return denoted by $\tilde{x}$, which follows the distribution characterized by the cumulative distribution function $G_x$. The return of the safe asset $x_0$ is known.

The banker has to decide on exposure to the risky project $s \in \{0, 1\}$ at $t = 0$, which maximizes the expected compensation at $t = 1$. Thus, his/her belief about the return of the portfolio is expressed by $s\tilde{x} + (1-s)x_0$. Accordingly, the belief about the compensation is:

$$w(s, \tilde{x}) \equiv \max\{w_0 + \beta(s\tilde{x} + (1-s)x_0 - \theta), w_0\}.$$

Moreover, we assume that there is transaction cost $\lambda s$ ($\lambda > 0$) for having exposure to the risky asset. Since the banker chooses the exposure that maximizes the expected compensation, his/her investment decision is characterized by:

$$s^*(x) = \arg\max_{s \in \{0,1\}} E_x[w(s, \tilde{x})] - \lambda s,$$

where he/she expects to receive:

---

2We observe that compensation tends to be higher in a region with higher risk exposure. Assuming that a banker is indifferent across regions, there has to be some cost associated with risk taking. For example, a banker may be accountable to both regulators and clients when he/she has greater exposure to risky asset or, simply, may be risk-averse.
\[ w^*(x) \equiv E_x[w(s^*(x), \bar{x})]. \]

Then, we obtain the following solution:

\[
s^*(x) = \begin{cases} 
1 & \text{if } E_x[w(1, \bar{x})] - \lambda > E_x[w(0, \bar{x})] \\
0 & \text{if } E_x[w(1, \bar{x})] - \lambda \leq E_x[w(0, \bar{x})]. 
\end{cases}
\]

**B. Comparative statics**

Next, we analyze how the incentive of taking risk is altered by parameters in our model.\(^3\) Let the value of fully investing in the risky asset relative to fully investing in the safe asset be \( \Delta(x) \). It is characterized by:

\[
\Delta(x) \equiv \begin{cases} 
\beta \int_{\theta}^{\infty} (\bar{x} - \theta) dG_x(\bar{x}) - \lambda & \text{if } \theta > x_0 \\
\beta \int_{\theta}^{\infty} (\bar{x} - \theta) dG_x(\bar{x}) - \beta (x_0 - \theta) - \lambda & \text{if } \theta \leq x_0.
\end{cases}
\]

First, we find that the value of risk taking decreases with the distance between \( \theta \) and \( x_0 \):

\[
\frac{\partial \Delta(x)}{\partial \theta} = \begin{cases} 
-\beta [1 - G_x(\theta)] & \text{if } \theta > x_0 \\
\beta G_x(\theta) & \text{if } \theta < x_0.
\end{cases}
\]

To provide intuition behind this result, I consider the case in which a bank executive has a risky investment project that has a chance for a good outcome and a chance for a bad one, with the performance of a bank above the performance threshold in the good state and below the performance threshold in the bad state. When the performance threshold is lower than the risk free rate, the increase in the performance threshold lowers the payoff that the banker receives at the risk free rate and the payoff that the banker receives from the risky investment in the high state. However, it does not affect the payoff that the banker receives from the risky

\(^3\)See also Box 3.3 of *International Monetary Fund (2014)* for a simplified version of this discussion.
investment in the low state. As a result, on average the decrease in the payoff is milder for the risky investment.

When the performance threshold is higher than the risk free rate, the decline in the performance threshold does not affect the payoff that the banker receives at the risk free rate or the payoff that the banker receives from the risky investment in the bad state. However, it increases the payoff that the banker receives from the risky investment in the good state. As a result, on average the increase in the payoff is greater for the risky investment.

Thus, in both cases, the incentive for risk taking rises when the performance threshold is closer to the risk free rate.

Second, we show that an increase in the risk free rate discourages risk taking by increasing the payoff associated with investing in the safe asset:

\[
\frac{\partial \Delta(x)}{\partial x_0} = \begin{cases} 
0 & \text{if } \theta > x_0 \\
-\beta & \text{if } \theta < x_0
\end{cases}.
\]

Third, we show the relation between the incentive parameter \(\beta\) and the incentive for risk taking:

\[
\frac{\partial \Delta(x)}{\partial \beta} = \begin{cases} 
\int_\theta^\infty (\tilde{x} - \theta)dG_\theta(\tilde{x}) & \text{if } \theta > x_0 \\
\int_\theta^\infty (\tilde{x} - \theta)dG_\theta(\tilde{x}) - (x_0 - \theta) & \text{if } \theta \leq x_0
\end{cases}.
\]

We note that an increase in the incentive parameter can both encourage and discourage risk taking. It unambiguously raises the compensation associated with the return above the risk free rate. If the risk free rate is below the performance threshold, the compensation associated with the return below the risk free rate remains unchanged relative to the compensation at the risk free rate, after the increase in the incentive parameter. Therefore, it necessarily raises the incentive for taking risk. However, if the risk free rate is above the performance threshold, the compensation associated with the return below the risk free rate decreases relative to the compensation at the risk free rate. As a result, performance-based compensation does not necessarily increase risk-taking incentives.
C. Bonus capping

Lastly, we investigate how a bonus cap affects the incentive to take risk. A bonus cap makes the compensation schedule less convex by setting the maximum amount of bonus payable. It is usually expressed as a multiple of a fixed salary. We denote the multiple by $\rho$ ($\rho > 0$). Then the regulated compensation schedule is described as:

$$w(s, \bar{x}) \equiv \max \{ w_0 + \min \{ \beta (s \bar{x} + (1-s)x_0 - \theta), \rho w_0 \}, w_0 \}.$$

When a bank executive does not earn the maximum bonus at the risk free rate, $\rho$ satisfies $\frac{\rho w_0}{\beta} + \theta \geq x_0$. Unless otherwise noted, we assume this condition. If $\frac{\rho w_0}{\beta} + \theta < x_0$, the banker earns the highest compensation when he/she fully invests in the safe asset as long as $\lambda$ is positive. Thus, he/she does not have any exposure to the risky asset.

