Borradores de ECONOMÍA

The Effects of Diversification on Banks' Expected Returns

Por: Dairo Estrada, Angela González Arbeláez , Javier Gutiérrez Rueda.

No. 524
2008

BANCO DE LA REPÚBLICA
COLOMBIA

tá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Col

The Effects of Diversification on Banks' Expected Returns*

Dairo Estrada
Angela González Arbeláez
Javier Gutierrez Rueda†

Abstract

In financial theory, the optimal allocation of assets and its relationship with profitability has been one of the main concerns; the question has always been if banks should focus or diversify their assets. In our case, we would like to answer this question focusing in diversification of the loan portfolio, presenting a theoretical model that considers the possible gains from diversification, while taking into account the effects of monitoring. Additionally, we present empirical evidence on this matter for the Colombian banking system. According to the model, we find that once the banks have chosen its optimal level of monitoring, expected return is always higher when the bank decides to focus. Additionally, the empirical results suggest that there are no possible gains form diversification in bank's cost and that, on average, the effects of focusing the loan portfolio reduces bank's return while showing positive effects of focusing on an specific sector.

Keywords: Diversification, Risk, Colombian Banking System.

*JEL Classification:*G00, G21, G30

---

*The opinions contained herein are those of the authors and do not represent those of the Banco de la República or its Board of Directors. Only authors are responsible for remaining errors.

†Authors are *Head* and *Staff* of the Financial Stability Department, Banco de la República de Colombia. E-mail: destrada@banrep.gov.co, agonzarb@banrep.gov.co, jgutieru@banrep.gov.co. We would like to specially thank Andrés Langebaek for his inputs to this work. The initial idea of making an analysis on diversification and profitability was proposed by him.

1 Introduction

In financial theory, the optimal allocation of assets and its relationship with profitability has been one of the main concerns; the question has always been if banks should focus or diversify their assets. In our case, we would like to answer this question focusing in diversification of the loan portfolio, presenting a theoretical model that considers the possible gains from diversification, while taking into account the effects of monitoring. Additionally, we present empirical evidence on this matter for the Colombian banking system.

In financial literature we can identify two different theories of how banks should allocate their assets. On one hand, corporate finance theory suggests that banks should focus their portfolio so as to reduce information asymmetries and to maximize benefits from greater expertise. On the other hand, traditional banking theory argues that banks should diversify as much as possible their portfolio in order to reduce risk, reducing the probability of a costly failure.

Corporate finance argues that there is a negative relationship between diversification and profitability that is usually sustained by agency problems at two different levels: according to Denis et al. (1997) managers diversify beyond optimal levels without sufficient corporate control; and diversification, specially regional, increases asymmetry information problems that make monitoring more costly and difficult to provide. Moreover, Berger and DeYoung (2001) state that the lack of scope economies can be translated in higher costs (i.e. learning, human capital with sector or regional experience, higher variable costs for having new costumers). On this line, Hayden et al. (2006) find evidence that shows that portfolio diversification across sectors, industries and region leads to a negative effect on banks' profitability rather than increasing bank returns. Also, Achayra et al. (2006) find that "in contrast to the recommendations of traditional portfolio and banking theories, diversification of bank assets is not guaranteed to produce superior return performance and/or greater safety for banks"[1].

Banking theory suggests that there is a positive relationship between profitability and diversification. This view sustains that credit portfolio diversification allows for some compensation between losses of some credits with the earnings of others; with this compensation, centralized monitoring is profitable, Diamond (1996). In addition, according to Winton (1999) banks should use diversification as a tool for enhancing benefits only if they face moderate downside risk levels and monitoring incentives need to be strengthen . Moreover, there is an argument in favor of the existence of economies of scale in the business administration, and the reduction of product and labor and, financial market failures Chandler (1977).

However, it is important to notice that the effects of diversification vary according to the size and type of financial intermediary. Winton (1997) finds that diversification

[1] Achayra Viral V., Hasan Iftekhar and Saunders Anthony. (2006). "Should Banks Be Diversified? Evidence from Individual Bank Loan Portfolios". Journal of Business, vol. 79, No. 3, 2006: pg 1356.

affects competition among financial intermediaries since large diversified banks have the ability to offer a higher expected return to investors than small riskier banks. Moreover, large banks have the power to centralize costly monitoring and avoid the duplication of monitoring effort by small investors, Diamond (1996).

It is important to take into account the effect that diversification has in the benefit function. Winton (1997) argues that a better diversified bank faces less risk, thus reducing the probability of bad outcomes and the costs associated with them. Another way of reducing costs has to do with monitoring. Winton (1999) recognizes that increased diversification may lessen monitoring effectiveness, increasing the frequency and severity of bad-outcomes, resulting on an increase in banks' costs.

Summarizing, there is not a consensus for the relationship between risk and focus, some empirical works have shown that this relationship is positive, depending on the risk faced by the financial entities; while some others have shown that the costs of diversification can be greater than the benefits.

In the model that we present in the following section, we find that once the banks have chosen its optimal level of monitoring, expected return is always higher when the bank decides to focus. Nevertheless this results have to be evaluated when some of the assumptions of the model are relaxed.

Some empirical works have found that diversification has a positive effect on bank's profitability, when the assumptions proposed by Winton (1999) hold. Achayra et al. (2006) analyze the relationship between risk and return, and the level of diversification for the Italian banking system. They used an annual database of 105 commercial banks for the period between 1993 and 1999, using as return measures ROA and stock return; and as risk measures five different indicators, which included expected and unexpected losses. For the quantification of the effects of diversification, the variables employed where two Herfindahl-Hirschman Indexes (HHI): one for the industrial sector and a second for the household sector. The evidence for the Italian banking system suggests that "both industrial and sectoral loan diversification reduce bank return while endogenously producing riskier loans for high-risk banks in our sample. For low-risk banks, these forms of diversification either produce an inefficient risk-return trade-off or produce only a marginal improvement"[2].

Hayden et al. (2006) consider the case for German banks using an annual database[3] from 1996 to 2002, and find that banks use diversification as a tool to change their risk-return profile instead of operating in a constant risk-return efficiency level. Additionally, they find that the benefits of diversification depend on the risk level faced by banks. As return measures, they use the ratio of operating profits to assets and operating profits to equity; their results are robust for both measures. As independent variables they used three different HHI to capture the levels of concentration for region, sector, and

[2] Achayra Viral V., Hasan Iftekhar and Saunders Anthony. (2006). "Should Banks Be Diversified? Evidence from Individual Bank Loan Portfolios". Journal of Business, vol. 79, No. 3, 2006: pg 1357.

[3] The database consisted of 3,760 individual institutions including banks and it's subsidiaries.

industry; and the ratio of unexpected losses to total exposure as a measure of risk.

Stiroh (2004) considers the impact of focus and diversification strategies on the performance of community banks. He uses annual data obtained from the Consolidated Report of Conditions and Income for the period 1984-2000. In order to capture the effects of diversification strategies, he includes two concentration measures: a revenue HHI and a non-interest income HHI. The first one intends to capture diversification from non-interest and interest income, while the second aims to measure diversification within non-interest bearing activities. They find that community banks try to expand their operations to diversify their income, but they end up moving beyond their areas of comparative advantage.

In the same line of revenue diversification, Goddard et al. (2007) analyze the effects of shifting into non-interest income activities by U.S. credit unions. They use semi-annual data from the *Call Reports* of these institutions in the sample period 1993-1 to 2004-2 and include two measures to capture diversification. The first one is the ratio of non-interest income to operating income (*NONSH*) and, the second, is an income concentration index. They found that large credit unions have been able to improve their performance at the cost of a higher risk, while small credit unions don't have the scale nor the expertise to engage activities different to their core products.

In our empirical framework we are going to consider, as the main explaining factors of the return indicators, risk and three different types of loan diversification: *(i)* Sectoral, *(ii)* type of loans and *(iii)* regional. On one hand, we find that there is positive relationship between return and risk, as it is suggested by portfolio theory. On the other hand, and as predicted by our model, there exists a negative relationship between return and type of loan diversification, and that sectoral diversification has a non-linear relationship with the expected return measures.

It is important to mention that the indexes used as measures of concentration, are used in the absence of others that could better explain the levels of focus in the economy and its effect on expected returns. Moreover, this framework not necessarily goes in the same line of the theoretical explanation of diversification, since this theoretical explanation includes variables like monitoring or structures with free riding or moral hazard problems, that can't be empirically measured. Nevertheless, these indexes and the different variables used to measure the cost and benefits of diversification, are a good approximation of the theoretical model presented.

