



How loan portfolio diversification affects risk, efficiency and capitalization: A managerial behavior model for Austrian banks

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ABSTRACT

The aim of this paper is to analyze how diversification of banks across size and industry affects risk, cost and profit efficiency, and bank capitalization for large Austrian commercial banks over the years 1997–2003. Employing a unique dataset, provided by the Austrian Central Bank, we test for several different types of managerial hypotheses, formalized according to a modified version of the Berger and DeYoung model [Berger, A.N., DeYoung, R., 1997. Problem loans and cost efficiency in commercial banks. *Journal of Banking and Finance* 21, 849–870]. We find that, although diversification negatively affects cost efficiency, it increases profit efficiency and reduces banks' realized risk. Finally, diversification seems to have a positive impact on banks' capitalization.

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1. Introduction

A large body of literature in corporate finance has attempted to address the question of focus or diversification in the business activities of firms. Classical finance theory suggests that diversification should be a way to reduce the risk within a portfolio of assets (Haugen, 2001). Given asymmetric information in banking markets, theory highlights that diversification reduces the cost of financial intermediation (Diamond, 1984) and increases the incentive to monitor (Cesari and Daltung, 2000).

However, recent literature questions the beneficial role of diversification for banks, no matter which measures of diversification are used (diversification of income sources, industries or geographical regions). Defining diversification as the mix of banks' sources of income (interest income, provisions, trading, etc.), DeYoung and Roland (2001), Stiroh (2004), and Stiroh and Rumble (2006)

draw a rather bleak picture on the role of diversification. This is due to the higher volatility of non-interest income, which seems to offset or even outweigh diversification benefits.

Baele et al. (2007) find that diversification increases systematic risk, although banks seem to benefit from diversification in their franchise value. In this respect, Laeven and Levine (2007), however, demonstrate the existence of a diversification discount for financial conglomerates. In terms of diversification across industries, Acharya et al. (2006) show that diversification both reduces bank returns while producing riskier loan portfolios for high-risk banks. This is due to a deterioration in the effectiveness of monitoring. Kamp et al. (2006) underpin this cautious picture of the benefits of diversification across different industries. Results on geographical diversification, however, seem to be slightly more balanced. Deng et al. (2007) employ deposit dispersion to measure geographical diversification and find that diversification improves the risk return trade-off of US bank holding companies. In the same way, Hughes et al. (1999) uncover a positive effect of interstate diversification on production efficiency after the passage of the Riegle-Neal Interstate Banking and Banking Efficiency Act in 1994, whereas in an earlier study Hughes et al. (1996) show a positive

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correlation between geographic diversification and bank efficiency only for relatively inefficient banks.¹ For a sample of large European and US banks, Bos and Kolari (2005) find a positive effect of diversification on bank efficiency. Looking at bank size few recent papers analyze the link between revenue diversification and financial performance. For a sample of small European credit institutions, Mercieca et al. (2007) find no direct diversification benefits within and across business lines and an inverse association between non-interest income and bank performance. Lepetit et al. (2008) show for a broad set of European banks that small credit institutions expanding into non-interest income activities present higher risk and higher insolvency risk. Goddard et al. (2008) investigate the impact of revenue diversification on financial performance for US credit unions. They find that small credit unions should avoid revenue diversification and should continue to operate on the traditional credit lines.

So far, literature suggests that diversification – independent of whether measured in terms of income, geographical reach or industry – will not necessarily turn out to be beneficial for banks. In this paper, we try to shed further light on the issue, focusing on the effect that both diversification across different industries and loan book granularity can have on bank performance. In particular we analyze the effect that diversification may have over time on a bank's realized risk and on cost and profit efficiency for large Austrian commercial banks over the years 1997–2003. We assume different hypotheses on the behavior of the banks and model our framework using a revised version of the Berger and DeYoung (1997) approach, which enables us to capture the inter-temporal relationships between diversification, banks' risk and their operational performance in terms of cost and profit efficiency.

The paper is organized as follows. Section 2 introduces the theoretical framework for our hypotheses, as well as the specification of the model employed in our analysis. Section 3 describes the data used in our empirical analysis, some stylized facts on the Austrian banking sector and the results on the cost and profit efficiency estimates. In Section 4, we present the empirical findings on our managerial behavior model. Section 5 concludes the paper. All the methodological issues related with efficiency measurement and the specification of cost and profit functions are gathered in the Appendix.

2. Theoretical framework and model specification

Our analysis focuses on the link between diversification and bank efficiency (both on cost and profit), as well as on the link between diversification and realized ex-post risk. As suggested in literature, many factors can have an influence on the level of risk assumed by a bank, such as agency problems between managers and shareholders, ownership structure, regulatory actions or moral hazard behavior.² By formulating our hypotheses, we thus assume that managers are not risk neutral. They may very well be risk seeking (moral hazard behavior) or risk averse; their behavior can affect the decision towards focusing or diversifying. Furthermore, both theoretical and empirical literature on the determinants of banks' risk-taking behavior yields conflicting predictions as well as conflicting empirical evidence. As underlined also by Altunbas et al. (2007), one reason for this outcome is that most of the examined hypotheses are non-exclusive.

Looking at the effect of diversification on the realized ex-post risk, the classical theory of finance suggests that a higher diversification in a bank's loan portfolio should reduce realized risk, mea-

sured by the amount of provisions for bad loans (*classical diversification hypothesis*). In banking, however, diversification per se is no guarantee for a reduction in the risk of failure or for better performance. One reason for this is the importance of loan monitoring.³

If the management lacks the time/expertise to monitor the loan granting process to new customer segments or new industries effectively, more diversification does not necessarily imply less provisioning (*lack of expertise hypothesis*). A second reason why high diversification does not necessarily lead to a reduced need for provisioning may be due to the quality and composition of the portfolio. If a bank has a less diversified portfolio focused on low risk lending activities (e.g. lending to the public sector), the need for provisioning might still be lower than for a bank with a more diversified portfolio of highly risky assets. Therefore, one has to control for the quality of a bank's portfolio when analyzing the impact of diversification on realized risk. We do so by including economic capital to correct for risk-weighted assets.

