A NON-PARAMETRIC EFFICIENCY AND PRODUCTIVITY ANALYSIS OF TRANSITION BANKING

by

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To my parents – with affection,
and my daughter Janel – a
constant source of inspiration

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Abstract

This thesis examines banking efficiency and the productivity of thirteen transition Central and Eastern European banking systems during 1998-2003 using Data Envelopment Analysis (DEA). It proposes a non-parametric methodology for non-radial Russell output efficiency measure of banking firms, incorporating risk as an undesirable output. In addition, the proposed efficiency measure handles unrestricted data, i.e. both positive and negative. The Luenberger productivity index is suggested, which is applicable to technology where the desirable and undesirable outputs are jointly produced, and are possibly negative. Furthermore, the thesis addresses the main issue in the literature on banking performance measurement, which concerns the lack of consistency in the conceptual and theoretical considerations in describing the banking production process. Consequently, a meta-analysis tool, to examine the choice of inputs and outputs definitions in the banking efficiency literature, is suggested. In addition, the performance measures are estimated using three alternative definitions of the banking production process focusing on the risk and environmental dimensions of bank efficiency and productivity, with further comparative analysis using bootstrapping and kernel density techniques. Overall, the empirical results suggest that in Central and Eastern Europe Czech, Hungarian and Polish banks were the most technical efficient banks and the banking risk was mainly affected by external environmental factors during the analyzed period. Productivity analysis implies that the main driver of productivity change in the Central and Eastern European banks is the technological improvement. As meta-analysis revealed, the choice of particular approach of describing the banking production process is determined not by the availability of particular input or output variable information but the concepts of researcher's theoretical considerations. Statistical tests and density analysis indicate that efficiency scores, returns parameters and productivity indexes are sensitive to the choice of particular approaches.

Key words: DEA, negative data, undesirable output, banking, transition economy, bootstrapping, kernel density analysis

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CHAPTER ONE: INTRODUCTION

In May 2004, ten countries, primarily from Central and Eastern Europe (CEE), joined the European Union. While two new member states, Cyprus and Malta, have long histories of being financial centres with well-developed banking environments. Eight post-communist new member countries have had to make major strides in establishing functioning market economies and changing their financial systems to catch up with EU levels. The transformation of the CEE countries and the development of their banking systems has attracted considerable attention in terms of highlighting the need to better understand the competitiveness and the efficiency of financial institutions in the process of financial integration and convergence in the EU. That is, since the banking sector plays an important role in financial systems, its 'stability' is crucial for the overall 'systemic stability' in the country and given the high economic cross-border repercussions of any instability, for the stability in the entire region itself. Hence, in this thesis I aim to investigate the efficiency and productivity of banking systems in the CEE region with particular focus on risk management.

The banking markets of the CEE countries[1] have undergone significant restructurisation, moving away from a socialistic system to a market one. In the process of this restructurisation the 'monobank' system was broken down and a two – tier banking system was established. During the initial stages of the transition the weak legacy of the banking system reforms, poor supervisory environment and the mismanagement of the banking privatisation programme led to banking crises in the region. However, throughout the transition, the supervision and regulation of the banking sector was gradually improved and the banking system strengthened, thus leading to financial deepening in the economy and an increased profitability in the sector. The discussion of the banking sector development in CEE countries in more detail with particular focus on the historical background of the banking systems, the restructuring and establishment of a two – tier banking system, the banking crises, a status check of the current health of the banking system and a comparative analysis of

[1] For the purpose of the thesis, the CEE region is taken to be comprised of the following thirteen countries: Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, the Moldova, Poland, Romania, Russia, Slovakia, Slovenia and Ukraine.

the macroeconomic and banking sector indicators for the countries of Western Europe and the CEE is presented in the Chapter 2 of the thesis.

The aforementioned changes in the CEE banking market, as well as increasing interest in the financial and economic development of the region among academics and practitioners, motivates the examination of banking efficiency and productivity in these CEE transition economies. However, the first hurdle that such as analysis faces is the difficulty of modelling banking production processes not only because of "the usual difficulties in studies of this kind, such as measuring "input" properly, but raise even more difficult questions concerning concepts of output" (Speagle and Kohn, 1958, p. 22). Several input/output approaches are suggested in the literature, nevertheless there is no consensus among them. I employ a meta-analysis tool to examine whether the choice of approach of inputs and outputs definitions in the banking efficiency literature are primarily conceptual and based on theoretical considerations (Chapter 3).

In Chapter 4, I propose an undesirable output framework to construct the banking production process where the banking risk is the undesirable by-product. In doing so, I classify 'bad' output production modelling into two categories, technological and behavioural, depending on the relationship between desirable and undesirable outputs. In the context of the behavioural origin of undesirable output, I focused on banking production and extended the three-stage DEA procedure suggested by Pastor (1999a) to decompose undesirable output in banking (risk) into endogenous and exogenous components. In the proposed models, I also impose the axiom of weak disposability of undesirable outputs (see Färe, Grosskopf, Lovell and Pasurka (1989)) and the relevant concepts of efficiency incorporate a range directional distance function approach following Silva Portela, Thanassoulis and Simpson (2004) to handle unrestricted data, i.e., both negative and non-negative values. To reduce the effect of slacks on the efficiency measure, I estimate the non-radial Russell measure of output technical efficiency.

Since I utilise three alternative input/output methodologies, namely Intermediation, Production and Profit/Revenue based approaches, I perform a comparative analysis of sensitivity of the efficiency measures and provide an analysis of the reported returns to scale to the choice of the input/output approach adopted in Chapter 5. Along with the distribution and inter-distribution mobility analysis of efficiency scores across alternative approaches proposed by Tortosa-Ausina (2002a), I estimate and statistically compare the distributions of estimated efficiency scores using the Kolmogorov-Smirnov and Wilcoxon-Mann-Witney tests, as suggested by Banker and Natarajan (2004), and the distributions of the *true* efficiency scores utilising the bootstrap-based Simar-Zelenyuk-adapted-Li test (Simar and Zelenyuk, 2006).

Another contribution of the thesis is the proposition of a Luenberger productivity index applicable to the technology where the desirable and undesirable outputs are jointly produced and are possibly negative (Chapter 6). Moreover, the chapter proposes a decomposition of the technological shift and the efficiency change components of Luenberger productivity index into factors determined by environmental effects, risk management effects and the technology adjusted for the risk and environment. In addition, I statistically assess the sensitivity of the Luenberger productivity indexes to the choice of the modelling methodology using statistical tests and both univariate and bivariate kernel density analysis.

The last chapter, Chapter 7, concludes the thesis, summarises contributions and achievements, and then outlines areas for further work. And, I hope you will enjoy reading this thesis as much as I enjoyed the research which it describes.

CHAPTER TWO: BANKING SECTOR DEVELOPMENT IN CENTRAL AND EASTERN EUROPE

2.1. Introduction

It is well known that the stable and efficient banking system forms a key factor in the economic development of a country due to the particularly important role of external finance providers in financial systems: banks direct savings to investment opportunities; they form a significant component of the corporate governance mechanism of organisations and they provide payment and clearing systems (media of exchange). Therefore, successful transition from rigid state control to a free market system requires a strong and well-functioning banking system where savers and investors have confidence in the financial system, and in banks, in particular, as they are a repository for their funds.

Over the past one and half decades, Central and Eastern European transition Countries (CEEC) have made tremendous progress in integrating with the world economy. Financial systems of CEEC have undertaken substantial efforts to build a new financial infrastructure under the constraints of the legacies from central planning, while the new conditions created by the transition process policies. Banking reforms in these countries were an integral part of restructuring the economy to establish market forces and sustain economic stability and growth. However, in the initial stages of the reforms, the economies of these countries experienced several severe financial crises, due both to the absence of effective regulatory and legal structures, and corporate distress. Nonetheless, the crises have accelerated the privatization process in the banking industry and foreign penetration into the banking market (Yildirim and Philippatos , 2003). Given the fact that, of the countries analysed, eight Central and Eastern European ones (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia), featured among the earliest and swiftest economic and banking reformers and later became members of the European Union in May 2004, it is particularly interesting to trace and compare the developments of their banking systems with banking systems of other analyzed CEE countries.

Thus, the analysis in this chapter focuses on a comparative discussion of the CEE countries' banking systems development processes. In particular, in the next section (Section 2.2) I look at transformation process of the banking systems, providing details of their historical background, the establishment of a two–tier banking system and the restructuring process itself. Section 2.3 discusses the banking crises (both systemic and borderline/smaller (non-systemic) banking crises) these CEE countries experienced. Section 2.4 gives a brief overview of the development dynamics of the current CEE countries' banking systems, particularly details on their banking system reforms, the banking privatisation process, the ownership structure of banking system and their financial intermediation activities and profitabilities. In Section 2.5, I analyse and compare the macroeconomic and banking sector indicators for the countries of Western and Eastern Europe. Section 2.6 offers some concluding remarks.

2.2. Transformation process of CEE countries' banking systems

In the late 1980s, most Eastern European countries started transforming from centrally planned economies to market oriented ones. Comprehensive macro – economic programs were undertaken to stabilise the economies of the countries and to introduce a market driven economy. Prior to these reforms, a socialist banking system was, in effect, in all the CEE countries. As a general rule, the socialist banking system consisted, in addition to a Savings Bank, of a monobank which was at the centre of this structure and performed the dual roles of a central bank and a commercial bank. The monobank was responsible for issuing currency, providing savings deposit facilities to households, managing payment system among the enterprises, ensuring that banks granted resources to the enterprises for undertaking their various investment activities and covering the deficits of the State budget. Additionally, there was a group of specialised banks concentrating on the area of economic activity (e.g. industry) and a Foreign Trade Bank which specialised in managing the foreign debt and assets, and the foreign exchange transactions of enterprises. However, credit granting in these banks was based on central plan decisions and political priority rather than on credit risk analysis, efficiency and profitability considerations as would be the case in banks operating in a market economy. In other words, banks in socialist banking system performed the role of government agencies. Moreover, the monobank acted as the Treasury of the state and was the sole source of credit for the economy (Thorne 1993, Yildirim and Philippatos, 2003).

After the collapse of the Communist regime in the late 1980s and early 1990s, the banking system of CEE countries started to change rapidly, in consequence of political opening and the introduction of market forces. At the onset of transition, schemes for restructuring the banking system were introduced. The key element of the banking restructuring reforms typically consisted of the introduction of a new regulatory and supervisory framework. The first aspect of the restructuring reforms was implemented by introducing a new central bank with the introduction of new banking laws, i.e. the breaking up of the monobank system to establish an independent central bank and set up a two-tier banking system with separate functions for the central bank and commercial banks. Table 2.1 presents main historical episodes of CEE countries' banking systems and covers the break-up of the monobank and establishment of a two-tier banking system, and introduction of national currency as the sole legal tender.

Table 2.1. Main historical episodes of CEE countries' banking systems

Country	New central banks law	Major amendments of central bank law	National currency adopted (sole legal tender)
Croatia	Nov 1992	Apr 2001 (U)	Jan 1992 May 1994
the Czech Republic	Dec 1992		
Estonia*	Mar 1990	May 2003(U)	Jun 1992 Jun 1992
Hungary	Oct 1991	2001 (U)	
Latvia*	Mar 1990	May 1992 (U)	May 1992 Jul 1992
Lithuania*	Feb 1990	Mar 1996 (U)	May 1992 Oct 1992
Moldova*	Jun 1991	Jul 1995 (U)	Jun 1992 Jul 1993
Poland	Jan 1989	1997 (U)	
Romania	Mar 1991	May 1998 (U)	
Russia*	Dec 1990	June 2002 (U)	Jul 1993 Jul 1993
Slovakia	Dec 1992 (D)		
Slovenia	Jun 1991	July 2002 (U)	
Ukraine*	Mar 1991	May 1999 (U)	Nov 1992 Nov 1992

Source: Maliszewski (2000), Croatian National Bank, Eesti Pank (Estonian central bank), Magyar Nemzeti Bank (the central bank of the Republic of Hungary), Bank of Russia.

Note: (U) – central bank independence upgraded, (D) – central bank independence reduced.

* In former Soviet Union countries, Soviet monobank system formally changed into two-tier banking system, consisting of Gosbank (State Bank of the USSR) and a number of specialized state-owned banking institutions in 1987. Dates on 'New central banks law' for these countries are dates of establishing of country's own independent central bank.

In most countries, the establishment of a two-tier system was an essential part of the macroeconomic stabilisation process. Although the countries of Central Europe took the lead in establishing independent central banks, closely followed by Baltic and CIS countries; Czech Republic, Hungary, Poland, Slovak Republic and Slovenia stabilized their economies at the start of the banking reform process. Their relative success in banking reforms was helped by a mixture of good policies and favourable initial conditions (see Maliszewski, 2000 and De Melo et al, 1997). Since Hungary and Poland were on the fast track to join the EU, they upgraded their central banks independence to meet the Maastricht criteria. Although the first years of the existence of Croatia and FYR Macedonia (former Yugoslav Republic), were marked by military conflicts and high inflation, Croatia achieved macroeconomic stabilisation without institutional changes. The new central bank law was introduced in 1991 in Romania, and in 1998, as part of the new government reform program, changes to the central bank law were introduced.

The banking systems and central banks of Countries of Commonwealth of Independent States (CIS) were initially restricted by the existence of the Rouble zone. The Baltic countries introduced their currencies first and left the monetary union. Other countries of the CIS subsequently introduced their own currencies, and upgraded their central banks' independence. In most CEE countries, the economy was more or less stabilised after leaving the rouble area, and central bank independence was used as an instrument to improve the credibility of their new policies (Maliszewski, 2000).

Table 2.2 presents GMT[2] indices of political and economic independence based on the central bank laws of the CEE countries. Components of the Political Independence (PI) index are G1 'Governor not appointed by the government', G2 'Governor appointed for more than 5 years', G3 'Provisions for governor's dismissal non – political only', B4 'None of the board appointed by the government', B5 'Board appointed for more than 5 years', R6 'No mandatory government representative in the board', R7 'Government approval of monetary policy is not required', C8 'Statutory responsibility to pursue monetary stability', C9 'Presence of legal provision

[2] GMT index is the central bank independence index (proxy for actual independence) calculated using Grilli, Masciandaro and Tabellini (1991) methodology.

supporting bank in conflicts with the government'. Economic independence of central bank (EI) index consists of the following eight components: D10 'Direct credit facility is not automatic', D11 'Direct credit facility is at the market interest rate', D12 'Direct credit facility is temporarily', D13 'Direct credit facility is of limited amount', D14 'Central bank does not participate in the primary market', D15 'All direct credit is securitized', M16 'Discount rate is set by the central bank', M17 'Supervision of commercial banks is not entrusted to the central bank (2 points) or not entrusted to the central bank alone (1 point)'. Each component is counted as one point. The measure of overall independence is obtained by summing the two sub – indices.

Table 2.2. Aggregate indices of political (PI), economic (EI) and overall (OI) independence of CEE countries' central banks

Country	Political independence (PI) (max 9)	Economic independence (EI) (max 9)	Overall independence (OI) (OI = PI + EI) (max 18)
Lithuania'96	8	7	15
Poland'97	7	7	14
Moldova'95	8	5	13
Estonia'93	6	7	13
the Czech Republic'92	8	5	13
Latvia'92	9	3	12
Croatia'92	7	4	11
Russia'95	5	6	11
Slovakia'92	5	6	11
Slovenia'91	7	4	11
Hungary'97	3	7	10
Romania'91	4	3	7
Ukraine'91	3	2	5

Note: The year attached to the country is the year of the latest enactment or amendment referring to.
Source: Maliszewski (2000)

During the banking system reforms, the licensing policy for most kinds of banking business was liberalised, sectoral restrictions on specialised banks were lifted and privately owned banks were established. However, quite liberal licensing policies coupled with shortcoming in the legal framework and supervisory system resulted in a very rapid increase in the number of banks (Table 2.3) which often engaged in unsound operating practices (Reininger, Schardax and Summer, 2001). These deficiencies together with an uncertain economic environment resulted in a number of banking crises which are described in the next section.

Table 2.3. Number of banks in the banking sector of CEE countries (1995 – 2003)

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003
Croatia	54	58	60	60	53	43	43	46	41
the Czech Republic	55	53	50	45	42	40	38	37	35
Estonia	18	15	12		7	7	7	7	7
Hungary						40	39	37	36
Latvia	42	35	32		24	22	23	23	23
Lithuania	15	12	12		15	14	13	14	15
Moldova	25	22	22	23	20	20	19	16	16
Poland	81	81	81	83	77	73	69	59	58
Romania						41	41	39	38
Russia	2297	2029	1697	1476	1349	1311	1319	1329	1329
Slovakia	33	29	29	26	25	23	21	20	21
Slovenia	41	36	34	34	31	28	24	22	22
Ukraine	230	229	227	175	161	154	152	157	158

Source: EBRD (2003, 2004), Croatian National Bank web-site, Czech National Bank web-site, National Bank of Poland web – site, National Bank of Slovakia web-site, Bank of Slovenia

2.3. Banking system crises in Central and Eastern Europe

As discussed in the previous section, the creation of a capitalist banking system in the CEE countries began with the formation of a two-tier banking system, where the commercial banking wing of the monobank was broken up into a number of state-owned commercial banks. However, these artificially established banks inherited many problems from central planning, such as old bureaucratic networks, capital inadequacy, non – performing loans to State Owned Enterprises (SOEs), non – diversified loan portfolios of unknown quality, loans from the savings bank or the central bank, inexperienced management and personnel, and underdeveloped branch networks. In some countries restrictions on the establishment of new banks were relaxed, and in others organization of new banks was encouraged to enhance competition. As a result, given the poor supervisory environment and the low qualifications of banking staff, these newly created banking institutions with so little genuine banking experience made many inefficient decisions. Moreover, most of banks were still under the state ownership and lent to the state-owned industries, which became an important source of inflationary pressure during the early phase of transition. Consequently, many of these CEE countries experienced severe banking crises due to the reasons stated above as well as delays in enterprise restructuring, failure to develop a well – functioning capital market, mismanagement of privatization programmes, a lack of proper banking regulations and speculative acquisitions and mergers. Table 2.4 gives details on the date, type, causes, scope and estimated losses and costs of the banking crises that the CEE sample countries experienced.

Most of banking crisis in CEE countries had little or no cross-boarder repercussions. However, the Russian crisis of August 1998 was at least one event in the history of the region which had major sub-regional, if not regional implications (Grigorian and Manole, 2006). Although, the Russian crisis revealed the weaknesses of the Russian economy and was a major adverse shock to the banking sector and the economy of Russia as a whole, it had adverse effects on the economies of the entire region. The direct effects of the Russian crisis on the financial sector were most notable in the CIS countries, and some of them were perhaps hit almost as hard as Russia itself. The CEE and Baltic countries were affected much less since, by then, they had reoriented most of their trade toward Western Europe.

Table 2.4. Banking system crises in Central and Eastern Europe

Country	Crisis Episode	Type of crisis	Causes of crisis	Scope of Crisis	Estimated losses/costs
Croatia	1995	S	Five banks accounting for about half of banking system loans were deemed insolvent and taken over by the Bank Rehabilitation Agency		
	1998 -99	S	Non-performing loans, inadequate loan loss provisioning and irresponsible competition for deposits	16 banks	
Czech Republic	1991 - 1995	S		Several banks have closed since 1993. In 1994–95, 38 percent of banking system loans were nonperforming	Through 1994, 12 percent of GDP was spent on bank support.
	1997	S	Speculative capital inflow; political and financial currency crisis	Unsustainable exchange rate, current account deficit, tough budget	
Estonia	1992 – 93	S	Strong initial transition recession, increase of minimum capital requirements, external factors	Three largest commercial banks, accounting for almost a third of the combined balance sheet of the banking sector at the time of crisis, plus a number of smaller banks	1.9 per cent of GDP
	1994 – 95	S	Connected lending practices, withdrawal of state accounts from Social Bank	Social Bank (Estonia's largest bank at the time of crisis)	
	1998	B		Three banks failed in 1998: Maapank (Agricultural Bank), which accounted for 3 percent of banking system assets, and two smaller banks: EVEA and ERA	Maapank's losses reached USD 500 million.
Hungary	1991 – 95	S		8 insolvent banks accounting for	Resolution costs estimated to total 10

				25 percent of financial system assets	percent GDP
Latvia	1995	S	Bank Baltija: aggressive and risky commercial bank expansion strategies; Other loss-making banks: requirement to release IAS-based financial statements	Bank Baltija: largest commercial bank, holding 30% of all bank deposits; and about a dozen other loss-making banks, comprising 20% of deposits of sector	2.7 per cent of GDP
Lithuania	1995 - 96	S	Larger banks: high-risk lending operations, unrestructured economic activities Smaller banks: tightening of prudential regulations	Affected larger banks accounted for two thirds of all commercial banking assets	3.1 per cent of GDP
Poland	1990s	S		7 out of 9 state – owned banks fail with 90 percent share of financial system assets	1993 recapitalisation costs USD 750 million, and USD900 million for the Bank for Food Economy and cooperative sector, for total equivalent to 2 percent GDP
Romania	1997 – 99	S	Insolvency of Credit Bank and Dacia Felix Bank in 1995; Increase of non-performing loans in 1996; Lack of creditworthiness of many recipient firms; Political handicap	Two largest commercial banks (Banca Agricola and Bancorex)	
Russia	1995	S	Liquidity problems	Interbank loan market fails	
	1998	S	Sharp fall of energy and raw material prices (1997 – 98), deterioration of Russia's external accounts, Asian crisis, withdraw from GKO market, political instability.	Default on the internal debt and the evaluation of the ruble on August 17; nearly 720 banks, which accounted for 4 percent of sector assets and 32 percent of retail deposits, were deemed insolvent. According to the Central Bank, 18 banks holding 40 percent of sector assets and 41	Aggregate banking capital shrank from USD 19.1 billion (end July'98) to USD 3.7 billion (end Dec'98) In 1999 bailout costs were estimated at $15 billion, or 5–7 percent of GDP.

				percent of household deposits are in serious difficulties and will require rescue by the state Impacted the most countries of CIS	
Slovakia	1991 -			In 1997 unrecoverable loans were estimated at 101 billion crowns, or about 31 percent of loans and 15 percent of GDP.	
Slovenia	1992 -94	S		Three banks, accounting for 2/3 of banking system assets, were restructured	Recapitalisation costs USD 1.3 billion
Ukraine	1997 – 98	S	Bad loans accounted for 50–65 percent of assets even in some leading banks. In 1998 banks were further hit by the government's decision to restructure government debt	By 1997, 32 of 195 banks were being liquidated, while 25 others were undergoing financial rehabilitation.	

Note: S – Systemic banking crises, B – borderline and smaller (nonsystemic) banking crises[3]
Source: Gorton and Winton (1998), Central Banking in Czech Republic (1999), Barisitz (2000, 2001, 2002), Reininger and Walko (2005), Caprio and Klingebiel (2003).

[3] The definitions of systemic and borderline and smaller (nonsystemic) banking crisis are as in Caprio and Klingebiel (2003).

2.4. Development dynamics of current banking systems of CEE countries

In the previous sections I reviewed the historical developments of the banking sectors of the CEE countries, focusing on the key historical episodes of their banking industries and their banking crises. In this part of the analysis, I provide a detailed overview of the key regional trends of the banking sectors in the CEE countries, particularly privatisation and ownership structures, market concentration, lending structures and financial intermediation.

Definition of country sub-groups

With the purpose of facilitating the analysis I have divided the 13 CEE countries' banking systems into three sub-groups: the accession countries, the negotiating countries and the CIS countries. Although by categorizing the countries into these subgroups, I reflect their stage of integration with the European Union, the degree of development of their banking sector and their geographical aspects are also taken into account.

The sub – groups I refer to are defined as follows: *Accession countries* (AC), which includes eight new EU members that joined in May 2004, (Czech Republic (CZ), Estonia (ES), Hungary (HU), Latvia (LV), Lithuania (LT), Poland (PL), Slovakia (SL) and Slovenia (SN)). In the analyzed region, these countries are clearly the most advanced in terms of legal and institutional reforms. *Negotiating countries* (NC), these are countries that were in the process of negotiations to join the EU (Croatia (CT) and Romania (RM)).[4,5] Finally, *Commonwealth of Independent States* (CIS), these are the former Soviet republics which are the neighbouring countries of an enlarged EU and who have suffered through severe recessions caused by the transition from planned economies (Russia (RF), Moldova (ML) and Ukraine (UN)).

[4] Although, Romania joined the EU in the second wave on the 1 Jan 2007, it is included in the analysis as a negotiating country.

[5] Due to data limitation, other acceding and negotiating countries are not considered. However, similarity of these countries include problems due to high growth of consumer loans, which affected the health of external balance and resulted establishing of restrictive measures by central banks (RZB Research Group, 2004).

Banking system reforms: EBRD index

Reforms of the banking sector are at different stages in these countries. Although, in general the banking system of the CEE countries has developed significantly over the past years, for some discussed countries there are still many challenges ahead (for example for the countries of CIS sub-group). Table 2.5 exhibits the progress of the analysed countries in developing their banking systems as for 2004.

Table 2.5. Banking system development ranking

CEE countries' Banking System Reform Index	
Rating	Country
1. Little progress beyond establishment of a two-tier system	
2. Interest rates significantly influencing the allocation of credit	Russia (2), Ukraine (2+)
3. Substantial progress in recapitalizing banks, bank auditing, establishment of a functioning prudential and supervisory system; significant presence of private banks; full interest rate liberalisation	Lithuania (3), Moldova (3-), Poland (3+), Romania (3), Slovenia (3+)
4. Well-functioning banking competition and prudential supervision	Hungary (4), Latvia(4-), Slovakia (4-), Croatia (4), Czech Republic (4-), Estonia (4)

Source: EBRD (2004)

According to the EBRD index of the banking system reforms, all the analysed CIS countries are classified around 2 (except Moldova 3-); most of the accession countries get index values of around 4. Ranking 3 classification contains countries from each sub-group, whereas accessed countries have ranks 3+ (Poland and Slovenia) and 3 for Lithuania. Negotiating country Romania gets ranking 3. As it was said above, Croatia has a very developed banking system and it is the only country not from Accession countries sub-group which has an EBRD banking system development ranking of 4.

These rankings are evident of the stage of banking sector development in the countries. However, for some countries (e.g. CIS countries) much remains to be done in order to improve the banking system functioning, namely to strengthen the regulatory framework, to increase financial intermediation etc.

Privatisation and foreign ownership

One of the important objectives of the banking system restructuring process in the CEE countries was the privatisation of the banks. According to Thorne (1993), there are three reasons for stressing bank privatisation as the final and most important goal in banking system restructuring of CEE countries[6]. These reasons are connected to each other and are presented in Table 2.6.

Table 2.6. Reasons for stressing banking privatisation in CEE countries

Reasons for stressing banking privatisation in CEE countries		
Adequate corporate structure	Efficient banking system and competition	Influence the banking restructuring strategy
Private ownership of banks provides better incentives to discipline the risk taking behaviour of managers, limits government intervention into the allocation of credit and enhance the incentives to improve monitoring and screening technologies for banks (Reininger, Schardax and Summer, 2001). Therefore, recapitalisation of the banks and a transfer of ownership to the private sector is the only way of assuring an adequate corporate governance structure based on an appropriate system of risk and rewards.	For the banking system to operate efficiently, in the sense that good banks will dominate the system and bad banks will be competed out of the system, a sufficient number of banks with adequate corporate structure is required. Privatisation is a way to increase the number of banks with such appropriate corporate structure.	The privatisation of state – owned banks influences the chosen restructuring strategy. In other words, the authorities should take into account the fact that 'the recapitalisation of a state owned bank only has the benefit of making explicit something that was implicit by its condition of being state – owned: that the state is responsible for the banks non – performing loans and the income loses that might be generated there of' (Thorne, 1993, p.987). Therefore, in most cases of bank privatisation, the main objective of any privatisation strategy which is to maximise the present discount value of the assets subject to being privatized, may not hold.