Since the upside of the risky return is not as large as before, the marginal value of increasing exposure to the risky asset is lower than before:

$$\frac{\partial (E_x[w(s, \bar{x})] - \lambda s)}{\partial s} = \beta \int_{s}^{\frac{\rho w_0}{\beta} + \frac{\theta - (1-s)x_0}{\beta}} (\bar{x} - x_0) dG_x(\bar{x}) - \lambda \leq \beta \int_{\frac{\theta - (1-s)x_0}{\beta}}^{\infty} (\bar{x} - x_0) dG_x(\bar{x}) - \lambda.$$

This implies that a bonus cap reduces the incentive for risk taking.

For analyzing the impact of a bonus cap on risk taking, we characterize the value of risk taking as follows:

$$\Delta(x; \rho) \equiv \begin{cases} \beta \int_{\theta}^{\frac{\rho w_0 + \theta}{\beta}} (\bar{x} - \theta) dG_x(\bar{x}) + \rho w_0 (1 - G_x(\frac{\rho w_0}{\beta} + \theta)) - \lambda & \text{if } \theta > x_0 \\ \beta \int_{\theta}^{\frac{\rho w_0 + \theta}{\beta}} (\bar{x} - \theta) dG_x(\bar{x}) + \rho w_0 (1 - G_x(\frac{\rho w_0}{\beta} + \theta)) - \beta (x_0 - \theta) - \lambda & \text{if } \theta \leq x_0 \end{cases}.$$
First, we find that $\Delta(x; \rho)$ is increasing in $\rho$ for any return $x$:

$$\frac{\partial \Delta(x; \rho)}{\partial \rho} = w_0(1 - G_x(\frac{\rho w_0}{\beta} + \theta)).$$

Second, we note that fixed salary $w_0$ affects $\Delta(x; \rho)$ in the same way as does $\rho$:

$$\frac{\partial \Delta(x; \rho)}{\partial w_0} = \rho(1 - G_x(\frac{\rho w_0}{\beta} + \theta)).$$

Third, we claim that $\theta$ affects $\Delta(x; \rho)$ in the same way it does without a bonus cap:

$$\frac{\partial \Delta(x; \rho)}{\partial \theta} = \begin{cases} 
-\beta[G_x(\frac{\rho w_0}{\beta} + \theta) - G_x(\theta)] & \text{if } \theta > x_0 \\
\beta G_x(\theta) + \beta[1 - G_x(\frac{\rho w_0}{\beta} + \theta)] & \text{if } \theta < x_0.
\end{cases}$$

Fourth, we show that the regulatory impact of a bonus cap is positively associated with the return of a risky asset, if a project with higher return has first-order stochastic dominance (with respect to a banker’s belief about the risky return) over a project with lower return:

$$\frac{\partial^2 \Delta(x; \rho)}{\partial \rho \partial x} = -w_0 \frac{\partial G_x(\frac{\rho w_0}{\beta} + \theta)}{\partial x}.$$

For example, suppose that there are two risky investments, one with a lower and one with a higher expected return. Both projects yield the identical return in the bad state, while the project with higher expected return yields a higher return than that with lower expected return in the good state. Then, the payoff that the banker receives from the risky investment with higher expected return in the good state is more likely to hit the bonus cap because the bonus cap only matters for the payoffs associated with high returns. Therefore, the expected payoff from the risky investment with higher expected return is more likely to decrease by a bonus cap than that from the risky investment with lower expected return.

In summary, we claim the following.
Proposition 1. A bonus cap reduces the incentive to invest in a risky asset. Suppose that a project with higher return has first-order stochastic dominance (with respect to a banker’s belief about the risky return) over a project with lower return, then the impact of a bonus cap becomes larger if the return to a risky asset is larger.

Proof. See the Appendix.

Proposition 1 suggests that a bonus cap suppresses risk taking for any type of project, but it is more effective for high-return projects. This implies that a bonus cap may not be effective in preventing risk shifting. Moreover, underinvestment may be encouraged by a bonus cap because it suppresses investment in risky projects with relatively high returns.

IV. REGIONAL MODEL

So far, we have focused on the investment decision of an individual banker. Now, we characterize the behavior of a representative regional bank that hires many bankers and how it is affected by bonus capping while taking into account labor market adjustments.