Looking next at the link between diversification and efficiency, we have to distinguish between cost and profit efficiency, given that the predicted effects can be conflicting. Starting with the link between cost efficiency and diversification, we can assume two alternative hypotheses. The first one, which we call *monitoring hypothesis*, suggests that diversification may dampen cost efficiency. This hypothesis is motivated by the fact that internal or regulatory guidelines may prescribe some level of monitoring independent of the level of diversification. Having a diversified portfolio with a large number of individual clients in different industries may thus increase monitoring costs and reduce cost efficiency. The *monitoring hypothesis* could furthermore be supported by the fact that managers may very well be risk averse instead of risk neutral.⁴ Therefore, they may be willing to incur additional costs for selecting a high quality loan portfolio and for monitoring its performance in order to reduce risk. This is particularly relevant if, for instance, a proportion of their income is tied to their bank's performance.

On the other hand, an alternative hypothesis (*idiosyncratic risk hypothesis*) would suggest that diversification can have a positive effect on cost efficiency. As diversification reduces the idiosyncratic risk, this may enable banks to loosen their monitoring efforts and therefore to lower operating costs, which ceteris paribus should lead to higher cost efficiency.

The ultimate guideline, however, on whether diversification pays off or not in terms of efficiency is to look at the link between diversification and profit efficiency. In line with classical finance theory and thus our *classical diversification hypothesis*, we would expect the risk-adjusted returns to be higher for a well-diversified portfolio, and we would therefore predict a positive relation between diversification and profit efficiency. Although diversification may be costly to handle as it entails cost inefficiencies (cf. *monitoring hypothesis*), rational managers should bear these costs only if diversification ultimately yields benefits from the profit efficiency perspective. We would therefore expect that, on the one hand, diversification decreases cost inefficiency and, on the other hand, increases profit efficiency. This hypothesis could also help explain the contradictory results for banks' cost and profit efficiency often documented in empirical literature.⁵

However, diversification could also result in low profit efficiency. If managers are risk averse, it could be rational for them to engage in costly monitoring (*monitoring hypothesis*) even though they are not able to raise profit efficiency. In order to reduce risk, risk averse managers may be willing to incur so many additional costs for selecting a high quality loan portfolio and for monitoring

¹ Another vast block of literature indirectly related to the issue of diversification concentrates on the effects of bank mergers on bank efficiency. See Amel et al. (2004) for an extensive literature review in this respect.

² See Berger and Udell (1997), Kwan and Eisenbeis (1997), Bonin et al. (2005) and Altunbas et al. (2007).

³ See also Acharya et al. (2006).

⁴ See also Hughes et al. (1996).

⁵ See Berger and Udell (1997) and Maudos et al. (2002).

Table 1
Summary of the hypotheses.

Hypothesis	Dependent variable	Expected sign of the diversification coefficient
Classical diversification hypothesis	Ex-post risk	Negative
Lack of expertise hypothesis	Ex-post risk	Positive
Idiosyncratic risk hypothesis	Cost efficiency	Positive
Monitoring hypothesis	Cost efficiency	Negative
Classical diversification hypothesis	Profit efficiency	Positive
Quiet life hypothesis	Profit efficiency	Negative
Economic capital hypothesis	Capitalization	Negative

its performance that not only cost but also profit efficiency is reduced (*quiet life hypothesis*).⁶ Finally, we look at the effect of diversification on bank capitalization. In this context, we are able to examine whether the level of capitalization is sensitive to the degree of diversification. If diversification is seen as a valid and necessary means to reduce risk by managers, regulators, creditors and/or owners, we expect more diversified banks to be able to operate with less capital than more concentrated peers (*economic capital hypothesis*). The amount of economic capital retained to cover unexpected losses should ceteris paribus be smaller for diversified banks. In Table 1 we present predicted outcomes for all hypotheses with respect to the dependent variable.

In order to test these hypotheses we use a framework that explicitly allows the modeling of inter-temporal causal relations between the variables. We thus employ a modified version of the managerial behavior model in which we combine the Berger and DeYoung hypotheses⁷ with our specific hypotheses (see Table 1).

Our model consists of three equations as in Berger and DeYoung (1997). In addition, we include two different measures of diversification to capture the effect that diversification across industries and loan book granularity can have on realized risk, efficiency and capital. We use a Granger-causality approach in order to test how diversification affects the variables of interest over time. Thus the model assumes the following specification:

$$PROV_{s,t} = f_1(PROV_{s,lag}, EFF_{s,lag}, CAP_{s,lag}, HIIN_{s,lag}, HISI_{s,lag}) + \varepsilon_{1,s,t} \quad (1)$$

$$EFF_{s,t} = f_2(EFF_{s,lag}, PROV_{s,lag}, CAP_{s,lag}, HIIN_{s,lag}, HISI_{s,lag}) + \varepsilon_{2,s,t} \quad (2)$$

$$CAP_{s,t} = f_3(CAP_{s,lag}, PROV_{s,lag}, EFF_{s,lag}, HIIN_{s,lag}, HISI_{s,lag}) + \varepsilon_{3,s,t} \quad (3)$$

where s identifies the bank; t is the time component; EFF is the level of cost/profit efficiency; $PROV$ measures the asset quality and is computed as the net-amount of charge-offs for credit and market risk over the sum of risk-weighted assets; $HIIN$ measures the diversification of a bank's loan portfolio across different industries by means of the corresponding Herfindahl Index normalized to 1 for total concentration; $HISI$ measures the degree of diversification in a bank's loan portfolio among different loan sizes/volumes measured by means of the corresponding Herfindahl Index normalized

⁶ See Berger and Hannan (1998) and Hahn (2005).