The privatisation process in the CEE countries was aimed to break down the discredited institutions of state ownership and to promote private ownership. In other words, the privatisation of the banking systems in the CEE countries was designed to eliminate the inappropriate incentives to bank management and enhance competition as well as attract capital injections and increase efficiency of banks through transferring ownership rights from the public to the private sector[7]. Table 2.7 shows the dynamics of the reduction of the market share of state – owned banks in the analysed countries.

[6] Thorne (1993) pointed out three reasons for stressing bank privatisation, which are described further. However, the general titles of these reasons are given by me.
[7] However, as previous sections discussed, the outcome of private ownership may not necessarily be efficient.

Table 2.7. Market share of state-owned banks
(in % of total assets of banking system)

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003
Croatia		78.4	41.9	43.1	45.6	5.7	5.0	4.0	3.0
the Czech Republic					38.5	24.3	3.7	4.5	3.1
Estonia	28.9	14.8	12.5		7.9	0	0	0	0
Latvia	9.9	6.9	6.8		2.6	2.9	3.2	4.0	4.1
Lithuania	61.8	54	48.8		33.6	28.6	8.3	0.1	0.1
Moldova				0.3	7.9	9.8	10.2	13.4	15.5
Poland	63.0	51.1	38.2	36.7	22.1	21.1	21.7	22.9	22.3
Romania					50.3	46.1	41.8	40.4	41.5
Russia			37	41.9			32.4	31.6	31.7
Slovakia					62.2	59.4	9.5	4.4	1.5
Slovenia							40.7	24.9	
Ukraine			13.5	13.7	12.5	11.9	11.8	12	9.8

Source: EBRD (2003, 2004), Croatian National Bank web-site, Czech National Bank web-site, National Bank of Poland web – site, National Bank of Slovakia web-site, Bank of Slovenia, RZB Research Group, 2004

Although progress in bank privatisation differs among the CEE countries, in most countries the privatisation process (precisely, the mode of privatisation namely tender and direct sales to foreign banks) encouraged foreign participation in the CEE countries banking sector. Foreign participation in the banking sector was considered as a mode to enhance competition, transfer know-how in conducting banking business and improve screening and monitoring technology and managerial skills.

Figure 2.1 shows the share of foreign ownership in the banking sector's equity in 2002. Most accession countries and negotiating countries have a high degree of foreign ownership, which resulted not only from privatisation, but also from the establishment of new banks. The market share of foreign banks in the CIS counties' banking systems remains rather low.

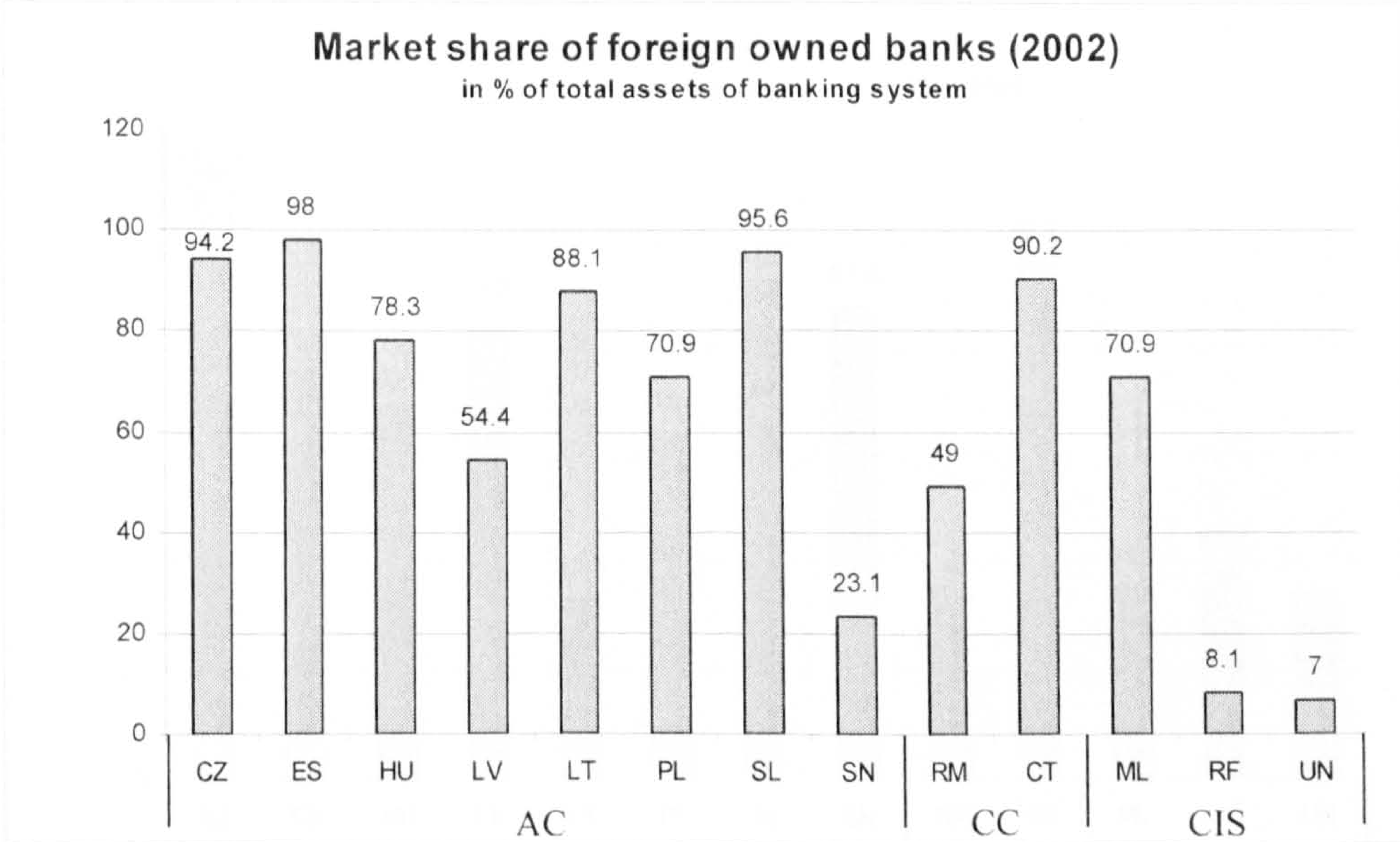


Figure 2.1. Market share of foreign owned banks in CEE countries.
Source: IMF, RZB Research Group, 2004, Central Bank of the Russian Federation,

Size and concentration of the banking sector

The sizes of the banking sectors of the CEE countries varies substantially, both in absolute value (measured in EUR mn.) and relative to the countries' GDPs (Figures 2.2 and 2.3). For example, Figure 2.3 suggests that the size of the banking sector in the Russian Federation, Czech Republic and Poland are, obviously, the largest among the discussed countries, as the economies of these countries are large. However, according to Figure 2.2, the variation of the size of the banking sector, relative to the size of the economy, does not have a corresponding correlation with the size in absolute terms. Accordingly, the CIS countries along with the accession country Lithuania and the negotiating Romania, have banking sectors sized less than 40% of their GDP levels. The banking sectors in the Czech Republic, Slovakia and Croatia, compared to their GDPs, are relatively large and their sizes exceed 90% of the countries' economies.

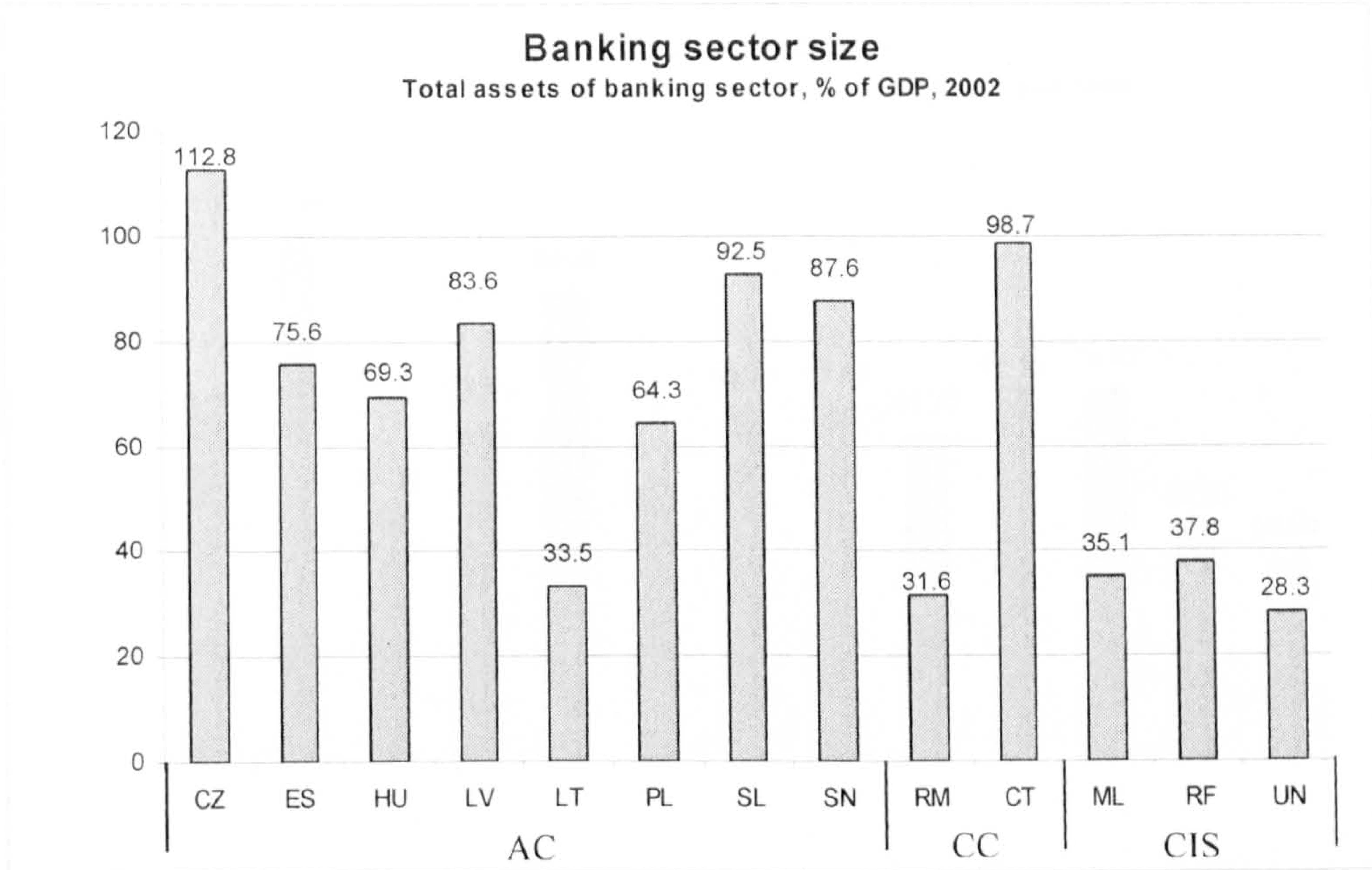


Figure 2.2. Banking sector size in CEE countries (as % of GDP)
Source: RZB Research Group, 2004, National Bank of Moldova

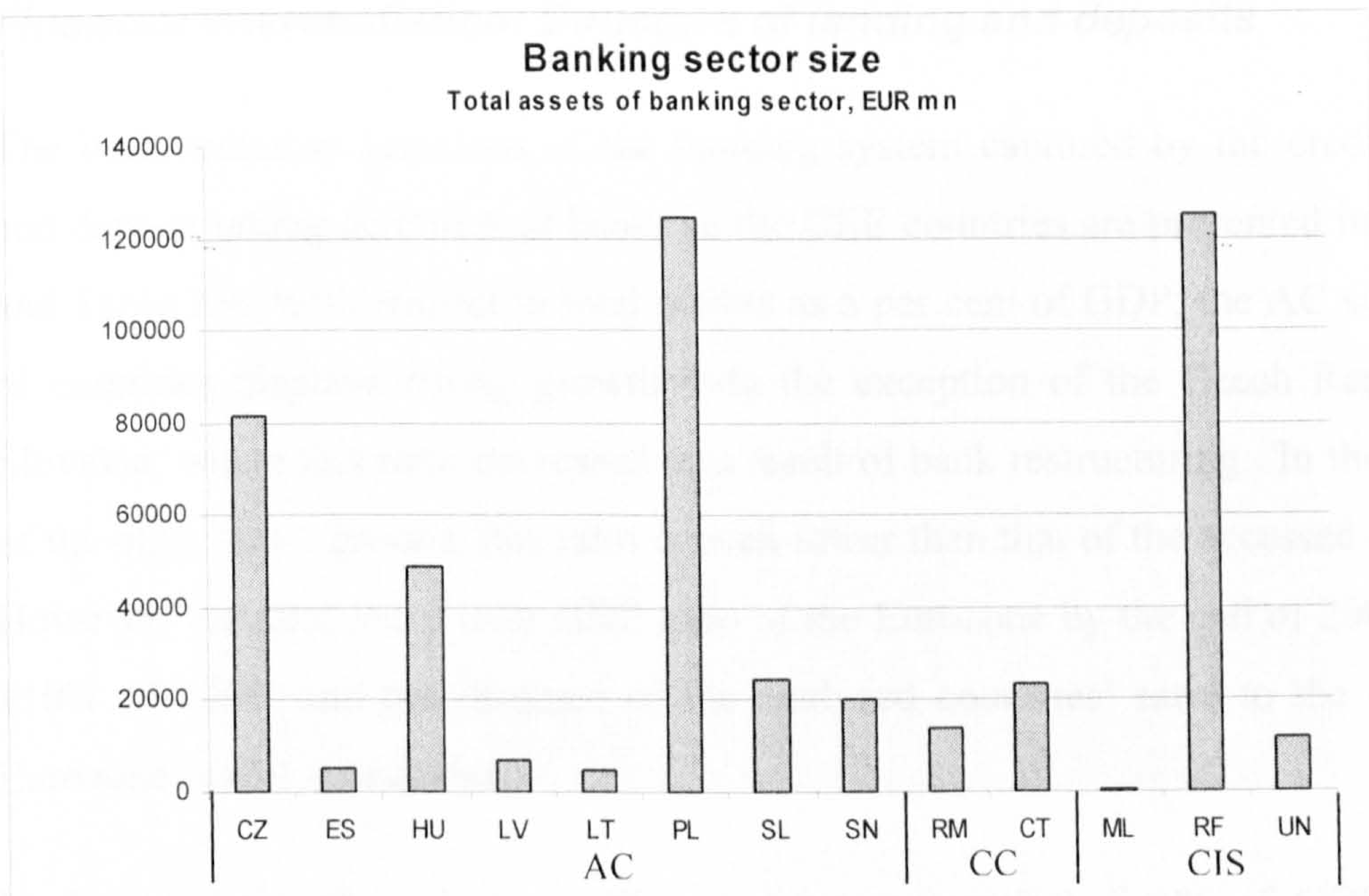


Figure 2.3. Banking sector size in CEE countries (EUR mn)
Source: RZB Research Group, 2004, National Bank of Moldova, own estimations

Usually, market concentration is higher in small countries, and therefore it is more meaningful to compare CEE countries across their peers among the sub group (Figure 2.4). Accordingly, in AC sub-group Baltic countries Estonia and Lithuania display the highest market concentration, while the Poland and Hungary – the least, and in the CIS sub-group Moldova has a highly concentrated banking sector while low market concentration is found in the Ukraine and Russia. Market concentration in the negotiating countries is also relatively high.

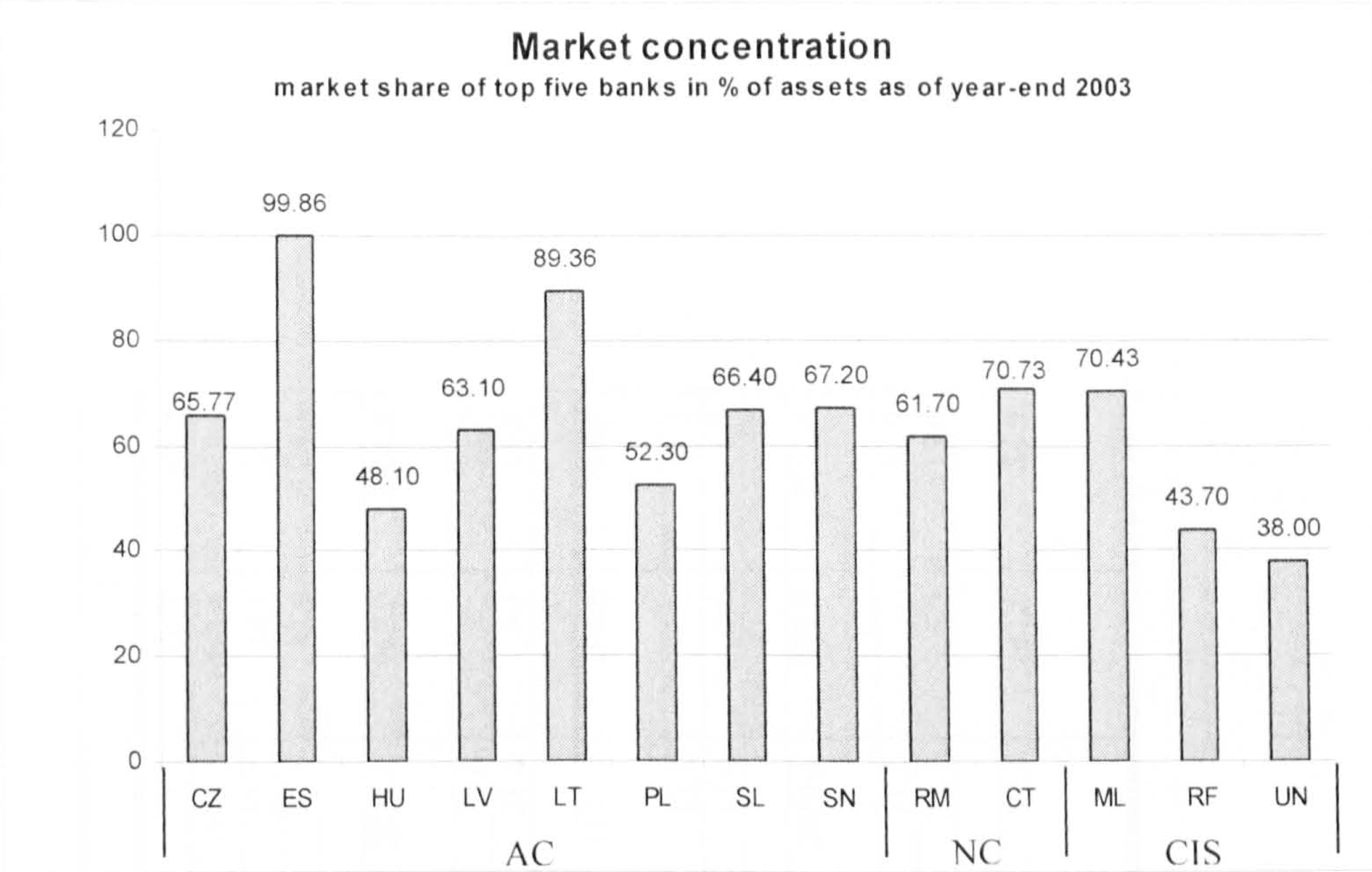


Figure 2.4. Market concentration of banking sector in CEE countries
Source: IMF, RZB Research Group, 2004

Financial intermediation: Structure of lending and deposits

The intermediation functions of the banking system captured by the credit delivery and deposit taking activities of banks in the CEE countries are presented in Table 2.8 and Table 2.9. With respect to total credits as a per cent of GDP, the AC sub – group of countries displays strong growth with the exception of the Czech Republic and Slovakia, where this ratio decreased as a result of bank restructuring. In the countries of the other sub – groups, this ratio is even lower than that of the accessed countries'. However, the total loans over GDP ratio of the Eurozone by the end of 2003 reached 110% of GDP, and the distance of the analyzed countries' ratio to the one of the Eurozone is still substantial.

In the structure of lending, credits to private enterprises (in % of GDP) strongly increased over the last years. The consumer loans segment of lending activity, the most dynamic field of banking in the CEE countries, displayed high growth rates in terms of EUR and % of GDP. However, the Eurozone ratio of credits to households over the GDP ratio by the end of 2003 was 49%, and again it is indicative of the substantial difference between these figures in the analyzed countries and Eurozone. The dynamics of deposit services in the CEE countries' banking systems shows much more moderate development (Table 2.9). Total deposits as a percent of GDP ratio has increased in all the discussed countries. The difference between this figure for the Eurozone (55% - 2003) is smaller than that of the credit categories.

Table 2.8. Structure of lending activity in CEE countries

	CT		CZ		ES		HU		LV		LT	
	2000	2003	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003
Total credits, EUR mn	7944.4	14433.8	24072.7	26635.1	1696.1	4405.6	11367.3	26107.8	1122.9	3790.2	1473.8	3921.3
growth in % yoy	10.1	11.6	-6.1	5.1	9.5	28.7	21.6	16.9	31.8	27.7	34.4	51.7
in % of GDP	39.6	58.1	45.7	35.8	34.8	59.3	25.1	37.2	16.9	43.3	13.9	24.7
Credits to private enterprises, EUR mn	2983.1	5394.6	17633.1	10588.2	944.1	1490.4	9313.4	16692.7	907.9	2524.4	962.0	2504.0
growth in % yoy		5.9	-8.4	-3.0	-2.0	20.2	20.1	6.8	26.2	20.6		51.7
in % of GDP	14.9	21.7	33.5	14.2	19.3	20.1	20.5	22.8	13.6	28.8	9.1	15.8
Credits to households, EUR mn	3066.2	7192.6	2112.4	6494.2	344.6	1229.6	1845.5	8864.2	162.4	1135.3	164.6	534.5
growth in % yoy		24.3	18.8	31.1	26.3	48.0	32.9	42.5	68.2	63.8		51.7
in % of GDP	15.3	29.0	4.0	8.7	7.1	16.6	4.1	12.1	2.4	13.0	1.5	3.4
Credits in foreign currency, EUR mn	834.4	1316.2	6775.9	3819.3	1297.3	3604.3	3208.8	6535.1	622.0	2019.6	907.8	2152.8
growth in % yoy		-6.1	-4.8	-6.9	11.5	36.6	28.9	27.3	39.1	31.2		63.0
in % of GDP	4.2	5.3	12.9	5.1	26.6	48.6	7.0	8.9	9.3	23.1	8.5	13.6
Credits in foreign currency, in % of total credits	10.5	9.1	28.1	14.3	76.5	81.8	28.2	25.0	55.4	53.3	61.6	54.9

(continued)

	PL		RM		RF		SL		SN		UN	
	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003
Total credits, EUR mn	39955.9	49346.2	3148.7	7368.8	21917.4	79246.2	9671.2	9768.8	7019.4	10640.6	2249.3	10182.1
growth in % yoy	22.5	-8.8	-31.9	44.0	29.5	29.3	5.3	16.0	19.9	12.2	20.0	34.0
in % of GDP	27.1	28.6	11.1	16.0	13.1	21.7	48.6	33.6	38.1	44.4	9.0	38.1
Credits to private enterprises, EUR mn	18297.2	22896.3	2402.5	4366.3	16349.2	62628.5	7183.6	5252.4	5147.1	8321.1	2118.4	8833.1
growth in % yoy	24.9	-10.8	-28.8	20.8	37.8	28.6	3.0	4.9	19.9	13.2	20.1	26.2
in % of GDP	12.4	13.3	8.4	9.5	9.8	17.2	36.1	18.1	27.9	34.7	8.5	22.4
Credits to households, EUR mn	13754.8	21613.2	160.1	1824.4	3945.6	11374.6	846.6	2067.8	1872.3	2319.5	130.9	1348.8
growth in % yoy	36.0	-3.2	-32.4	204.8	1.0	35.1	38.2	40.7	19.7	8.9	17.1	125.3
in % of GDP	9.3	12.5	0.6	4.0	2.4	3.1	4.3	7.1	10.2	9.7	0.5	3.4
Credits in foreign currency, EUR mn	6576.9	8643.8	1553.2	3313.9	11167.7	26766.0	1422.6	1985.4		2996.0	1090.8	5938.4
growth in % yoy	12.3	-2.0	-32.4	29.9	-5.3	19.0	6.1	38.0		30.1	0.9	34.3
in % of GDP	4.5	5.0	5.5	7.2	6.7	7.3	7.2	6.8		12.5	4.4	15.0
Credits in foreign currency, in % of total credits	16.5	17.5	49.3	45.0	51.0	33.8	14.7	20.3		28.2	48.5	58.3

Source: RZB Research Group, 2004, pp. 17, 19, 21, 23, 25, 27, 29, 31, 35, 37, 45, 47.

Table 2.9. Structure of deposits of CEE countries' banking system

	CT		CZ		ES		HU		LV		LT	
	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003
Total deposits, EUR mn	7303.5	16085.5	28333.7	46299.9	1687.8	3415.3	30799.1	54797.1	1060.5	2471.1	1857.6	4920.1
growth in % yoy	-8.9	6.6	-2.9	-0.3	22.9	9.6	13.6	11.4	21.6	16.5	30.8	26.0
in % of GDP	39.6	64.8	53.8	62.3	34.6	46.0	68.1	78.1	15.9	28.2	17.5	31.0
Deposits from households, EUR mn	6221.7	10667.8	18432.4	25557.9	748.4	1502.5	11057.4	17350.4	443.8	1412.8	975.9	2284.7
growth in % yoy	18.1	-1.8	-2.2	2.7	30.7	9.2	12.4	2.1	29.5	17.3	52.7	17.0
in % of GDP	27.3	42.6	35.0	34.4	15.3	20.2	24.5	24.7	6.7	16.1	9.2	14.4
Total deposits, in % of total credits	101.2	111.4	117.7	173.8	99.5	77.5	270.9	209.9	94.4	65.2	126.0	125.5

	PL		RM		RF		SL		SN		UN	
	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003
Total deposits, EUR mn	53396.6	61660.4	6369.0	9795.8	16953.0	52393.8	12038.7	19347.6	9398.4	13919.6	2319.5	9210.9
growth in % yoy	13.9	-11.8	0.5	4.2	39.5	27.3	14.8	4.6	6.7	1.7	32.6	35.1
in % of GDP	36.2	35.7	22.4	21.3	10.2	14.4	60.6	66.6	51.0	58.1	9.3	23.3
Deposits from households, EUR mn	40177.6	45074.4	3329.2	4667.4	11033.7	41932.6	6567.9	7851.6	5131.6	8865.6	824.0	4849.6
growth in % yoy	11.7	-16.5	-0.1	2.9	36.8	32.7	12.3	1.3	9.0	4.9	25.1	39.0
in % of GDP	27.2	26.1	11.7	10.1	6.6	11.5	33.0	27.0	27.8	37.0	3.3	12.3
Total deposits, in % of total credits	133.6	125.0	202.3	132.9	77.3	66.1	124.5	198.1	133.9	130.8	103.1	90.5

Source: RZB Research Group, 2004, pp. 17, 19, 21, 23, 25, 27, 29, 31, 35, 37, 45, 47.

Table 2.10. Average interest rates in the CEE countries' banking system

	CT (HRK)		CZ (CZK)		ES (EEK)		HU (HUF)		LV (LVL)		LT (LTL)	
	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003
Average interest rate spread	9.3	9.8	4.2	3.9	5.4	3.2	3.7	2.5	7.6	2.9	8.5	5.6
average lending rate	13.5	11.5	8.7	5.3	8.6	5.4			13.8	7.2		
average deposit rate	4.3	1.7	4.5	1.4	3.3	2.2			6.1	4.2		

	PL (PLN)		RM (ROL)		RF (RUB)		SL (SKK)		SN (SIT)		UN (UAH)	
	1999	2003	1999	2003	1999	2003	1999	2003	2000	2003	1999	2003
Average interest rate spread	7.4	6.7	20.5	14.6	27.1	15.7	6.4	4.3	6.4	4.5	26.2	10.7
average lending rate	20.3	9.6	65.9	25.4	42.4	21.1	16.9	7.6	14.6	9.3	43.3	17.5
average deposit rate	12.9	2.9	45.4	10.8	15.3	5.4	10.5	3.3	8.2	4.8	17.1	6.8

Source: RZB Research Group, 2004, pp. 17, 19, 21, 23, 25, 27, 29, 31, 35, 37, 45, 47.