A. Representative regional bank

Let us consider a representative regional bank of generic region \( j \). Let the distribution of return to the risky project for region \( j \) be characterized by the cumulative distribution function \( F_j \). Then, the average exposure to risky projects is:

\[
s_j^* \equiv \int_{-\infty}^{\infty} s_j^*(x) dF_j(x). \quad (1)
\]

Let \( w_j(s_j^*(x), x) \) be the compensation from investing in the risky project that yields a return of \( x \), which is received by the banker ex-post. This is distinct from the compensation from investing in the same project (\( w_j^*(x) = E_x[w_j^*(s_j^*(x), \bar{x})] \)), which is expected by the banker ex-ante. Then, the average compensation from investing in the risky projects, which is received by the banker ex-post, is:

\[
w_j^* \equiv \int_{-\infty}^{\infty} w_j(s_j^*(x), x) dF_j(x). \quad (2)
\]
We define risk shifting as the average incidence of investing in risky projects that yield returns below the risk free rate:

\[ rs^*_j \equiv \int_{-\infty}^{x_0} s^*_j(x) dF_j(x). \] (3)

Similarly, we define underinvestment as the average incidence of not investing in risky projects that yield returns above the risk free rate:

\[ ui^*_j \equiv \int_{x_0}^{\infty} (1 - s^*_j(x)) dF_j(x). \] (4)

Thus, risk shifting is interpreted as the probability of taking bad risk, while underinvestment is the probability of avoiding to take good risk.

B. Labor market equilibrium

Then, we characterize the labor market equilibrium of bankers. We assume that there are \( J \) regions where bankers can travel across. At equilibrium, each banker is indifferent to every region. Therefore, we characterize the labor market equilibrium of bankers by:

\[ u^* \equiv w^*_j - \lambda s^*_j - c_j \quad \forall 1 \leq j \leq J, \] (5)

where \( c_j \) is the entry cost to participate in the market \( j \).

C. Regulation with the restriction on the labor mobility of bankers

Next, we analyze the impact of bonus capping on a bank’s risk taking while controlling labor market adjustments. Immediately after bonus capping is introduced, a banker does not know the average compensation that he/she will actually receive under the new compensation schedule. This is because he/she does not yet know the return from his/her investment. Therefore, the banker remains in the region if the average compensation that he/she expects to receive
ex-ante is at least as large as the original one. Then the reservation value for the banker to stay in the regulated region is expressed by:

\[ v_j^* \equiv \int_{-\infty}^{\infty} w_j^*(x) dF_j(x) - \lambda s_j^* - c_j. \quad (6) \]

Let \( u_j^C(\hat{\rho}_j) \) be the average value that the banker expects to receive ex-ante after introducing the bonus cap \( \hat{\rho}_j \). Then it is characterized by:

\[ u_j^C(\hat{\rho}_j) \equiv w_j(0; \hat{\rho}_j) + \int_{-\infty}^{\infty} 1[\Delta_j(x_j; \hat{\rho}_j) > 0] \Delta_j(x_j; \hat{\rho}_j) dF_j(x_j) - c_j. \]

where \( \Delta_j(x_j; \hat{\rho}_j) \) is the value of risk taking after regulation and \( w_j(0; \hat{\rho}_j) \) is the compensation the banker earns at the risk free rate under the regulation.

To keep the banker within region \( j \), we need to make the banker who leaves for the new job pay \( v_j^* - u_j^C(\hat{\rho}_j) \).

**D. Regulation without any restriction on the labor mobility of bankers**

Lastly, we consider the case where a regulator does not control labor market adjustments. First, we notice:

\[ u_j^C(\hat{\rho}_j) < v_j^*. \]

Since it does not satisfy the participation condition of a banker, the compensation of a banker has to be adjusted upwards. Then the modified aggregate ex-ante expected utility \( u_j^L(\hat{\rho}_j, \hat{w}_0^j, \hat{\theta}_j) \) satisfies:

\[ u_j^L(\hat{\rho}_j, \hat{w}_0^j, \hat{\theta}_j) = v_j^*. \]

Keeping the incentive parameter unaffected, there may be two types of adjustment: (i) an increase in \( w_{0j} \) and (ii) simultaneous increases in \( w_{0j} \) and \( \theta_j \). For (i), the adjusted fixed salary
$w_{0j}$ satisfies:

$$v_j^* = w_j(0; \hat{\rho}_j; w_{0j}, \theta_j) + \int 1[\Delta_j(x_j; \hat{\rho}_j; w_{0j}, \theta_j) > 0]\Delta_j(x_j; \hat{\rho}_j; w_{0j}, \theta_j)dF_j(x_j) - c_j. \quad (7)$$

where $\Delta_j(x_j; \hat{\rho}_j; w_{0j}, \theta_j)$ is the value of risk taking and $w_j(0; \hat{\rho}_j; w_{0j}, \theta_j)$ is the compensation the banker earns at the risk free rate under the regulation. Since the right hand side of Equation (7) is continuous and strictly increasing in $w_{0j}$, it diverges to infinity as $w_{0j}$ goes to infinity. Moreover, it converges to $u_j^C(\hat{\rho}_j)$ as $w_{0j}$ goes to $w_0$. Therefore, there exists a unique $w_{0j}$ satisfying Equation (7).

Alternatively, the labor market may adjust both the fixed salary and the performance threshold, as suggested by Murphy (2013).\(^4\) In this case, the new performance threshold satisfies:

$$\hat{\theta}_j(w_{0j}) = \theta_j + \frac{w_{0j} - w_0}{\beta}. \quad \text{Then the new fixed salary is the solution of:}$$

$$v_j^* = w_j(0; \hat{\rho}_j; w_{0j}, \hat{\theta}_j(w_{0j})) + \int 1[\Delta_j(x_j; \hat{\rho}_j; w_{0j}, \hat{\theta}_j(w_{0j})) > 0]\Delta_j(x_j; \hat{\rho}_j; w_{0j}, \hat{\theta}_j(w_{0j}))dF_j(x_j) - c_j. \quad (8)$$

It is not clear if there is a unique $w_{0j}$ satisfying Equation (8), analytically. This is because the right hand side of Equation (8) may not be monotone in $w_{0j}$; an increase in the performance threshold can increase the distance between the performance threshold and the risk free rate and discourage risk taking, whereas an increase in $w_{0j}$ encourages risk taking. Therefore, we numerically search $w_{0j}$ that satisfies Equation (8) with various initial values, but we only find a single fixed salary that satisfies Equation (8) in our numerical search.