⁷ The Berger and DeYoung model (1997) explains the causality in the relationship between management behavior and efficiency by modeling the inter-temporal relationship across bad loans, bank capitalization and efficiency. They formulate four different hypotheses on managerial behavior. (i) The *bad management hypothesis* implies that bad managers do not adequately control for operating expenses and poorly manage their loan portfolio: low efficiency should cause an increase in problem loans. (ii) The *skimming hypothesis* assumes that the quality of a bank's loan portfolio is determined by the costs connected with the monitoring of lending activities: cost efficient banks are expected to have more problem loans. (iii) The *bad luck hypothesis* means that external factors increase problem loans, which in turn cause a decline of cost efficiency as monitoring costs have to be increased consequently. (iv) The *moral hazard hypothesis* suggests that managers of weakly capitalized banks are less risk averse and engage in risk taking behavior. Therefore, low bank capitalization causes an increase in problem loans. On the issue see also DeYoung et al. (2001) and Williams (2004).

to 1 for total concentration; CAP is the ratio of equity to total assets; it is a measure of bank capitalization and a proxy for economic capital held ex-ante to cover unexpected losses; ε stands for the error term.

Eq. (1) tests the effect of diversification on ex-post realized risk. A positive sign on the Herfindahl indices, which measure concentration, provides evidence for the *classical diversification hypothesis*, a negative sign for the *lack of expertise hypothesis*.

Eq. (2) tests the hypothesis that efficiency may depend on bank diversification. A positive effect of diversification on cost efficiency would yield a negative sign on the Herfindahl indices and would thus be indicative of the *idiosyncratic risk hypothesis*. Conversely, a positive sign on the Herfindahl indices would point towards the *monitoring hypothesis*. Taking profit efficiency as the dependent variable in Eq. (2) we can, accordingly, test for the *classical diversification hypothesis*, expecting a negative sign on the Herfindahl indices. We can also test for the *quiet life hypothesis*, which predicts a positive sign on the Herfindahl indices.

Eq. (3) closes the model and enables us to test the *economic capital hypothesis*. Here, we would expect a positive sign on the two Herfindahl indices, indicating that the amount of capital banks have to hold declines as diversification increases.

As regards the original hypotheses on managerial behavior formulated by Berger and DeYoung (1997), Eq. (1) also tests for the *bad management hypothesis* (we would expect a negative sign of the lagged X-efficiency variables), as well as the *skimming hypothesis* (we would expect a positive sign of the lagged X-efficiency variables). In addition, Eq. (1) may also be used to test for *moral hazard behavior*, when only a sub-sample of low-capitalized banks is used. In this case, we would expect a negative sign on the lagged coefficients of the capitalization variable (CAP). Finally, Eq. (2) also tests for the *bad luck hypothesis*: a negative relationship is expected between X-efficiency and lagged values of provisions.

3. Methodological issues

3.1. Data

In our empirical analysis, we use a unique data set from the Austrian banking market provided by the Austrian Central Bank (Oesterreichische Nationalbank/OeNB). This dataset allows us to measure cost and profit efficiency and to test our hypotheses on managerial behavior. Our sample comprises large Austrian commercial banks over the years 1997–2003. In particular, we select those banks that were among the 100 largest Austrian banks (measured by their total assets) in at least one of the years within the observation period. As the ranking of the top 100 banks is fairly stable during the observation period, this leads to a sample of 125 banks, out of which we drop 29 special purpose banks. Since our focus is to analyze the performance of the large Austrian commercial banks, the inclusion of these special purpose banks would have distorted results.⁸ We finally obtain a panel consisting of 659 observations for 96 commercial banks over 7 years. The banks in our sample held a total amount of EUR 459 billion of assets in 2003, which is approximately 78% of total banking assets of the

⁸ Specifically, we drop eighteen special purpose banks from the sample, focusing on a very limited number of banking activities (e.g., car financing, export guaranteeing and financing, real estate project financing, industrial holding companies that were legally obliged to have a banking license, etc.). Five Austrian building societies are also dropped from the sample because their business model is highly regulated and the full range of banking activities is not allowed to them. Finally, six branches of foreign banks are dropped because they have no banking license in Austria and their business activity largely depends on strategic decisions of their foreign parents.

Table 2

Sample composition versus the universe of the Austrian banks.

Variable	Mean	St. dev.	Min	Max	Total
<i>Sample</i>					
1997					
Banks					
Total Asset (EUR bn)	3.2	8.7	0.1	58.8	96 300.8
2003					
Banks					
Total Asset (EUR bn)	4.9	13.8	0.1	108.0	96 459.0
<i>Universe of all Austrian banks</i>					
1997					
Nr. of Banks					
Total Asset (EUR bn)	0.44	3.1	0.001	58.8	994 436.1
2003					
Nr. of Banks					
Total Asset (EUR bn)	0.68	4.7	0.001	108.0	896 605.1

Source: Oesterreichische Nationalbank (OeNB).

Table 3

Economic and banking system indicators.