Banking sector profitability

In banking, interest spreads drive a wedge between the rate of return to depositors and the financing costs to borrowers and, therefore, it affects the equilibrium between the supply of deposits and the demand for loans. The spread may be interpreted as an indicator of banking sector efficiency taking into account the minimum reserve requirements (Reininger, Schardax and Summer, 2001). But it is also, a major determinant of banking sector profitability. Table 2.10 reports the average interest spread in the discussed CEE countries and gives information about the average lending and deposit rates in the banking system. According to the Table 2.10, in the accession countries, financial intermediation is provided at a lower cost for the real sector of economy, and the interest spread of this sub-group of countries is similar to that of most developed industrial countries where the spreads are usually low. The negotiating countries report higher spreads, and the CIS countries spreads decreased over the last year but still remain relatively high.

Banking sector profitability in the CEE countries was inadequate in recent years. In 1999, some discussed countries' banking sectors suffered losses. The banking industry's Return on Equity (ROA) and Return on Assets (ROA) were even negative (Tables 2.11 and 2.12). Statistics for 2000 – 2003 show a clear improvement in banking profitability.

Table 2.11. Return on assets (ROA) in banking system of CEE countries

	1999	2000	2001	2001	2003
Croatia	0.7	1.4	0.9	1.6	1.6
the Czech Republic	-0.3	0.7	0.7	1.2	1.2
Estonia	1.5	1.2	2.7	1.6	1.7
Hungary		1.1	1.4	1.4	1.5
Latvia	1.0	1.6	1.5	1.5	1.4
Lithuania	0.1	0.4	-0.1	0.9	1.4
Moldova	4.2	7.4	4.3	4.3	4.5
Poland	0.9	1.1	1.0	0.5	0.5
Romania	-1.5	1.5	3.1	2.7	2.4
Russia	-0.3	0.9	2.4	2.6	2.6
Slovakia	-2.27	1.41	1.07	1.2	1.2
Slovenia	0.8	1.1	0.4	1.1	1.0
Ukraine		-0.1	1.2	1.2	1.0

Sources: IMF Country Report No. 05/64 (2005), RZB Research Group (2004) pp. 17, 19, 21, 23, 25, 27, 29, 31, 35, 37, 45, 47.

Table 2.12. Return on Equity (ROE) in banking system of CEE countries

	1999	2000	2001	2001	2003
Croatia	10.6	12.2	13.1	14.6	15.7
the Czech Republic	-5.3	13.1	16.6	27.4	23.7
Estonia	9.4	8.0	20.7	14.7	14.1
Hungary		13.5	17.7	16.2	19.5
Latvia	11.2	18.6	19.0	16.4	16.7
Lithuania	1.1	4.0	-1.1	8.5	13.4
Moldova	18.0	25.0	14.3	16.7	20.3
Poland	12.9	14.5	12.8	5.2	5.9
Romania	-15.3	12.5	21.8	18.8	19.3
Russia	-4.0	8.0	19.4	18.0	17.8
Slovakia	-30.2	9.5	14.4	13.6	12.9
Slovenia	7.7	11.4	4.7	13.0	12.8
Ukraine		-0.5	7.5	8.0	7.6

Sources: IMF Country Report No. 05/64 (2005), RZB Research Group, 2004.

Table 2.13 shows the size of nonperforming loans (for some countries classified loans) relative to the total assets of the banking sector. According to table 2.13, for some countries the current level of nonperforming loans seems to be fairly high (Poland, Slovakia, Slovenia and Ukraine). However, I should bear in mind the difference in the classification of the non-performing and classified loans according to the particular country's banking sector regulation the overview of which is given in Appendix A.

Table 2.13. Non-performing loans (in percent of total loans)

	1999	2000	2001	2001	2003
Croatia*	10.3	9.5	7.3	5.9	5.2
the Czech Republic		10.8	13.4	10.8	6.2
Estonia	1.7	1.0	1.3	0.8	0.4
Hungary		3.0	2.7	2.9	2.6
Latvia*	6.8	4.5	2.8	2.0	1.4
Lithuania*	11.9	10.8	7.4	5.8	2.6
Moldova	29.3	20.6	10.4	7.7	6.2
Poland*	13.7	15.5	18.6	22.0	21.8
Romania		6.4	3.9	2.8	8.3
Russia	13.4	7.7	6.2	5.6	5.0
Slovakia*	36.5	27.9	32.3	21.8	17.7
Slovenia*	11.0	12.4	12.8	13.3	13.6
Ukraine		29.6	25.1	21.9	28.3

Note: * Classified loans in % to total loans
Sources: IMF Country Report No. 05/64 (2005), IMF Country Report No. 04/357, IMF Country Report No. 05/213, IMF Country Report No. 04/316, RZB Research Group, 2004.

2.5. Comparative macroeconomic and banking sector indicators for Western Europe and CEE countries

The objective of this section is to compare the CEE countries economies with the economies of developed countries to look at differences in the size of the financial system, banking activity and macroeconomic indicators. Table 2.14 presents size indicators of the financial system in the CEE countries and the EU member countries: Italy, Greece, Austria and Germany; and the USA. The size of the banking system is measured by the ratio of the banking system's total assets over GDP. Total market capitalisation is the sum of stock market and bond market capitalisation for the transition countries, and stock market capitalisation for the developed countries. The size of non-bank intermediaries is the ratio of the total assets of the insurance sector, pension and investment funds and other institutional investors over GDP. Data in Table 2.14 shows that the CEE countries' financial sectors are small and still in their development stage, and still lag behind the financial system of developed countries.

Table 2.14. Comparative indicators for banking system of CEE and developed countries

	Banking system assets/GDP, In% 1998-2001 average	Non-bank intermediaries assets/GDP, in% 1998-2001 average	Market capitalisation, in% 1998-2001 average*****
Croatia	71.9	8.4****	14.0
the Czech Republic	101.9	18.6**	34.9
Estonia	75.6*		
Hungary	60.2	11.8****	55.5
Latvia	83.6*		
Lithuania	33.5*		
Moldova	35.1*		
Poland	52.3	4.3**	27.5
Romania	31.6*		
Russia	37.8*		
Slovakia	88.5		23.6
Slovenia	75.1	17.2****	26.5
Ukraine	28.3*		
Italy	105.7**	88.3***	58.2
Greece	110.0**	35.0***	80.3
Austria	187.1**	61.5**	15.6
Germany	178.8**	74.2**	61.6
USA	85.2**	198.0**	155.1

Note: * - 2002; ** - average 1998 – 2000: *** - average 1998 – 1999; **** - average 1998 – 2001; ***** - market capitalisation for transition countries includes stock market capitalisation and market value of bonds, for developed countries – only stock market capitalisation
Source: RZB Research Group, 2004, National Bank of Moldova, Dalić M. (2003)

Table 2.15 reports the corruption perception index for the CEE countries and selected developed countries. This is taken from the annual survey by the Berlin-based organization, Transparency International. Accordingly, this index defines corruption as the abuse of public office for private gain, and measures the degree to which corruption is perceived to exist among a country's public officials and politicians. According to Table 2.15, the AC sub-group countries show relatively lower corruption levels while the CIS countries corruption perception index is found to be high.

Table 2.15. Corruption perception index for CEE countries and selected developed countries

Country rank	Country	2004 CPI Score (10 -highly clean , 0 - highly corrupt)
31	Estonia	6.0
31	Slovenia	6.0
42	Hungary	4.8
44	Lithuania	4.6
51	Czech Republic	4.2
57	Latvia	4.0
57	Slovakia	4.0
67	Croatia	3.5
67	Poland	3.5
87	Romania	2.9
90	Russia	2.8
114	Moldova	2.3
122	Ukraine	2.2
42	Italy	4.8
49	Greece	4.3
13	Austria	8.4
15	Germany	8.2
17	USA	7.5

Source: Transparency International, 2004. Web: www.transparency.org.

2.6. Conclusion

The goal of this chapter was to provide an overview of the development of banking markets in Central and Eastern Europe. I have considered major specifics pertinent to economic transition in the region, and, in particular, to the stability and development of banking systems, such as banking system reforms, the privatisation process in the banking industry, the ownership structure of the banking system, the financial intermediation activity and the profitability of the sector.

As the analysis reveals, nowadays the CEE banking sector is characterised by a relatively high degree of heterogeneity. However, while the development of banking system, and economy in general, was different in each country, the region shared a common experience, which is the transition from a monobank to a two-tired banking system, which was marked by financial crises. Moreover, another similarity of the transformation is the privatisation of state-owned banks, the increasing shares of foreign banks' participation in the banking market, the gradual decline of the proportion of non-performing loans and an adequate capitalisation of the banking sector.

In conclusion, the CEE banking market was highly dynamic over the last years with rapid financial deepening, though at different levels in different countries. Therefore, it is particularly interesting to examine the development of the banking market in these countries and assess their efficiency and productivity.

CHAPTER THREE: META-ANALYSIS OF INPUTS AND OUTPUTS IN BANKING EFFICIENCY AND PRODUCTIVITY STUDIES, AND THE STRUCTURE OF BANK PRODUCTION

SUMMARY

The literature on efficiency and productivity analysis in the banking industry is vast and rapidly growing. However, this research differs considerably in how banks' inputs and outputs are defined and measured. These differences reflect the preference of researchers for different models of banking production, such as the intermediation, production and value-added approaches. Generally, inputs in these models are taken from a range of flow variables in the income account, while outputs are taken from a range of stock variables on both sides of the balance sheet. The comparison is further complicated by the fact that researchers often use different databases, which almost inevitably leads to different definitions and measurements of input and output variables, and of the types of banks, e.g. savings banks, commercial banks, retail banks and investment banks. For example, it is difficult to tell whether a certain choice of variables has been dictated by 'pure' theoretical considerations or simply by the issue of data availability. In this chapter I combine and examine research findings which employ the same database – Bankscope. The major objective is to systematically examine the use of flow and stock measures of inputs and outputs in different modelling frameworks of banking efficiency, where any differences in the choice of approach of inputs and outputs definitions are primarily conceptual (since the same data source was used) and therefore can be compared more effectively.

3.1. Introduction

Productivity and efficiency are important aspects of the economic performance and production structure in the banking industry, and much academic and public attention is devoted to these strategic facets. Nevertheless, as authors of one of the earliest studies on the definition of banking production, Speagle and Kohn (1958), argued that "the problems that generally beset the definition and measurement of output in economic activity were found equally in banking, with the addition of special difficulties inherent in the nature of the industry" (p. 23)., and despite substantial research efforts, it is generally recognised that even nowadays one of the main difficulties in these explorations, is a lack of agreement in the definition and measurement of a bank's inputs and outputs. Moreover, the treatment of deposit products is still the subject of considerable financial debates[8]. For example, Speagle and Kohn maintain that deposits may be considered the "raw material" of banking business and they are a bank's "lifeblood", and still consider them an output of the bank[9].

More to the point on this chapter, a keen interest in comparative studies is generally devoted to the above questions, i.e. to measurement methods and efficiency concepts, but not much thought is normally given to issues relating to the variation of data sources. I take up the challenge in this chapter by combining and examining research findings which employ the same database – the world banking information source: BankScope database. This chapter makes several major contributions to the literature. This is to my knowledge the only survey which provides a comprehensive, critical comparison of efficiency and productivity literature and makes no limitations on variable selection due to data accessibility bias. This study critically analyses basic methodologies of different models of banking production, such as the intermediation, production and value-added approaches and maintains an empirical verification procedure in which it provides ample comparison of empirical findings. In particular, I try to systematically examine the use of flow and stock measures of inputs and outputs in different modelling frameworks of banking efficiency. To analyse

[8] See Triplett (1992), Wykoff (1992), Hunter, Timme and Young (1990).

[9] Speagle and Kohn (1958) analyze the nature of labor-using bank operations and the response of labor input to growth and technical changes in the banking industry. The only input used in the study is labor.

methodological and empirical applications of banking production models, this work conducts a Meta analysis of 37 papers.

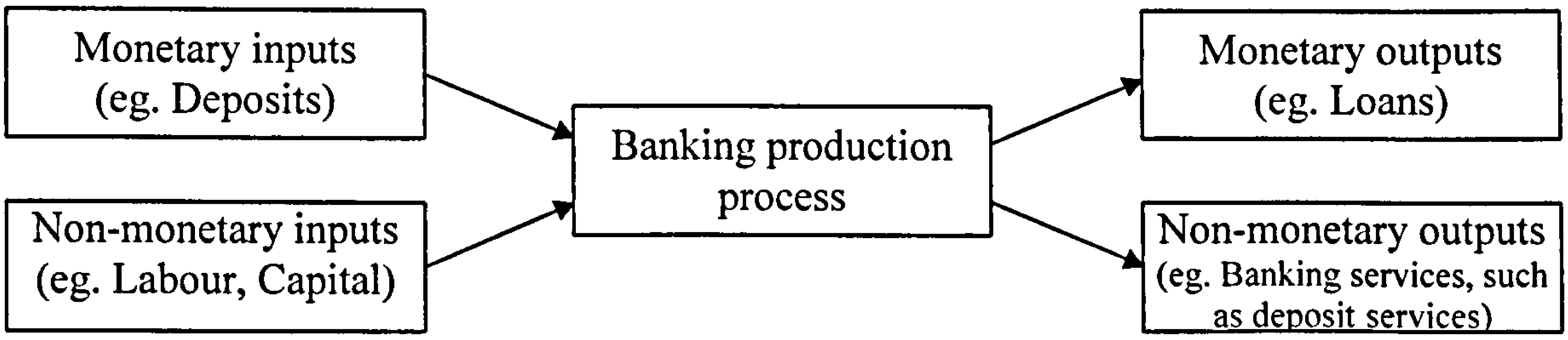
The chapter is organized as follows. First, I discuss and compare the banking production process and banking inputs and outputs in the measurement modelling literature (Section 3.2). Then, in Section 3.3, I construct the Meta study database of banking efficiency studies which used the Bankscope database, and systemise the modelling frameworks of measurement of inputs and outputs in the banking efficiency literature. The last section, Section 3.4, gives conclusions to the meta-analysis.

3.2. *Modeling banking production process: review of approaches*

Characterizing the banking production process and its underlying determinants is fundamental to modeling and measuring the economic performance of banks. It is recognized that in terms of production efficiency, the performance of banks is considered transformation process of multiple inputs into multiple outputs. However, due to the integrated nature of the banking production process, and the functions of financial intermediaries, methodological developments face difficulties in the definition and measurement of banking inputs and outputs. For example, the production activity of financial firms can be viewed as the transformation of non-financial inputs into financial outputs[10]. If so, the primary factors on the input side of a financial service business are straightforward and characterized by labour and capital. Therefore, only the output side is subject to the characterization and measurement issues. On the other hand, since deposits can be viewed both as an input or an output, not only non-monetary but also monetary inputs as well as outputs could be involved in the banking production process (See Figure 3.1).

[10] I trace out this definition of financial institutions to the work of Fixler and Zieschang, 1999. They adopt user-cost framework in their survey.

Figure 3. 1. Banking production process



There is an extensive research literature on specifying the appropriate methodology of modeling of the banking production process, covering the financial framework of the inputs and outputs, definitional problems and reasonable measures for their quantities. The literature distinguishes the following approaches to banks' activity specification.

The production approach defines the banking activity as the production of services. This approach has been adopted by the contributions of Benston (1965) and Bell and Murphy (1968). Under this approach, banks are viewed as firms, which transform physical inputs (capital and labour) into different categories of outputs (loan and deposit accounts). In this framework, deposits are outputs and it is assumed that a bank provides depository services as a form of production in its own right. According to this approach, inputs and outputs are measured in physical quantities, and productivity and efficiency analysis is based on the comparison of quantities of services given with the quantity of resources used (Mlima and Hjalmarsson, 2002). This highlights a basic problem of the production approach, which considers the measurement of output volumes, i.e. whether the number of accounts, number of operations on these accounts, or the quantity in monetary units as the relevant measure. According to Freixas and Rochet, 1997, usually researchers use currency units of measurement (dollar amounts, for example) because these can be obtained more easily. The possible biases, in this case, could be corrected by adding heterogeneity factors for homogenizing the data. This approach is sometimes called the service provision approach. In their study Mlima and Hjalmarsson, 2002 pointed out that this approach is also known as the value-added approach, but I present a separate discussion of the value-added approach later in this section.

The second main theoretical paradigm for modeling banking production structure is the intermediation approach. Under this approach, banks are intermediators of financial services and the key role of banks is resource mobilization and distribution, by performing which they facilitate smooth investment activities in the economy. Indeed, in this approach banks are considered intermediary institutions and the banking production process is seen as the transformation of borrowed money – deposits – into the money lent to borrowers, i.e. loans (see, for instance, Sealey and Lindley (1977) for a discussion). The intermediation approach specifies banking activities more comprehensively than the production approach in view of the fact that the banking production process originates from the transformation of different characteristics of deposits and loans: divisible, liquid and riskless deposits (typically) into indivisible, illiquid and risky loans (Freixas and Rochet, 1997).

As a consequence of a comprehensive specification of costs, the intermediation approach has become more popular in the recent literature and exists in a number of forms. For example, the approach has different versions including asset approach, profit or user cost approach and risk management approach. The asset approach is regarded as one form of the intermediation approach, but sometimes as the intermediation approach itself. It assumes that the banking production process focuses on liabilities as inputs and assets as outputs, so that one of the cases is where funds are inputs and loans are outputs. The asset approach has been criticized by Berger and Humphrey (1992) because it ignores the fact that banks might spend significant resources for transactions and saving deposits. In the profit or user cost approach the financial input-output status of each product is determined by the sign of its user cost price, i.e. by the net contribution of the product to bank revenue. This framework focuses on the maximization of a bank's profit and so the comparison of financial returns and the opportunity costs of funds are considered. Thus, if the return to a commodity is greater than its opportunity cost then the commodity is regarded as output, if not it is regarded as an input (Hancook, 1991). Hence, if I follow Hancock's rule, in simplified example, demand deposits would be classified as outputs, since banks very often pay no interest on them but provide unpriced services, such as check cashing, use of ATMs, and other transactions services, while time deposits would be classified as inputs, since they have an interest cost. According to Berger et al., 1993 this approach reduces mis-specification and mis-measurement problems. However, some problems still arise with this approach.

This approach is sensitive to interest rate fluctuations, since as interest rates fluctuate, so does the user cost. It may cause an item which is considered to be an output in one period to turn into an input in the next period if the sign of its user cost changes. Second, there is an issue of complexity of marginal revenues and costs measurement for each individual liability item, because as in case of demand deposits, I argue that they have no interest cost, but it does not mean, that they have no costs, because banks are subject to the acquisition cost of demand deposits which is equal to the cost of unpriced services produced by the bank. Thus the answer to the question whether an item is an input or output becomes a subject of significant measurement error and is sensitive to changes in data over time (Grigorian D.A. and Manole V., 2002).

The risk management approach is also considered a form of the intermediation approach (Mlima and Hjalmarsson, 2002), but some authors (e.g. Freixas and Rochet, 1997) distinguish it as a separate approach – the so – called modern approach. This approach is used to incorporate risks in the measurement of banks' activities. In this framework, the specificity of banks' activities is to take risks in order to produce acceptable returns. This idea was already implicit in Hughes and Mester, 1993; Mester, 1996; Heshmati, 1997. A number of promising trends are apparent in the literature on the risk management modeling of banks' economic performance. Methodological developments, with perhaps the most potential are those incorporating the probability of the banks' failure and the quality of the banks' assets in the estimations. In the next Chapter I will extend the idea of the risk management methodology not only in the framework of the Intermediation approach, but also in the modeling of Production and Profit/Revenue based methodologies.

Finally, the value added approach defines banks' inputs and outputs according to their share of value added (Berger and Humphrey, 1992). This approach assumes that any item on both sides of the balance sheet may be identified as outputs or inputs depending on their contribution to the generation of bank value added. Also, according to Maggi and Rossi (2003), any balance sheet item is considered as output if it absorbs a relevant share of capital and labour, otherwise it is treated as input or non-relevant output. Weelock and Wilson (1995) argue that while the value-added approach and the user-cost approaches differ in their details, empirically, they tend to suggest similar classification of inputs and outputs. However, given the similarities, the main exception in the classification is demand deposits, which are an output in user-cost approach, and both an input and an output in value-added approach.[11] Also, the value added approach differs from the user cost approach in that it is based on actual operating cost data rather than determining these costs explicitly (Grigorian D.A. and Manole V., 2002).

As Berger and Humphrey (1997) pointed out, there is no 'perfect approach, and as Favero and Papi (1995) argue, all of these approaches have their strengths, but none of them is necessarily perfect. For example, the production approach focuses on operating costs and takes no account of important issues like the cost of deposits, which is a crucial component in interest and non-interest expenses trade-off (Humphrey, 1991). But at the same time, this approach may be more appropriate for comparative efficiency analyses of bank branches, especially when transactional activity pattern differences exist between branches. The intermediation approach, on the other hand, includes both operating and interest expenses, but primarily concentrates on defining such activities as receiving funds at interest and using them to make loans, and ignores others, for example transaction services.

With respect to the aforementioned approaches, it has been argued in the literature that these approaches, along with Bergendhal's (1998) idea[12], could be pooled into two broadly defined ones, which are profit maximization and service provision (Grigorian and Manole, 2006). Thus, profit maximization combines features of Bergendhal's profit maximization and risk management and service provision brings together elements of service provision, intermediation and utility provision. However, in the next Chapter, I suggest another combination of the managerial goals suggested by Bergendhal and link them to the input/output methodologies utilized in the thesis.

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[11] This approach is also known as a dual approach, because it considers both the input and output characteristics of deposits.

[12] Bergendhal, 1998 mentioned that efficient bank management targets five fundamental goals: profit maximization, risk management, service provision, intermediation, and utility provision.

In the reminder of this Chapter, I investigate the extent to which the choice of approach of banks' activity specification depends on researchers' theoretical considerations. I am interested in a systematic analysis of the applications of flow and stock measures of inputs and outputs in different modelling frameworks of banking efficiency and I examine studies, which used a single source of data – the Bankscope data base.

3.3. Inputs and outputs in banking efficiency studies using Bankscope: A Meta study

To evaluate the controversial concepts of banks' activity specification the Meta study scientific tool will be used. This method is sometimes called the "study of studies" or "analysis of analyses"[13]. This research methodology provides a systematic way of bringing together findings from previous empirical research on a given issue. This tool helps construct an analytical framework for the research synthesis of comparative case studies of surveys undertaken in this area. In this chapter we slightly amend the traditional meta-study focus by comparing theoretical and methodological issues, rather than empirical findings of different studies.

In our meta-study we review 37 studies that use a relatively easily accessible data base of financial information for banks – the comprehensive and global database of Bureau van Dijk – Bankscope. For analytical purposes, we construct a table, which systematically covers important information concerning the research design. In addition to the applied approaches of banking inputs and outputs, information about the analyzed country and methodology used has also been included in the table (see Table 3.1).

[13] First this methodology was used by Gene Glass in 1976. It was referred to a philosophy and was not a statistical technique. Glass argued that literature review should be as systematic as primary research and should interpret the results of individual studies in the context of distributions of findings, partially determined by study characteristics and partially random. Since that time, meta-analysis has become a widely accepted research tool in a variety of disciplines (Bangert-Drowns and Rudner, 1991)

Table 3. 1. Summary of recent banking efficiency and productivity studies used Bankscope data base

	Authors	Methodology	Analysed country	Approach	Inputs	Outputs
1	Altunbas Y., Liu M., Molyneux P. and Seth R. (2000)	Stochastic cost frontier, 139 banks in 1993-1995, 136 banks in 1996	Japan	Intermediation approach	1) Labour 2) Deposits 3) Capital	1) Total loans 2) Total securities 3) Total off-balance sheet items
2	Altunbas Y., Evans, L., and Molyneux P. (2001)	SFA, DFA, 1989-1996, 125-1816 banks	Germany	Intermediation approach	1) Labour 2) Deposits 3) Capital	1) Mortgage loans 2) Public sector loans 3) Other loans 4) Other earning assets 5) Off-balance sheet items
3	Beccalli E., Casu B. and Girardone C.	DEA, SFA, 1999, 2000, 90 banks	France, Germany, Italy, Spain, UK	Intermediation approach	SFA 1) Average cost of labour 2) Average cost of deposits 3) Average cost of capital DEA 1) Personnel expenses 2) Other administrative expenses 3) Interest expenses 4) Non-interest expenses	1) Total loans 2) Other earning assets 1) Total loans 2) Other earning assets
4	Bonin J., Hasan I. and Wachtel P. (2003)	SFA, 67 banks	Bulgaria, the Czech Republic, Croatia, Hungary, Poland, Romania		1) Price of capital 2) Price of funds	1) Total deposits 2) Total loans 3) Total liquid assets 4) Investments other than loans and liquid assets
5	Bos J.W.B. and Schmiedel H.De	Stochastic frontier, Metafrontier, 5193 banks, 1993-2000	Belgium, France, Germany, Italy, Netherlands, Spain, Switzerland, UK	Intermediation approach	1) Labour price 2) Financial capital price 3) Physical capital price	1) Loans 2) Investments 3) Off-balance sheet items
6	Bou-Said M.-J. and Saucier P., (2003)	DEA, 160 Japanese banks, 1993 - 1999	Japan	Production approach	1) Personnel expenses 2) Total fixed assets 3) Other expenses and external funds	1) Loans 2) Customer deposits 3) Equity investment 4) Off balance sheet and other earning asset
7	Brown K. (2003)	DEA, range from 19 to 24 banks, 1998-2001	14 Muslim countries	Intermediation approach	1) Personnel expenses 2) Non-interest expenses	1) Total deposits 2) Loans 3) Other earning assets

8	Casu B. and Girardone C.(2002a)	DEA, SFA, 1993-1997	France, Germany, Italy, Spain, UK	Intermediation approach	SFA 1) Average cost of labour 2) Average cost of deposits 3) Average cost of capital DEA 1) Personnel expenses 2) Other administrative expenses 3) Interest expenses 4) Non-interest expenses	1) Total loans 2) Other earning assets 1) Total loans 2) Other earning assets
9	Casu B. and Girardone C.	DEA (Malmquist index), 2086 banks, 1994-2000	France, Germany, Italy, Spain, UK	Intermediation approach	1) Personnel expenses 2) Interest expenses 3) Total operating expenses	1) Loans 2) Securities 3) OBS items
10	Casu B. and Girardone C.(2002b)	SFA (Fourier flexible form), DFA, DEA, 36 financial conglomerates – 1996, 40-1997, 44 – 1998, 48 - 1999	Italy	Intermediation approach	1) Average cost of labour 2) Average cost of deposits 3) Average cost of capital	1) Total loans 2) Securities
11	Casu B. and Molyneux P. (2000)	DEA, 750 banks, 1993-1997	France, Germany, Italy, Spain, UK	Intermediation approach	1) Total costs (interest expenses, non-interest expenses, personnel expenses) 2) Total deposits	1) Total loans 2) Other earning assets
12	Casu B., Girardone C. and Molyneux P. (2004)	DEA, Stochastic frontier, 1895 banks, 1993-1997	France, Germany, Italy, Spain, UK	Intermediation approach	1) Labour 2) Deposits 3) Capital	1) Total loans 2) Other earning assets
13	Cavallo L. and Rossi S.P.S. (2002)	Translog stochastic frontier, 442 banks, 1992-1997	France, Germany, Italy, Netherlands, Spain, and the UK	Dual approach	1) Price of labour 2) Price of capital 3) Price of deposits	1) Loans 2) Deposits 3) Financial investments
14	Chakravarty S. P. and Williams J.M. (2002)	Fourier flexible cost function, 1999	Germany	Intermediation approach	1) Price of labour 2) Price of physical capital 3) Price of financial capital	1) Customer loans 2) Interbank assets 3) Securities and investments 4) Contingent liabilities
15	De Guevara J.F., Maudos J. and Pérez F. (2002)	Translogarithmic cost function, 1105 – 2148 banking firms, 1992-1999	France, Germany, Italy, Spain, UK		1) Price of labour 2) Price of capital 3) Price of deposits	1) Total assets
16	Drake L.M., Hall M.J.B. and Simper R. (2006)	DEA, 1995-2001	Hong Kong	Profit approach	1) Personnel expenses; 2) Other operating expenses 3) Loan loss provisions	1) Net interest revenue 2) Net commission revenue 3) Other income
17	Fries S. and Taci A. (2004)	SFA, 289 banks, 1994-2001	Bulgaria, Croatia, Czech Republic, Estonia, FYR Macedonia, Hungary, Kazakhstan, Latvia, Lithuania, Poland, Romania, Russia, Slovak Republic, Slovenia, Ukraine	Intermediation approach	1) Proxy measure for the average cost of non-financial inputs (total non-interest to total assets) 2) Price of physical capital	1) Loans 2) Deposits