For both (i) and (ii), we anticipate that the regulatory impact will be offset by an increase in a fixed salary. However, it is unclear how much a bonus cap can reduce risk shifting ceteris paribus, and how much labor market adjustments offset (or overwhelm) the regulatory impact. To answer these questions, we calibrate the model and simulate the impact of regulation in the next few sections.

V. CALIBRATION

In this section, we describe the strategy for calibrating the model and present the estimated parameters.

\(^4\)See Figure 3 of Murphy (2013).
A. Data

First, we observe the aggregate ex-post compensation and the average fixed salary of bank CEOs in each region from 2005 to 2013 ($\{w_{0j}, w^*_j\}_{1 \leq j \leq J}$) from S&P Capital IQ (Tables 2 and 8).

Second, we observe the aggregate exposure to risky assets of each region for the same period ($\{s^*_j\}_{1 \leq j \leq J}$) from the market beta of the banking sector in each region (Table 8).\(^5\)

Third, we set the average three-month U.S. Treasury bill rate between 2005 and 2013 for the return on safe assets of every region ($x_0$). This is equal to 1.5 percent.

Fourth, since banks in each region have exposure to the global market, we compute the geographical breakdown of their assets (Table 3). To complete this, we use the BIS consolidated banking statistics. The BIS data allows us to compute total foreign claims as well as claims on the individual countries of banks headquartered in the BIS reporting countries. We follow the definition of regions used in *International Monetary Fund (2014)*, which is explicitly described in Table 3. The definition is based on *Macey and O’Hara (2003)* definition of regional corporate governance models: Anglo-American, Franco-German or Advanced European, and Other. Therefore, we separate Anglo-Saxon countries like UK and Ireland from continental Europe even if they all belong to Western Europe, because the corporate governance models of Anglo-Saxon countries are different from those of continental Europe.

We note that a substantial number of countries described in Table 3 do not report to the BIS. In the BIS data, although the non-reporting countries are captured in their role as borrowers, they are not captured in their role as lenders. Because of this, our geographical breakdown data over-represent banks headquartered in the BIS reporting countries. However, we also note that banks headquartered in the BIS reporting countries tend to dominate a large part of total assets in each region. For each region, we obtain the aggregated claims on the other regions and obtain the aggregated total assets of banks from SNL financial and FDIC. By dividing the former by the latter, we obtain the geographical breakdown of asset exposure of banks.

\(^5\)Since banks usually have a well-diversified portfolio of risky assets, we assume that the set of risky assets is close to the constituents of a local market portfolio. Let exposure to risky assets be $\theta$. Let $L$, be the leverage ratio. Let the ROA (relative to the risk free rate) of banks be $B$ and that of the local market portfolio be $M$. Then, $B = \theta M$. Therefore, the ROE (relative to the risk free rate) of banks will be $L_B B$ and that of the local market portfolio will be $L_M M$. Finally, we can express $\text{beta}$ as:

$$\beta = \frac{\text{COV}(L_B B, L_M M)}{\text{VAR}(L_M M)} = \frac{L_B L_M \text{COV}(\theta M, M)}{L_M \text{VAR}(M)} = \frac{\theta L_B \text{VAR}(M)}{L_M \text{VAR}(M)} = \frac{\theta L_B}{L_M}.$$

Therefore, exposure to risky assets is given by: $\theta = \beta \frac{L_M}{L_B}$. 
banks in each region. We use the average geographical breakdown of each region from 2005 to 2013 for our estimates.

Next, we observe the ROA of all constituents in each region’s local equity index for each region by year. We draw samples for the simulation by year because this enables us to estimate risk shifting and underinvestment by year. Many regulators are interested in risk shifting during economic crises, so it is valuable to provide estimates for the year 2008 in addition to overall estimates. We construct the empirical distribution of ROA for each invested region by year (Table 4). The mixture distribution generated from the convex combination of the geographical breakdown of bank assets and the ROA distribution of each invested region replicates the distribution of the risky return of each region \( \{F_j\}_{1 \leq j \leq J} \).

Lastly, we take the historical coefficient of variation of each constituent\(^7\) to estimate the degree of uncertainty for risky investment.\(^8\) We assume that a banker’s belief about a risky return is normally distributed around the true return with a standard deviation based on the historical coefficient of variation.

Consequently, our sampling consists of three steps. For each region, we draw a project’s location using the geographical breakdown we established. Then, we non-parametrically draw a constituent by sampling with replacement from the set of constituents of local equity index associated with the location we drew in the first step. Finally, for the drawn constituent, we draw forecast errors from the normal distribution associated with that constituent.