	1997	1998	1999	2000	2001	2002	2003	2004	2005
<i>Economic indicators for Austria</i>									
Real GDP growth	2.1	3.6	3.3	3.7	0.5	1.6	0.8	2.5	2.9
Unemployment rate %, Eurostat definition	4.4	4.5	3.9	3.6	3.6	4.2	4.3	4.9	5.2
<i>Banking system indicators for Austria</i>									
RoA (in %)	0.32	0.34	0.31	0.42	0.46	0.25	0.35	0.46	0.53
Loan-loss provisions in % of total loans	3.2	3.2	3.0	2.9	3.1	3.3	3.3	3.2	3.0

Source: Oesterreichische Nationalbank (OeNB).

whole Austrian banking market for that year.⁹ In terms of their number, however, our sample represents 11% of all Austrian banks in 2003, showing that the Austrian banking sector is fairly dispersed in terms of number of credit institutions, mainly due to the co-operative nature of the Austrian banking sector characterized by many small stand-alone co-operative and savings banks.¹⁰ The mean bank size in our sample measured by total assets is 4.9 bn EUR, with the largest bank having total assets of 108 bn EUR and the smallest one 100 m EUR (Table 2).

By our selection of the banks for our analysis, we make sure that the sample is not subject to a survivorship bias, which could distort the outcome of our investigation. For this reason, our sample contains all banks existing at any point in time, independent of whether they disappeared or merged later on. During the observation period, we registered only four mergers (one big merger between *Bank Austria* and *Creditanstalt* and three small mergers between co-operative banks) and no defaults. Given the stability in the banks' size ranking of our sample, which is often associated with the banks' performance, one could argue that a survivorship bias might also be present. In other words, the banks in our sample could simply be those with the best/most steady performance, whereas other banks outside our sample performed worse and had to exit the market. However, if we look at the entire Austrian banking sector, we observe that the number of defaults is very limited too. From 1997 to 2003 only

three very small banks defaulted, whereas 95 banks merged (less than 10% of the total number of Austrian banks), mainly small co-operative and savings banks (see Table 2).

Finally, to reduce the effect of business cycle on bank performance, we select a sample period (1997–2003), which roughly covers a full economic cycle. As Table 3 shows, the sample period from 1997 to 2003 covers an entire cycle of the Austrian economy. Whereas the period from 1997 to 2000 was characterized by an accelerating growth rate of the overall economy, the economic activity in Austria slowed down considerably from 2001 to 2003 leading to a delayed increase in both the unemployment rate and loan-loss provisions in the banking system. As a corollary, the profitability of the banking-systems measured in terms of RoA also declined in 2002. Both the Austrian economy as well as the banking system profitability recovered from 2004 onwards.

For each bank, our dataset consists of mandatory supervisory reporting data, comprising unconsolidated data on balance sheet and profit and loss account positions as well as data on the bank's (regulatory) solvency. These data are complemented by a unique dataset on each bank's loan portfolio based on single loan data as reported to the Austrian central credit register. The register comprises detailed debtor specific information on all major loans, i.e. loans with an outstanding value of at least EUR 350,000 granted by Austrian financial institutions. At the end of the year 2003, approximately 67% of the total volume of all (direct) lending activities of our sample banks was covered by the credit register entries.

Table 4 provides descriptive statistics for the variables used in our model (Eqs. (1)–(3)) for the year 2003. Concerning these variables, we note that the values for our measure of realized risk (*PROV*) range from –6.45% to +10.34% of total assets, indicating that our sample banks' investment portfolios are very heterogeneous. As regards the banks' diversification profiles measured by

⁹ With total assets amounting to EUR 605 bn at the end of 2003, the Austrian banking sector is rather small in size compared to the whole European banking market (i.e., 2.2% of the whole EU banking sector). It is, however, highly developed in terms of its intermediation depth (total assets over GDP approximately 265 % at the end of 2003) and representative for the median EU-15 economy. For further details, see European Central Bank (2003).

¹⁰ According to the ECB data, Austria recorded 0.1 independent credit institutions per thousand inhabitants at the end of 2003, whereas the median value for the EU-15 was 0.02.

Table 4

Descriptive statistics of the variables used in Eqs. (1)–(3), year 2003.

Variables used in models on managerial behavior		Mean	St. dev.	Min	Max	Total
PROV	Risk (net-charge-offs for credit and market risk)	0.77%	1.40%	–6.45%	10.34%	0.70%
HIIN	Diversification of loans across different industries (Herfindahl Index)	0.155	0.137	0.046	0.698	0.095
HISI	Diversification of loan portfolio across different sizes (Herfindahl Index)	0.019	0.026	0.002	0.142	0.010
CAP	Capital Base (equity ratio)	8.49%	4.89%	1.52%	39.20%	7.21%

Table 5

Cost and profit efficiency for Austrian commercial banks for the quartiles of the distribution of total assets from 1997 to 2003.

		1997	1998	1999	2000	2001	2002	2003
Cost efficiency	1st quartile (<393 mio)	0.929	0.923	0.916	0.926	0.909	0.900	0.874
	2nd quartile (<683 mio)	0.934	0.928	0.923	0.906	0.903	0.901	0.908
	3rd quartile (<3089 mio)	0.915	0.917	0.917	0.907	0.914	0.908	0.890
	4th quartile (>3089 mio)	0.918	0.908	0.904	0.903	0.894	0.890	0.885
Profit efficiency	1st quartile (<393 mio)	0.387	0.381	0.372	0.349	0.347	0.340	0.364
	2nd quartile (<683 mio)	0.427	0.378	0.373	0.369	0.330	0.319	0.313
	3rd quartile (<3089 mio)	0.384	0.386	0.374	0.370	0.366	0.350	0.325
	4th quartile (>3089 mio)	0.401	0.389	0.362	0.345	0.335	0.322	0.304

Table 6

Robustness of results on efficiencies.