The following sections are organized as follows: in section two we present the theoretical model of banks' loans diversification. In section three we describe the data used for the empirical analysis, section four focuses on the estimation of benefit and cost functions and concluding remarks are in section five.

2 The model

In this section we develop a model that allows us to explain under which conditions banks engage in multiple-bank lending activities in order to diversify their loan portfolio. This model is based on Holmström and Tirole (1993) and Carletti et al. (2007). From the latest, we take some of their assumptions to structure our model. We use this model to capture the effects of diversification on expected returns, using monitoring as one of the main explaining factors.

The model is developed based on a two-period economy ($t = 1, 2$) with two banks ($j = 1, 2$), n entrepreneurs, and k investors. Each bank has one unit of funds with which they extend loans to entrepreneurs. Each entrepreneur has a risky investment project that needs to be financed. They have to compete to obtain financing from banks and only two of them obtain the funds needed.

Each project has a random return R, where $R \sim i.i.d.$ across projects. Each project ($i = 1, 2$) needs one unit of external funding at $t = 1$, and yield a return $X_i \in \{0, R\}$ at $t = 2$. The project success depends on the entrepreneur's behavior. If he behaves, the project has a success probability p_H and if he doesn't the probability is p_L, considering that $p_H > p_L$. If the entrepreneur misbehaves he receives a private benefit B that can be though as a managerial cost. Private benefit generates a moral hazard problem because entrepreneur's behavior is not observable and he is protected by limited liability. Additionally, since banks raise deposits and are also protected by limited liability, depositors face moral hazard problems from the bank, however, we are not considering this last moral hazard problem.

Each bank has an amount E_j of inside equity and they raise an amount D of deposits, so that $E + D = 1$. Banks pay a fixed rate r for deposits and at the end of period 2 they pay investors rD. With this funds a bank can choose between financing solely one project or financing two projects. If the latest is chosen, each bank finances half of the project and they share evenly its return. The idea around financing two projects is that by doing so banks achieve a better degree of diversification (though is limited)[4]. Also, banks can allocate their funds in an alternative investment that offers a gross return y.

Banks lend to an entrepreneur that offers a positive expected return higher than y. We follow the assumptions of Carletti et al. (2007) to ensure that lending is not feasible without monitoring. That said, the main assumptions of our model are:

$$P_H R > y > P_L R + B \tag{A1}$$

and

[4]Diversification is considered as limited because banks can only lend to two entrepreneurs, if the banks were able to lend to more entrepreneurs the benefits of diversification could be greater. As is shown by Diamond (1996)

$$\Delta P \left(R - \frac{y}{P_H} \right) < B \tag{A2}$$

where $\Delta P = P_H - P_L$. Assumption A1 means that credit lending to an entrepreneur is only worthy when he behaves, otherwise the bank should allocate their funds in the alternative investment. Assumption A2 makes references to the private benefit, B is high enough to persuade entrepreneurs to misbehave. Given this two assumptions banks must monitor to make lending feasible.

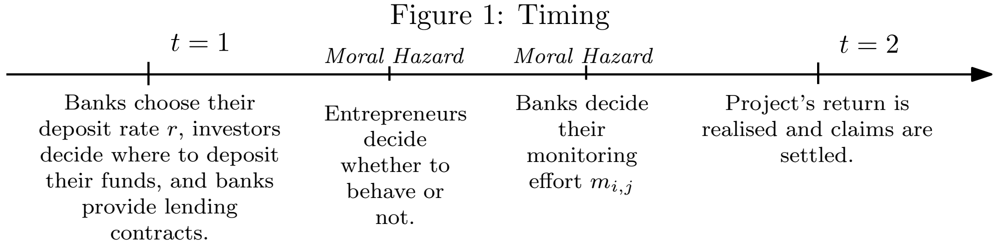
By monitoring projects banks may detect and prevent entrepreneurs' misbehavior, thus increasing the success probability and reducing the private benefit from B to b, so that:

$$\Delta P \left(R - \frac{y}{P_H} \right) > b \tag{A3}$$

Each bank must choose the amount of effort invested in monitoring $m_{i,j} \in [0, 1]$, which can be interpreted as the probability with which the banks makes an entrepreneur i behave. Monitoring implies a cost $C(m_{i,j}) = \frac{c}{2} m_{i,j}^2$, where c represents the cost of monitoring each project. The convexity of $C(m_{i,j})$ represents a continuous increasing difficulty for a bank to obtain additional information of the entrepreneurs actions and, also, diseconomies of scale in monitoring. As can be seen, the first and second derivative of the cost function with respect to monitoring, are positive: $\left(\frac{\partial C(m_{i,j})}{\partial m_{i,j}} = c m_{i,j} > 0 \text{ and } \frac{\partial^2 C(m_{i,j})}{\partial m_{i,j}^2} = c > 0 \right)$.

The timing of the model is described in Figure 1:

Figure 1: Timing



We solve the model for individual-bank lending and then for multiple-bank lending. With this results we compare each model's expected return evaluated in the optimal level of monitoring, and determine under which conditions diversification could yield a higher return.

2.1 Individual-bank lending

In this subsection we derive the equilibria for individual-bank lending. At $t = 1$ banks set the deposit rate r, guaranteeing depositors a return $r \geq y$. Afterwards, each bank chooses the project with the highest expected return and finances it. In between $t = 1$ and $t = 2$, banks determine the level of monitoring effort, so that it maximizes the bank's expected return function. Since banks act independently, we solve the model for one representative bank[5].

The bank's expected return is given by:

$$E[\pi] = mp_H(R - rD) + (1 - m)p_L(R - rD) - yE - \frac{c}{2}m^2 \tag{2.1}$$

where the first two terms on the right side of the equation represent the expected return after depositors have been repaid, the third term yE is the opportunity cost of equity, and the last term is the monitoring costs.

The probability for depositors of being repaid depends on the success probability of the project, given that banks are protected by limited liability and deposit contracts are subject to bankruptcy risk. If the project is not successful then, depositors can't be repaid.

The first order condition with respect to m, gives the optimal level of monitoring:

$$m^* = \frac{\Delta p(R - rD)}{c} \tag{2.2}$$

An increase on the rate of return R or on the success probability of the project, increases monitoring effort, *ceteris paribus.* Under the same circumstances an increase on r reduces the monitoring effort since banks try to keep the expected return unchanged, otherwise, the project could become not feasible. An increase on r represents a higher cost for bank's deposits, reducing the bank's expected return. Since the bank wants to keep at least the same expected return, other costs, like monitoring, have to be reduced. Finally, and as it is to be expected, an increase in the monitoring cost reduces the monitoring effort due to the reduction of the expected return.

In equilibrium, higher monitoring efforts benefits banks and depositors in the way that it increases the success probability of the project, reducing the bankruptcy risk and the probability of expected shortfalls. Additionally, it is important to consider that external financing generates a *moral hazard* problem, that increases with the amount of deposits as banks are protected by limited liability. Seen from this point of view, the higher the inside equity E invested in the project, the higher is the stake of the bank, hence they have a greater incentive to monitor increasing the probability of success. To summarize, monitoring incentives increases with project's return and equity, while it falls with rate of deposits and monitoring cost.

[5]Since both banks are identical, the solutions are symmetrical.

2.2 Multiple-bank lending

Now we turn to the case of multiple-bank lending. The main difference with the model explained above is that now each bank finances half of each project and, at the end, they split the projects' return equally. Similar to the previous model, banks set the deposit rate r[6] and chooses its monitoring effort $(m_{i,j})$ that maximizes the expected return. Where $i = 1, 2$ represents the project to by financed by the $j = 1, 2$ bank.

In this case banks lend half of its funds to each entrepreneur[7] and end up financing half of each of the two projects and, if the projects are successful they receive half of each project's return $\frac{R}{2}$. Banks choose simultaneously the amount of monitoring effort in a non-cooperatively fashion, however, their efforts are mutually related. Since monitoring is a cost for the bank, if the other bank is being successful detecting the misbehavior of any of the entrepreneurs, this could be an opportunity cost for the first bank, because its effort of monitoring won't be needed. Nevertheless this game is static, where none of the banks' monitoring effort can be observed by the other. Therefore, the total monitoring effort, form both banks, in project i is given by:

$$M_i = m_{i,j} + m_{i,-j} - m_{i,j}m_{i,-j} \tag{2.3}$$

where M_i is the total monitoring effort, $m_{i,j}$ is the effort exerted by bank j and $m_{i,-j}$ is the monitoring effort of the other bank.