### B. Estimation

Our goal is to estimate structural parameters by the simulated method of moments. First, we estimate the cost of investing in a risky project as well as the entry cost of each region \( (\lambda, \{c_j\}_{1 \leq j \leq J}) \) using Equation (5). Notice that we obtain the following linear relationship:

---

\(^6\)For Asia, we use the TOPIX, the SSE Composite Index, and the CNX 500. For Anglo-Saxon countries, excluding the U.S., we use the FTSE All-Share, the S&P/ASX 300, and the S&P TSE Composite Index. For the U.S., we use the S&P 500. For Continental Europe, we use the DAX 100, the CAC All-Share, Milan Comit General, IBEX 35, IBEX Medium & Small Caps, and the AEX All-Share. For EMEA, we use the ISE National All-Share, the Russian RTS, and the DJ TA 100 Index. We drop any constituents without full observation of the ROA between 2005 and 2013.

\(^7\)Standard deviation of the ROA between 2005 and 2013/absolute mean of the ROA between 2005 and 2013.

\(^8\)The standard deviation of forecast errors is recovered by multiplying the absolute value of the ROA with the coefficient of variation.
\[(w_j^* - w_1^*) = \lambda (s_j^* - s_1^*) + (c_j - c_1) \quad \forall 2 \leq j \leq J. \quad (9)\]

After arbitrarily determining region 1, we can regress the aggregate ex-post compensations (relative to region 1) on the aggregate exposures to risky assets (relative to region 1).\(^9\) The coefficient is the cost of investing in risky projects, while the entry cost of each region (relative to region 1) is calculated by adding the constant and the residual. Without loss of generality, we set \(c_1 = 0\).

Next, we estimate the remaining parameters \(\{\theta_j, \beta_j\}_{1 \leq j \leq J}\) using Equations (1) and (2). Note that we have already obtained the estimator for the cost of investing in risky projects \((\hat{\lambda})\). Since Equations (1) and (2) provide us with \(2J\) equations, we can estimate at most \(2J\) parameters if we know all the rest of the parameters and the distributions.

Utilizing the data, we are able to predict the investment decision of an individual banker for each region if we are given \(\{\theta_j, \beta_j\}_{1 \leq j \leq J}\). After a sufficient number of iterations, we can predict the aggregate ex-post compensation and exposure to risky assets for each region. We try to match the theoretical prediction with the observed data by choosing appropriate \(\{\theta_j, \beta_j\}_{1 \leq j \leq J}\).

Formally, for each region \(j\), we start by drawing a region in which to invest and associated constituents \(K\) times to get \(\{x_j^k\}_{k=1}^K\) and forecast errors per constituent \(R\) times to get \(\{\tilde{x}_{jk}^r\}_{r=1}^R\). In our estimation, we set \(K = 9000\) (1000 per year) and \(R = 100\). Then, we approximate the integrals represented by the right hand side of Equations (1) and (2) by Monte Carlo simulation as follows:

\[
\hat{s}_j^*(x_j^k) = 1[\beta_j \frac{1}{R} \sum_{r=1}^R [1[\tilde{x}_{jk}^r > \theta_j](\tilde{x}_{jk}^r - \theta_j) - 1[x_0 > \theta_j](x_0 - \theta_j)] - \hat{\lambda} > 0] \\
\hat{w}_j^*(\hat{s}_j^*(x_j^k), x_j^k) = w_0 + \beta_j 1[\hat{s}_j^*(x_j^k)x^k + (1 - \hat{s}_j^*(x_j^k))x_0 \geq \theta_j][\hat{s}_j^*(x_j^k)x^k + (1 - \hat{s}_j^*(x_j^k))x_0 - \theta_j].
\]

Then, we minimize the approximated objective function with constraints as below:

\(^9\)The identifying assumption is the independence of \(\{s_j\}_{1 \leq j \leq J}\) from \(\{c_j\}_{1 \leq j \leq J}\).
\[
\hat{g} = \left\{ \begin{array}{l}
\frac{\sum_{k=1}^{K} \hat{s}_{j}(x_{k})}{K} - s_{j}^{*} \\
\frac{\sum_{k=1}^{K} \hat{w}_{j}(x_{k})}{K} - w_{j}^{*}
\end{array} \right\}_{j=1}^{J}
\]

\[
\min_{\{\theta_{j}, \beta_{j}\}_{1 \leq j \leq J}} \hat{g}' \hat{g} \quad s.t. \beta_{j} \geq 0.
\] (10)

C. Estimated parameters

We report our estimated parameters in Tables 7 and 8. We also present the fitness of our model in Table 9. We find that our estimation is sufficiently close to observed data. From the first step, we find that the cost of risky investment is positive, implying that the CEO of a financial institution is burdened with some cost when investing in a risky asset. Alternatively, this may be interpreted as risk aversion. The entry costs in the U.S. and the other Anglo-Saxon countries are larger than those in Asia. This may be because it requires a larger investment of human capital to become a CEO in these countries. From the second step, we find that the incentive parameter is larger in emerging regions and smaller in advanced regions. The estimated performance threshold of each region is close to the risk free rate.

Next, we estimate the status-quo of risk shifting and underinvestment using Equations (3) and (4) via Monte Carlo simulation (Figures 1 and 2). First, we find that risk shifting is not proportional to the exposure to risky assets. For example, the exposure to risky assets is higher in the U.S. than in continental Europe but risk shifting is much lower in the U.S. Moreover, we observe that risk shifting peaks around 2008, confirming the tendency of gambling for resurrection during financial crises in all regions. Second, our estimates indicate that there is substantial underinvestment.