	SFA	DFA	TFA
<i>Spearman rank correlations between efficiency results obtained using different techniques^a</i>			
SFA		0.88***	0.46***
DFA	0.88***		0.51***
TFA	0.49***	0.55***	
<i>Spearman rank correlations between efficiency values obtained from SFA-estimations and standard performance measures</i>			
	Return on Assets	Cost Ratio	Cost-Income-Ratio
Cost Efficiency	0.13***	–0.16***	–0.15***
Profit Efficiency	0.47***	–0.01	–0.49***

^a The upper triangular matrix shows results on robustness checks for cost efficiency, the lower the corresponding outcomes for profit efficiency.

*** Indicates statistical significance at the 1% level.

two Herfindahl Indices (*HIIN* and *HISI*), we also observe large variations across banks. Finally, the same holds true for the variable *CAP* which captures the banks' equity base: again the significant variation across banks (minimum: 1.52%, maximum: 39.2%) is striking.

3.2. Cost and profit efficiency estimates and consistency checks

Table 5 presents the results for our cost and profit efficiency estimates for each year, divided into four size quartiles. Efficiency estimates were obtained by employing the Stochastic Frontier Approach (SFA).¹¹ Following the suggestion of Bauer et al. (1998), we compare SFA-efficiency results with efficiency outcomes using the Thick Frontier Approach (TFA) and the Distribution Free Approach (DFA). This enables us to assess the robustness of SFA efficiency scores.¹²

In line with the results of Hahn (2005), efficiency levels of Austrian banks have declined over the observation period in all four size quartiles. Furthermore, profit efficiency levels seem to be much lower than cost efficiency levels, indicating that banks operate closer to the efficient cost frontier than to the efficient profit frontier. As can be predicted, smaller banks seem to perform better in terms of cost and profit efficiency.

In a second step, we check the robustness of our SFA results (Table 6) by comparing them to efficiency scores using TFA and DFA as well as to standard non-frontier measures of performance, such as

banks' ROA, their cost ratio or their cost/income ratio.¹³ The results of these consistency checks support our efficiency estimates by means of Spearman rank correlations. Both DFA and TFA estimates show highly significant positive rank correlations with the SFA results. In terms of the comparison with standard non-frontier measures of performance, cost and profit efficiency results display significant rank correlations, all of them (with one exception) showing the expected signs.

4. Empirical results on the managerial behavior model

The Eqs. (1)–(3) of the model are estimated using the Arellano-Bond dynamic panel data model. We choose a specification with two lags for both dependent and explanatory variables, which are supported by *F*-tests. The results of the regressions employing both, cost and profit efficiency, are shown in Table 7.¹⁴

First we investigate the effect of diversification on realized risk (Eq. (1)) and check which of the two alternative hypotheses – the *classical diversification hypothesis* or the *lack of expertise hypothesis* – is supported by our empirical analysis. The coefficients of the independent variables are consistent with regard to the cost and

¹³ See Hahn (2005) for a comparison with other results on Austrian banks' efficiency.

¹⁴ As a further robustness check, we re-estimate Eqs. (1)–(3) for a sample of banks constructed as follows: 1997 data are from banks that were the 100 largest in size in 1996; data in 1998 are sampled from banks that were the largest in size in 1997 and so on. The estimation results obtained for these robustness checks are qualitatively similar to the findings report in the paper and do not change the interpretations of our hypotheses. Results are available upon request.

¹¹ For further details, see the Appendix.

¹² For more details on efficiency measurement, we refer to the Appendix.

Table 7

Granger-causality tests on management behavior hypotheses using cost and profit efficiency results.

Equation Dependent Variable Variable	Cost efficiency			Profit efficiency		
	(1)	(2)	(3)	(1)	(2)	(3)
	$\Delta PROV$ Coefficient	ΔEFF Coefficient	ΔCAP Coefficient	$\Delta PROV$ Coefficient	ΔEFF Coefficient	ΔCAP Coefficient
$\Delta PROV(-1)$	0.0529***	-1.08E-06*	-0.0074	0.0105***	-4.68E-05***	-0.0001
$\Delta PROV(-2)$	0.3041***	-1.45E-06***	-0.0151**	0.2295***	-1.89E-05***	0.0275**
$\Delta EFF(-1)$	68.1020***	2.1648***	46.3064***	2.1912***	2.0287***	1.4921***
$\Delta EFF(-2)$	-71.4608***	-1.1714***	-48.3115***	-3.0065***	-1.0315***	-1.1186***
$\Delta CAP(-1)$	-0.1096	4.59E-06	0.4482***	0.2348***	-3.43E-05	0.3555***
$\Delta CAP(-2)$	0.0164**	-4.85E-07*	0.0018	0.0041	-1.73E-06*	0.0091
$\Delta HIIN(-1)$	0.0010	5.265E-07***	-0.0001	0.0193	-3.68E-06***	-0.0036
$\Delta HIIN(-2)$	0.0123***	2.67E-07***	0.0030***	0.0162***	-3.87E-07***	0.0077***
$\Delta HISI(-1)$	0.0231***	2.81E-07**	-0.0064***	0.0030***	-1.53E-06***	-0.0087***
$\Delta HISI(-2)$	0.0297***	3.85E-07*	-0.0025	0.0229***	-2.18E-06***	-0.0052
Constant	0.0013**	-2.49E-07*	0.0027***	-0.0111**	-1.95E-05*	0.0049***
Structural tests	p-Value	p-Value	p-Value	p-Value	p-Value	p-Value
Sargan test	0.35	0.98	0.23	0.29	0.15	0.23
Test for autocorrelation	0.21	0.28	0.46	0.22	0.12	0.39

* Significant at 10% level.