18	Green C.J., Murinde V. and Nikolov I. (2004)	Translog cost function (with two cost share equation), 273 banks, 1995-1999	Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland and Romania	Intermediation approach	1) Labour 2) Capital 3) Deposits	1) Loans 2) Other earning assets 3) Non-interest income
19	Grigorian D.A. and Manole V. (2002)	DEA, 209-266 banks, 1995-1998	Armenia, Belarus, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Moldova, Poland, Romania, Russian Federation, Slovak Republic, Slovenia, Ukraine	Profit maximization Service provision	1) Labour 2) Fixed assets 3) Interest expenditure 1) Labour 2) Fixed assets 3) Interest expenditure	1) Revenues 2) Net loans 3) Liquid assets 1) Deposits 2) Net loans 3) Liquid assets
20	Huizinga H.P., Nelissen J.H.M. and Vennet R.V. (2001)	Nonhomothetic functional form of the translog function, 52 M&A, 1994 – 1998	Bank M&A (Europe)	Intermediation approach	1) Deposits 2) Labour	1) Loans 2) Securities or other earning assets
21	Kuosmanen T. and Post T. (1999)	DEA, 453 largest commercial banks of EU, 1997			1) Equity capital 2) Debt capital 3) Operational costs	1) Total earning assets
22	Laeven L. (1999)	DEA,171 banks,1992-1996	Indonesia, Korea, Malaysia, Philippines, Thailand	Intermediation approach	1) Interest expenses 2) Labour expenses 3) Other operating expenses	1) Loans 2) Securities
23	Lozano-Vivas A., Pastor J.T. and Hasan I. (2001)	DEA, 1993, 612 commercial banks	Belgium, Denmark, France, Germany, Italy, Luxembourg, Netherlands, Portugal, Spain and UK	Value-added approach	1) Personnel expenses 2) Non-interest expenses	1) loans 2) deposits 3) other earning assets
24	Lozano-Vivas, Pastor and Pastor (2002)	DEA, 612 banks (of 10 European countries), 1993	Belgium, Denmark, France, Germany, Italy, Luxembourg, Netherlands, Portugal, Spain, UK	Value added approach	1) Personnel expenses; 2) Non-interest expenses	1) Loans 2) Deposits 3) Other earning assets
25	Maggi B. and Rossi S.P.S. (2003)	Distribution free model, 1995-98	15 European banks, USA	Modified production approach (European banks) Value-added approach (USA)	1) Price of labour 2) Price of deposits 3) Price of capital 1) Labour 2) Capital	1) Deposits 2) Loans 3) Services 1) Deposits 2) Loans 3) Services
26	Matousek R. (2004)	DFA, 1994-2001, 1174 observations	Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia	Intermediation approach	1) Interest, fees and commission/ deposits 2) Non-interest cost/fixed assets 3) Operating expenses/ assets	1) Deposits 2) Loans 3) Liquid assets
27	Maudos J., Pastor J.M., Pe'rez F. and Quesada J. (2002)	FEM, REM, DFA, 832 banks, 1993-1996	Austria, Belgium, Finland, France, Germany, Italy, Luxembourg, Portugal, Spain, UK.	Intermediation approach	1) Cost of loanable funds 2) Cost of labour 3) Cost of physical capital	1) Loans 2) Other earning assets 3) Deposits

28	Montinola G. and Morena R. (2001)	DEA, range from 17 to 33 banks, 1992-1999	Philippines	Production stage Intermediation stage	1) Equity capital 2) Personnel expenses 3) Interest paid 1) Deposits 2) Operating expenses excluding personnel	1) Deposits 2) Other operating income 1) Loans 2) Bank income
29	Schure P. and Wagenvoort R. (1999)	Recursive Thick Frontier Approach (RTFA), 1974 credit institutions, 1993-1997	EU – 15	Value-added approach	1) Price of loanable funds 2) Price of labour 3) Price of buildings	1) Customer deposits 2) Loans 3) Equity investments 4) Off-balance sheet items 5) Other services
30	Vennet R.V. (2002)	Translog cost function, 62 cross-border banks, 1990 – 2001	Austria, Belgium, Denmark, Finland, France, Germany, Italy, Luxemburg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK	Intermediation approach	1) Deposits 2) Labour	1) Loans 2) Securities and other earning assets
31	Weill (2002)	Iterative Seemingly Unrelated Regression estimation technique (ITSUR), 34 banks, 1994, 1997	Poland and Czech Republic	Intermediation approach	1) Labour 2) Financial capital	1) Loans 2) Investment assets
32	Weill (2004)	SFA, DFA and DEA; cost frontier, 688 banks, 1992-1998	France, Germany, Italy, Spain, Switzerland	Intermediation approach	1) Labour 2) Physical capital 3) Borrowed funds	1) Loans 2) Investment assets
33	Weill L.	SFA, 1996 – 739 banks, 2000 - 640 banks	11 Western European and 6 Eastern European countries	Intermediation approach	1) Personnel expenses 2) Other non-interest expenses 3) Interest paid	1) Loans 2) Investment assets
34	Weill L. (2003)	SFA, 31 Polish banks, 26 Czech banks, 1997	Czech Republic, Poland	Intermediation approach	1) Personnel expenses 2) Other non-interest expenses 3) Interest paid	1) Loans 2) Investment assets
35	Williams J.	Fourier flexible cost function, savings banks,1990-1998	Denmark, France, Germany, Italy, Spain, UK	Intermediation approach	1) Price of financial capital 2) Price of labour 3) Price of physical capital	1) Customer loans 2) Securities and interbank assets 3) Non-interest income
36	Williams J. and Gardener E.P.M. (2003)	SFA, 6309 observations, 1990-1998	Denmark, France, Germany, Italy, Spain, UK	Intermediation approach	1) Price of financial capital 2) Price of labour 3) Price of physical capital	1) Customer loans 2) Securities 3) Customer deposits 4) Non-interest income
37	Yildirim H.S. and Philippatos G.C. (2002)	SFA, DFA, 1993-2000	Czech Republic, Estonia, Croatia, Hungary, Latvia, Lithuania, FYR of Macedonia, Poland, Romania, Slovenia, the Slovak Republic, Russian Federation.	Value added approach	1) Borrowed funds 2) Labour 3) Physical capital	1) Loans 2) Investments 3) Produced deposits

The analysis is presented in the form of a meta-regression model, which evaluates the relation between the approach used in the study and the input and output variables specification adopted[14]. In our meta-analysis we review 41 studies which are obtained from the information contained in Table 3.1. Consideration of the specificities of the banking production process discussed in the previous sections led us to the multinomial logistic model specification with the chosen approach as the dependent variable W_i being presented in the form of categorical variable.[15] The choice of the MLR model is characterised by the use of K *unordered* choices to represent the different model specifications. This allows the description of the studies to be categorical in nature, so that there is no numerical significance to the ordering of the study types. This model uses as the category identifier: k = 1,..., K, where:

k = 1 production approach

...

k = K unspecified model approach

The key variable to be explained by the regression is the numerical count of each type of study used in the sample, and the regression is estimated by maximum likelihood methods. The model determines the choice of study type by the probabilistic odds of choosing that type conditional on the relative strength of one or more explanatory variables. Adopting the logistic function as the underlying density function of the random choices leads to the conditional or multinomial logit model:

$$Prob(type = j) = exp(\mathbf{x}'_j \beta) \Big/ \sum_k exp(\mathbf{x}'_k \beta)$$

so that the corresponding log-odds ratio is

[14] In view of the fact that a single piece of research may use more than one approach, in meta – analysis we do not group together the papers containing two approaches, for that reason in our meta – analysis 'study' does not equate to 'paper'.

[15] In previous model specification and estimations we run the analysis using the MetaStat 1.5 program (developed by Rudner L.M., Glass G.V., Evartt D.L. and Emery J.). Meta-Stat 1.5 is a comprehensive package designed to help in the meta-analysis of research studies in the social and behavioral sciences. Statistical techniques presented by the software are based on traditional assumptions of random sampling and independence. For regression analysis it uses the iterative stepwise approach. The key advantage of this approach is that it allows the computation of regression statistics (R^2 and beta weights) without having to invert the correlation matrix. Thus the non-multicolinearity restriction is not needed for computing the multiple correlation and accuracy is improved. The standard errors for the beta weights, and hence the corresponding t-statistics are based on Gauss-Jordon inverted correlation matrix (Rudner et al., 2002). However, the results were very sensitive to the changes of categories of the dependent variable which was avoided by using multinomial logistic regression (MLR).

$$\log it(p_j) = \log[\Pr ob(type = j)/\Pr ob(type = K)] = \mathbf{x}_j{}'\boldsymbol{\beta}$$

The explanatory variables may be specific to the study in question or they may be general over all studies. The coefficients $\boldsymbol{\beta}$ measure the effect on the probability of choosing a study of type *j* relative to the probability of choosing a study of type *K*, the basic choice. In this case the basic choice is taken as the intermediation approach, so that an intuitive interpretation of the regression model is:

probability of model j relative to probability of the intermediation model = $\mathbf{x}_j{}'\boldsymbol{\beta}$.

In other words, the following model is specified:

$$Logit(p_{W_j}) = \sum \mathbf{x}_j\ \boldsymbol{\beta}$$

where W_t is a matrix of response with $k = 4$ levels (k = 1 when Production approach was utilized in the study, K = 2 – for Intermediation approach, k = 3 – Value-added approach and k = 4 when researchers unspecified the input/output approach) and is multinomial distributed, and *X* is a matrix of predictors. To predict the choice of the approach (outcome in our multinomial logit model) we use the Input/Output variable, dummy for published studies (1 – if the study is published, 0 – if not) and the year the study was published (or became available for unpublished works). Input variables are combined into 6 groups: i) inputs based on labour factor; ii) inputs based on deposits; iii) capital based inputs; iv) interest expenses; v) non-interest expenses; vi) inputs describing quality of banking activity. Groups describing the output variables are following: i) loans; ii) securities and/or investments; iii) other earning assets; iv) off-balance sheet items; v) non – interest revenue; vi) interest revenue; vii) deposits as outputs; viii) liquid assets. All Input/Output groups are presented in the form of dummy variables being 1 if this type of Input/Output used in the study, and 0 – otherwise.

With respect to the heterogeneity among studies, we made the following specification in the studies – input and output categories are combined on a general basis and stand on authors' definitions. Obviously, different combinations of groups of the input and output variables may be used in the meta-regression and thus may affect the estimation results. However, we believe that the groups described above capture all the specificities of each approach used in the categorical dependant variable.

Before the MLR analysis, in order to have a clear picture of the studies presented in the Table 3.1, we present a frequency analysis of the variables used in the studies, viz., labour, deposits and capital, loans, deposits and OBS items in Figures 3.2- 3.8 respectively.