The bank's expected return is now given by:

$$E[\pi_j] = \sum_{i=1}^{2} \left(M_i p_H \left(\frac{R}{2} - rD \right) + (1 - M_i) p_L \left(\frac{R}{2} - rD \right) - \frac{c}{2} m_{i,j}^2 \right) - yE \tag{2.4}$$

As before, the first two terms of the sum can be interpreted as the bank's expected return from the two financed projects after depositors have been repaid. The third term represents the monitoring effort cost, while the last term of the expected return, is the opportunity cost of equity. Nevertheless, one of the main differences is that the monitoring cost is higher, since the bank now monitors two different projects.

The main features of multiple bank lending are expressed by equations (2.3) and (2.4). First, since banks do not coordinate their monitoring effort and it is not observable, bank j has the incentive to reduce their effort since he can benefit from the others bank's monitoring, thus resulting in a *free riding* problem. In addition, there might exist duplication of effort given that banks can end up monitoring the same entrepreneur's behaviors. Secondly, bank's achieve a greater degree of diversification by financing two independent projects, therefore, reducing the banks'portfolio variance and the expected shortfalls.

[6] Since the market structure is a monopoly, the interest rate on deposits is the same for both banks.
[7] $i = 1, 2$

In this case, the first order condition with respect to $m_{i,j}$ is given by:

$$m_{i,j} = \frac{1}{c}\left(\Delta p\left(\frac{R}{2} - rD\right)(1 - m_{i,-j})\right) \tag{2.5}$$

Since banks are symmetrical, the reaction function for the other bank is equivalent:

$$m_{i,-j} = \frac{1}{c}\left(\Delta p\left(\frac{R}{2} - rD\right)(1 - m_{i,j})\right) \tag{2.6}$$

Solving for bank j, equations 2.5 and 2.6 give the optimal monitoring level when both banks monitor:

$$m^*_{i,j} = \frac{\Delta p\left(\frac{R}{2} - rD\right)}{c + \Delta p\left(\frac{R}{2} - rD\right)} \tag{2.7}$$

From Equations (2.2) and (2.5) we find that bank j´s return is better diversified in the case of multiple bank lending, reducing their exposure to credit risk and the variance of the loan portfolio.

In the multiple-bank equilibrium the incentives to monitor are altered due to the *free riding* problem and duplication of effort is an issue. As can be seen in appendix A both banks would choose to diversify if the return of the project is sufficiently high, if $R \geq 2rD$. If the return of the project is not large enough ($0 < R < 2rD$), there would be two Nash equilibriums where only one of the banks monitors (see Appendix B). In this case the effort of monitoring is higher and given by:

$$m^*_{i,j} = \frac{\Delta p\left(\frac{R}{2} - rD\right)}{c} \tag{2.8}$$

As in individual bank lending, monitoring incentives increase with project's return and equity and reduce with increments of the deposits rate, monitoring cost and other bank's monitoring. As can be seen from (2.7) and (2.8), the optimal level of monitoring when one bank monitors is higher than the optimal when both banks monitor.

This results suggest that banks rather engage individual-bank lending since their expected return, when the monitoring is in its optimal level, is always greater than when they perform multiple bank activities (see Appendix C). The intuition behind these results is that when the bank chooses the multiple-bank lending case, the probability of success is the same while the cost of monitoring is higher since the bank now has to monitor two projects. However, this results are consistent under the assumptions made before, where the return of both projects is the same, the success probabilities for each project remain constant, and both banks set the same interest rate on deposits.

3 Data

The main data source used for our analysis are the bank's balance sheet and income statements provided by the Financial Superintendence of Colombia[8]. Additionally, we used the Form 322 to obtain information about loan allocation across regions for each one of the banks of the sample. The information coming from the income statements were annualized and all the variables are expressed in real terms of 1998, using the CPI.

Our sample consists of quarterly information of 47 financial institutions, between commercial banks and BECH[9], for the period 1995Q1 - 2007Q4. Along the period of analysis the number of institutions changed because of mergers, acquisitions and new entries to the financial system (i.e: for the first period, the sample had 31 banks and 9 BECH, at the end of the period, there where only 16 banks).

We estimated two different functions in order to capture and analyze the effects of focus on expected returns. The first function we estimated was the traditional benefit function. Nevertheless, since we used monitoring as one of the main inputs in the theoretical model, we need to estimate another function that would be able to capture this relation. Since the effort of monitoring is not observable, we used an approximation and estimated a cost function that would be able to capture the effects of monitoring and its relation with diversification and its impact on expected returns. We used these two different functions in order to clarify the different effects of focus on profitability, recognizing that diversification can have impacts on profitability through benefits or costs.

3.1 The variables

Benefit Function

As return measures we created two profitability indicators: *RCA* and *RCE*, which are mere modifications of the traditional ROA and ROE. In the numerator we have the Financial Margin, measured as the difference between interest income and interest expenses, instead of net income. This measures allow us to analyse return of the loan portfolio and the impact that diversification has on it.

[8]Specifically, we used Form 341 and the PUC (Plan Único de Cuentas), the latest is the system used for all the financial institutions to report the required information to the Financial Superintendence.

[9]These are the banks that were specialized in mortgage lending. Since 1999, this entities were required to convert into commercial banks.

$$RCA = \frac{Financial \;\; Margin}{Total \;\; Assets}$$

$$RCE = \frac{Financial \;\; Margin}{Total \;\; Equity}$$

To measure diversification we use a *Herfindahl-Hirschman Index (HHI)*, which is a traditional accepted measure of concentration. It is calculated as the sum of squares of the exposure of each bank, as a fraction of total exposure. It is represented by the following equation :

$$HHI = \sum_{i=1}^{n} \left(\frac{S_i}{S} \right)^2$$

where n is the number of groups, S_i represents the exposure of bank i and S is the total exposure. The HHI is defined in the interval $(\frac{1}{n}, 1)$. It takes the value of $\frac{1}{n}$ when the portfolio is perfectly diversified and 1 when it is fully concentrated.

For our estimations we constructed three different indexes to capture different ways of diversification: a loan portfolio index, a sectoral index, and a regional index. The first HHI considers diversification across the four different types of loans that banks offer to their clients (*HHI-L*)[10], the second one (*HHI-S*), measures diversification across the seventeen sectors in which the economy is disaggregated[11], and the third index makes reference to diversification across the thirty-three provinces (*HHI-R*)[12].

Our approach for risk is based on two different indicators: The first one is a measure of expected losses *NPL* and the second, is a weighted indicator of the RCA's volatility introduced by Altam (1968) called *Z-score*.

$$NPL = \frac{Non\text{-}Performing \;\; Loans}{Total \;\; Loans}$$

$$Z\text{-}score(i - years) = \frac{RCA - \frac{E}{A}}{\sigma_{RCA}(i - years)}$$

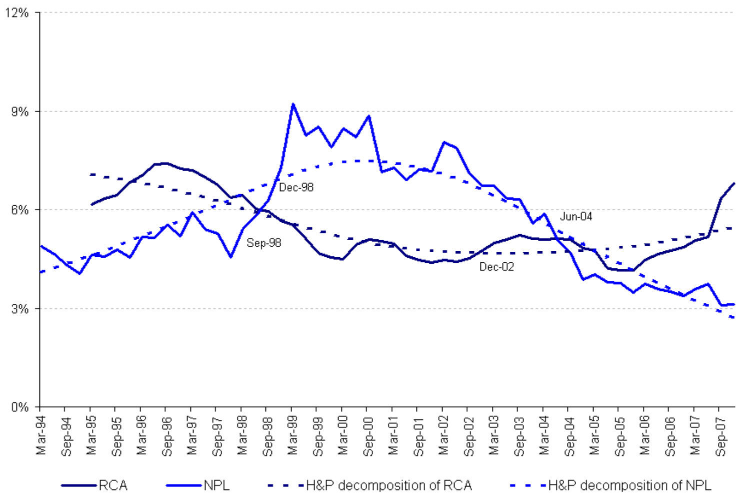
[10] In Colombia there are four different types of credits: Commercial, consumption, mortgage and micro-loans. Micro-loans are oriented to small and medium enterprises.

[11] This classification is taken according to DANE(Departamento Administrativo Nacional de Estadística).

[12] According to DANE, Colombia is divided into thirty-two provinces, and for different calculations, the capital, Bogotá D.C., is also considered as an additional province.

where E is equity, A is total assets, and $\sigma_{RCA}(i\text{-}years)$ is the standard deviation of RCA, where $i\text{-}years$ is the length of the period used to measure the standard deviation. We computed three different σ[13] in order to capture the persistence of the RCA's volatility.

Figure 2: **Hodrick-Prescott Decomposition of RCA and NPL**



Source:Financial Superintendence of Colombia, Banco de la República's calculations.