** Significant at 5% level.

*** Significant at 1% level.

profit specifications (first and fourth column of Table 7). The lagged values of the two measures of diversification (*HIIN* and *HISI*) are significant and positive suggesting that high concentration (i.e., low diversification) implies larger provisions for risk. Based on this outcome, we would thus reject the *lack of expertise hypothesis* and consequently support the *classical diversification hypothesis*. In line with classical theory of finance, a higher diversification of a bank's loan portfolio indeed reduces realized risk measured in terms of the amount of provisions for bad loans. The estimates of Eq. (1) also suggest the presence of *bad management behavior* in the sense of Berger and DeYoung (1997) for the sample of Austrian banks. The overall impact of the lagged values of cost and profit efficiency (i.e. the sum of the two efficiency coefficients) is negative, indicating that a decrease in the level of cost and profit efficiency Granger-causes an increase in the need for bank provisioning. In other words, well-managed banks, in terms of cost and profit efficiency, experience less need for provisions and therefore less realized risk. Finally, our estimates (Eq. (1)) provide no evidence for the *moral hazard hypothesis* according to which low bank capitalization should cause an increase in problem loans. Our results, in fact, show that an increase in bank capitalization seems to Granger-cause a higher need for provisions in both cost and profit specifications, meaning that higher levels of capital allow for taking on more risk.¹⁵ As a next step, we focus on the link between diversification and cost and profit efficiency. Starting with the cost efficiency specification (Eq. (2)), both measures of concentration (*HIIN* and *HISI*) are positive and significant, indicating that higher concentration increases cost efficiency. We would thus reject the *idiosyncratic risk hypothesis* and interpret the result as a support for the *monitoring hypothesis* instead. High diversification achieved by expansion into many different industries and a very granular loan book dampens cost efficiency. Conversely, in the profit efficiency case, the coefficients of the lagged values of our concentration indices are all negative and significant. This is again in line with classical theory of finance, according to which we would expect the risk-adjusted return to be higher for a well-diversified portfolio (*classical diversifica-*

tion hypothesis). Although diversification may be costly to run and thus entail cost inefficiencies, it ultimately increases profit efficiency. Higher quality and better monitoring of a loan portfolio should lead to an increase in risk-adjusted returns via a decrease in expected losses. Furthermore, our evidence also provides support for the Berger and DeYoung *bad luck hypothesis*, according to which external factors, such as a decrease in GDP, financial market instabilities, etc., increase problem loans, which in turn cause a decline in efficiencies as monitoring efforts have to be enhanced. This is what we detect if we look at the coefficients of the lagged values of provisions (Eq. (2)), which are significantly negative in both the cost and the profit efficiency specifications, indicating that an increase in problem loans Granger-causes lower cost and profit efficiency. Finally, we look at the results for Eq. (3) in which the dependent variable is the bank's economic capital. As regards the impact of diversification on capital requirements, we obtain mixed results. On the one hand, the overall impact of concentration across industries is positive and significant in both specifications, indicating that an increase in diversification reduces the capital required by managers, regulators, creditors and owners. This is again consistent with classical theory of finance and furthermore supports the *economic capital hypothesis*. On the other hand, diversification across different loan sizes does not yield a reduction in capital. This evidence (Eq. (3)), however, has to be interpreted with caution, as in both the cost and the profit efficiency specifications almost half of the coefficients are statistically not significant.

5. Conclusions

This paper has investigated the effects that bank diversification across size and industry can have on risk, cost and profit efficiency, and bank capitalization for large Austrian commercial banks over the years 1997–2003. We use a unique dataset with data on risk and asset quality, which allows us to test for several different types of managerial behavior by using a modified version of the Berger and DeYoung (1997) model, based on the Granger-causality approach.

In our empirical investigation, we find that overall diversification has a positive effect on the performance of the Austrian banks. In particular, our main results show that: (i) diversification reduces realized risk and therefore the need for provisioning (*classical diversification hypothesis*); (ii) diversification decreases cost effi-

¹⁵ We furthermore check for the robustness of these results by estimating equation (1), using only a subset of banks for which the values of CAP are below the sample median. As suggested in Berger and DeYoung (1997), weakly capitalized banks may have higher incentives for moral hazard behavior. Results remain robust, with the coefficients on the two lag terms being significantly positive.

Table A.1
Specification tests.

Hypothesis	Test	Test statistic	p-Value	Decision
<i>Specification tests for cost function</i>				
No Fourier terms (Tranlsog form)	Wald	17.68	0.00	Rejected
	Likelihood ratio	15.76	0.01	Rejected
No technical progress	Wald	41.83	0.00	Rejected
	Likelihood ratio	88.29	0.00	Rejected
No risk preferences	Wald	17.35	0.01	Rejected
	Likelihood ratio	57.00	0.00	Rejected
<i>Specification tests for profit function</i>				
No Fourier terms (Tranlsog form)	Wald	14.91	0.02	Rejected
	Likelihood ratio	15.05	0.02	Rejected
No technical progress	Wald	15.26	0.00	Rejected
	Likelihood ratio	26.90	0.00	Rejected
No risk preferences	Wald	12.11	0.09	Rejected
	Likelihood ratio	12.09	0.044	Not rejected

ciency and increases profit efficiency (*monitoring hypothesis* and *classical diversification hypothesis*); (iii) diversification across industries reduces capital requirements (*economic capital hypothesis*).

In addition, we also find evidence for some of the Berger and DeYoung (1997) hypotheses on managerial behavior. Firstly, our estimates show that lower efficiency Granger-causes a greater need for provisioning (and vice versa), pointing towards the *bad management behavior hypothesis*. Secondly, the data also support the *bad luck hypothesis*, as an increase in problem loans in turn decreases efficiency. The data, however, support neither the *skimping hypothesis* nor the *moral hazard hypothesis*.