Figure 3. 2. Frequency of approaches used in the analysed studies

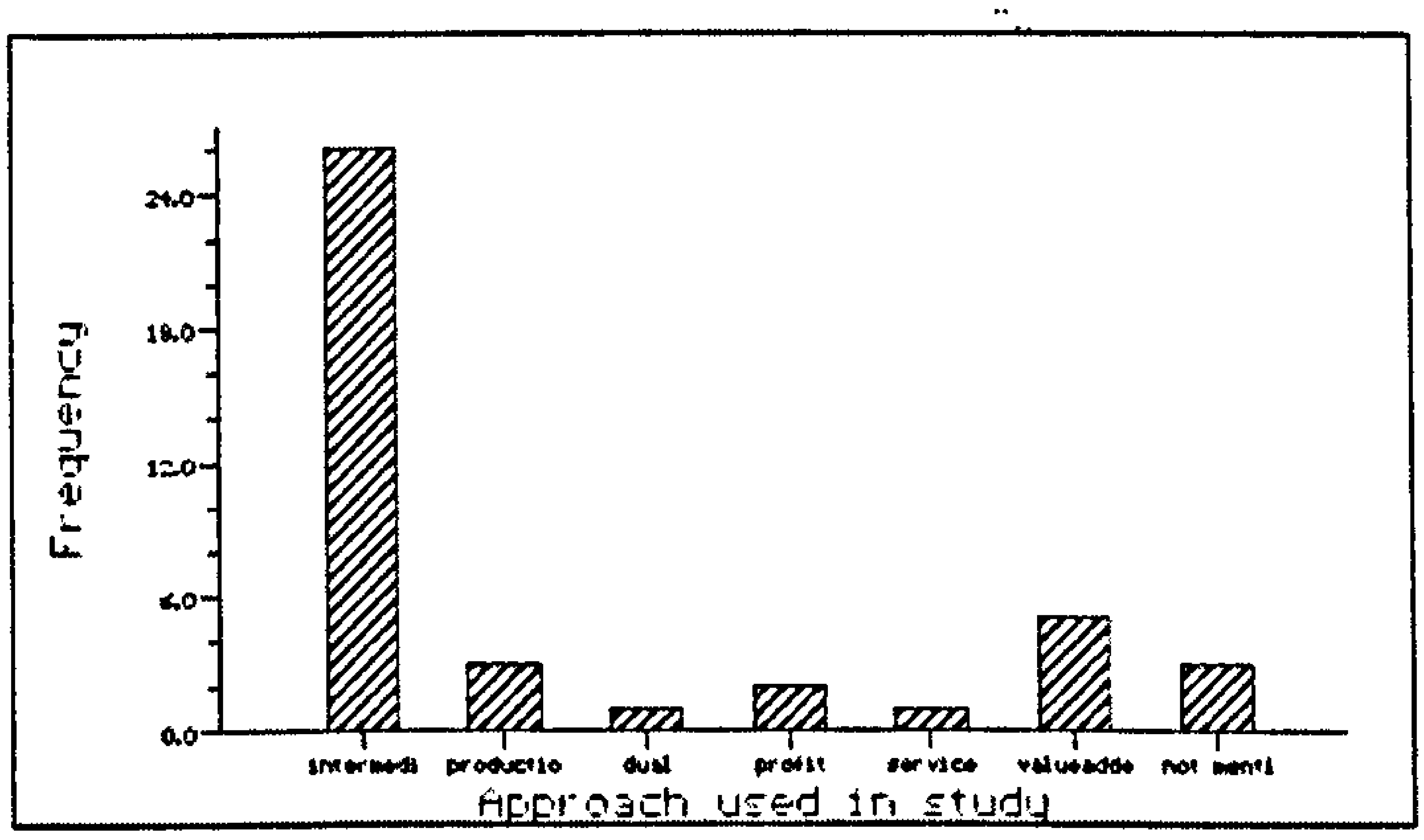


Figure 3. 3. Frequency of inputs based on labour in the analysed studies

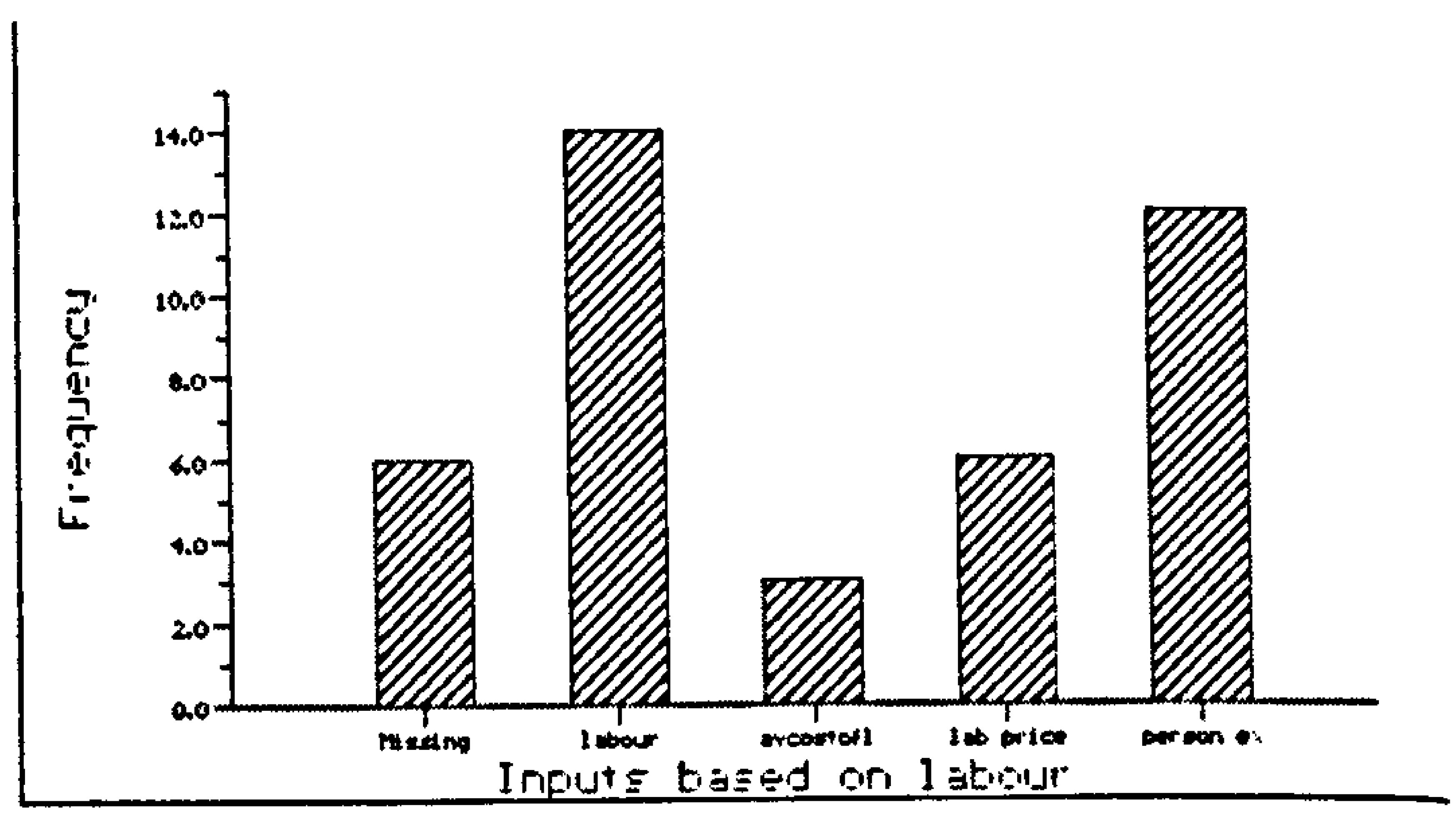


Figure 3. 4. Frequency of inputs based on deposits in the analysed studies

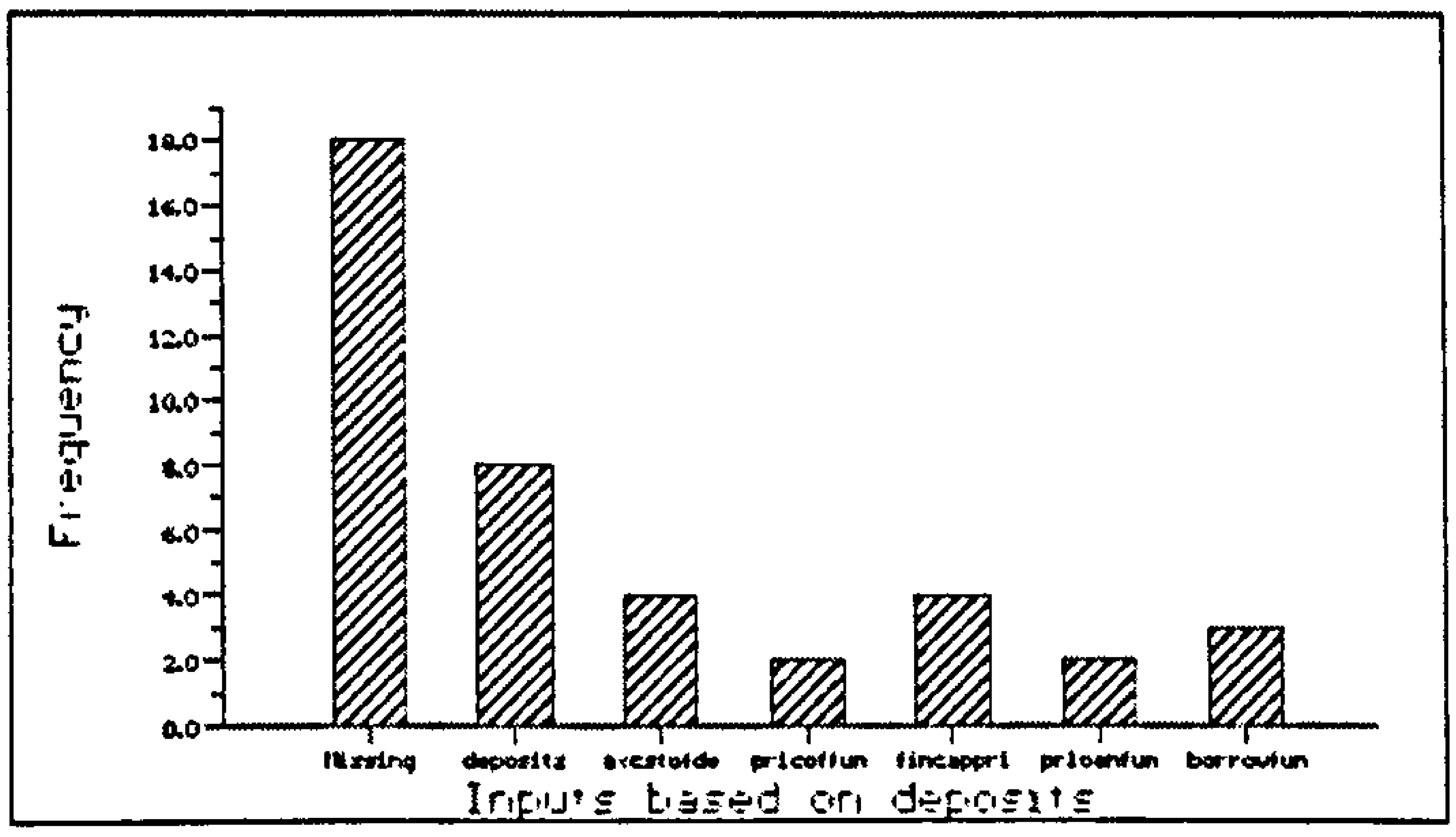


Figure 3. 5. Frequency of inputs based on capital in the analysed studies

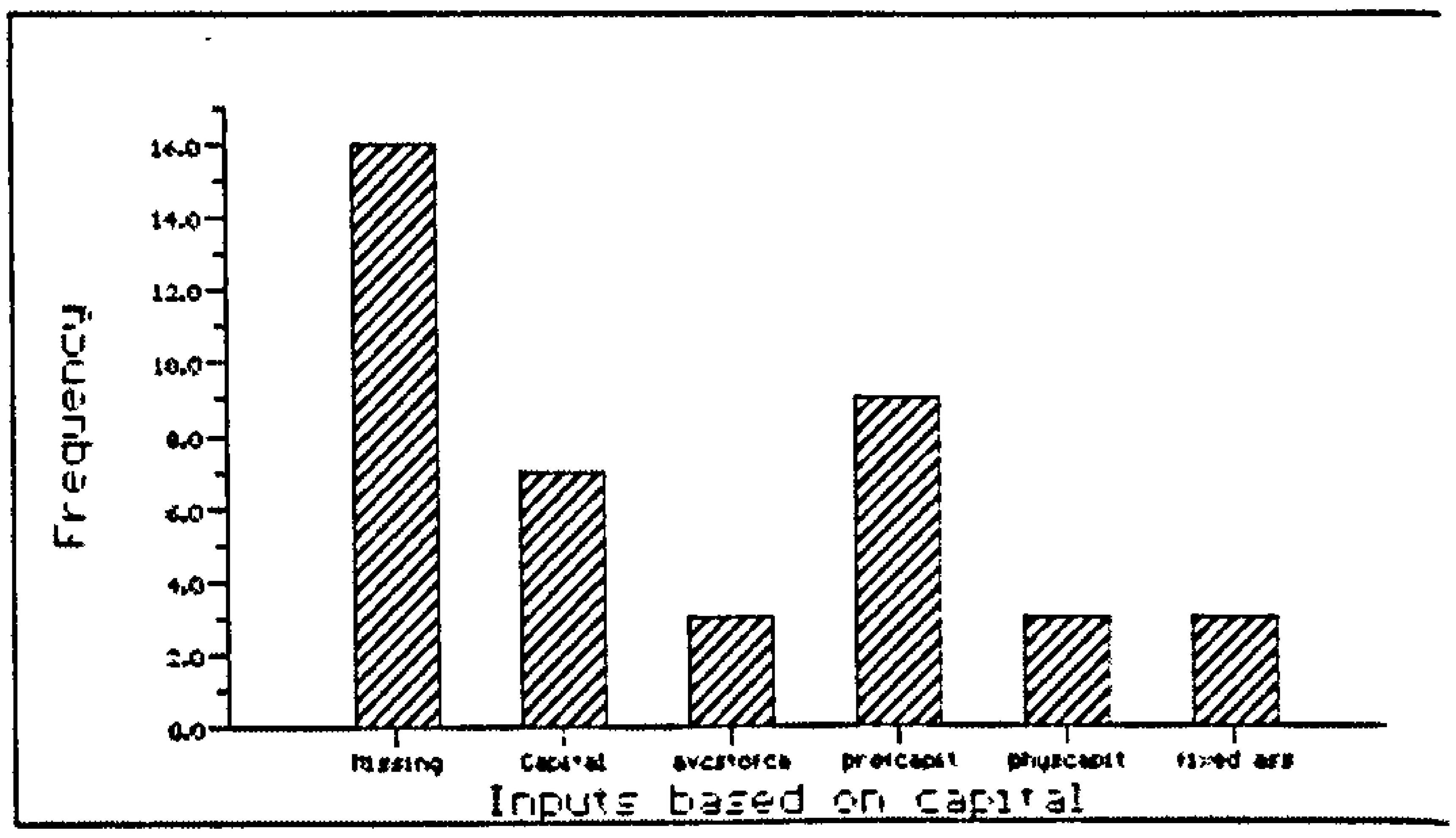


Figure 3. 6. Frequency of loans as output in the analysed studies

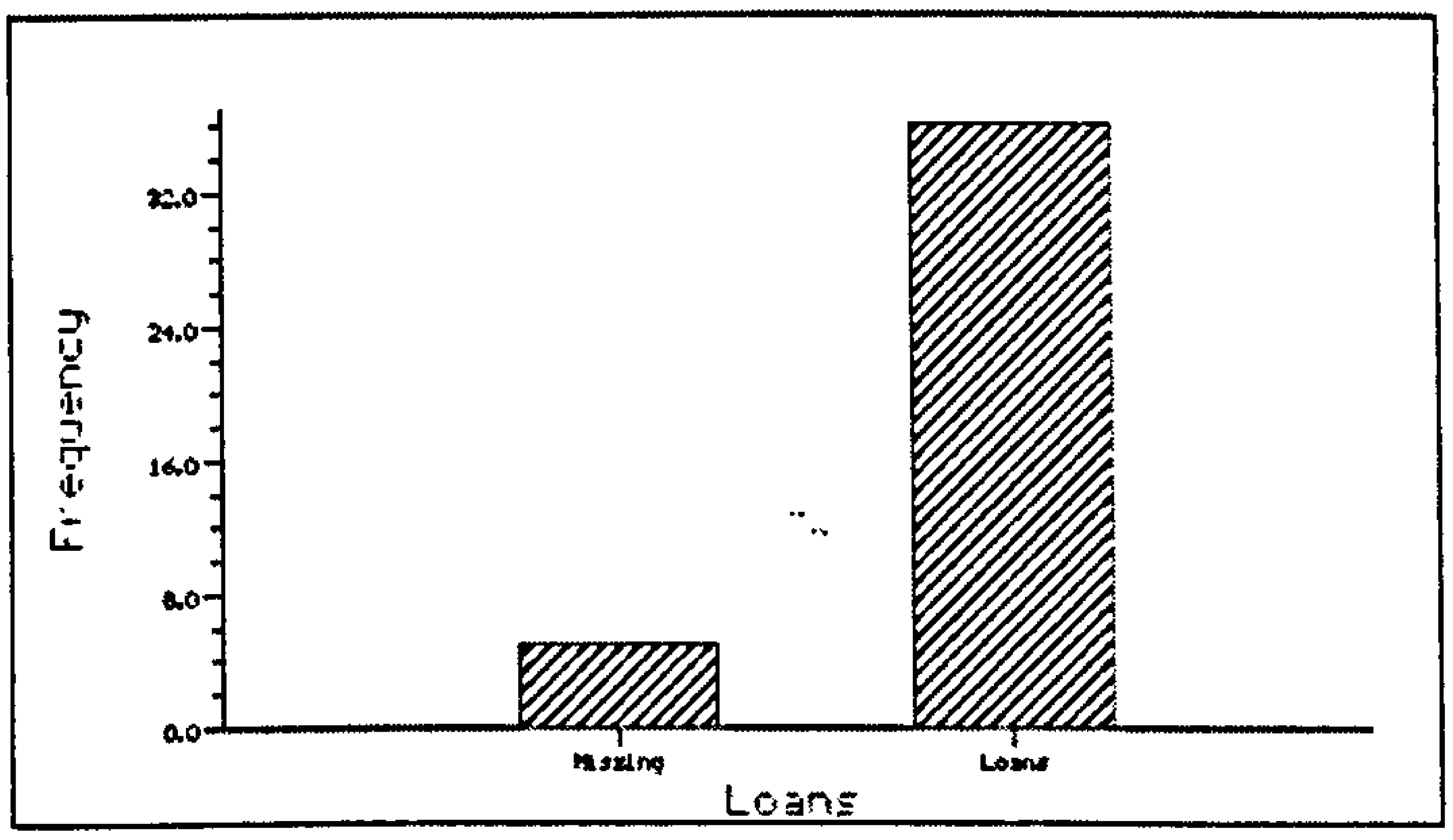


Figure 3. 7. Frequency of deposits as output in the analysed studies

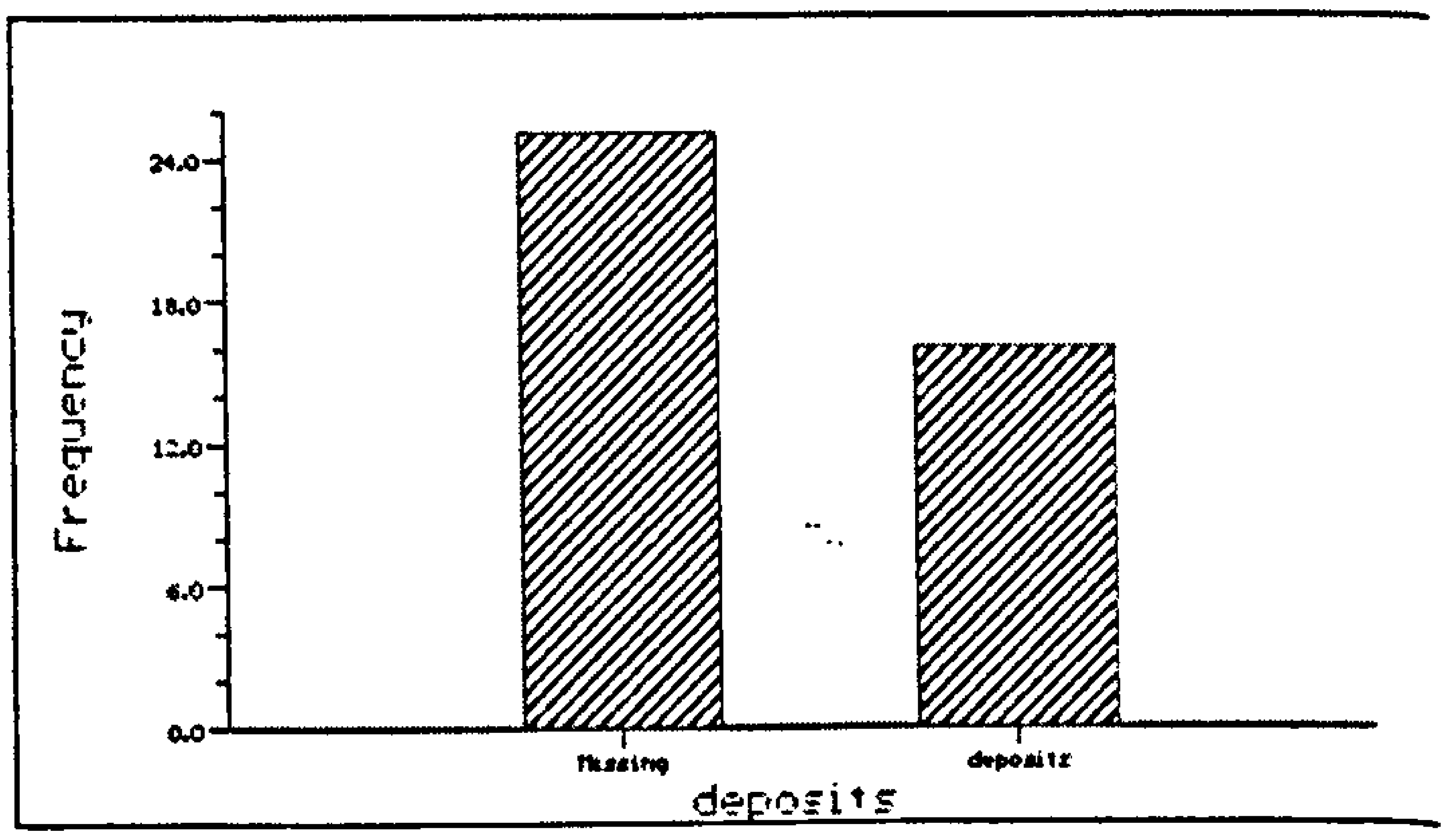
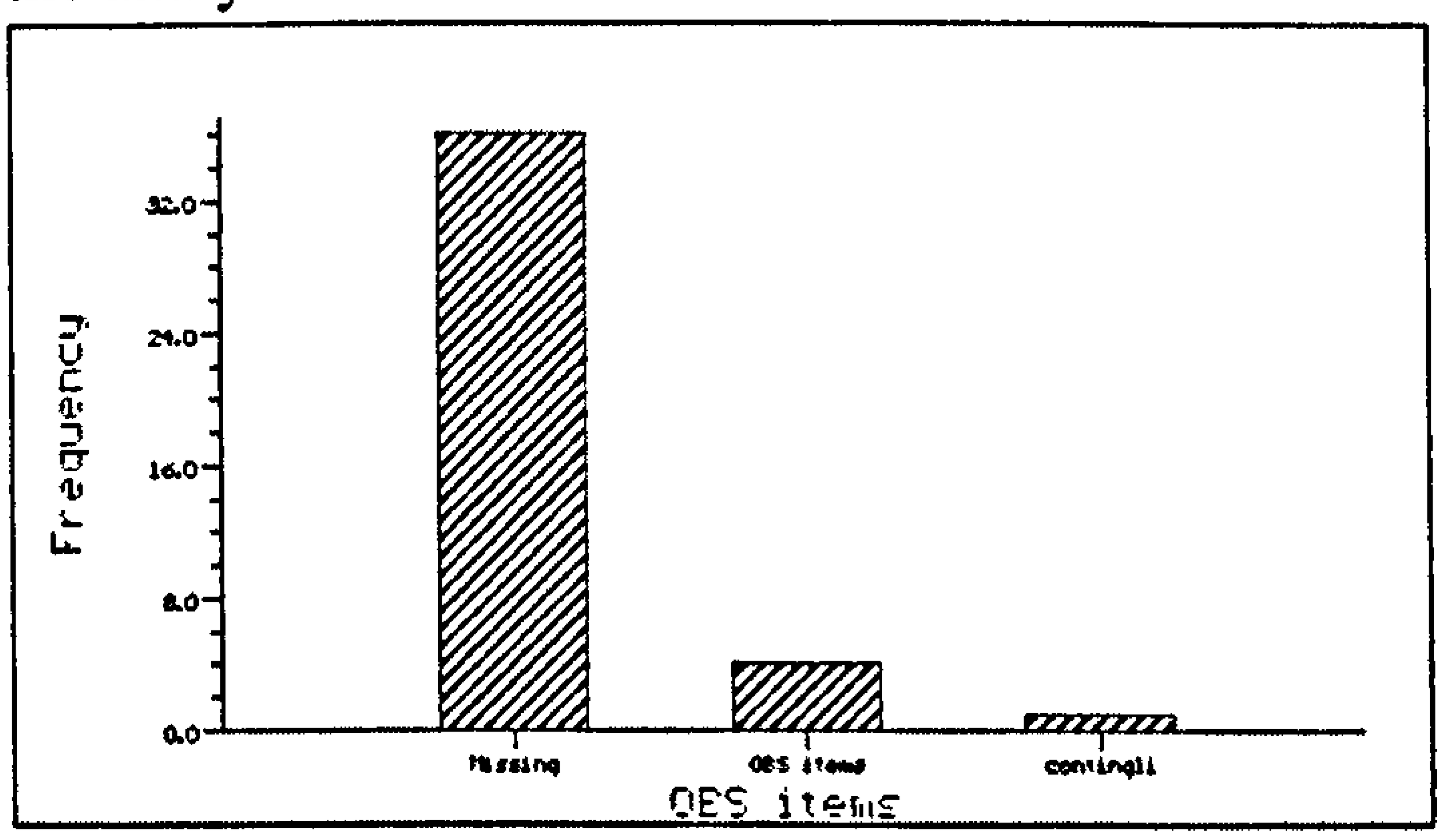


Figure 3. 8. Frequency of OBS items as output in the analysed studies



As can be seen from Figure 3.2, papers that make use of the intermediation approach outnumber the others by at least five to one. This indicates that in 63.4% of empirical analysis, researchers prefer to use the intermediation approach, followed by value added approach (12.2%). The production approach was used in 7.3% of papers, the profit approach – in 4.9 %, and the rather new – dual approach was used in 2.4%. Profit maximization and service provision approaches share 4.9% and 2.4% respectively. According to Berger and Humphrey (1991), the intermediation approach captures the varied nature of modern banking firms and therefore this argument can be treated as an explanation of the popularity of this approach. Consequently, as a base outcome in our MLR, we use the Intermediation approach as being the most popular in our sample. And to reduce the dimensionality of K_j to the four levels described previously, we classify the dual approach as a type of value-added approach, the profit – as type of Intermediation approach, and the service provision approach - as type of Production approach.[16]

Figure 3.3 indicates that 35 studies use labour as an input, whereas deposits are used only in 21 studies (Figure 3.4), and capital in 23 studies. According to Figure 3.6, loans are used as output in 36 studies. It means that almost all studies of banking production approaches tend to agree to classify loans as output. And some surveys indicate that their focus is on revenue generating elements (Drake L.M. et al., 2006), or those which use a single output model with output variable being total assets (De Guevara J.F., Maudos J. and Pérez F., 2002). Deposits are classified as output in 16 studies out of 41 (Figure 3.7). Figure 3.8 indicates a noteworthy trend, which is the inclusion of Off-balance-sheet items and contingent liabilities into the analysis as an output variable. In 9.8% and 2.4% of studies respectively these variables were included into the outputs.

3.4. Results

The results table, Table 3.2 picks out, in bold, the cases where the explanatory variables are statistically significant at the 10 percent level or less (*p-value* 0.10 or less). Overall, four key findings can be identified. Two refer to the general variables:

[16] The results of the MLR estimation using the Production approach as a base outcome are presented in the Appendix B.

1. Consistently, the *Year* variable has a negative effect on the choice of model relative to the intermediation model, although its statistical significance is weak. This demonstrates that while researchers over time seem to be converging on the intermediation model as the most preferred type, other models still make an appearance in later work. Overall, however, the popularity of the non-intermediation approaches seems to be declining over time. This perhaps reflects an increasingly more complex view of what banks do in practice.

Table 3. 2. Results of Multinomial Logistic Meta-Regressions

	Production	Value-Added	Unspecified		Production	Value-Added	Unspecified
X_{labour}	0.08 (0.932)	1.44 (0.151)	**-2.24 (0.025)**	Y_{loans}	-1.08 (0.280)	1.54 (0.124)	-1.47 (0.141)
D_{publ}	**-1.91 (0.056)**	-0.84 (0.404)	0.11 (0.914)	D_{publ}	**-1.94 (0.052)**	-0.70 (0.483)	0.52 (0.607)
Year	-0.09 (0.932)	-1.44 (0.151)	-0.10 (0.919)	Year	0.68 (0.500)	-1.54 (0.124)	-0.51 (0.607)
$X_{deposit}$	0.13 (0.896)	-0.80 (0.423)	0.18 (0.857)	Y_{invest}	-0.09 (0.931)	-0.03 (0.974)	-0.11 (0.910)
D_{publ}	**-1.98 (0.048)**	-1.22 (0.224)	0.17 (0.865)	D_{publ}	**-1.98 (0.047)**	-1.38 (0.167)	0.15 (0.878)
Year	-0.73 (0.465)	-0.61 (0.543)	-0.27 (0.786)	Year	-0.67 (0.502)	-1.02 (0.310)	-0.19 (0.851)
$X_{capital}$	0.46 (0.642)	0.06 (0.952)	0.16 (0.873)	Y_{earn}	-0.39 (0.699)	0.24 (.808)	-0.60 (0.547)
D_{publ}	**-1.67 (0.094)**	-1.38 (0.168)	0.15 (0.882)	D_{publ}	**-1.76 (0.078)**	-1.33 (0.184)	0.18 (0.857)
Year	-0.47 (0.642)	-0.95 (0.341)	-0.24 (0.814)	Year	-0.70 (0.483)	-1.22 (0.221)	-0.21 (0.831)
$X_{int\text{-}exp}$	0.39 (0.696)	-0.00 (1.000)	-0.00 (1.000)	Y_{obs}	0.14 (0.888)	0.27 (0.789)	-0.00 (1.000)
D_{publ}	**-1.96 (0.050)**	**-1.79 (0.074)**	0.17 (0.865)	D_{publ}	**-1.95 (0.051)**	-1.32 (0.186)	0.15 (0.880)
Year	-0.96 (0.337)	-0.15 (0.885)	-0.21 (0.834)	Year	-0.87 (0.386)	-1.22 (0.221)	-0.18 (0.854)
X_{nonint}	-0.00 (1.000)	-0.03 (0.976	-0.44 (0.660)	Y_{nonrev}	-0.00 (1.000)	-0.00 (1.000)	-0.00 (1.000)
D_{publ}	**-1.76 (0.078)**	-1.35 (0.176)	0.17 (0.868)	D_{publ}	**-1.95 (0.052)**	-1.34 (0.179)	0.19 (0.853)
Year	-0.30 (0.762)	-1.16 (0.245)	-0.20 (0.841)	Year	-0.63 (0.530)	-0.98 (0.326)	-0.23 (0.820)
$X_{quality}$	-0.00 (1.000)	-0.00 (1.000)	-0.00 (1.000)	Y_{intrev}	-0.19 (0.850)	-0.00 (1.000)	-0.00 (1.000)
D_{publ}	**-1.94 (0.053)**	-1.33 (0.185)	0.18 (0.855)	D_{publ}	**-1.97 (0.049)**	-1.62 (0.104)	0.17 (0.861)
Year	-0.89 (0.372)	-1.23 (0.219)	-0.23 (0.821)	Year	-0.68 (0.497)	-0.69 (0.490)	-0.22 (0.827)
				Y_{depos}	**14.94 (0.000)**		0.71 (0.477)
				D_{publ}	**-2.21 (0.027)**	**-2.09 (0.037)**	0.11 (0.909)
				Year	**-14.94 (0.00)**	**-3140.7 (.000)**	-0.14 (0.887)

Note: Table presents estimated parameter Z statistics with p – value in brackets.

2. The same effect holds for the *publication* dummy variable. Amongst the large number of published and unpublished papers on banking efficiency which have used the Bankscope database, the use of the non-intermediation approaches diminishes when the research passes the publication refereeing process.

Turning now to individual study specific variables, two further clear conclusions emerge.

3. First, the use of *deposits* as an output massively increases the probability that a production model is used. The size of the marginal effect surpasses all other parameters by a factor of 10 or more, and the *p-value* is zero to three decimal places. Unequivocally, it can be said that the use of *deposits* as an output is associated with the production approach.

4. Second, no other output or input variable is statistically significant at the 10 per cent level or less in explaining the choice of model type. Interestingly, this includes the use of both *loans* and *other earning assets* as outputs. In other words, the use of *loans* and *other earning assets* as outputs does not lead to a statistically significant decrease in the probability of using a non-intermediation model.

The lack of significance of many variables suggests a lack of consistency in the choice of input/output approaches amongst research studies and a lack of agreement about relevant inputs and outputs. Therefore, with respect to the weaknesses of meta studies, which lie in the heterogeneity of the analysed studies and the bias towards published papers, I can conclude that in choosing the approach and defining the input and output variables, researchers mainly rely on concepts of their theoretical considerations. And the choice of a particular approach of describing the banking production process is not affected by the availability of a particular input or output variable information.

3.5. Conclusion

This chapter has attempted to fill a gap in the literature by reviewing the recent literature on efficiency and productivity analysis in the banking industry with focus on inputs and outputs definition and measurement, and by combining and examining research findings which employ the same database – Bankscope.

Given the findings of above section, it is, thus, noteworthy that the specified theoretical differences in the choice of inputs and outputs definitions and input and output variables used in surveys could differ. In particular, in the Table 3.1 one can find some work where researchers do not specify the approach. Also it is worth noting that the different specifications of inputs and outputs are used even when researchers follow the same approach. Indeed, yet again these facts are proof of the difficulty of defining inputs and outputs in the banking industry. Thus, as a myriad of different variables are used to describe the banking production process, researchers would readily admit that the difference in choice of inputs and outputs can influence efficiency scores (see Berg *et al*, 1991). Therefore we simply cannot anticipate and much less systematically analyze these concepts.

CHAPTER FOUR: DEALING WITH ENVIRONMENTAL VARIABLES AND RISK DECOMPOSITION IN BANKING: UNDESIRABLE OUTPUT FRAMEWORK

SUMMARY

In this chapter I propose the technological and behavioural modelling of production with undesirable output and extend the three-stage DEA procedure suggested by Pastor (1999a) to decompose undesirable output in banking (risk). The models proposed estimate the non-radial Russell measure of output technical efficiency of production and incorporate undesirable outputs and negative components. I use the axiom of weak disposability of undesirable outputs (Färe, Grosskopf, Lovell and Pasurka (1989)), and handle unrestricted data in the proposed models using the range directional distance function (Silva Portela, Thanassoulis and Simpson (2004)). I apply these models to the discussed Eastern European banking systems using the Intermediation, Production and Profit input/output methodologies.

4.1. Introduction

Risk is the fundamental element of the banking business. In the process of providing financial services, commercial banks typically expose themselves to various kinds of financial risks, including credit, market, interest rate and liquidity risk. The economic liberalisation and shift to a market driven economy in the transition countries led to competition intensification in their banking industry resulting in complexity of banking risk. Aside from the credit risk (the risk of customer or counterparty default) involved in lending operations, banking risks generally are mostly linked to exposures resulting from adverse movement in market rates or prices, with the further potential that a bank will be unable to meet its obligations. Although all banking risks are critical components of a comprehensive risk management, the effective management of credit risk is essential for the long-term success of a banking institution. This is because credit risk remains the leading source of problems in banks world-wide[17].

Judgments about the *ex-post* risk awareness of a bank are typically based on bank financial statements and reports that contain accounting and other data, and loan losses or non-performing loans which are used as one measure of the risk profile and portfolio quality of a bank (FRBSF Economic Letter, 1999). Recently, banking efficiency studies have explicitly accounted for banking risk by incorporating this information via variables capturing the quality of the bank's assets and the probability of the bank's failure (Table 4.1). For example, in parametric studies, risk was incorporated as arguments in the cost function or as the dependant variable of an equation in a system of equations implicitly assuming that the risk was of an exogenous nature. Generally, the volume of non-performing loans or their ratio to the total loans was used as a proxy for the (credit) risk. As it was argued in the literature (Berger and DeYoung, 1997), the inclusion of non-performing loans into the analysis as problem loans or risk has the advantage of being contingent on less managerial discretion than the use of the loan loss provisions. Therefore, to estimate management efficiency, in the parametric studies of Altunbas et al. (2000) and Pastor and Serrano (2005), the loan loss provisions were utilised.

[17] More details on credit risk and its management can be found in the papers issued by the Basel Committee, such as 'Credit risk modelling: Current Practices and Application' (Apr 1999), 'Principles for the Management of Credit Risk' (Sept 2000) and 'Sound Credit Risk Assessment and Valuation for Loans' (Jun 2006).

Table 4. 1. Overview of banking efficiency studies incorporated risk in the modelling

Author(s)	Methodology	Country analysed	Approach	Inclusion of environmental variables into analysis	Risk decomposition	Incorporation of Risk	
						Variable used	Variable Category
Mester (1996)	Stochastic cost translog function	USA (1991-92), 214 banks	Intermediation	N	N	1) Default risk: average volume of equity capital	Arguments of cost function
						2) Assets' quality: volume of non-performing loans in 1992	Arguments of cost function
Berger and DeYoung (1997)	Stochastic Fourier-flexible cost translog function	USA, 1985 – 1994		Dummy variable for region indication	N	Ratio of non-performing loans to total loans	Dependent variable of equation in Granger-causality model
Pastor (1999a)	DEA	Spain (1985 – 1995)		Y	Y	Provisions for Loan Losses	Input
Altunbas et al (2000)	Stochastic Fourier-flexible cost function	Japan (1993 – 1996)	Intermediation	N	N	1) Output quality proxy: loan-loss provisions as a proportion of total loans;	Arguments of cost function (interactive with output and input price)
						2) Risk preferences: Equity capital	Arguments of cost function
						3) Liquidity risk: ratio of liquid assets to total assets	Arguments of cost function

Pastor (2002)	DEA	Italy, Spain, France, Germany (1992 – 1994)	Value-added	Y	Y	Credit risk: Provisions for Loan Losses	Input
Drake and Hall (2003)	DEA	Japan (149 banks)	Intermediation	N	N	Loan Loss Provisions	Uncontrollable (non-discretionary) input
Drake, Hall and Simper (2005)	DEA (SBM)	Japan	Intermediation, Production, Profit/Revenue-based	N	N	Total Provisions: Loan Loss Provisions + Other provisions	Input
Drake, Hall and Simper (2006)	DEA: SBM and regression analysis	Hong Kong	Profit approach	Y	N	Loan Loss Provisions	Input
Pastor and Serrano (2005)	Distribution Free Analysis: Cost efficiency and Profit Efficiency	Germany, Belgium, Spain, France, Italy, Luxembourg, Portugal (1993 – 1997)	Value-added	Y	Y	Credit risk: Provisions for Loan Losses	Dependant variable of an equation in the system of equations

Note: “Y” – Yes, “N” – No.

Moreover, in the latter study the environmental variables were included into the analysis with the purpose of decomposing risk into exogenous and endogenous elements.

In all the non-parametric studies presented in Table 4.1, the banking risk was defined by the loan loss provisions or total provisions and was incorporated into the banking production model as an input. This implied on endogenous origin for the risk[18]. Furthermore, the surveys of Pastor (1999a and 2002) suggest a decomposition of risk into internal and external components depending on the origin of the risk. And the internal risk (controllable by the bank) is also included in the model as an input. Additionally, the models in these studies estimate efficiency measures of the bank taking into account the environmental condition banks operating in. This was done by the use of cyclical and banking sector specific sector variables integrated into the models as non-discretionary inputs. An alternative, statistical, way of quantifying the effect of environmental and market factors on efficiency taking into account banking risk is via the Slack-Based Model of Tone (2001). This is presented in the study of Drake, Hall and Simper (2006).

Although most of the efficiency studies on banking risk assume banking production processes where all the outputs are desirable and the risk is either an input or an exogenous variable in the model, I consider an undesirable output framework for the same. As the goal of bank management is to better match the economic capital with the bank's risk profile and to effectively assess the quality of loans and other banking services and products, inefficient risk management can affect the financial stability of the bank and even lead to the bank's failure. However, the risk and expected profit of the banks are positively related, i.e. higher the risk, higher the anticipated profit. At the same time I need to bear in mind that the higher risk assumes higher probability of failure and therefore the likelihood of getting the higher profits from risky assets is lower than in less risky assets.

Therefore, from the bank's perspective, loans are not always 'high quality' output in view of the fact that the quality of the loan depends on its riskiness and the

[18] The exception is the study of Drake and Hall (2003) in which the risk was considered as an exogenous factor affecting the banking production and included into the non-parametric linear programming model as an uncontrollable or non-discretionary input.

probability of its repayment. Although according to the survey of Speagle and Kohn (1958) on employment and banking output (one of the earliest discussions on banking inputs and outputs), "from a social-economic standpoint, loans may be considered 'high quality' output" (p.34). Furthermore, loans as an output of banking production contain a risk, the level of which bank managers are interested in minimising to the optimum level, at which point the risk taking by the bank and its exposure is the lowest given the optimal expected profits. Thus, in order not to "miscalculate a bank's level of inefficiency; e.g., banks scrimping on credit evaluations or producing excessively risky loans might be labeled as efficient when compared to banks spending resources to ensure their loans are of higher quality" (Mester, 1996, p.1026), I included risk into the analysis. However, "if we want to consider risk as an *undesirable quality* we must *reward* (increasing their efficiency) those banks that are good risk managers" (Pastor, 1999a, p. 376, first emphasis is mine). To do so I treated the banking risk as an undesirable output of banking production[19]. In addition, in the modelling I take into account that the minimisation of the risk requires costs (for example, risk assessment systems (credit scoring, credit history etc), monitoring of loans), and therefore the risk is incorporated not as a strongly disposable component (as it was modelled in all the non-parametric studies discussed earlier) but as a weakly disposable undesirable output. Analogously to all non-parametric studies, I take Loan Loss Provisions (LLP) as a proxy for risk. I further assume that the Eastern European banks are not engaged in income smoothing behaviour using the provisions for loan losses accounts[20].

However, to construct a model incorporating an undesirable output, it is important to identify the origins of the 'good' and 'bad' outputs in the production framework. In this study, I distinguish between two types of production processes with desirable and undesirable outputs: those that are based on *technological* relationships between the 'good' and 'bad' outputs, and those, which assume a *behavioral* origin of desirable and undesirable outputs.

[19] Additionally, according to Berger and DeYoung (1997), the bad management hypothesis they test suggested that the major risks facing financial institutions are caused internally. Consequently, I include the risk into the model directly as part of the production process (as undesirable output).
[20] An existence of negative values of LLP in some analysed banks (given the fact that the positive LLP are tax-deductible) may suggest that Eastern European banks are not smoothing their incomes through LLP.

In the context of *behavioral* modeling I focus on the banking production process and extend the three-stage sequential DEA procedure suggested by Pastor (1999a) to decompose the undesirable outputs in banking risk into endogenous (poor management) and exogenous (macroeconomic) factors. Moreover, this procedure also takes into account external factors affecting efficiency, which makes it specifically useful for cross-country (cross-region) analysis where it is deemed that these variables are important in accounting for the potential differences in country-specific banking technology and environmental and/or regulatory conditions.[21,22,23] In addition, I also posit that as corruption is an obstacle which can impair banking and business performance, this should also be taken into account. Indeed, according to the Corruption Perception Index (Transparency International), in many parts of the CEE region corruption is endemic.[24] Therefore, another contribution of this thesis to the literature is that along with the other environmental variables, I include a corruption perception index in the analysis.