As control variables we used three different measures: The first control variable is *Equity on assets* and it intends to capture the different risk aversion levels among banks. The second variable is *personnel* and it is used as a proxy of cost efficiency (Achayra et al. (2006)), it is calculated as the ratio of personnel cost to total assets. Finally, we control with a dummy for the crisis period (*Crisis*). In order to define this variable we used a Hodrick-Prescott filter and decomposed the NPL and the RCA; afterwards, chose the years where NPL was above and the RCA was below their long-term trend, simultaneously (see figure 2).

$$Personnel = \frac{Personnel\ \ Costs}{Assets}$$

Cost Function

The cost function was constructed following Estrada and Osorio (2004), where the dependent variable *Total Cost* is defined as the sum of interest, personnel and administrative expenses. We divided the independent variables between inputs and outputs, and estimated two different cost functions with different outputs in order to identify possible gains from diversification.

In the first approach, we used *gross loans* as our main output. In the second, we used

[13] One, two and three years.

three outputs: *commercial loans*, *consumption loans*, and *mortgage loans*[14]. Both of the cost functions included three input prices. The first price is the price of financial capital w_1, computed as the ratio between interest expenses and shot-term funding, where the short term funding (STF) is defined as the sum of saving accounts, checking accounts and certified deposits (CD).

$$w_1 = \frac{Interest\ \ Expenses}{Short\text{-}term\ \ Funding}$$

The second input is the price of labor w_2 defined as the personnel expenses per employee, calculated as the ratio between personnel expenses and total number of employees. The data available for the last variable is incomplete, thus, we estimated the remaining data assuming a constant relationship between the number of employees[15] and fixed assets[16]. Finally, the third input price w_3 is the price of physical capital calculated as the ratio between administrative fees and physical assets.

$$w_2 = \frac{Personnel\ \ Expenses}{Total\ \ Number\ \ of\ \ Employees}$$

$$w_3 = \frac{Administrative\ \ Fees}{Physical\ \ Assets}$$

For this estimation we control by four variables[17]. The first variable, *size*, is intended to capture bank's size effects on the cost function and it is measured as the ratio of a bank's assets to the total assets of the system. Secondly, *NPL* aims to capture the possible effects of risk on the total cost. As a third control we used the *IPI*[18] and its purpose is to capture the economic cycle. Finally, we included the dummy variable *Crisis*.

As we mentioned before, we included two different types of financial institutions in our sample, banks and BECH. Since the last ones were specialized in mortgage loans, we included a dummy variable to capture the difference between these two groups. We decided to use this variable after we found different performance levels and other characteristics between banks and BECH, even though, the results showed that this

[14]In this definition we excluded micro-loans due to data availability.

[15]The data available was provided by Asobancaria.

[16]For this estimation we followed Estrada and Osorio (2004) obtaining the following results:

$$\underset{}{\ln(\text{employees})} = \underset{(0.1517)}{-1.5227} + \underset{(0.0147)}{0.8475} * \ln(\text{fixed\ \ assets})$$

with standard error in parenthesis.

[17]The control variable size was not included for this estimation because it is highly correlated with commercial and gross loans.

[18]IPI stands for Industrial Production Index

variable is not statistically significant, thus we avoid including it in the result estimations presented in section 4.

3.2 Summary statistics

Table 1 presents summary statistics for the variables included in the benefit function estimation. As can be seen the mean of HHI Loans is 0.8679 showing a high concentration for loans, while the mean for the indexes of sector and region are 0.3416 and 0.4264, respectively, showing a moderate level of concentration.

Table 1: **Summary Statistics for the Benefit Function Variables**

Variable	*Obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
RCA	704	0.0571	0.0356	-0.0193	0.1830
RCE	704	0.5358	0.3142	-0.1348	1.6640
HHI Loans	723	0.6302	0.1689	0.2942	1.0000
HHI Sector	723	0.2899	0.1216	0.1159	1.0000
HHI Region	723	0.3634	0.1908	0.0581	1.0000
NPL	723	0.0563	0.0362	0.0000	0.2763
Z-Score (3)	658	-9.5635	12.3098	-75.9598	20.6580
Personnel	704	0.0279	0.0122	0.0009	0.0695
Equity on assets	723	0.1088	0.0312	0.0122	0.2436

Looking at the return measures shows that in the case of the RCA its standard deviation is low, while the one for the RCE is ten times larger, the same can be observed for the mean of this two variables, while the RCA mean is 0.0571, the mean for the RCE is 0.5358. In the case for the control variable $Personnel$ the media of this ratio is close to 3%. It is important to notice the large variance of the risk measure $Z-Score(3)$, its standard deviation is 12.3098, with a minimum value of -75.9598 and a maximum of 20.6580, a similar case of large variation is presented in the control variable $Equity\ \ on\ \ assets$.

Regarding size, each financial institution of the sample represents, on average, 3.37% of the total assets of the sample. Even though, the entity with largest participation represents around the 20% of the total assets, showing evidence of large differences between the size of the financial institutions included in the sample.

Table 3 presents the correlations of the variables mentioned above. As can be seen there is a high correlation between the regional and sectoral Herfindahl indexes, this can be the result of the high specialization of some provinces of Colombia in some sectors of the industry. For example, there are a few mining provinces that concentrate an important share of the loans destined to this sector, as a result the financial institutions that concentrate most of these type of credits have a higher correlation between these two indexes (close to one).

For the case of the cost function variables, Table 2 shows the summary statistics. In the

Table 2: **Summary Statistics for the Cost Function Variables**

Variable	*Obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
Total Cost	1329	2,642,757	2,396,992	45,319	15,400,000
Gross Loans	1329	12,400,000	13,900,000	97,940	129,000,000
Consumption	1271	3,154,583	3,583,517	66	28,600,000
Commercial	1329	7,697,950	10,300,000	97,940	97,800,000
Mortgage	728	2,960,260	4,949,402	100	25,000,000
w_1	1329	15.8427	10.6159	2.5800	121.7600
w_2	1329	296.4975	179.1370	5.0300	2,040.1900
w_3	1329	8.2864	5.0420	0.7100	68.0400
Size	1329	0.0333	0.0327	0.0010	0.2077
NPL	1298	0.0583	0.0456	0.0001	0.5122
IPI	1329	116.5776	13.2651	96.6600	160.5500

case of Gross Loans the mean and the standard deviation are similar. These behavior is not rare since it includes all types of loans and all types of financial institutions of the sample, small and large. On average, the largest amount of loans is 79.54 times larger than the smallest one, in December 2007 the smallest amount of loans of an entity was \$1.87 b, while the largest amount was \$129 b.

In table 4 the correlation matrix for the explanatory variables of the cost function are presented. There are a few variables with a high correlation i.e *Commercial* and *Consumption* with *Gross loans*. This behavior is to be expected since the latest is constructed as the sum of all types of loans. Additionally, they are not used together in the estimations because they are part of different approaches for the cost function.

Table 3: **Correlation Matrix for the Benefit Function (Variables in First Differences)**

	HHI-L	*HHI-S*	*HHI-R*	*NPL*	Z_1	Z_2	Z_3	*Pers*	*E/A*
HHI-L	1.00								
HHI-S	0.03	1.00							
HHI-R	0.03	0.02	1.00						
NPL	-0.13	-0.04	0.05	1.00					
Z_1	-0.09	0.04	0.03	-0.01	1.00				
Z_2	-0.12	0.03	0.02	0.04	0.32	1.00			
Z_3	-0.14	-0.02	0.04	0.02	0.18	0.53	1.00		
Pers	-0.02	0.00	0.00	0.19	-0.11	-0.07	-0.13	1.00	
E/A	0.10	-0.07	-0.10	-0.03	-0.25	-0.32	-0.44	0.24	1.00

Table 4: **Correlation Matrix for the Cost Function (Variables in First Differences)**

	T.Loan	*Cons*	*Comm*	*Mort*	w_1	w_2	w_3	*Size*	*NPL*	*IPI*	*Cris*
T.Loan	1.00										
Cons	0.53	1.00									
Comm	0.68	0.14	1.00								
Mort	0.29	0.06	0.09	1.00							
w_1	-0.18	-0.05	-0.22	0.04	1.00						
w_2	-0.09	-0.03	-0.09	-0.02	0.33	1.00					
w_3	-0.20	-0.08	-0.19	0.03	0.82	0.45	1.00				
Size	0.47	0.17	0.27	0.60	-0.13	-0.02	-0.10	1.00			
NPL	-0.19	-0.01	-0.28	0.08	0.25	0.05	0.20	-0.05	1.00		
IPI	0.04	0.08	0.01	0.01	-0.22	-0.13	-0.19	-0.02	-0.03	1.00	
Cris	-0.21	-0.22	-0.12	-0.06	-0.06	0.03	0.08	-0.01	0.12	-0.09	1.00

4 Empirical Framework

In this section we present the results of the estimations for the benefit and cost functions of the banks included in the sample. In order to assess the effects of diversification and risk on banks' return, we regress return on concentration measures and the risk indicator as shown in the following equation:

$$RCA_i = \beta_0 + \beta_1 HHI\text{-}L_i + \beta_2 HHI\text{-}R_i + \beta_3 HHI\text{-}S_i + \beta_4 risk_i + \sum_{i=5}^{7} \beta_i X_i + \epsilon_i \quad (4.1)$$

Where X_i is the set of control variables mentioned in section 3, including the dummy *Crisis*; the HHI are intended to capture the average effects of diversification on bank's return. And ε_i represents a stochastic shock to the benefit function. We estimated this function using Pooled-OLS[19].