From a policy point of view, our empirical investigation has the following implications for the Austrian banks. Firstly, promoting banks' diversification in Austria may have the advantage of increasing profit efficiency, which is in line with classical theory of finance. In other words, spreading one's business activities across different industries and size classes may help banks to boost their performance further, which is of particular interest in highly competitive banking markets. For the Austrian banking sector in particular, an optimal loan diversification could be helpful to counter the effect of continuously declining interest rate margins on bank performance. Secondly, we provide evidence that increased diversification efforts lead to lower future provisioning, which could result in a reduction of realized risk. This reasoning is also supported by Koetter and Porath (2007), who show, for a sample of German banks, that diversification indirectly leads to lower default probabilities.

Thirdly, our data indicated that higher diversification enables banks to operate at lower levels of equity capital and thus helps them save scarce and costly resources. Fourthly, prudential regulation and supervision could contribute to the reduction of banks' risk of failure by limiting their exposures to external shocks. Limits on loan concentrations, encouragement of interstate mergers and/or loan sales may help insulate banks from such shocks. To this end, macroeconomic-stress testing exercises assessing the impact of macroeconomic shocks on the quality of banks' loan books (Blaschke et al., 2001) could help spot bank vulnerabilities.

Finally, our results show that "bad management" may be one of the causes for deteriorating loan quality. Supervisors should underline the importance of setting comprehensive supervisory standards for bank-wide risk management. The more risk-sensitive Basel II regulatory framework that explicitly includes a supervisory review process is an important first step in this direction (Basel Committee on Banking Supervision, 2004).

We thus conclude, with all the caveats of our empirical investigation, that exploiting diversification resulted in gains for the large Austrian commercial banks over the period of observation. Supervisors and researchers may want to investigate this issue further as

our promising results should not be generalized to other countries, banking-systems or time-spans without additional investigation on a cross-country level of analysis.

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Appendix A. Efficiency measurement

In order to measure the efficiency of Austrian banks, we employ the Stochastic Frontier Approach (SFA). The literature suggests a range of different approaches to model banks' cost and profit functions, which differ mainly in the way they define the inputs and outputs of the banks' production function. We employ the *modified production approach*¹⁶ according to which deposits can be included in both the input and the output variables: the interests paid on deposits are accounted as an input, while the volume of deposits is considered as an output (see Bauer et al., 1993). We thus shape the cost and alternative profit functions using loans, deposits and other earning assets as outputs, while the price of labor, the price of capital and the price of deposits as classified as inputs. We furthermore account for banks' risk preferences and for technical progress in the modeling of banks' production functions. Risk preferences of banks are approximated by the amount of equity held in excess of the supervisory requirements.¹⁷ Technical change is accounted for by a time trend. The inclusion of these two control variables is supported by Wald and Likelihood Ratio tests on the respective (un)restricted models. As regards the functional form, we use a Fourier flexible form (FF) specification instead of the usual Translog (TL) function¹⁸, which is also underpinned by Wald and Likelihood ratio tests (see Table A.1).

As a result, our cost and profit functions are specified as follows:

¹⁶ We also conduct our estimates using the production approach, which yields similar results to the point of being comparable.

¹⁷ The need to control for risk preferences of financial institutions in the estimation of cost/profit functions and measures of X-efficiency is well accepted in literature (see e.g. Altunbas et al., 2000). Usually the ratio of equity capital to a bank's total assets is used as a means of measuring risk preferences. A given equity ratio can however indicate both high or low risk preferences depending on the actual risk exposure a bank has.

¹⁸ The Fourier flexible form (FF) specification, as pointed out in literature (see Gallant, 1981; Mitchell and Onvural, 1996; Berger and Mester, 1997) is able to give a better fit of the data than the standard Translog (TL) production function.

Table A.2

Descriptive statistics of the variables used in cost and profit functions for the year 2003.

Variables used in the cost and profit functions		Mean	St. dev.	Min	Max	Total
TC	Total cost (EUR bil)	0.189	0.499	0.002	4.080	17.800
TP	Total profit (EUR bil)	0.033	0.068	0.001	0.416	3.140
Q1	Total loans to customers and banks (EUR bil)	3.881	10.900	0.489	88.000	364.850
Q2	Total deposits with customers and banks (EUR bil)	3.282	9.581	0.361	75.700	308.546
Q3	Total other assets and securities (EUR bil)	0.802	2.148	0.004	14.300	75.416
P ₁	Price of labour (personnel expenses/total assets)	1.20%	0.68%	0.06%	5.39%	0.74%
P ₂	Price of funds (interest expenses/deposits with customers and banks plus securitized liabilities)	2.37%	1.11%	0.96%	9.25%	2.74%
P ₃	Price of physical capital (total depreciation and other capital expenses / total fixed assets)	4.60%	2.79%	0.22%	15.18%	2.86%
R	Risk preferences (equity minus supervisory required equity according to risk)	0.143	0.499	0.003	4.119	13.500
T	Time trend			1998	2003	