In relation to the non-parametric model that I introduce, I also impose the axiom of weak disposability of undesirable outputs in a piecewise linear representation of the production technology, as suggested by Färe, Grosskopf, Lovell and Pasurka (1989). In addition, the relevant concepts of efficiency incorporate a range directional

[21] Short survey of studies incorporated environmental, economic and regulatory factors in bank efficiency analysis can be found in Drake, Hall and Simper, 2006.

[22] The environmental variables used in single country's banking system too. For instance, analysis in the analysis of Hong Kong banks Drake, Hall and Simper (2006) included the following macroeconomic variable: private consumption, government expenditure, GDP fixed capital formation, net export of goods, net export of services, discount window base rate, unemployment, retail sales values, expenditure on housing, and current account balance; and the following regulatory variable: dummy variable for the Hong Kong property crash/Asian financial crisis, dummy variable for handover to the PR of China, dummies for 1999 and 2001. Pastor (1999a) in the analysis of Spanish banking system initially considered the following business cycle and structural economic variables affecting the risk and efficiency: rate of growth of GNP, average rate of growth of GNP in last 5 years, average rate of growth of private investment rate in last 5 years, average rate of growth of public investment rate in last 5 years, unemployment rate, lagged unemployment rate, unemployment rate of growth, average unemployment rate of growth in last 5 years, variance of unemployment within year, variance of the unemployment in the prior period, private investment per person, private investment per km^2, public investment per person, public investment per km^2, GNP per person, GNP per km^2, branches per person, branches per km^2, diversification index of bank branches, sector diversification index by sectors.

[23] To incorporate country-specific environmental conditions into the analysis of French and Spanish banking industries, Dietsch and Lozano Vivas (2000) used the following environmental variables: population density, per capita income, density of demand, Herfindhal index of concentration, average capital ratio, intermediation ratio, number of branches per km^2. Pastor (2002) find that risk in his Spanish, Italian, French and German banking systems analysis is influenced by inter-annual coefficient of the variation of nominal GDP, growth rate of GDP, cumulative growth of GDP, and the efficiency is influenced by per capita wage, density deposits, national income per branch, capital adequacy ratio.

[24] More info about the corruption can be found in the World Bank web-site, http://psdblog.worldbank.org/psdblog/eastern_europe_and_central_asia.

distance function approach following Silva Portela, Thanassoulis and Simpson (2004) to handle unrestricted data, i.e., both negative and non-negative values. The models proposed, therefore, estimate the non-radial Russell measure of output technical efficiency in banking production incorporating undesirable outputs and negative components. Finally, I also consider three different frameworks to the banking production process, viz. the Intermediation, Production and Profit/Revenue input/output specification approaches. This is primarily to analyse the sensitivity of the results. Moreover, to my knowledge, this is the first attempt to apply this type of three-stage undesirable output framework to the study of CEE banking systems.

The chapter is organised as follows. In Section 4.2, I briefly review studies on banking efficiency analysis in the CEE countries and the theoretical and empirical literature on undesirable output modelling. I further suggest a new classification. In section 4.3 I describe the data and methodology proposed in the thesis. Section 4.4 presents the empirical results and, finally, I provide concluding remarks in Section 4.5.

4.2. CCE Bank Efficiency and technological and behavioral modeling approaches incorporating undesirable outputs.

In relationship to the literature that discusses the standard analyses of financial intermediary efficiency measurement, there is a dearth of studies that consider cross-country comparisons within Eastern Europe. For example, Croatian banks were examined by Kraft and Tirtiroglu (1998) and Jemric and Vujcic (2002); Hungarian banks by Hasan and Marton (2003); Polish banks by Opiela (2000); and Taci and Zampieri (1998) investigated the cost efficiency of Czech banks. However, interestingly, these studies have found conflicting results with respect to policy conclusions. That is, with respect to the performance of private- and state-owned banks, Kraft and Tirtiroglu (1998) find that Croatia's newly established private banks are less efficient than old private and state banks, whereas (Taci and Zampieri, 1998) investigations find that the cost efficiency of Czech banks shows that private banks appear more efficient.

Although not all of these studies explicitly distinguish between foreign owned and domestic owned banks, several have given some evidence of foreign – owned banks performance. For example, Jemric and Vujcic (2002) find that foreign – owned banks in Croatia are significantly more efficient than domestically owned banks. The same conclusion is made for Poland by Opiela (2000)[25] and for Hungary by Hasan and Marton. However, Weil (2003) who examines Polish and Czech banks finds that the greater efficiency of foreign banks could be attributed to advantages in corporate governance and better skills, rather than to the scale and mix of their operations.

Further, the remaining studies that have dealt with cross – country comparisons of Eastern European transition countries; Fries, Neven and Seabright (2002) examine the performance and profitability of 515 banks in 16 transition countries over 1994 – 99; and find that a bank's performance depends on the 'reform environment'. Grigorian and Manole (2006) estimate bank efficiency in 17 countries and conclude that there is strong evidence of higher efficiency being associated with foreign controlling ownership, and weaker evidence of efficiency improving as a result of prudential rules improving. The authors also find that privatization does not lead to a statistically significant improvement in efficiency. Finally, Yildirim and Philippatos (2002) estimate bank cost and profit efficiency across 12 transition countries (1993 – 2000) and find that profit efficiency levels are lower than cost efficiency, and this relation is stronger for foreign banks than for other banks in the considered countries. They also find evidence of higher efficiency levels associated with large banks, which is at variance with studies such that of Bonin, Hasan and Wachtel (2003).

The measurement of firms' performance accounting for undesirable outputs, has recently received increasing attention and several modeling approaches for incorporating bad outputs have been proposed. For example, Scheel (1998) compares non – parametric DEA approaches for the joint production of good and bad outputs and classifies them as direct and indirect approaches. According to this classification, indirect approaches treat desirable and undesirable outputs differently by using a monotone decreasing function *f*. In other words, undesirable output data is

[25] Opiela (2000) employs SFA and observes that there is a larger number of 100 percent efficient banks among foreign – owned than among Polish-owned banks, however this result is more suggestive than conclusive.

transformed by the monotonically decreasing function f, so that the transformed bad output data can be included in the technological set as desired output. Hence, three types of transformation procedures can then be distinguished: the '*additive inverse*' where the undesirable output U is included into the program as desirable output and takes values $f\ (U) = -U$[26]; '*translated*' - where the monotonically decreasing function f takes the form of $f_i^k(U) = -u_i^k + \beta_i$ and β_i is a sufficiently large scalar; and '*multiplicative inverse*' where the undesirable output U, before its incorporation into the program, is transformed to a 'normal' - desirable output using the function $f_i^k(U) = 1/u_i^k$.

Alternatively, a researcher can use the direct approach, where the structure of a technology set is changed in such a way that the original data on an undesirable output is incorporated into the program but with modified assumptions; that is, imposing the weak disposability assumption on bad output. As Scheel (1998) argues, the direct approach is used in cases where it is impossible to reduce bad output without simultaneous reduction of the good output. Hence, prior to the choice of the modeling approach, in order to allow for proper and objective quantification and measurement of the performance of firms with respect to the 'bad' byproducts of the production process, the nature of the undesirable output and its relationship to the desirable utput(s) have to be defined. I classify two different types of undesirable output origin: technological and behavioural, see Figure 4.1.

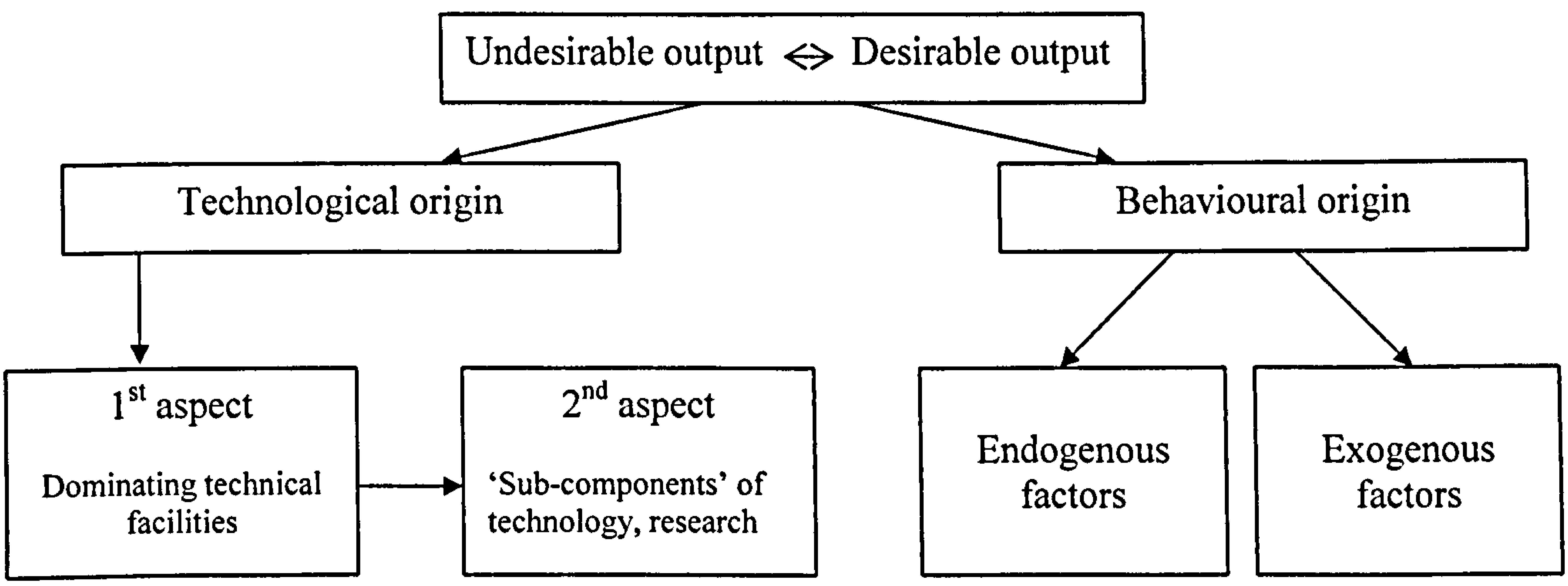


Figure 4. 1. Technological and behavioural type of relationships between desirable and undesirable

[26] This is equivalent to the treating the undesirable output as an input.

The technological nature of an undesirable output can be characterised by two aspects. That is, the technical facilities necessary for the output production, provided that these facilities are dominant elements in the determining the production process. For example, in electricity production, these facilities differ by the type of energy source fuel: nuclear, coal, gas and oil, water etc. It is clear, that the undesirable output and its relation to the good outcomes of production process in different types of electricity generating plants are different. The second aspect is related to the technology used in the particular type of firm, as well as to the directions of the on-site research and product development activities within the firm and/or industry. Again, in the example of the electricity production companies, the companies which utilise natural gas and oil, differ by the electricity generating technology (combined or simple cycle) and operating mode (baseload or peaking). Evidently, even in the same type of electricity production but with different sub-components of technological process, the level of bad output (e.g., CO_2) emission can vary.

A second type of undesirable output can be deemed as behavioural. While the technological origin of bad by-products maintains the idea that the relationship between desirable and undesirable outputs of the production process is subject to physical endogenous factors, the second type of undesirable output attributes behavioural peculiarities which can be either exogenous or endogenous to the firm. In fact, endogenous behavioural factors may be the same among the different industries (e.g. bad management), but the exogenous factors could also vary from industry to industry. In the context of the banking industry, the nature of an undesirable output of production process is related to several factors which are illustrated in Figure 4.2.

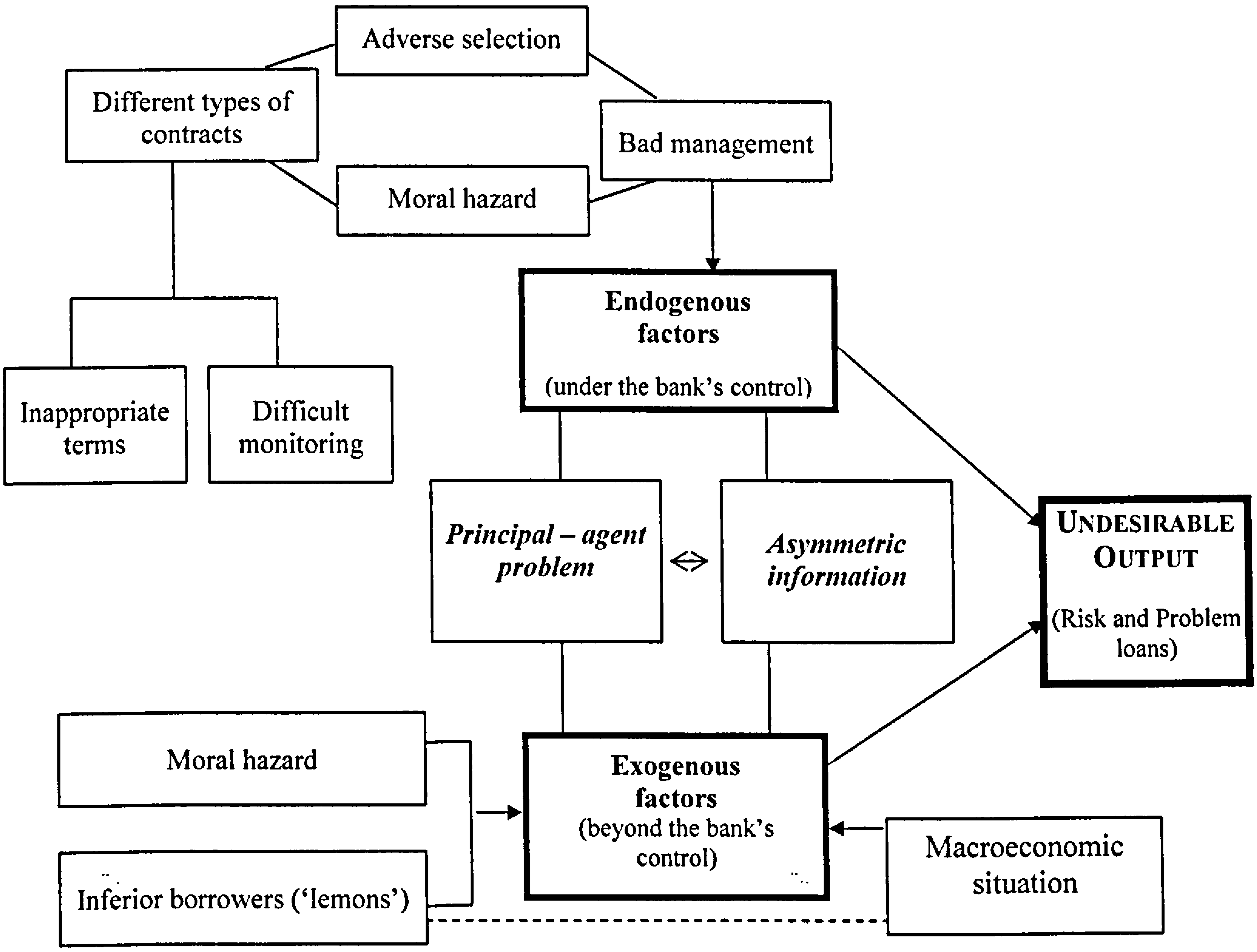


Figure 4. 2. Behavioural nature of undesirable output in banking industry

The undesirable output of the production process is particular to the banking industry. In Figure 4.2, I distinguish between two special characteristics of the market where banks operate: asymmetric information and the existence of principal – agent problems. In relation to banking firms, these two factors could be either endogenous or exogenous. For example, asymmetric information can occur when one side of a banking contract (bank or bank's customer) has information that the other does not. From a bank's perspective, this could mean that the bank has greater knowledge, typically of the service itself, than it's customer. But it could also imply that the customers possess superior knowledge in relation to the terms of the contract, for instance various priorities in relation to their business needs. The principal – agent issue arises because of the differences between principal's and his/her agent interests (for a survey, see Altunbas et.al. (2000), Llewellyn (1995, 1998, 1999), and Peristiani and Wizman (1997)).

The endogenous factors are controllable by the bank and are mainly related to management behavior[27]. The factors which may cause bad management (X-efficiencies) are adverse selection (when bank management cannot determine some characteristics of the borrower that are relevant to the determination of the loan contract price), and moral hazard of management (managers act in their own interests). These could arise because of different types of contracts as a result of difficulties in their monitoring and 'appropriate' terms specification. However, the exogenous factors of undesirable output originating in the banking production process are beyond the bank's control and related to macroeconomic variables and to customers (in this case to borrowers). These factors include the moral hazard of borrowers (a situation in which borrowers, who do not bear the full cost of their actions and have an incentive to behave in ways which are not beneficial to the bank) and inferior borrowers – the so called 'lemons'.

Hence in this study, I utilize a non-parametric specification which incorporates undesirable outputs, implements weak disposability of the undesirable outputs and strong disposability of inputs and desirable outputs (see also, Färe et al (1989) and Färe and Grosskopf (2004)). Moreover, the models defined in this study have three features; they estimate the non-radial Russell measure (Hua et al, 2007); they calculate efficiency in the presence of negative data using a directional distance function approach proposed by Silva Portela et al (2004); and they incorporate non-discretionary inputs (macroeconomic and banking sector environmental variables). That is, suppose I have n number of banks ($j= 1, \ldots, n$). The model assumes that production process is captured by the following expression,

[27] An approach which considers bank's management behavior through the intertemporal relationships between cost efficiency, asset quality, capitalization and risk, is suggested by Berger and DeYoung (1997). They look at specific types of management behavior which are bad management, bad luck, skimping and moral hazard behavior. They utilize Granger causality methods and find that in case of US banking sector the increase in problem loans leads to reduction in cost efficiency - bad luck. The fall of cost efficiency which is followed by the increasing of problem loans at industry level, lead efficient banks to be engaged in skimping behavior (bad management).

$$P: R_+^m \rightarrow P(x) \subseteq R^s, \text{ where} \qquad (4.1)$$

and $x \in R_+^m$ denotes input vectors, $y = (y^g, LLP) \in R^s$ denotes the output vectors, subvector y^g defines good outputs, subvector *LLP* denotes the undesirable output of banking production[28], and $P(x)$ is the output set and represents the set of all output vectors producible by the input vector x. I assume that the bad output *LLP* is weakly disposable and that good outputs are strongly disposable. The matrix of observed inputs by M is $n \times M$, and $n \times S$ is a matrix of observed outputs by $S = (Y^g, LLP)$, where Y^g is a submatrix of observed 'good' outputs and *LLP* is a submatrix of observed risk. Matrix M is non-negative and has strictly positive row sums and column sums, whereas matrices Y^g and *LLP* can be negative.

Since Y^g and *LLP* can be negative, in the models I apply the following Range Directional vectors where (see, Silva Portela et al (2004)),

$$R_{LLP_0} = LLP_0 - \min_j \{LLP_j\} \qquad (4.2)$$

$$R_{r0}^g = \max_j \{y_{rj}^g\} - y_{r0}^g \quad , r = 1, \ldots, R \qquad (4.3)$$

Equation (4.2) shows the range of possible improvement of unit *o* in increasing the desirable outputs y^g The range of possible improvement of unit *o* in the decreasing undesirable output *LLP* is captured by equation by (4.3). The three stages of the analysis are now presented.

4.2.1. Stage 1. 'Risk management efficiency'

As shown in Figure 4.2, risk in banking arises due to endogenous and exogenous factors. Hence, I need to remove the effect of external factors from the risk, since banks can reduce only that part of risk which attributed to managerial inefficiency (see Pastor, (1999a) and (1999b)). One of the potential problems is that the accounting process of bank data (via the profit and loss account) allows the LLP (proxy for risk in the models) to be negative. For that reason, the following method, based on range directional DEA, is utilized to decompose LLP into endogenous and

[28] The same as Pastor (1999a), Hughes and Mester (1993), Mester (1996), Altunbas et al (2000), Drake and Hall (2003), Drake, Hall and Simper (2005) I use Loan Loss Provisions (LLP) as a proxy for bank credit risk. But, unlike to these studies, LLP is considered as undesirable output of banking production process.

exogenous components. The exogenous factors are incorporated into the model as non-discretionary inputs[29].

Max γ

s.t.

$$\sum_{j=1}^{n} \lambda_j LLP_j \le LLP_0 - \gamma_0 R_{LLP_0}$$

$$\sum_{j=1}^{n} \lambda_j L_j \ge L_0$$

$$\sum_{j=1}^{n} \lambda_j Z_{pj}^{+} \le Z_{p0}^{+}, \qquad p = 1,...,P \tag{4.4}$$

$$\sum_{j=1}^{n} \lambda_j Z_{qj}^{-} \ge Z_{q0}^{-}, \qquad q = 1,...,Q$$

$$\sum_{j=1}^{n} \lambda_j = 1, \qquad \lambda_j \ge 0, \ \forall j$$

where λ_j is a vector of non-negative weights, LLP_j is the amount of loan loss provisions, L_j is the amount of loans, $Z_j^{+} = (Z_{1j}^{+}, Z_{2j}^{+},..., Z_{Pj}^{+})$ and $Z_j^{-} = (Z_{1j}^{-}, Z_{2j}^{-},..., Z_{Qj}^{-})$ are the vectors of positively or negatively (respectively) the external cyclical conditions of the economy, which affect banking risk.

The value of $\bar{\gamma}_j$ is the proportion of risk due to factors internal to bank, i.e., bad management. That is, if $\bar{\gamma}_j = 1$, then the bank is risk management inefficient, whereas a bank with $\bar{\gamma}_j = 0$ is found to be risk management efficient. Therefore, the larger $\bar{\gamma}_j$ denotes that the larger is the proportion of loan loss reserves assigned to inefficient risk management.

4.2.2. Stage 2. 'Efficiency adjusted for risk'

In this stage of the analysis I propose a new measure of output efficiency incorporating desirable and undesirable outputs (both possibly negative) which are derived from the range directional good output and bad output distance functions (4.2) and (4.3). The measure of output efficiency extends the work of Färe et al (1989) and

[29] Non-discretionary input can be defined as an input which is exogenously fixed and beyond the discretionary control of DMUs (Banker and Morey, 1986). Non-discretionary inputs comprise those factors that are sign of different economical (macro-, or on industry level) and political (governance) aspects which may affect risk attitude and performance of banks.

Färe and Grosskopf (2004). These studies impose a weak disposability assumption on undesirable outputs. In addition, the former study uses a hyperbolic efficiency measure whereas later uses directional output distance function with an appropriately chosen direction of undesirable output to construct a model which accounts for the reduction of undesirable output. Yet, these interesting methods are rather restrictive, because they measure radial efficiency which requires a proportional change of both desirable and undesirable output. That is, the production process may not allow for equiproportional increases in good and decreases in bad output. In addition, the radial expansion/contraction may leave slack in certain outputs; hence, I develop a non-radial linear programming model which measures Russell efficiency and accounts for undesirable outputs with possible negative desirable and undesirable outputs.

The proposed output-oriented model for banking is as follows:

$$\text{Max } \theta = \frac{1}{s}\sum_{r=1}^{R}\alpha_r + \frac{1}{s}\beta$$

s.t.

$$\begin{aligned}
&\sum_{j=1}^{n}\lambda_j x_{ij} \le x_{i0} \\
&\sum_{j=1}^{n}\lambda_j y_{rj}^{g} \ge y_{r0}^{g} + \alpha_r R_{r0}^{g} \\
&\sum_{j=1}^{n}\lambda_j LLP_j = LLP_0 - \beta_0 R_{LLP_0} \\
&\sum_{j=1}^{n}\lambda_j = 1, \qquad \lambda_j \ge 0
\end{aligned} \tag{4. 5}$$

where $s = R + 1$, because in the modelling of banking production, I assume that the only undesirable output is risk (LLP as a proxy). However, as in Figure 4.2, and as it is mentioned in Pastor ((1999a) and (1999b)), banks can minimise only that part of risk which is due to the internal factors. For this reason, the following model accounts for that part of the risk that arises due to the bad management of the bank (γLLP):

$$\text{Max } \rho = \frac{1}{s}\sum_{r=1}^{R}\alpha_r + \frac{1}{s}\beta$$

s.t.

$$\sum_{j=1}^{n}\lambda_j x_{ij} \le x_{i0}$$
$$\sum_{j=1}^{n}\lambda_j y_{rj}^g \ge y_{r0}^g + \alpha_r R_{r0}^g$$
$$\sum_{j=1}^{n}\lambda_j \gamma_j LLP_j = \gamma_0 LLP_0 - \beta_0 R_{\gamma_0 LLP_0} \tag{4. 6}$$
$$\sum_{j=1}^{n}\lambda_j = 1, \qquad \lambda_j \ge 0$$

where $R_{\gamma_j LLP_0} = \gamma_0 LLP_0 - \min_j\{\gamma_j LLP_j\}$. This allows the measurement of a bank's risk performance since model (4.6) estimates the efficiency level of banks by taking into account the risk which is due exclusively to poor risk management.

The comparison of the efficiency measure which accounts for total risk $(1\text{-}\theta_j)$ obtained by estimating model (4.5) with efficiency measure adjusted for risk sourced to internal factors $(1\text{-}\rho_j)$ obtained by estimating model (4.6), will present an insight into which factors affect bank performance. Since external cyclical factors are beyond the bank's control, the bank should also take them into account in order to minimise their impact. Therefore, the ratio of these two efficiency measures shows whether the bank successfully copes with external factors and how the internal management efficiency affects overall riskiness. Along with Pastor (1999b), I call this ratio the 'Risk Management Effect' (RME).

$$RME_j = \frac{1-\theta_j}{1-\rho_j} \tag{4. 7}$$

If a bank has RME=1, this implies that the bank is risk management efficient, if RME<1 then bank is risk management inefficient and endogenous factors affect the performance of the bank. Finally, if RE>1, then the bank is risk management inefficient and exogenous factors affect the performance of bank.

4.2.3. Stage 3. Efficiency adjusted for risk and environment.

Model (4.6) considers internal factors affecting the bank's risk management and adjusts for the factors of exogenous cyclical dynamics of the economy. However, the internal management of the bank can be affected by the economic factors of the banking system, since the efficiency of the banking system can itself affect the efficiency of one particular bank in the system. For that reason, I adjust for the risk of the exogenous macroeconomic factors calculated by Model (4.6), by adding the banking system specific variables. The new Model is as follows.[30]

$$\text{Max } \Omega = \frac{1}{s}\sum_{r=1}^{R}\alpha_r + \frac{1}{s}\beta$$

s.t.

$$\begin{aligned}
&\sum_{j=1}^{n}\lambda_j x_{ij} \le x_{i0} \\
&\sum_{j=1}^{n}\lambda_j y_{rj}^{g} \ge y_{r0}^{g} + \alpha_r R_{r0}^{g} \\
&\sum_{j=1}^{n}\lambda_j \gamma_j LLP_j = \gamma_0 LLP_0 - \beta_0 R_{\gamma_0 LLP_0} \\
&\sum_{j=1}^{n}\lambda_j Q_{pj}^{+} \le Q_{p0}^{+}, \qquad p = 1,\dots,P \\
&\sum_{j=1}^{n}\lambda_j Q_{qj}^{-} \ge Q_{q0}^{-}, \qquad q = 1,\dots,Q \\
&\sum_{j=1}^{n}\lambda_j = 1, \qquad \lambda_j \ge 0
\end{aligned} \tag{4. 8}$$

where $Q_j^{+} = (Q_{1j}^{+}, Q_{2j}^{+}, \dots, Q_{Pj}^{+})$ and $Q_j^{-} = (Q_{1j}^{-}, Q_{2j}^{-}, \dots, Q_{Qj}^{-})$ are the vectors of banking system specific variables with a positive or negative influence. The optimal solution Ω_j is adjusted by risk and by the environmental factors of the banking system.

The comparison of (1-ρ_j) and (1-Ω_j) gives an insight into the impact of the environmental factors of the banking system on the efficiency of the bank. This ratio represents an 'Environment Effect' (EE).