VI. Counterfactual analysis

In this section, we simulate the impact of a bonus cap on risk shifting and underinvestment with the calibrated model.
A. Main results

First, we simulate the average impact of a bonus cap on average risk shifting and underinvestment over the period from 2005 to 2013 for each region. The bonus cap is represented as a multiple of a fixed salary. Initially, we consider the case where the labor mobility of bank executives is restricted. Using the parameters estimated in Section 5 coupled with each proposed cap (a cap is more severe if it is lower), we simulate the investment decisions of bank executives with the compensation scheme redefined in Section 4. As we have done in Section 5, we predict risk shifting and underinvestment for each proposed cap. We find that risk shifting is substantially reduced in all regions with a moderate cap size (Figures 3 and 4). However, there is a trade-off between a reduction of risk shifting and an increase in underinvestment for all the regions. The regulatory impact is largest in emerging regions because the fixed salary is so low that a bonus cap is very powerful.

Next, we assume that labor mobility of bank executives is not restricted. Using the parameters estimated in Section 5 coupled with each proposed cap, we compute the equilibrium base salary of each region, maintaining the ex-ante expected utility of the banker at its original level. We do this for each type of labor market adjustment. In our simulation, we find only one equilibrium fixed salary for each proposed cap when the labor market adjustment involves the shift in the performance threshold. After obtaining a new base salary, we again simulate the investment decisions of bank executives and estimate risk shifting and underinvestment after labor market adjustments. We find that labor market adjustments substantially offset the regulatory impact on risk shifting and underinvestment for most regions (Figures 5-8). For Asia, Anglo-Saxon ex U.S., U.S., and Continental Europe, only very tight caps (5 x fixed wage or less) reduce risk shifting. As an exception, for case (ii), moderate caps eliminate risk shifting for EMEA due to a shift in the performance threshold.

B. Is a bonus cap useful in times of financial crisis?

Next, we present the impact of a bonus cap on risk shifting in 2008 (Figures 9 and 10), since reducing risk shifting around economic crises is of particular interest. Our simulation suggests that the impact of a bonus cap on risk shifting is substantially offset by labor market adjustments in 2008 for most regions, regardless of case (i) or (ii), although the labor market during economic crises may be rigid compared to normal times so that labor market may not adjust as much as we estimate. For case (ii), as we have seen above, we find that only in
EMEA risk shifting is substantially reduced after labor market adjustments in 2008 due to a shift in the performance threshold.

VII. DISCUSSION

Our analysis implies that there is substantial variation in the level of risk shifting across regions under the existing system, meaning that it is important for regulators to know the level of risk shifting in advance, in order to find the right targets to regulate. For example, we find that risk shifting is lower in the U.S. relative to the other regions.

A bonus cap can be an effective policy tool for eliminating risk shifting only in the absence of labor market adjustments. To substantially reduce risk shifting by the bonus cap, regulators have to eliminate labor market adjustments. In practice, they can set bonus caps on all the sectors bank executives may move to. In line with this implication, the European Banking Authority (EBA) said that national regulators would no longer be allowed to exempt small banks and some large asset managers from rules that cap bonuses as a proportion of fixed pay (European Banking Authority, 2015).

However, our analysis also implies that the bonus cap aggravates the underinvestment problem. Eliminating labor market adjustments never resolves an increase in underinvestment.
REFERENCES


Balachandran, Sudhakar, Bruce M. Kogut, and Hitesh Harnal, 2011, “Did Executive Compensation Encourage Extreme Risk-taking in Financial Institutions?”


APPENDIX

The first claim is verified by the following:

\[ \Delta(x; \rho') - \Delta(x; \infty) = - \int_{\rho'}^{\infty} \frac{\partial \Delta(x; y)}{\partial \rho} dy \]

\[ = - \int_{\rho'}^{\infty} w_0 (1 - G_x(\frac{yw_0}{B} + \theta)) dy \]

\[ < 0, \]

where \( \rho' \) is an arbitrary finite positive cap. This result implies that any bonus cap reduces the option value of risk-taking.

Assuming first-order stochastic dominance, that is \( G_{x'}(.) < G_{x''}(.) \) if \( x' > x'' \), the second claim is verified by the following:

\[ (\Delta(x'; \rho') - \Delta(x'; \infty)) - (\Delta(x''; \rho') - \Delta(x''; \infty)) \]

\[ = \int_{\rho'}^{\infty} \left( \frac{\partial \Delta(x''; y)}{\partial \rho} - \frac{\partial \Delta(x'; y)}{\partial \rho} \right) dy \]

\[ = \int_{\rho'}^{\infty} \int_{x''}^{x'} \frac{\partial G_z(\frac{yw_0}{B} + \theta)}{\partial x} dz dy \]

\[ < 0. \]