$$\begin{aligned}
\ln(H_{st}) = & \alpha_0 + \sum_{i=1}^3 \alpha_i \ln(y_{ist}) + \sum_{k=1}^3 \beta_k \ln(p_{kst}) \\
& + \frac{1}{2} \sum_{i=1}^3 \sum_{j=1}^3 \chi_{ij} \ln(y_{ist}) \ln(y_{jst}) + \frac{1}{2} \sum_{i=1}^3 \sum_{j=1}^3 \delta_{ij} \ln(p_{ist}) \ln(p_{jst}) \\
& + \sum_{i=1}^3 \sum_{j=1}^3 \phi_{ij} \ln(y_{ist}) \ln(p_{jst}) + \sum_{i=1}^3 \gamma_i \cos(y_{ist}) \\
& + \sum_{i=1}^3 \eta_i \sin(y_{ist}) + \sum_{i=1}^3 l_i \cos(p_{ist}) + \sum_{i=1}^3 \kappa_i \sin(p_{ist}) \\
& + \sum_{i=1}^3 \sum_{j=1, i \neq j}^3 \lambda_{ij} [\cos(y_{ist}) + \cos(y_{jst})] \\
& + \sum_{i=1}^3 \sum_{j=1, i \neq j}^3 \mu_{ij} [\sin(y_{ist}) + \sin(y_{jst})] \\
& + \sum_{i=1}^3 \sum_{j=1, i \neq j}^3 v_{ij} [\cos(y_{ist}) - \cos(y_{jst})] \\
& + \sum_{i=1}^3 \sum_{j=1, i \neq j}^3 o_{ij} [\sin(y_{ist}) - \sin(y_{jst})] \\
& + \sum_{i=1}^3 \sum_{j=1, i \neq j}^3 \pi_{ij} [\cos(p_{ist}) + \cos(p_{jst})] \\
& + \sum_{i=1}^3 \sum_{j=1, i \neq j}^3 \varpi_{ij} [\sin(p_{ist}) + \sin(p_{jst})] \\
& + \sum_{i=1}^3 \sum_{j=1, i \neq j}^3 \theta_{ij} [\cos(p_{ist}) - \cos(p_{jst})] \\
& + \sum_{i=1}^3 \sum_{j=1, i \neq j}^3 \vartheta_{ij} [\sin(p_{ist}) - \sin(p_{jst})] + \rho R_{st} + \tau T_t + \varepsilon_{st} \quad (4)
\end{aligned}$$

where H is total cost TC or total profits TP ,¹⁹ y_i is the i th output and p_k is the price of the k th input. R_{st} and T_t are two control variables: R is the proxy for the risk preferences of bank s , T is a time dummy accounting for technical change over time. ε_{st} is the error term.

Table A.2 provides descriptive statistics for all variables used in the estimations of efficiencies.

The restrictions in the form of the linear homogeneity conditions and cost exhaustion are obtained by normalizing total costs/profits, the price of labor and the price of deposits by the price of capital. The trigonometric addends in the FF specification are rescaled coherently with our sample size.²⁰

¹⁹ We employ here a profit function, which uses the same exogenous variables as the cost function. This specification is known in the literature as the *alternative* profit specification (Berger and Mester, 1997; Maudos et al., 2002). As usual in the estimation of the profit function (see e.g. Hasan and Marton, 2003), we incorporate a constant term (which is equal to 1 plus the absolute value of the minimum profit value in the sample) into the total profit variable (TP), which avoids taking the log of a negative number.

²⁰ In order to obtain consistent and asymptotically normal estimates, we truncate the number of parameters following the rule expounded in Mitchell and Onuvral (1996), according to which the number of parameters should be set equal to the number of observations raised to the power of two-thirds. The effective number of regressors is further reduced after correcting for multicollinearity.

The SFA explains the deviation of the observed cost function from the efficient frontier with an error term split in two components: the random noise and the technical or allocative inefficiency. Thus following SFA, the error term ε_{st} can be disentangled into two elements: V_{st} , which is the error term accounting for random noise in the data and is assumed to be iid $N(0, \sigma_V^2)$; and U_{st} ; which is a non-negative random variable referring to the technical inefficiency and thus measuring how far the s th firm operates above the efficient cost frontier. In the case of the profit function (TP), the disturbance term is specified as $V_{st} - U_{st}$. In accordance with the stochastic model of Battese and Coelli (1992), the predictions of an individual bank's cost/profit efficiency (EFF_H) may then be written as:

$$EFF_{H_{s,t}} = E(H_{s,t}|U_{s,t}, \varphi_{s,t})/E(H_{s,t}|U_{s,t} = 0, \varphi_{s,t}) \quad (5)$$

where H is total cost or total profits, φ_{st} are the regression parameters. This expression can assume values between 1 and infinity and corresponds to $e^{U_{st}}$.

Following the suggestion of Bauer et al. (1998), one should check for the consistency of the obtained efficiency estimates. This is possible by comparing the results obtained based on the Stochastic Frontier Approach with efficiency outcomes resulting from other techniques such as the Thick Frontier Approach (TFA) and the Distribution Free Approach (DFA). The TFA uses the same functional form as SFA but is based on a regression which is estimated using only the best performers in the data set (i.e., those in the lowest average-cost quartile for their size class). Inefficiency is measured as the distance from the frontier estimated on the basis of the sample of these best performing banks. The DFA avoids the distributional assumptions of the SFA²¹. According to this approach, the distribution free inefficiency is based on the distance between the estimated cost/profit function and the s th effective bank cost/profit in the sample ($s = 1, \dots, N$). This assumes that over the observation period the random part of the error term peters out with the error term caused by remaining inefficiency.²²

By using the estimated efficiency scores obtained from the TFA and DFA specification, we check whether SFA efficiency estimates are consistent in their ranking. We furthermore check the validity of our SFA results by comparing them to standard non-frontier measures of performance, such as banks' ROA, their cost ratio or their cost income ratio, as proposed in Bauer et al. (1998).²³ The results are given in Section 3 of this paper.

²¹ See Battese and Coelli (1995).

²² For both DFA and TFA, a brief overview can be found in Berger and Humphrey (1997).

²³ For evidence comparing our efficiency results in the context of other studies of bank efficiency in Austria, see Hahn (2005).

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