[30] A general non-parametric model which accounts for undesirable outputs with possible negative desirable and undesirable outputs and estimates non-radial Russell efficiency measure with or without non-discretionary inputs with negative and positive impact on efficiency, are available from authors upon request.

$$EE_j = \frac{1-\rho_j}{1-\Omega_j} \quad (4.9)$$

The environmental variables are non-discretionary inputs (or outputs depending on the effect of this factor on the efficiency). Therefore, when EE_j=1, it implies that a bank operates in more favourable environment; and when EE_j<1 then it implies that a bank operates in more difficult environment. Based on these ratios, I can decompose (1-θ_j), obtained by estimating model (4.5), into the following components.

$$(1-\theta_j) = (1-\Omega_j)\frac{(1-\rho_j)}{(1-\Omega_j)}\frac{(1-\theta_j)}{(1-\rho_j)} = (1-\Omega_j)EE_j RME_j \quad (4.10)$$

The decomposition (4.10) allows an investigation into the efficiency measure θ_j and highlights the origins of banking efficiency. Accordingly, changes of banking efficiency (1-θ_j) are related to changes of efficiency adjusted by risk and environment (1-Ω_j), changes of Environmental Effect (EE_j), and changes of the Risk Management Effect (RME_j).

4.3 Data and methodology

As data on each bank is not available for every year, in the sample of a balanced panel, I include 159 commercial banks which operated in Croatia (CT), the Czech Republic (CZ), Estonia (ES), Hungary (HU), Latvia (LV), Lithuania (LT), Moldova (ML), Poland (PL), Romania (RM), Russia (RF), Slovakia (SL), Slovenia (SN) and Ukraine (UN) during 1998 – 2003. The beginning of the sample period was chosen in order to consider the post-banking crises effect on the efficiency of commercial banks of the region. The distribution of banks across countries and their percentage share of total assets as a proportion of the whole banking system respectively is presented in Table 4.2[31]. It is noted that the sample does not represent the entire population of banks of some countries but the relatively successful top tier of banks of country's banking system (e.g., Romania, Russia, Ukraine).

[31] List of the analyzed banks can be found in Appendix C.

Table 4. 2. Distribution of banks across the countries (1998 – 2003) and assets of sample banks as percentage of total banking system assets in 2002.

Country	CT	CZ	ES	HU	LV	LT	ML
Number of banks	18	9	4	6	18	8	5
Total Assets (% of total banking system assets)	90.4	68.9	91.1*	55.8	93.3	91.0	60.9
Share of analysed banks' total assets in overall sample's total assets (%)	7.8	20.7	2.6	10.1	2.4	1.7	0.1

Country	PL	RM	RF	SL	SN	UN	**Total**
Number of banks	20	8	33	11	10	9	**159**
Total Assets (% of total banking system assets)	60.2	44.8	21.1	69.6	98.2	30.0	–
Share of analysed banks' total assets in overall sample's total assets (%)	27.8	2.3	9.8	6.2	7.3	1.2	**100**

Note: * Percentage of total assets in total banking system assets of analysed Estonian banks is as in 2003.

Source: RZB Research Group (2004), Bankscope, own calculation

As discussed in previous chapter, despite substantial research efforts, it is generally recognised that one of the main difficulties in the analysis of economic performance and production structure in the banking industry is lack of agreement in the defining and measuring of banks' inputs and outputs. Literature suggests a range of different methodologies which were described in previous chapter. Indeed, the choice of input/output approach has to reflect the objective of the bank. Hence, I may consider the banking production processes from different angles and classify Bergendhal's (1998) bank management targets into three broadly defined ones; profit maximization, intermediation and service/utility production (Figure 4.3). Thus, profit maximization combines features of Bergendhal's profit maximization (Profit/Revenue approach); service/utility production brings together elements of service provision and utility provision (Production approach); and finally – intermediation (Intermediation approach). Because of banking business specificity, risk management is vitally important; consequently, I include this fundamental goal of bank management into all the aspects of banking production.

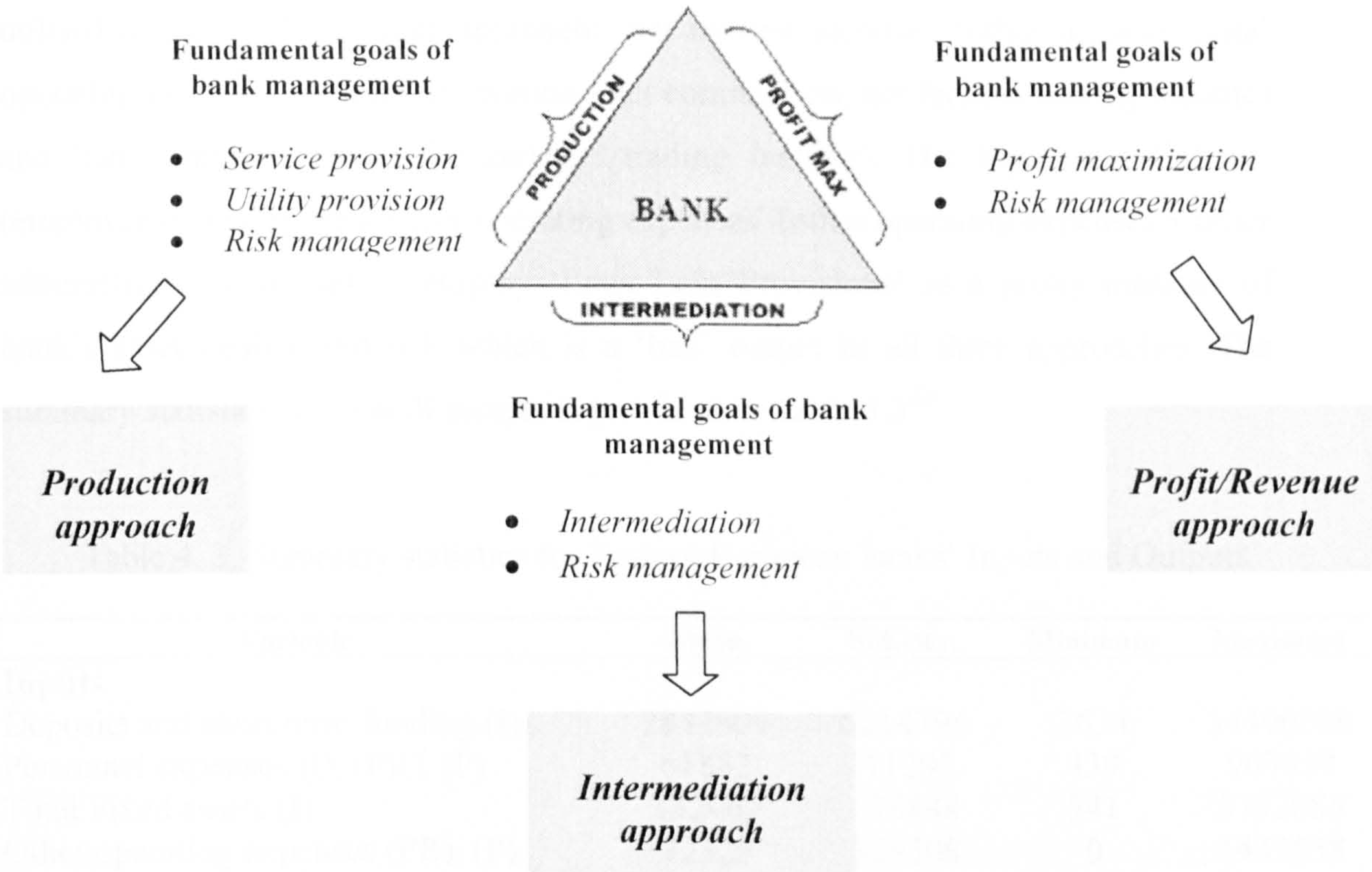


Figure 4. 3. Fundamental goals of bank management and Input/Output methodologies

Therefore, to model the banking production process considering undesirable by-products, I specify Intermediation, Production and Profit/Revenue-based approaches (in line with Drake, Hall and Simper (2005)) which take into account the quality and risk of banks' assets by incorporating in the output side good and bad outputs.[32] In modeling the Intermediation approach I use 'deposits' (deposits and short term funding), 'labour' (personnel expenses) and 'capital' (total fixed assets) as inputs, and 'loans' (total customer loans), 'other earning assets' (total other earning assets), 'net commission, net fee and net trading income' and 'other income' (total operating income - net interest revenue - net commission, net fee, net trading income) as desirable outputs. In the case of the Production approach, I have five desirable outputs and two inputs. The desirable outputs are: 'loans' (total customer loans), 'other earning assets' (total other earning assets), 'net commission, net fee and net trading income', 'deposits' (deposits and short term funding), 'other income' (total operating income - net interest revenue - net commission, net fee, net trading income). The two inputs are 'labour' (employee expenses) and 'other operating expenses' (other

[32] These input/output modelling approaches have been used by Drake, Hall and Simper (2005) in examining Japanese banking system using SBM. I slightly changed the input/output variables specification in order to account for the 'bad' output.

operating expenses + other administrative expenses). Three desirable outputs are utilised in the Profit/Revenue approach: 'net interest income', 'other income' (total operating income - net interest revenue - net commission, net fee, net trading income) and 'net commission, net fee and net trading income'. The inputs are 'labour' (employee expenses) and 'other operating expenses' (other operating expenses + other administrative expenses). I employ 'Loan Loss Provisions' as a proxy measure of bank's asset quality and risk which is a 'bad' output in all three approaches. The summary statistics for overall sample is provided in Table 4.3[33].

Table 4. 3. Summary statistics for Eastern European banks' Inputs and Outputs

Variable	Mean	Std.Dev.	Minimum	Maximum
Inputs				
Deposits and short term funding (I)	2842609	5214396	2634	34400000
Personnel expenses (I), (PR), (P)	61852	111297.	439	963459
Total Fixed assets (I)	132069	276848	341	3792885
Other operating expenses (PR), (P)	72325	129308	0	1443558
Outputs				
Desirable outputs				
Total customer loans (I), (P)	1667050	2775524	412	18800000
Total other earning assets (I), (P)	1470471	3168465	1030	25400000
Net Interest Revenue (PR)	127984	268104.4	-141163	4015469
Other Income (I), (P), (PR)	16576	67628	-280331	980210
Net commission, net fee and net trading income (I), (PR), (P)	76784	162079	-1419131	1183182
Deposits and short term funding (P)	2842609	5214396	2634	34400000
Undesirable outputs				
Loan Loss Provisions (I), (PR), (P)	37612	162977	-1033022	2707264

Note. Figures are presented in PPP USD 000s for CEE countries over 1998-2003. (I) Intermediation Approach, (PR) Profit/Revenue Approach, (P) Production Approach

In this research I consider the cyclical economic variables (Z_j), which are GDP (based on PPP) per capita, GDP deflator (2004 base), GDP change (in percent), inflation, inflation change (in percent), and unemployment rate. Along with the cyclical variables, I include in the analysis a corruption perception index. This variable captures the impact of a factor which has the potential to severely impact the performance of banks and business.

[33] Summary statistics for individual countries are given in Appendix D.

Moreover, the following banking system specific variables are considered as potential non-discretionary inputs (Q_j): concentration, overhead costs and net interest margin of the banking system, deposit money bank versus central bank assets, and average wage in the financial intermediation industry. Additionally, corruption was also considered as a possible factor influencing efficiency. Environmental variables description and data sources are given in Table 4.4 and more details on each environmental variable can be found in Appendix E.

To test the influence of the variables, I utilise the nonparametric procedures suggested by Banker and Natarajan (2004). The null hypothesis was that the efficiency scores estimated by the model with and without particular environmental variables are from the same population, i.e., the environmental variable is not influential. The alternative hypothesis is that the efficiency scores estimated by the model with and without particular environmental variables are from different populations, which means that the environmental variable influences the efficiency and risk of banks in problems (4.4) and (4.8) respectively. Table 4.5 reports the D-values (Kolmogorov-Smirnov test statistics) and probabilities of considered variables.

Table 4.5 presents all considered cyclical variables and corruption influence the risk in banking. I assume that GDP per capita, GDP deflator, GDP change and corruption negatively affect risk; and inflation, inflation change and unemployment rate have positive effect on risk. The risk decomposition is same for all three input/output methodologies. The impact of concentration and net interest margin on efficiency is estimated utilising the Intermediation approach. I assume that concentration has negative effect on efficiency, whereas net interest margin – positive. Efficiency measures calculated using the Production and Profit/Revenue approach are positively effected by net interest margin and corruption perception in the banking system, and negatively - by overhead cost in the banking industry.

Table 4. 4. Selected environmental variables and description

Name	Description	Source
Variables characterising cyclical dynamics of the economy		
GDPCAP - GDP (based on PPP) per capita	GDP Based on Purchasing Power Parity (PPP) Valuation of Country GDP is expressed in constant national currency per person.	IMF, WORLD ECONOMIC OUTLOOK Database, September 2004
GDPDEF - GDP deflator (2004 base)	The GDP deflator is derived by dividing current price GDP by constant price GDP (Base 2004)*	Same as above
GDPCH - GDP change (in percent)	Annual percent change of GDP (in percent)	Same as above
INFL - Inflation	*Consumer prices index.* Data for inflation are averages for the year, not end-of-period data. The index is based on 1995=100. **	Same as above
INFLCH - Inflation change (in percent)	Annual percent change of inflation (as described earlier) (in percent)	Same as above
UNEMPL - Unemployment rate	Rate of unemployment***	International Labour Organisation ((BA) Labour force survey), United Nations Economic Commission for Europe
Corruption index		
CORR - Corruption Perception Index	The TI Corruption Perceptions Index (CPI) ranks countries in terms of the degree to which corruption is perceived to exist among public officials and politicians.	Transparency International, Internet Centre for Corruption Research
Environmental variables characterising banking system		
CONCENT - Concentration	Assets of three largest banks as a share of assets of all commercial banks in the system	Financial Structure and Economic Development Database, World bank
OVCOST - Overhead costs	Accounting value of a bank's overhead costs as a share of its total assets	Same as above
MARGIN - Net interest margin	Accounting value of bank's net interest revenue as a share of its interest- bearing (total earning) assets	Same as above
DEPOS - Deposit money bank vs. central bank assets	Ratio of deposit money bank claims on domestic nonfinancial real sector to the sum of deposit money bank and Central Bank claims on domestic nonfinancial real sector	Same as above
AVWAGE - Average wage in the industry	Average wage in the financial intermediaries institutions ****	International Labour Organization, OANDA Corporation, HM Revenue and Customs (HMRC), Statistics and Analysis of Trade Unit (SATU)

Note: * Data in the source database are expressed in the base year of each country's national accounts. The base year was changed and calculated by author.

** For many central and eastern European and CIS countries, inflation for the earlier years is measured on the basis of a retail price index. Consumer price indices with a broader and more up-to-date coverage are typically used for more recent years.

*** Unemployment rate for Moldova 1998 approximate and calculated by author using rate of registered unemployment and difference between registered and total unemployment in 1999

**** All categories are reflect wages for International Labour Organization's tabulation category J 'Financial Intermediation' which includes codes 65 for 'Financial Intermediation, except Insurance and Pension Funding', 66 for 'Insurance and Pension Funding, except Compulsory Social Security', 67 for 'Activities auxiliary to Financial Intermediation'. Data for Russia (1999-2001) is proxy and calculated by author (reflects the growth of wage in Belarus).

Table 4. 5. Kolmogorov-Smirnov test of influence of the environmental variables on the efficiency

Intermediation approach

Variables characterising cyclical dynamics of the economy and Corruption - Programme (4)		*Environmental variables characterising banking system - Programme (8)*	
Variable	KS D-Statistics (P-value)	Variable	KS D-Statistics (P-value)
GDPCAP	0.1981 (0.000)	**CONCENT**	0.0660 (0.031)
GDPDEF	0.3333 (0.000)	AVWAGE	0.0482 (0.217)
GDPCH	0.4769 (0.000)	**MARGIN**	0.0734 (0.012)
INFL	0.2725 (0.000)	DEPOS	0.0419 (0.371)
INFLCH	0.2914 (0.000)	OVCOST	0.0535 (0.131)
UNEMPL	0.3176 (0.000)	CORR	0.0545 (0.117)
CORR	0.3512 (0.000)		

Production approach

Variables characterising cyclical dynamics of the economy and Corruption - Programme (4)		*Environmental variables characterising banking system - Programme (8)*	
Variable	KS D-Statistics (P-value)	Variable	KS D-Statistics (P-value)
GDPCAP	0.1981 (0.000)	CONCENT	0.0440 (0.314)
GDPDEF	0.3333 (0.000)	AVWAGE	0.0566 (0.094)
GDPCH	0.4769 (0.000)	**MARGIN**	0.0681 (0.024)
INFL	0.2725 (0.000)	DEPOS	0.0566 (0.094)
INFLCH	0.2914 (0.000)	**OVCOST**	0.0818 (0.003)
UNEMPL	0.3176 (0.000)	**CORR**	0.0734 (0.012)
CORR	0.3512 (0.000)		

Profit/Revenue-based approach

Variables characterising cyclical dynamics of the economy and Corruption - Programme (4)		*Environmental variables characterising banking system - Programme (8)*	
Variable	KS D-Statistics (P-value)	Variable	KS D-Statistics (P-value)
GDPCAP	0.1981 (0.000)	CONCENT	0.0472 (0.239)
GDPDEF	0.3333 (0.000)	AVWAGE	0.0503 (0.179)
GDPCH	0.4769 (0.000)	**MARGIN**	0.0996 (0.000)
INFL	0.2725 (0.000)	DEPOS	0.0482 (0.217)
INFLCH	0.2914 (0.000)	**OVCOST**	0.0723 (0.014)
UNEMPL	0.3176 (0.000)	**CORR**	0.0671 (0.027)
CORR	0.3512 (0.000)		

Note: Bold-typed variables are influencing banking efficiency/risk at 5% level of significance.

4.4. Estimation results.

4.4.1. Risk management efficiency and risk decomposition.

The average risk management efficiency results of the break-down of LLP due to external and internal factors are presented in Figure 4.4. The Figure 4.4 shows the average LLP decomposition across all considered Eastern European banks which is averaged using a weighted geometric average.

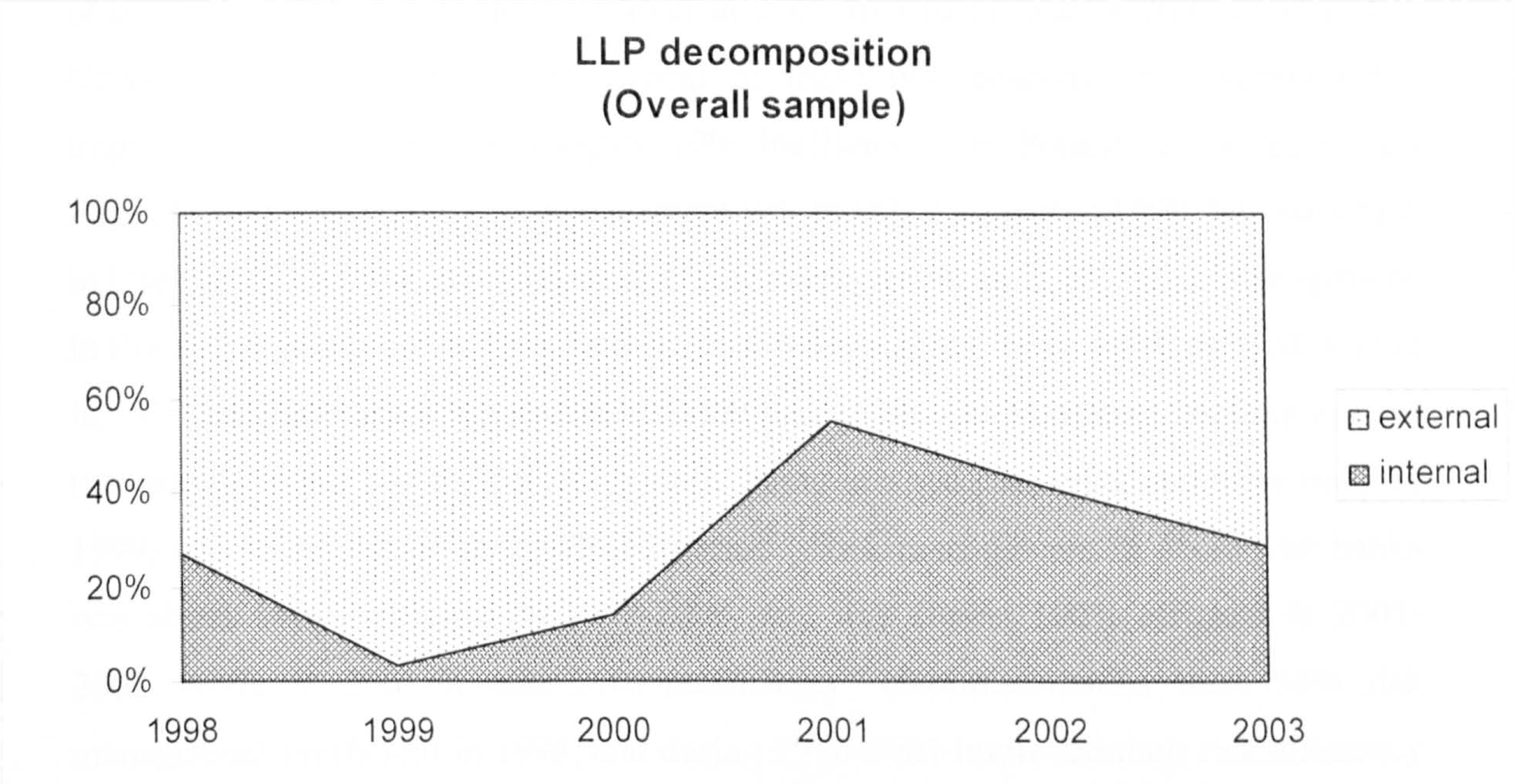


Figure 4. 4. LLP decomposition for the analyzed Eastern European countries banking systems.

In 1998 the risk due to internal factors (bad management) was 26.9% and it declined sharply in 1999 to 3.7%. This could be explained by the 'disaster myopia' phenomenon, since most of the considered countries had financial crises in the middle of 1990s. However the Russian crisis of August 1998 was at least one event in the history of the region, which had major regional and sub-regional implications. This possibly led banks to be more risk averse in 1999. However, as the 'disaster myopia' phenomenon argues, by the time of the impact due to the event becomes less, and the decomposition of LLP in later years reflects these changes.

Although the overall panel data sample presents thirteen banking systems operating in one geographical region, it is worth noting that the risk management efficiency analysis for individual countries shows that the differences in the risk management across banking systems are substantial.[34] For example, the proportion of internal risk in Croatian, Hungarian, Slovenian and all Baltic banking systems is relatively low and steady over the analysed period. Noticeably, the overall aggregate risk decomposition predominantly mirrors Czech, Polish and Russian banks risk decomposition, and this is not unexpected since they present 58.3% of the sample. Although in the Czech Republic and Russia the lowest level of endogenous risk was

[34] Figures on Banking Risk decomposition by countries are presented in Appendix F.

observed in 1999 and the highest level in 2001 in Russia, and in 2001-2002 in the Czech Republic, the risk management in these two countries was substantially improved in 2003 and was roughly 20% inefficient. In Poland, as in the Czech Republic and Russia, the risk management was mostly efficient in 1999, but worsened in later years with the most aggressive risk management in 2003. Risk management in Romanian banks varied from year to year: being aggressive in 1998, and risk averse in 1999 and then again aggressive in 2000 and so on. In Slovakian banking system risk managements had the reverse pattern, being less risky in 1998, and more risky in 1999, and so on during the analysed period. Risk management in Moldovan banks was about 50% inefficient in 1998-2000, and was almost 100% efficient in 2001-2002, while in 2003 it was 26% inefficient. Ukrainian banks were 90% risk management inefficient in 1998, and during 1998-2001 improved their risk efficiency which became 9% in 2001, and this remained stable at this level for rest of the sample period. Interestingly, in 2001 or 2002 the majority of banking systems had an aggressive risk management strategy (this excludes Moldovan and Ukrainian).

4.4.2. Efficiency adjusted for risk, adjusted for risk and environment and decomposition of banking efficiency.

Tables 4.6, 4.7 and 4.8 provide a summary of the geometric average efficiency measures $(1-\theta)$ and adjusted efficiency measures $(1-\rho)$ and $(1-\Omega)$ obtained under the Intermediation, Production and Profit/Revenue based approaches[35], while a comparative analysis of the efficiency measures across these alternative methodologies on the three dimensional plots for the whole sample over the analyzed period is provided in Figures 4.5 to 4.7.

[35] I use weighted geometric mean and weights for $(1-\theta)$ are total output less for LLP, for $(1-\rho)$ and $(1-\Omega)$ are total output less for γLLP. Because of the specificity of DEA analysis, all provided efficiency estimates are based on estimated panel data sample, therefore country's efficiency level presents an average of efficiency scores of all country's banks analysed in the paper hence calculated relative to all the banks of the sample. The same logic is behind the average efficiency level of analysed sub-groups.