This result implies that the reduction in the option value of risk-taking is larger when the return on investment is higher.
<table>
<thead>
<tr>
<th>Authors/Title</th>
<th>Independent Variable</th>
<th>Measure</th>
<th>Sign</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Monetary Fund (2014)</td>
<td>Share of salary</td>
<td>Default risk, beta, and ROA volatility</td>
<td>(+)</td>
<td>International</td>
</tr>
<tr>
<td></td>
<td>Equity-based pay</td>
<td></td>
<td>(-)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compensation horizon</td>
<td></td>
<td>(-)</td>
<td></td>
</tr>
<tr>
<td>Acrey, McCumber, and Nguyen (2011)</td>
<td>Compensation elements</td>
<td>SEER risk variables and EDF</td>
<td>Mostly none</td>
<td>US</td>
</tr>
<tr>
<td>Bai and Elyasiani (2013)</td>
<td>Sensitivity to asset return volatility</td>
<td>Default risk and ROA volatility</td>
<td>(+)</td>
<td>US</td>
</tr>
<tr>
<td>Balachandran, Kogut, and Harnal (2011)</td>
<td>Equity-based pay</td>
<td>Default risk</td>
<td>(+)</td>
<td>US</td>
</tr>
<tr>
<td>Chesney, Stromberg, and Wagner (2012)</td>
<td>Sensitivity to asset return volatility</td>
<td>Write-downs</td>
<td>(+)</td>
<td>US</td>
</tr>
<tr>
<td>DeYoung, Peng, and Yan (2013)</td>
<td>Sensitivity to asset return volatility</td>
<td>Idiosyncratic risk and beta</td>
<td>(+)</td>
<td>US</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to asset return</td>
<td></td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Hagendorff and Vallascas (2011)</td>
<td>Sensitivity to asset return volatility</td>
<td>Merger-related default risk</td>
<td>(+)</td>
<td>US</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to asset return</td>
<td></td>
<td>(-)</td>
<td></td>
</tr>
<tr>
<td>Tung and Wang (2011)</td>
<td>Inside debt holding</td>
<td>Idiosyncratic risk and fall in bond price</td>
<td>(-)</td>
<td>US</td>
</tr>
</tbody>
</table>

Table 1. Summary of the empirical literature
<table>
<thead>
<tr>
<th>Region</th>
<th>Fixed salary (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td>479,338</td>
</tr>
<tr>
<td>Anglo-Saxon ex U.S.</td>
<td>1,276,595</td>
</tr>
<tr>
<td>U.S.</td>
<td>2,472,828</td>
</tr>
<tr>
<td>Continental Europe</td>
<td>1,337,889</td>
</tr>
<tr>
<td>EMEA</td>
<td>245,443</td>
</tr>
</tbody>
</table>

**Table 2. Fixed salary by region**

<table>
<thead>
<tr>
<th>Vis–a–vis</th>
<th>Asset exposure (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Asia</td>
</tr>
<tr>
<td>Asia</td>
<td>77.9</td>
</tr>
<tr>
<td>Anglo-Saxon ex U.S.</td>
<td>4.5</td>
</tr>
<tr>
<td>U.S.</td>
<td>11.6</td>
</tr>
<tr>
<td>Continental Europe</td>
<td>5.5</td>
</tr>
<tr>
<td>EMEA</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Note: Asia includes China, Hong Kong SAR, India, Japan, Korea, Malaysia, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, and Thailand. Anglo-Saxon ex U.S. includes Australia, Canada, Ireland, South Africa, and United Kingdom. Continental Europe includes Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Italy, Liechtenstein, Netherlands, Norway, Portugal, Spain, Sweden, and Switzerland. EMEA includes Hungary, Israel, Jordan, Lithuania, Poland, Russia, Saudi Arabia, Slovenia, Tunisia, Turk, and Zimbabwe.

**Table 3. Asset exposure by vis–a–vis region**
<table>
<thead>
<tr>
<th>Region</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>Coefficient of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td>4.21 (8.53)</td>
<td>4.72 (7.65)</td>
<td>5.58 (10.75)</td>
<td>4.50 (9.10)</td>
<td>2.47 (10.61)</td>
<td>3.97 (8.08)</td>
<td>4.38 (8.40)</td>
<td>4.21 (10.20)</td>
<td>3.97 (6.59)</td>
<td>3.85 (32.37)</td>
</tr>
<tr>
<td>Anglo-Saxon ex U.S.</td>
<td>6.76 (18.41)</td>
<td>14.33 (201.71)</td>
<td>8.32 (14.75)</td>
<td>3.62 (14.82)</td>
<td>2.68 (16.11)</td>
<td>8.26 (12.24)</td>
<td>7.39 (11.17)</td>
<td>6.44 (11.50)</td>
<td>7.40 (13.59)</td>
<td>4.46 (57.61)</td>
</tr>
<tr>
<td>U.S.</td>
<td>9.00 (9.52)</td>
<td>8.73 (8.26)</td>
<td>9.03 (7.86)</td>
<td>6.83 (10.07)</td>
<td>6.56 (8.29)</td>
<td>8.18 (6.68)</td>
<td>8.60 (6.30)</td>
<td>7.87 (7.07)</td>
<td>7.97 (5.85)</td>
<td>1.93 (17.65)</td>
</tr>
<tr>
<td>Continental Europe</td>
<td>6.55 (18.26)</td>
<td>6.08 (9.95)</td>
<td>6.29 (9.42)</td>
<td>3.05 (10.85)</td>
<td>2.11 (9.17)</td>
<td>3.66 (11.62)</td>
<td>4.41 (28.37)</td>
<td>2.23 (11.90)</td>
<td>1.90 (14.01)</td>
<td>2.69 (8.77)</td>
</tr>
<tr>
<td>EMEA</td>
<td>5.69 (15.23)</td>
<td>8.18 (13.51)</td>
<td>3.66 (73.45)</td>
<td>2.47 (21.72)</td>
<td>4.88 (17.30)</td>
<td>5.84 (13.38)</td>
<td>6.46 (12.46)</td>
<td>5.75 (8.12)</td>
<td>7.21 (43.34)</td>
<td>32.45 (478.61)</td>
</tr>
</tbody>
</table>

Note: Standard deviation in parentheses.