In table (5) we present the results of the estimations when the *RCA* is the dependent variable, while in table (6) the results correspond to the *RCE*. For both measures of return we estimated equation (4.1) with several restrictions, and found that all coefficients remain relatively stable for all specifications. From the results we can state that $HHI\text{-}R$ is not statistically significant in explaining banks returns, while $HHI\text{-}L$ is highly significant[20]and it has a negative effect on bank's return. These results are restated by all the specifications that include this indexes. The $HHI\text{-}S$ is significant at 5% when the dependent variable is RCA [21] and has a positive effect on bank's return. The negative coefficient of the $HHI\text{-}L$ suggests that, on average, the effects of focusing the loan portfolio reduces bank's return while the positive coefficient for $HHI\text{-}S$ shows

[19]We used this estimation method after performing a Haussman test for panel effects and the Breusch and Pagan Lagrangian multiplier test for random effects.

[20]At 1% when the return measure is the RCA and at 5% when the RCE is the dependent variable.

[21]If the dependent variable is RCE, HHI-S is not statistically significant.

Table 5: **Estimations for the Benefit Function: Dependent Variable RCA**

	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)
$d.HHI-L$	-0.0385***	-0.0373***				-0.0404***
	0.0068	0.0068				0.0067
$d.HHI-S$	0.0302**		0.0253*			0.0273*
	0.0109		0.0111			0.0112
$d.HHI-S^2$	-0.0259*		-0.0214*			-0.0243*
	0.0105		0.0108			0.0108
$d.HHI-R$	-0.0027			-0.0032		-0.0021
	0.0031			0.0031		0.0032
$d.Z_3$	0.0004***	0.0004***	0.0005***	0.0005***	0.0005***	
	0.0001	0.0001	0.0001	0.0001	0.0001	
$d.Per$	0.1964*	0.2060*	0.2244*	0.2363**	0.2337**	0.2092*
	0.0858	0.0860	0.0877	0.0879	0.0879	0.0880
$d.E/A$	0.1230***	0.1200***	0.1177***	0.1124***	0.1140***	0.0608***
	0.0169	0.0168	0.0172	0.0173	0.0172	0.0158
$Cris$	-0.0009*	-0.0009*	-0.0012**	-0.0012**	-0.0012**	-0.0010*
	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
$Cons$	0.0004	0.0004	0.0007*	0.0007*	0.0007*	0.0004
	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Obs.	631	631	631	631	631	631

us evidence for the positive effects of focusing on an specific sector, nevertheless, the quadratic form of this index shows that this type of focus has decreasing, but positive, effects on bank's return.

In addition, we find that risk has a positive effect on return in all specifications, in other words, the higher the risk a bank face the higher are the returns, this result is in accordance with the guidelines of portfolio theory and Markowitz's Mean-Variance theory. Moreover, the results show that the dummy variable captures the negative effect of the crisis on bank's return. However, this results do not hold in the case when the RCE is the independent variable.

From the point of view of the cost function we examine the effects of diversifications by estimating two equations of the cost function. In the first one we include loans as a whole (*gross loans*) and in the second one we estimate the equation by including loans by type. If diversification helps reducing cost, we expect that the sum of the marginal effects evaluated in the mean of the explanatory variables[22] to be less in the second equation than in the first one.

$$Ln(TC) = \beta_0 + \beta_1 Ln(gross\ loans) + \sum_i \beta_i w_i + \sum_{i=6}^{8} \beta_i X_i \tag{4.2}$$

[22]This is excluding control variables.

Table 6: **Estimations for the Benefit Function: Dependent Variable RCE**

	(2a)	**(2b)**	**(2c)**	**(2d)**	**(2e)**	**(2f)**
d.HHI-L	-0.1870**	-0.1890**				-0.2024**
	0.0704	0.0702				0.0677
d.HHI-S	0.0152		0.0130			0.0064
	0.0294		0.0296			0.0278
d.HHI-R	-0.0275			-0.0313		-0.0224
	0.0318			0.0319		0.0320
$d.Z_3$	0.0030***	0.0030***	0.0032***	0.0032***	0.0032***	
	0.0006	0.0006	0.0006	0.0006	0.0006	
d.Per	3.7057***	3.6906***	3.8232***	3.8563***	3.8307***	3.9574***
	0.8900	0.8887	0.8923	0.8920	0.8916	0.8918
d.E/A	-0.2585	-0.2521	-0.2751	-0.2982	-0.2820	-0.6803***
	0.1756	0.1740	0.1753	0.1752	0.1745	0.1602
Cris	-0.0051	-0.0051	-0.0067	-0.0067	-0.0066	-0.0054
	0.0043	0.0043	0.0043	0.0043	0.0043	0.0042
Cons	0.0062*	0.0061*	0.0076**	0.0076**	0.0075**	0.0067*
	0.0029	0.0029	0.0028	0.0028	0.0028	0.0028
Obs.	631	631	631	631	631	631

$$
\begin{aligned}
Ln(TC) &= \beta_0 + \beta_1 Ln(consumption\ loans) + \beta_2 Ln(commercial\ loans) \\
&\quad + \beta_3 Ln(mortgage\ loans) + \sum_i \beta_i w_i + \sum_{i=7}^{9} \beta_i X_i
\end{aligned}
\tag{4.3}
$$

In table (7) we present the results of the estimation for the first specification (Eq.4.2). The results show that *gross loans* and the three prices included in the regression are highly significant in explaining bank's cost. These four variables have a positive effect on bank's cost, as it is to be expected. The variable *size* captures efficiently the magnitude of bigger banks on the cost function, this variable is highly significant in these specifications. The variable risk, measured as *NPL*, is not statistically significant in explaining bank's cost. This results is counterintuitive since one could expect that the higher the *NPL*, the higher the cost for the bank, since they are not receiving interest payments for those loans. We find that the economic cycle has a negative effect on bank's cost, that could be thought as economies of scale. The variable *Crisis* has a negative effect on bank's cost, that is, in the crisis periods bank's costs were lower. This effect could be explain given that in crisis periods banks reduce their loan activities and re-allocate their portfolio to safer investments.

Table (8) shows the results for the second specification of the cost function (Eq.4.3). In this case the only loan significant variables are consumption and commercial loans[23]. As in the first equation, all prices are highly significant and have a positive effect on bank's cost. For this estimation, *NPL* is significant and has a negative coefficient, meaning that a higher level of non-performing loans is traduced into a lower cost, as above, this result is counterintuitive.