**Table 4. Mean ROA and coefficient of variation by vis-à-vis region**
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda$</td>
<td>Cost of risky investment</td>
</tr>
<tr>
<td>$c_x$</td>
<td>Entry cost of region x</td>
</tr>
<tr>
<td>$\beta_x$</td>
<td>Incentive parameter of region x</td>
</tr>
<tr>
<td>$\theta_x$</td>
<td>Benchmark of region x (Percent)</td>
</tr>
</tbody>
</table>

Table 5. List of parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimator</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda$</td>
<td>3,593,384</td>
</tr>
<tr>
<td>$c_{AS;ex;U}$</td>
<td>1,962,863</td>
</tr>
<tr>
<td>$c_{U.S.}$</td>
<td>3,746,119</td>
</tr>
<tr>
<td>$c_{CE}$</td>
<td>623,313</td>
</tr>
<tr>
<td>$c_{EMEA}$</td>
<td>821,428</td>
</tr>
</tbody>
</table>

Note: All the entry costs are relative to the entry cost in Asia.

Table 6. Estimated parameters (first step)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimator</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_{ASIA}$</td>
<td>$5.25 \times 10^7$</td>
</tr>
<tr>
<td>$\beta_{AS;ex;U}$</td>
<td>$3.04 \times 10^7$</td>
</tr>
<tr>
<td>$\beta_{U.S.}$</td>
<td>$3.91 \times 10^7$</td>
</tr>
<tr>
<td>$\beta_{CE}$</td>
<td>$3.93 \times 10^7$</td>
</tr>
<tr>
<td>$\beta_{EMEA}$</td>
<td>$4.76 \times 10^7$</td>
</tr>
<tr>
<td>$\theta_{ASIA}$</td>
<td>1.80</td>
</tr>
<tr>
<td>$\theta_{AS;ex;U}$</td>
<td>-3.18</td>
</tr>
<tr>
<td>$\theta_{U.S.}$</td>
<td>-3.09</td>
</tr>
<tr>
<td>$\theta_{CE}$</td>
<td>2.20</td>
</tr>
<tr>
<td>$\theta_{EMEA}$</td>
<td>0.60</td>
</tr>
</tbody>
</table>

Table 7. Estimated parameters (second step)
<table>
<thead>
<tr>
<th>Region</th>
<th>Exposure to risky assets (Percent)</th>
<th>Compensation (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>Estimated</td>
</tr>
<tr>
<td>Asia</td>
<td>26.5</td>
<td>28.0</td>
</tr>
<tr>
<td>Anglo-Saxon ex U.S.</td>
<td>24.3</td>
<td>24.2</td>
</tr>
<tr>
<td>U.S.</td>
<td>30.8</td>
<td>30.8</td>
</tr>
<tr>
<td>Continental Europe</td>
<td>23.1</td>
<td>23.1</td>
</tr>
<tr>
<td>EMEA</td>
<td>38.9</td>
<td>41.0</td>
</tr>
</tbody>
</table>

Table 8. Fitness of our model

Figure 1. Risk shifting under the existing system
Figure 2. Underinvestment under the existing system
Policy impact is measured against the level of risk shifting or underinvestment without regulation. A solid line shows the impact on risk shifting, while a dashed line shows the impact on underinvestment. A lower cap means severer regulation.

**Figure 3. Regulatory impact on risk shifting without labor market adjustments**
Policy impact is measured against the level of risk shifting or underinvestment without regulation. A solid line shows the impact on risk shifting, while a dashed line shows the impact on underinvestment. A lower cap means severer regulation.

**Figure 4. Regulatory impact on underinvestment without labor market adjustments**
Policy impact is measured against the level of risk shifting or underinvestment without regulation. A solid line shows the impact on risk shifting, while a dashed line shows the impact on underinvestment. A lower cap means severer regulation.

Figure 5. Regulatory impact on risk shifting with labor market adjustments (i)
Policy impact is measured against the level of risk shifting or underinvestment without regulation. A solid line shows the impact on risk shifting, while a dashed line shows the impact on underinvestment. A lower cap means severer regulation.

Figure 6. Regulatory impact on underinvestment with labor market adjustments (i)
Policy impact is measured against the level of risk shifting or underinvestment without regulation. A solid line shows the impact on risk shifting, while a dashed line shows the impact on underinvestment. A lower cap means severer regulation.

**Figure 7.** Regulatory impact on risk shifting with labor market adjustments (ii)
Policy impact is measured against the level of risk shifting or underinvestment without regulation. A solid line shows the impact on risk shifting, while a dashed line shows the impact on underinvestment. A lower cap means severer regulation.

Figure 8. Regulatory impact on underinvestment with labor market adjustments (ii)
Policy impact is measured against the level of risk shifting or underinvestment without regulation. A solid line shows the impact on risk shifting, while a dashed line shows the impact on underinvestment. A lower cap means severer regulation.

Figure 9. Regulatory impact on risk shifting in 2008 with labor market adjustments (i)
Policy impact is measured against the level of risk shifting or underinvestment without regulation. A solid line shows the impact on risk shifting, while a dashed line shows the impact on underinvestment. A lower cap means severer regulation.

Figure 10. Regulatory impact on risk shifting in 2008 with labor market adjustments (ii)