[23]Mortgage loans is only significant in specification (4c)

Table 7: **Estimations for the Cost Function**

	(3a)	(3b)	(3c)	(3d)
d.Gross loans	0.1608***	0.1365***	0.1163***	0.1484***
	0.0233	0.0260	0.0301	0.0240
$d.Ln(w_1)$	0.1334***	0.4480***		
	0.0272	0.0171		
$d.Ln(w_2)$	0.0731***		0.1475***	
	0.0087		0.0105	
$d.Ln(w_3)$	0.2805***			0.4049***
	0.0227			0.0126
d.Size	8.9096***	8.9259***	6.5253***	8.9083***
	0.8186	0.9170	1.0563	0.8441
d.NPL	-0.2372	-0.3344*	0.3903*	-0.2047
	0.1363	0.1526	0.1738	0.1396
d.IPI	-0.0020***	-0.0024***	-0.0033***	-0.0024***
	0.0004	0.0004	0.0005	0.0004
Crisis	-0.0213***	-0.0039	-0.0253***	-0.0275***
	0.0057	0.0063	0.0072	0.0058
Constant	-0.0006	-0.0033	0.0098*	0.0011
	0.0033	0.0037	0.0043	0.0034
No. of obs.	1,252	1,252	1,252	1,252

Table 8: **Estimations for the Cost Function**

	(4a)	(4b)	(4c)	(4d)
d.consumption	0.1610***	0.1542***	0.1453***	0.1624***
	0.0180	0.0222	0.0331	0.0202
d.Commercial	0.1586***	0.1523***	0.0463	0.1297***
	0.0258	0.0317	0.0470	0.0288
d.Mortgage	0.0081	0.0029	0.0501**	0.0121
	0.0084	0.0104	0.0154	0.0094
$d.Ln(w_1)$	0.3621***	0.7787***		
	0.0306	0.0221		
$d.Ln(w_2)$	0.0624***		0.2133***	
	0.0095		0.0158	
$d.Ln(w_3)$	0.3294***			0.5775***
	0.0229			0.0143
d.Size	6.8016***	7.6652***	1.2973	6.0235***
	0.9860	1.2098	1.7923	1.0964
d.NPL	-0.6662***	-0.7833***	0.2673	-0.4634**
	0.1299	0.1595	0.2337	0.1437
d.IPI	-0.0013***	-0.0014**	-0.0042***	-0.0021***
	0.0004	0.0005	0.0007	0.0004
Crisis	0.0010	0.0232**	-0.0091	-0.0174**
	0.0060	0.0073	0.0108	0.0066
Constant	-0.0136***	-0.0183***	-0.0010	-0.0076
	0.0038	0.0047	0.0069	0.0042
No. of obs.	680	680	680	680

When we analyze the sum of the marginal effects for the dependent variables, evaluated in the mean, we find that their are greater for the second equation. This result suggests that the effects of loan focusing in reducing cost is greater than from diversifying the loan portfolio. This result implies that there are not possible gains form diversification in bank's cost.

Sensitivity Analysis

In this subsection we want to assess the return volatility of each bank with respect to changes in the concentration levels, specifically in the HHI's. To do this we calculated the standard deviation of each bank's index during the last three years.

With different combinations of these standard deviations we shocked the HHI's and estimated the returns using the results of the RCA's estimation. The shocks were divided into 8 groups:

- Shock 1: plus one standard deviation of the HHI-L
- Shock 2: minus one standard deviation of the HHI-L
- Shock 3: plus one standard deviation of the HHI-S
- Shock 4: minus one standard deviation of the HHI-S
- Shock 5: plus one standard deviation of the HHI-L plus one of the HHI-S
- Shock 6: plus one standard deviation of the HHI-L minus one of the HHI-S
- Shock 7: minus one standard deviation of the HHI-L plus one of the HHI-S
- Shock 8: minus one standard deviation of the HHI-L minus one of the HHI-S

Figure 3: **Shocks 1 and 2**

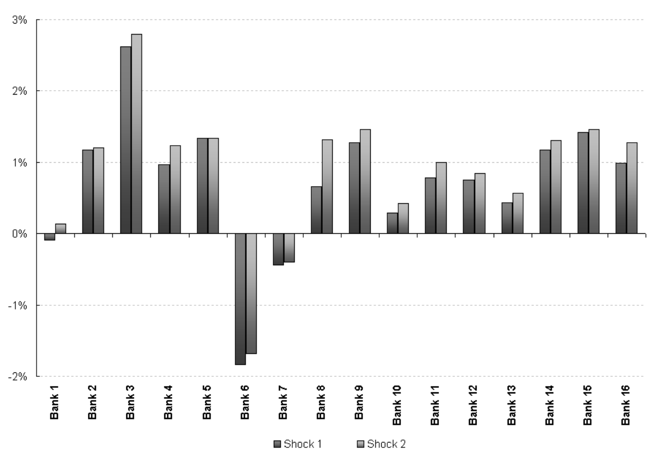


Figure 3 shows the results for shock 1 and shock 2. The results show that, on average, increasing loan concentration in one standard deviation improves bank returns by 0.72%, while, decreasing it by the same amount improves them by 0.89%. This shows that, on average, banks can benefit from loan diversification. We found that bank 1 returns decreases when loan concentration increases and increases when the opposite happens. Also, banks 6 and 7 do not benefit from neither focusing nor diversifying on loan type.[24].

Figure 4: **Shocks 3 and 4**

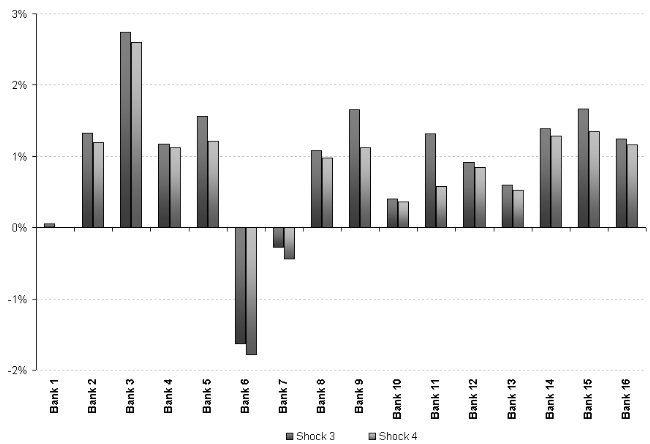
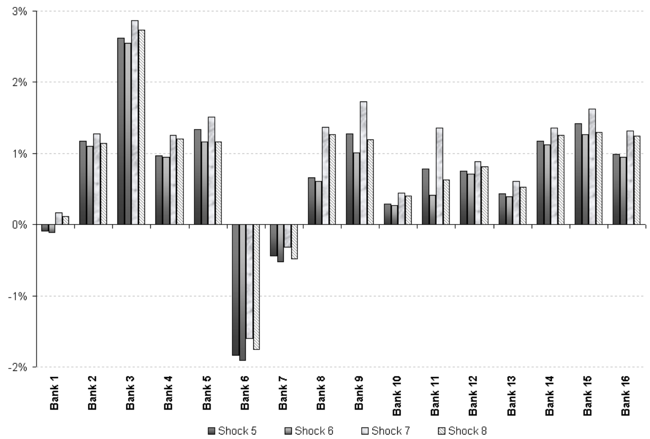


Figure 4 shows the results for shock 3 and shock 4. The results suggest that banks can benefit more, on average, from focusing in sectors. Increasing sector concentration by one standard deviation yields a profit increase of 0.95%, whereas, increasing sector diversification by the same amount increases profits by 0.76%. As mentioned before, banks 6 and 7 do not benefit from focusing or diversifying by economic sector. Additionally, these two banks are the only ones that obtain a better result from diversifying rather than from focusing by sectors.

Figure 5 shows the results for shock 5 through 8. As one can notice, the most profitable strategy for banks is to increase loan diversification by on standard deviation and increase their type of loan focus by the same amount. This strategy yields an increase of bank returns near to 1%. As it is to be expected, the worst strategy among all is to focus by type of loan and diversify by economic sector, though, it renders an increase on returns for almost all banks. When analyzing combined shocks we find that Bank 1 only benefits when he decides to increase type of loan diversification, and they get their best result when combined with sector focusing, as all other banks. Again, we find that banks 6 and 7 do not obtain a positive result from any of the strategies considered.

[24]Nevertheless it is important to notice that the estimations depend on the level of return observed on the last period.

Figure 5: **Shocks 5 through 8**



5 Concluding Remarks

In the previous sections we presented a theoretical model for analyzing the effects of focus on bank's expected return and found that, once the bank has chosen its optimal level of monitoring, the expected return from diversification is always smaller than the expected return when banks choose to focus. Additionally, the incentives to monitor depend positively on project's return and the equity invested in the project by the bank; and negatively on the deposit rate, the cost of monitoring, and bank's $-j$ monitoring effort.

According to the empirical evidence, we found that banks can take advantage of *type of loan* diversification to increase their returns. However, this benefit could be offset by *sectoral* diversification, since the main profits from focusing by type of sector are higher than those reachable through diversification. In addition, the empirical evidence confirm the positive relationship between risk and return stated by portfolio theory. In accordance with the results of the sensitivity analysis, we may conclude that banks should take advantage of the strategy described by shock 7, since it is the one that yields the best result in terms of return.

References

Achayra Viral V., Hasan Iftekhar and Saunders Anthony. (2006). "Should Banks Be Diversified? Evidence from Individual Bank Loan Portfolios". Journal of Business, vol. 79, No. 3, 2006.

Altman, Edward I. (1968) Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy. *Journal of Finance* 23, No. 4(1968), 589-609.

Berger Allen, Hancock Diana and Humphret David. (1993). "Bank efficiency derived from the profit function". Journal of Banking and Finance No. 17 pp. 317-347, 1993.

Berger Allen N. and DeYoung Robert. (2001). "The Effects of Geographic Expansion on Bank Efficiency". Journal of Financial Services Research, Vol. 19, No. 2-3, pp. 163-184, 2001.

Carletti Elena, Cerasi Vittoria and Daltung Sonja (2007). "Multiple-bank lending: diversification and free-riding in monitoring". July , 2007.

Cerasi Vittoria and Daltung Sonja. (2000) "The optimal size of a bank: Cost and benefits of diversification". European Economic Review, No. 44, pp. 1701-0726, 2000.

Chandler, Alfred D. (1977). The Visible Hand: The Managerial Revolution in American Business. *Harvard University Press*. Cambridge.

Clark Jeffrey. (1996). "Economic Cost Scale Efficiency and Competitive Viability in Banking". Journal of Money, Credit and Banking, Vol. 28, No. 3, Part 1. pp. 342-364, August 1996.

Degryse Hans and Steven Ongena.(2007). "The impact of competition on bank orientation". *Journal of Financial Intermediation*, 16(2007) 399-424.

Denis D. J., Denis D. and A. Sarin.(1997). "Agency problems, Equity Ownership and Corporate Diversification". *Journal of finance* Vol. 52

Diamond W. Douglas (1996). Financial Intermediation as Delegated Monitoring: A simple example. *Economic Quarterly*. Volume No. 82/3. Federal Reserve Bank of Richmond.

Estrada Dairo and Osorio Poldy. (2004) "Effects of Financial Capital on Colombian Banking Efficiency". ESPE No. 47, diciembre 2004.

Ferrier Gary and Lovell C. (1990). "Measuring Cost Efficiency in Banking: Econometric and linear programming evidence". Journal of Econometrics, No. 46, pp. 229-245, 1990.

Goddard John, McKillop Donal and Wilson John. (2007). "The Diversification and Performance of US Credit Unions". Journal of Banking and Finance, 2007.

Hancock Diana. (1986). “A model of the financial firm with imperfect asset and deposit elasticities”. Journal of Banking and Finance, No. 10, pp. 37-54, 1986.

Hayden Evelyn, Porath Daniel and Westernhagen Natalja von. (2006). “Does diversification improve the performance of German banks? Evidence from individual bank loan portfolios”. Deutsche Bundesbank, Dicussion Paper Series 2: Banking and Financial Studies, No. 05/2006, 2006.

Holmström Bengt and Tirole Jean. (1993). “Market Liquidity and Performance Monitoring”. Journal of Political Economy, 101 :678-709, 1993.

Stiroh Kevin (2004). “Do Community Banks Benefit from Diversification”. Journal of Financial Services Research, 25:2/3, 135-160, 2004.

Tirole Jean. (2006). “The Theory of Corporte Finance”. Princeton University Press, 2006.

Winton Andrew, “Competition among Financial Intermediaries When Diversification Matters”. Journal of Financial Intermediation. No. 6, pp. 307-346, 1997.

Winton Andrew. (1999). “Don’t Put All Your Eggs in One Basket? Diversification and Specialization in Lending”. Wharton School Center for Financial Institutions, University of Pennsylvania. Center for Financial Institutions Working Papers No. 00-16, 1999.

A Multiple-bank lending equilibrium

The expected return function for the multiple-bank model is given by (A.1), while (A.2) represents the expected return function when only one bank decides to monitor.

$$E[\pi_{jz}] = \sum_{i=1}^{2}\left(M_i p_H\left(\frac{R}{2} - rD\right) + (1 - M_i)p_L\left(\frac{R}{2} - rD\right) - \frac{c}{2}m_{i,j}^2\right) - yE \quad \text{(A.1)}$$

$$E[\pi_{ju}] = \sum_{i=1}^{2}\left(m_{i,j} p_H\left(\frac{R}{2} - rD\right) + (1 - m_{i,j})p_L\left(\frac{R}{2} - rD\right) - \frac{c}{2}m_{i,j}^2\right) - yE \quad \text{(A.2)}$$

Replacing $M_i = m_{i,j} + m_{i,-j} - m_{i,j}m_{i,-j}$ in (A.1), the expression can be rewritten as:

$$\begin{aligned} E[\pi_{jz}] \quad = \quad & \sum_{i=1}^{2}(m_{i,j} + m_{i,-j} - m_{i,j}m_{i,-j})p_H\left(\frac{R}{2} - rD\right) + \\ & \sum_{i=1}^{2}\left[(1 - m_{i,j} - m_{i,-j} + m_{i,j}m_{i,-j})p_L\left(\frac{R}{2} - rD\right) - \frac{c}{2}m_{i,j}^2\right] - yE \end{aligned}$$

The banks' expected return when both banks monitor is greater than the expected return when only one bank monitors ($E[\pi_{jz}] > E[\pi_{ju}]$) if and only if:

$$\sum_{i=1}^{2}\left\{m_{i,-j}(1 - m_{i,j})\left[\Delta p\left(\frac{R}{2} - rD\right)\right]\right\} > 0$$

Since $m_{i,-j}(1 - m_{i,j}) > 0$ and $\Delta p > 0$, both banks would choose to monitor if and only if:

$$R > 2rD \quad \text{(A.3)}$$

B Multiple-bank lending equilibrium

B.1 Nash Equilibria

In this appendix we are presenting the game for the banks, with the optimal level of monitoring in each case, showing that the results are two Nash equilibriums where only one of the banks monitors.

- In the case of multiple bank lending we showed that the optimal level of monitoring $m*$ for each bank is the same and equal to:

$$m^* = \frac{\Delta p(\frac{R}{2} - rD)}{c + \Delta p(\frac{R}{2} - rD)}$$

Additionally, since in this case both banks monitor, the total optimal monitoring level is given by:

$$\begin{aligned} M^* &= m^* + m^* - m^* m^* \\ M^* &= 2m^* - (m^*)^2 \end{aligned}$$

With these optimal levels of monitoring, the expected return of the representative bank is:

$$\begin{aligned}
E[\pi_j] &= 2M^* \left(\frac{R}{2} - rD\right) \Delta p + 2p_L \left(\frac{R}{2} - rD\right) - c(m^*)^2 - yE \\
E[\pi_j] &= [4m^* - 2(m^*)^2]\Delta p \left(\frac{R}{2} - rD\right) - c(m^*)^2 + 2p_L \left(\frac{R}{2} - rD\right) - yE \\
E[\pi_j] &= 4m^*\Delta p \left(\frac{R}{2} - rD\right) - (m^*)^2 \left[2\Delta p \left(\frac{R}{2} - rD\right) + c\right] + 2p_L \left(\frac{R}{2} - rD\right) - yE \\
E[\pi_j] &= \frac{4\left[\Delta p\left(\frac{R}{2} - rD\right)\right]^2}{c + \Delta p\left(\frac{R}{2} - rD\right)} - \left[\frac{\Delta p\left(\frac{R}{2} - rD\right)}{c + \Delta p\left(\frac{R}{2} - rD\right)}\right]^2 \left[2\Delta p \left(\frac{R}{2} - rD\right) + c\right] \\
& \quad + 2p_L \left(\frac{R}{2} - rD\right) - yE \\
E[\pi_j] &= \left[\frac{\Delta p\left(\frac{R}{2} - rD\right)}{c + \Delta p\left(\frac{R}{2} - rD\right)}\right]^2 \left[3c + 2\Delta p \left(\frac{R}{2} - rD\right)\right] + 2p_L \left(\frac{R}{2} - rD\right) - yE \quad \text{(B.1)}
\end{aligned}$$

Where equation (B.1) is the expected return for each bank, when both banks monitor.

- Nevertheless, in the case when only one bank monitors, the expected return for this bank is different. The optimal level of monitoring and the total effort of monitoring are:

$$
\begin{aligned}
m_1^* &= \frac{\Delta p \left(\frac{R}{2} - rD\right)}{c} \\
M^* &= m_1^*
\end{aligned}
$$

  With these levels of monitoring, the expected return of the bank that monitors is given by:

$$
\begin{aligned}
E[\pi_j] &= 2M_1^* \left(\frac{R}{2} - rD\right) \Delta p + 2p_L \left(\frac{R}{2} - rD\right) - c(m_1^*)^2 - yE \\
E[\pi_j] &= m_1^* \left(2\Delta p \left(\frac{R}{2} - rD\right) - cm_1^*\right) + 2p_L \left(\frac{R}{2} - rD\right) - yE \\
E[\pi_j] &= \frac{\Delta p \left(\frac{R}{2} - rD\right)}{c} \left[\Delta p \left(\frac{R}{2} - rD\right)\right] + 2p_L \left(\frac{R}{2} - rD\right) - yE \\
E[\pi_j] &= \frac{[\Delta p \left(\frac{R}{2} - rD\right)]^2}{c} + 2p_L \left(\frac{R}{2} - rD\right) - yE \qquad \text{(B.2)}
\end{aligned}
$$

  where equation (B.2) represents the expected return of the bank that monitors, when only one bank monitors.

- Meanwhile, the expected return of the bank that doesn't monitors is given by:

$$
\begin{aligned}
E[\pi_j] &= 2M_1^* \left(\frac{R}{2} - rD\right) \Delta p + 2p_L \left(\frac{R}{2} - rD\right) - yE \\
E[\pi_j] &= \frac{2\left[\Delta p \left(\frac{R}{2}\right) - rD\right]^2}{c} + 2p_L \left(\frac{R}{2} - rD\right) - yE \qquad \text{(B.3)}
\end{aligned}
$$

- Finally, if neither of the banks monitors, the expected return is given by:

$$
E[\pi_j] = +2p_L \left(\frac{R}{2} - rD\right) - yE \qquad \text{(B.4)}
$$

Given all the payments mentioned above, the payments matrix is given by Figure (6)

With these payments, the equilibriums are: $Nash_1 = \{monitoring, no \;\; monitoring\}$, $Nash_2 = \{no \;\; monitoring, monitoring\}$. This equilibriums are explained as follows:

Figure 6: Payments matrix

	Monitoring	*No Monitoring*
Monitoring	$B.1$, $B.1$	$B.2$, $B.3$
No Monitoring	$B.3$, $B.2$	$B.4$, $B.4$

- $C > A$

$$
\begin{aligned}
C &> A \\
&\text{iif} \\
\frac{2\left[\Delta p\left(\frac{R}{2} - rD\right)\right]^2}{c} &> \left[\frac{\Delta p\left(\frac{R}{2} - rD\right)}{c + \Delta p\left(\frac{R}{2} - rD\right)}\right]^2 \left(3c + 2\Delta p\left(\frac{R}{2} - rD\right)\right) \\
2\left[c + \Delta p\left(\frac{R}{2} - rD\right)\right]^2 &> c\left(3c + 2\Delta p\left(\frac{R}{2} - rD\right)\right) \\
2\left[\Delta p\left(\frac{R}{2} - rD\right)\right]^2 &+ c\left[2\Delta p\left(\frac{R}{2} - rD\right) - c\right] > 0 \qquad \text{(B.5)}
\end{aligned}
$$

Since one of the conditions of the model is that the cost of monitoring has to be smaller than the expected earnings $c < \Delta p\left(\frac{R}{2} - rD\right)$, all terms in equation (B.5) are positive and the conditions holds. This result means that when the other bank monitors, the strategy of *No monitoring* is the best response for the bank. This condition holds for either bank.

- $B > D$

$$
\begin{aligned}
B &> D \\
&\text{iif} \\
\frac{\left[\Delta p\left(\frac{R}{2} - rD\right)\right]^2}{c} &> 0 \qquad \text{(B.6)}
\end{aligned}
$$

The condition given in equation (B.6) holds, meaning that when the other bank's strategy is *No monitoring* the best response of the bank is *monitoring*.

These previous results show that the result of the game are two Nash Equilibrium where only one of the banks monitors.

C Multiple-bank lending vs. Single-bank lending

C.1 When $R < 2rD$

The expected return in single-bank lending ($E[\pi_{ND}]$) is greater than the expected return from multiple-bank lending when only one bank monitors ($E[\pi_{ju}]$) if:

$$(R - rD)(p_L + \Delta p m_1) - \frac{c}{2}m_1^2 > \sum_{i=1}^{2} \left(\frac{R}{2} - rD\right)(2p_L + \Delta p m_{i,j}) - \frac{c}{2}m_{i,j}^2$$

Replacing the optimal level of monitoring in each case, gives the following result:

$$\begin{aligned}(R - rD)\left(p_L + \frac{\Delta p^2(R - rD)}{c}\right) - \frac{\Delta p^2(R - rD)}{2c} > \\ \left(\frac{R}{2} - rD\right)\left[2p_L + 2\Delta p\left(\frac{\Delta p(\frac{R}{2} - rD)}{c}\right)\right] - \left(\frac{\Delta p^2\left(\frac{R}{2} - rD\right)^2}{c}\right)\end{aligned} \quad \text{(C.1)}$$

rearranging, (C.1) can be rewritten as:

$$\begin{aligned} cp_L(R - rD - R + 2rD) + \Delta p^2\left[\frac{(R - r)^2}{2} - \left(\frac{R}{2} - rD\right)^2\right] &> 0 \\ cp_L rD + \Delta p^2\left(\frac{R^2}{2} - \frac{(rD)^2}{2}\right) &> 0 \end{aligned} \quad \text{(C.2)}$$

Since $R > rD$, all terms in (C.2) are positive, and the condition holds. When the monitoring level is optimal, the expected return from single-bank lending is greater than multiple-bank lending.

C.2 When $R > 2rD$

In this case, since the return is high enough, both banks choose to monitor. Similar to the previous subsection, single-bank lending expected return is greater than the case of multiple-bank lending when:

$$(R - rD)(p_L + \Delta p m_1) - \frac{c}{2}m_1^2 > \sum_{i=1}^{2}\left[\left(\frac{R}{2} - rD\right)[2p_L + \Delta p M_i] - \frac{c}{2}m_{i,j}^2\right] \quad \text{(C.3)}$$

Since the optimal level of monitoring is the same for both banks in the case of multiple-bank lending, the optimal level of monitoring for both projects is also the same $M_1^* = M_2^* = M^*$. By replacing M^* in (C.3), the expression is now given by:

$$p_L(R-rD)+\Delta p m_1(R-rD)-\frac{c}{2}m_1^2 > 2p_H M\left(\frac{R}{2}-rD\right)+2p_L(1-M)\left(\frac{R}{2}-rD\right)-cm_{1,j}^2$$

Rearranging terms and replacing the optimal level of monitoring gives the following equation:

$$\begin{aligned}(R-rD)\left(p_L+\frac{\Delta p^2(R-rD)}{c}\right)-\frac{\Delta p^2(R-rD)^2}{2c} &> \frac{4\Delta p^2(\frac{R}{2}-rD)^2}{c+\Delta p(\frac{R}{2}-rD)}\\ &-\frac{\Delta p^2(\frac{R}{2}-rD)^2[c+2\Delta p(\frac{R}{2}-rD)]}{(c+\Delta p(\frac{R}{2}-rD))^2}+2p_L\left(\frac{R}{2}-rD\right)\end{aligned} \tag{C.4}$$

the equation (C.4) can be rewritten, giving the following results:

$$p_L rD+\Delta p^2\left[\frac{(R-rD)^2}{2c}-\frac{3(\frac{R}{2}-rD)^2}{c+\Delta p(\frac{R}{2}-rD)}\right]>0$$

If both terms of the equation are positive, the condition will hold. Since the first term and Δp are positive, the condition of non-negativity will depend on the sign of the expression in brackets. The condition will hold if and only if:

$$\frac{(R-rD)^2}{2c} > \frac{3(\frac{R}{2}-rD)^2}{c+\Delta p(\frac{R}{2}-rD)} \tag{C.5}$$

As can be seen, this condition holds since the numerator of the ratio on the right hand side of (C.5) is greater than the numerator of the ratio on the left side. In addition, the denominator of the first ratio is smaller than the denominator on the left ratio.

$$
\begin{aligned}
(R - rD)^2 &> 3\left(\frac{R}{2} - rD\right)^2 \\
R^2 - 2RrD + (rD)^2 &> 3\left(\frac{R^2}{4} - RrD - (rD)^2\right) \\
\frac{R^2}{4} + RrD + 4(rD)^2 &> 0
\end{aligned}
$$

and

$$
\begin{aligned}
2c &< c + \Delta p\left(\frac{R}{2} - rD\right) \\
c &< \Delta p\left(\frac{R}{2} - rD\right)
\end{aligned}
$$

The last line shows that the cost of monitoring has to bee smaller than the expected earnings, which is a condition of the model. If the cost of monitoring is higher than the expected earnings, the bank won't have enough incentives to monitor, since the expected returns will turn out to be negative.

Summarizing, when both banks decide to monitor and choose the optimal level of monitoring, the expected return from focus is always higher than the expected return from diversification. The expected return from single-bank lending is greater than the multiple-bank lending case. The intuition behind these results is that when the bank chooses the multiple-bank lending case, the probability of success is the same while the cost of monitoring is higher since the bank now has to monitor two projects.