Table 4. 6. Non-radial efficiency measure *(1-θ)* and adjusted efficiency measures *(1-ρ)* and *(1-Ω)* for the analysed Eastern European countries banking systems reported by Intermediation approach

	Efficiency (1-θ)						*Efficiency adj. by risk (1-ρ)*						*Efficiency adj. by risk and env. (1-Ω)*					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
Accessed countries																		
CZ	0.989	0.963	0.996	0.912	0.934	0.999	0.985	0.970	0.946	0.900	0.950	0.988	0.990	0.999	0.999	0.981	0.952	0.999
ES	0.795	0.919	0.824	0.792	0.907	0.933	0.811	0.921	0.863	0.859	0.851	0.887	0.991	0.999	0.995	0.997	0.997	0.999
HU	0.895	0.914	0.927	0.903	0.956	0.964	0.890	0.911	0.940	0.929	0.926	0.931	0.961	0.980	0.904	0.871	0.901	0.903
LV	0.799	0.959	0.929	0.875	0.951	0.954	0.805	0.959	0.921	0.919	0.908	0.928	0.806	0.976	0.914	0.900	0.935	0.945
LT	0.796	0.925	0.838	0.796	0.941	0.954	0.806	0.922	0.840	0.839	0.873	0.889	0.974	0.966	0.920	0.898	0.915	0.911
PL	0.927	0.937	0.891	0.877	0.869	0.881	0.885	0.937	0.875	0.878	0.811	0.840	0.885	0.921	0.873	0.850	0.843	0.865
SL	0.844	0.945	0.868	0.786	0.883	0.926	0.865	0.940	0.860	0.903	0.819	0.839	0.981	0.949	0.933	0.890	0.827	0.834
SN	0.841	0.904	0.850	0.795	0.877	0.883	0.829	0.904	0.862	0.855	0.855	0.864	0.890	0.899	0.850	0.831	0.869	0.873
Average	*0.912*	*0.939*	*0.917*	*0.868*	*0.904*	*0.932*	*0.899*	*0.939*	*0.900*	*0.890*	*0.869*	*0.896*	*0.938*	*0.952*	*0.922*	*0.896*	*0.888*	*0.910*
Negotiating countries																		
CT	0.840	0.925	0.839	0.817	0.886	0.907	0.846	0.931	0.882	0.886	0.856	0.861	0.847	0.938	0.873	0.844	0.855	0.857
RM	0.846	0.987	0.982	0.858	0.844	0.790	0.895	0.989	0.974	0.922	0.798	0.771	0.973	0.947	0.893	0.875	0.847	0.890
Average	*0.844*	*0.962*	*0.902*	*0.832*	*0.872*	*0.871*	*0.878*	*0.966*	*0.923*	*0.886*	*0.837*	*0.833*	*0.929*	*0.944*	*0.882*	*0.855*	*0.852*	*0.867*
CIS countries																		
ML	0.890	0.985	0.985	0.966	0.984	0.982	0.813	0.984	0.956	0.980	0.979	0.982	0.829	0.993	0.979	0.988	0.990	0.992
RF	0.896	0.973	0.917	0.895	0.927	0.926	0.870	0.971	0.917	0.909	0.861	0.909	0.884	0.986	0.908	0.876	0.868	0.923
UN	0.809	0.956	0.855	0.823	0.874	0.891	0.810	0.949	0.853	0.876	0.911	0.940	0.810	0.984	0.880	0.896	0.934	0.950
Average	*0.887*	*0.971*	*0.908*	*0.883*	*0.919*	*0.919*	*0.863*	*0.968*	*0.907*	*0.904*	*0.871*	*0.916*	*0.877*	*0.986*	*0.905*	*0.881*	*0.880*	*0.929*
Total sample average	**0.899**	**0.947**	**0.914**	**0.868**	**0.903**	**0.924**	**0.891**	**0.947**	**0.903**	**0.892**	**0.866**	**0.894**	**0.926**	**0.956**	**0.915**	**0.890**	**0.883**	**0.909**

Table 4. 7. Non-radial efficiency measure *(1-θ)* and adjusted efficiency measures *(1-ρ)* and *(1-Ω)* for the analysed Eastern European countries banking systems reported by Production approach

	Efficiency (1-θ)						*Efficiency adj. by risk (1-ρ)*						*Efficiency adj. by risk and env. (1-Ω)*					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
Accessed countries																		
CZ	0.993	0.999	0.831	0.679	0.770	0.999	0.988	0.999	0.757	0.696	0.700	0.999	0.989	0.999	0.780	0.702	0.701	0.999
ES	0.825	0.886	0.892	0.860	0.918	0.916	0.809	0.894	0.798	0.862	0.810	0.900	0.881	0.997	0.837	0.862	0.891	0.987
HU	0.934	0.953	0.888	0.878	0.922	0.938	0.805	0.936	0.845	0.902	0.864	0.897	0.977	0.996	0.859	0.902	0.912	0.954
LV	0.834	0.947	0.940	0.881	0.948	0.941	0.833	0.947	0.871	0.909	0.870	0.886	0.964	0.997	0.876	0.998	0.998	0.994
LT	0.853	0.927	0.899	0.847	0.959	0.940	0.824	0.925	0.819	0.880	0.846	0.858	0.949	0.992	0.990	0.880	0.983	0.994
PL	0.923	0.912	0.911	0.890	0.853	0.849	0.839	0.918	0.834	0.865	0.805	0.820	0.847	0.919	0.847	0.866	0.819	0.829
SL	0.859	0.959	0.969	0.848	0.877	0.914	0.838	0.963	0.865	0.916	0.818	0.847	0.961	0.995	0.953	0.954	0.863	0.905
SN	0.876	0.916	0.903	0.889	0.919	0.825	0.823	0.919	0.825	0.890	0.836	0.796	0.884	0.943	0.853	0.891	0.839	0.815
Average	*0.924*	*0.944*	*0.891*	*0.819*	*0.852*	*0.910*	*0.870*	*0.945*	*0.815*	*0.828*	*0.789*	*0.881*	*0.922*	*0.964*	*0.843*	*0.835*	*0.812*	*0.910*
Negotiating countries																		
CT	0.851	0.890	0.845	0.759	0.805	0.851	0.799	0.894	0.781	0.812	0.779	0.806	0.933	0.998	0.789	0.812	0.816	0.886
RM	0.946	0.978	0.627	0.761	0.797	0.646	0.925	0.979	0.487	0.746	0.606	0.556	0.938	0.983	0.985	0.999	0.997	0.999
Average	*0.914*	*0.945*	*0.734*	*0.760*	*0.802*	*0.782*	*0.884*	*0.947*	*0.625*	*0.787*	*0.716*	*0.719*	*0.937*	*0.989*	*0.876*	*0.877*	*0.873*	*0.919*
CIS countries																		
ML	0.911	0.968	0.972	0.975	0.976	0.976	0.837	0.965	0.953	0.980	0.962	0.965	0.840	0.986	0.960	0.982	0.999	0.998
RF	0.847	0.915	0.932	0.867	0.866	0.846	0.729	0.908	0.844	0.867	0.761	0.830	0.880	0.956	0.885	0.955	0.906	0.939
UN	0.808	0.851	0.863	0.805	0.770	0.646	0.647	0.842	0.785	0.833	0.750	0.703	0.904	0.999	0.970	0.995	0.980	0.978
Average	*0.844*	*0.908*	*0.922*	*0.858*	*0.850*	*0.801*	*0.721*	*0.900*	*0.836*	*0.862*	*0.761*	*0.803*	*0.882*	*0.961*	*0.898*	*0.962*	*0.919*	*0.947*
Total sample average	**0.910**	**0.938**	**0.880**	**0.820**	**0.847**	**0.874**	**0.848**	**0.938**	**0.799**	**0.829**	**0.776**	**0.848**	**0.918**	**0.966**	**0.854**	**0.858**	**0.836**	**0.918**

Table 4. 8. Non-radial efficiency measure *(1-θ)* and adjusted efficiency measures *(1-ρ)* and *(1-Ω)* for the analysed Eastern European countries banking systems reported by Profit/Revenue-based approach

	Efficiency (1-θ)						*Efficiency adj. by risk (1-ρ)*						*Efficiency adj. by risk and env. (1-Ω)*					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
Accessed countries																		
CZ	0.809	0.919	0.824	0.832	0.903	0.906	0.787	0.964	0.758	0.716	0.773	0.947	0.852	0.985	0.964	0.930	0.954	0.981
ES	0.800	0.892	0.793	0.773	0.931	0.874	0.742	0.890	0.795	0.813	0.783	0.844	0.902	0.998	0.824	0.813	0.869	0.983
HU	0.904	0.980	0.902	0.877	0.955	0.949	0.839	0.970	0.890	0.910	0.890	0.903	0.955	0.992	0.898	0.910	0.912	0.939
LV	0.816	0.959	0.911	0.805	0.958	0.947	0.757	0.954	0.820	0.870	0.843	0.863	0.959	0.997	0.828	0.997	0.995	0.994
LT	0.882	0.945	0.890	0.779	0.967	0.956	0.752	0.938	0.794	0.832	0.818	0.842	0.963	0.998	0.987	0.839	0.979	0.998
PL	0.898	0.834	0.842	0.849	0.888	0.872	0.695	0.794	0.831	0.836	0.809	0.838	0.798	0.903	0.858	0.846	0.814	0.847
SL	0.807	0.935	0.854	0.760	0.908	0.929	0.757	0.983	0.798	0.860	0.784	0.814	0.887	0.991	0.858	0.887	0.828	0.879
SN	0.848	0.914	0.838	0.797	0.909	0.849	0.749	0.910	0.799	0.831	0.796	0.797	0.870	0.938	0.812	0.835	0.798	0.800
Average	*0.868*	*0.888*	*0.851*	*0.831*	*0.913*	*0.903*	*0.746*	*0.880*	*0.817*	*0.820*	*0.810*	*0.870*	*0.851*	*0.947*	*0.883*	*0.882*	*0.873*	*0.908*
Negotiating countries																		
CT	0.843	0.894	0.744	0.730	0.843	0.867	0.744	0.895	0.782	0.803	0.773	0.791	0.885	0.999	0.795	0.803	0.791	0.853
RM	0.985	0.987	0.989	0.963	0.996	0.854	0.950	0.986	0.964	0.977	0.696	0.690	0.958	0.991	0.979	0.999	0.994	0.999
Average	*0.960*	*0.969*	*0.911*	*0.860*	*0.924*	*0.861*	*0.917*	*0.967*	*0.904*	*0.901*	*0.732*	*0.743*	*0.947*	*0.993*	*0.919*	*0.913*	*0.891*	*0.918*
CIS countries																		
ML	0.963	0.986	0.985	0.968	0.984	0.984	0.762	0.983	0.939	0.976	0.959	0.971	0.763	0.989	0.943	0.978	0.999	0.997
RF	0.644	0.911	0.892	0.830	0.889	0.883	0.560	0.894	0.815	0.836	0.721	0.849	0.624	0.980	0.848	0.911	0.863	0.949
UN	0.835	0.888	0.799	0.774	0.842	0.716	0.699	0.868	0.788	0.831	0.788	0.790	0.840	0.999	0.944	0.998	0.969	0.959
Average	*0.671*	*0.908*	*0.878*	*0.822*	*0.882*	*0.848*	*0.579*	*0.890*	*0.812*	*0.837*	*0.737*	*0.836*	*0.650*	*0.984*	*0.867*	*0.928*	*0.885*	*0.952*
Total sample average	**0.809**	**0.905**	**0.865**	**0.832**	**0.906**	**0.883**	**0.727**	**0.898**	**0.827**	**0.833**	**0.781**	**0.845**	**0.808**	**0.963**	**0.884**	**0.897**	**0.878**	**0.922**

According to the efficiency results calculated using the Intermediation approach, the average efficiency scores vary between 89.9% in 1998 and 92.4% in 2003. Despite this low variation in the overall aggregated efficiency scores, it is clear that the most technically efficient banks are in the Czech Republic and Hungary where the efficiency level in these countries varies between 90 and 100%. Banks in the rest of the sample have roughly the same technical efficiency level ranging between 80% and 90%. However, the average efficiency results of the Moldovan and Ukrainian banks are much higher than the sample aggregate. A posited reason is that Moldovan and most Ukrainian banks are small-sized banks, and the since the sample contains few number of such banks, the models in the analysis might not be able to discriminate between them very well as I have assumed variable returns to scale production. Although the aggregate levels of efficiency are different, the trends in the efficiency levels in all the countries of the region over time are similar. Accordingly, the efficiency level increased from 1998 till 2000, sharply declined in 2001, and rose again thereafter.

In general, the adjustment of banking technical efficiency in the CEE countries for risk has increased the efficiency level reported by the Intermediation approach for the accessed and negotiating countries, while the incorporation of credit risk lowers the efficiency of the CIS countries. These results suggest that banks in the accessed and negotiating countries had better risk management strategies than those in the CIS countries. The consideration of environmental variables slightly improves the results of Romania, Ukraine and Moldova.

In contrast, the average efficiency scores for the sample, according to the Production approach, range from 91% in 1998 to 87% in 2003, with the lowest score of 82% recorded in 2001. As with the Intermediation approach, the Czech, Polish and Hungarian banks appear to out-perform the banks in the rest of the countries. The adjustments for the risk and for risk and environment give similar results as to those of the Intermediation modeling methodology. Finally, the Profit/Revenue-based approach produces evidence of inefficiency levels which vary between 9 and 19 per cent. This contrasts with an inefficiency level of around 5 to 13 per cent according to the Intermediation approach and between 6 and 16 per cent according to the

Production approach. According to the Profit approach, the Czech Republic, Hungary and Poland are the most technically efficient. It is interesting to note, however, that the downturn in relative efficiency levels in 2001 and 2002, which was reported by previous two methodologies as well, had the most significant effect on the efficiency level of Czech banking industry. But by 2003, Czech banks improved their efficiency (100%). 'Risk' and 'risk and environment' adjustments of efficiency have the same effect as in previous input/output approaches.

It is clear from Figures 4.5-4.7 that the variation in efficiency scores across the Intermediation, Production and Profit/Revenue approaches for all three *(1-θ)*, *(1-ρ)* and *(1-Ω)* efficiency measures are relatively similar. However, the peaks and dips of the slope in the graphs are evidence that the efficiency results calculated by different input/output modeling specifications are not stable and vary across the efficiency evaluation methods. Similar to the findings of Drake, Hall and Simper (2005) and contrary to Tortosa-Ausina (2002a), I found that the Intermediation approach produces relatively higher efficiency scores than the Production methodology. However, unlike Drake et al (2005), the Profit/Revenue based efficiency scores were the lowest.

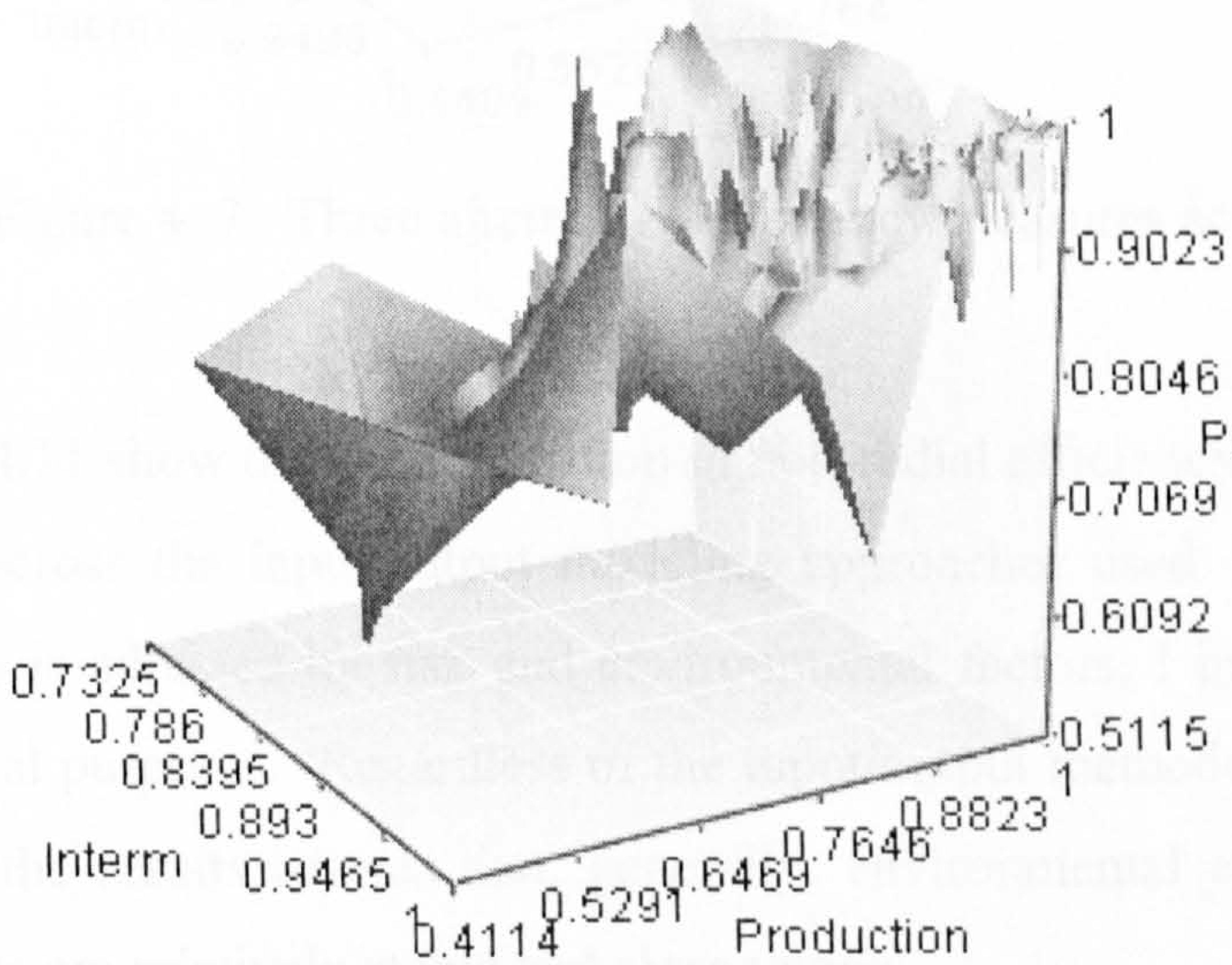


Figure 4. 5. Three alternative efficiency measures across the *(1-θ)*

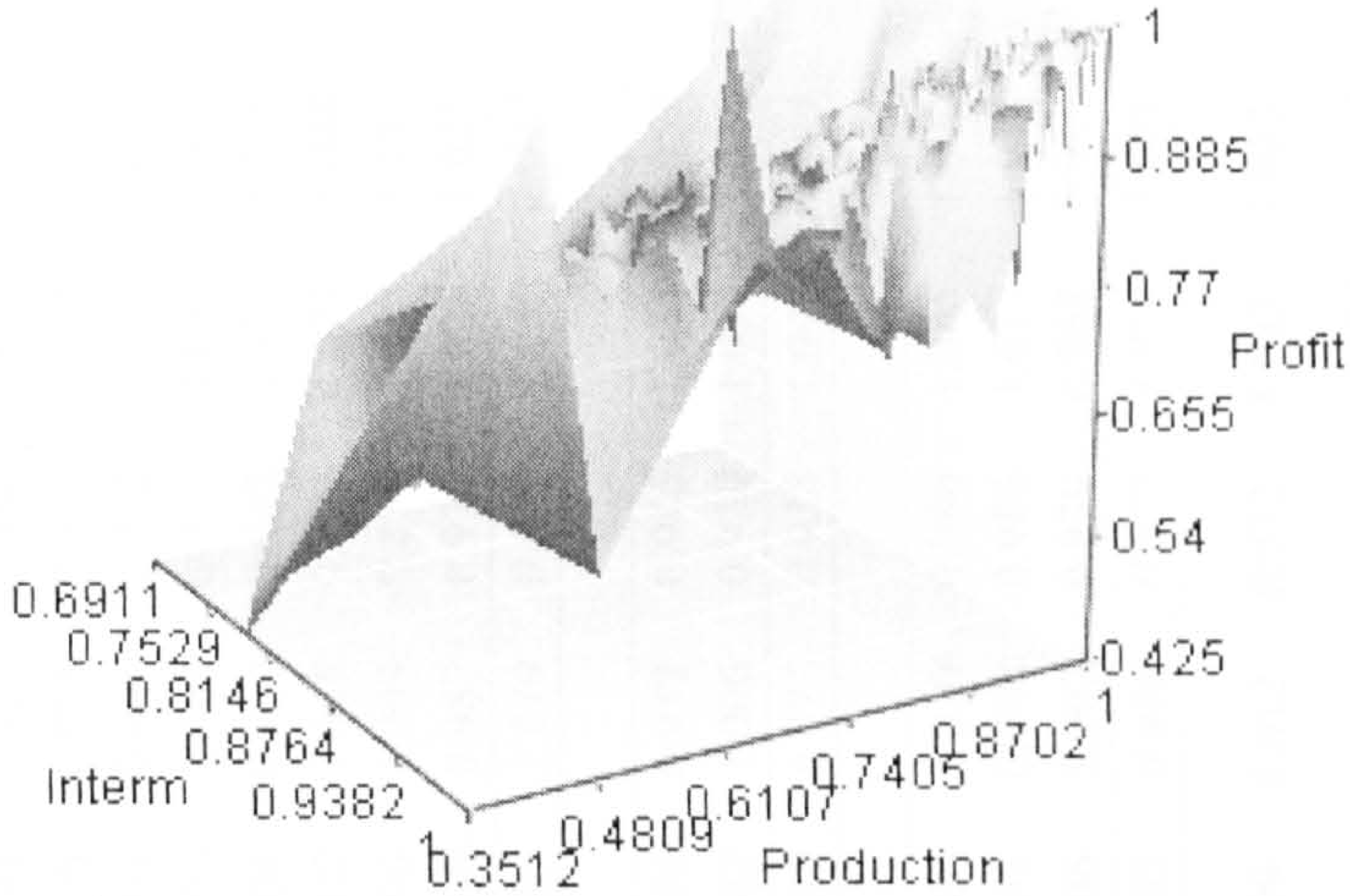


Figure 4. 6. Three alternative efficiency measures across the $(1-\rho)$

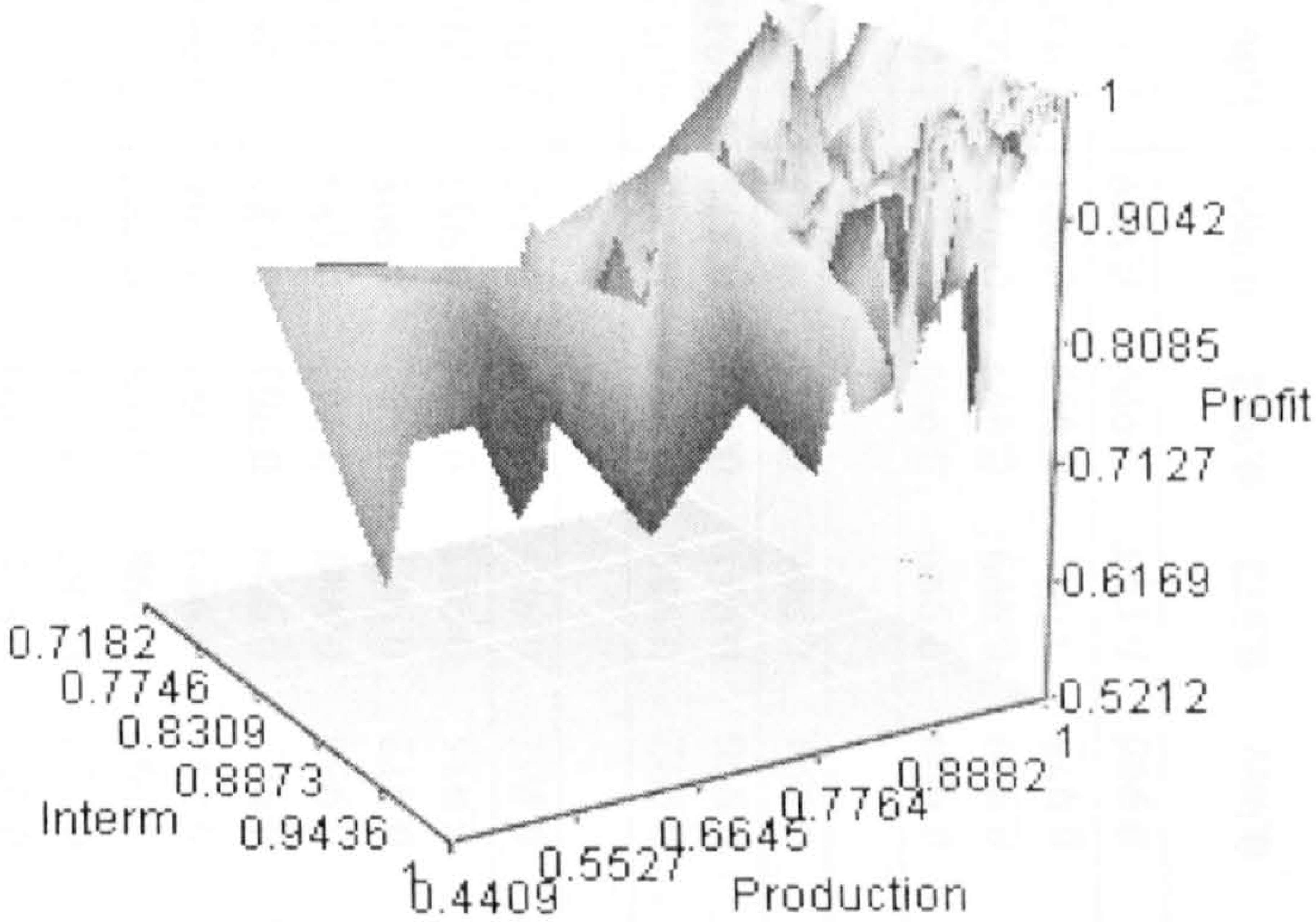


Figure 4. 7. Three alternative efficiency measures across the $(1-\Omega)$

Tables 4.9 – 4.11 show the decomposition of non-radial efficiency $(1-\theta)$ in terms of equation 4.10 across the input/output modeling approaches used. Although the efficiency measure is adjusted by risk and environmental factors, I include it in the Tables for analytical purposes. Regardless of the input/output methodology used, the decomposition of the results reveals that, generally, environmental effects and risk management effects are relatively stable and close to one.

Table 4. 9. Decomposition of non-radial efficiency $(1-\theta)$ accounted for undesirable outputs and negative outputs for the analysed Eastern European countries banking systems reported by Intermediation approach

	Efficiency adj. by risk and env. (1-Ω)						*Env.effect (1-ρ)/(1-Ω)*						*Risk management effect (1-θ)/(1-ρ)*					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
Accessed countries																		
CZ	0.990	0.999	0.999	0.981	0.952	0.999	0.995	0.971	0.961	0.945	0.999	0.988	1.004	0.991	1.053	1.034	0.983	1.011
ES	0.991	0.999	0.995	0.997	0.997	0.999	0.889	0.922	0.867	0.862	0.857	0.887	0.980	0.998	0.954	0.921	1.065	1.052
HU	0.961	0.980	0.904	0.871	0.901	0.903	0.946	0.997	0.999	0.998	0.999	0.999	1.005	1.004	0.985	0.972	1.032	1.031
LV	0.806	0.976	0.914	0.900	0.935	0.945	0.927	0.990	0.993	0.989	0.980	0.996	0.991	1.000	1.008	0.952	1.046	1.028
LT	0.974	0.966	0.920	0.898	0.915	0.911	0.838	0.955	0.905	0.909	0.965	0.984	0.987	1.004	0.997	0.948	1.077	1.073
PL	0.885	0.921	0.873	0.850	0.843	0.865	0.991	0.992	0.966	0.987	0.963	0.984	1.047	1.000	1.018	0.999	1.073	1.048
SL	0.981	0.949	0.933	0.890	0.827	0.834	0.912	0.982	0.912	0.967	0.992	0.998	0.975	1.006	1.009	0.869	1.078	1.103
SN	0.890	0.899	0.850	0.831	0.869	0.873	0.910	0.974	0.955	0.982	0.984	0.955	1.014	1.000	0.987	0.929	1.025	1.021
Average	*0.938*	*0.952*	*0.922*	*0.896*	*0.888*	*0.910*	*0.962*	*0.982*	*0.961*	*0.968*	*0.978*	*0.985*	*1.014*	*0.999*	*1.019*	*0.975*	*1.039*	*1.040*
Negotiating countries																		
CT	0.847	0.938	0.873	0.844	0.855	0.857	0.933	0.986	0.992	0.986	0.997	0.998	0.992	0.994	0.952	0.943	1.035	1.052
RM	0.973	0.947	0.893	0.875	0.847	0.890	0.986	0.997	0.996	0.931	0.954	0.878	0.945	0.997	1.006	0.930	1.057	1.025
Average	*0.929*	*0.944*	*0.882*	*0.855*	*0.852*	*0.867*	*0.967*	*0.992*	*0.994*	*0.966*	*0.983*	*0.963*	*0.961*	*0.996*	*0.977*	*0.938*	*1.042*	*1.044*
CIS countries																		
ML	0.829	0.993	0.979	0.988	0.990	0.992	1.000	0.999	0.999	0.999	0.999	0.998	1.096	1.000	1.030	0.986	1.005	1.000
RF	0.884	0.986	0.908	0.876	0.868	0.923	0.997	1.000	0.999	0.999	0.999	0.999	1.029	1.002	0.998	0.985	1.077	1.018
UN	0.810	0.984	0.880	0.896	0.934	0.950	0.999	0.992	0.975	0.981	0.999	0.997	1.000	1.006	1.002	0.939	0.958	0.947
Average	*0.877*	*0.986*	*0.905*	*0.881*	*0.880*	*0.929*	*0.997*	*0.998*	*0.996*	*0.996*	*0.999*	*0.999*	*1.027*	*1.002*	*0.999*	*0.977*	*1.054*	*1.003*
Total sample average	**0.926**	**0.956**	**0.915**	**0.890**	**0.883**	**0.909**	**0.969**	**0.986**	**0.969**	**0.972**	**0.982**	**0.986**	**1.001**	**0.999**	**1.012**	**0.972**	**1.042**	**1.033**

Note. Technical efficiency $(1-\theta)$ (from eq.4.10) equals the product of efficiency adjusted by the risk and environment $(1-\Omega)$, the environmental effect $(1-\rho)/(1-\Omega)$ and the risk management effect $(1-\theta)/(1-\rho)$.

Table 4. 10. Decomposition of non-radial efficiency *(1-θ)* accounted for undesirable outputs and negative outputs for the analysed Eastern European countries banking systems reported by Production approach

	Efficiency adj. by risk and env. (1-Ω)						*Env.effect (1-ρ)/(1-Ω)*						*Risk management effect (1-θ)/(1-ρ)*					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
Accessed countries																		
CZ	0.989	0.999	0.780	0.702	0.701	0.999	0.999	0.999	0.970	0.992	0.999	0.999	1.004	1.000	1.097	0.975	1.099	1.000
ES	0.881	0.997	0.837	0.862	0.891	0.987	0.918	0.896	0.953	0.999	0.909	0.912	1.019	0.991	1.118	0.997	1.133	1.016
HU	0.977	0.996	0.859	0.902	0.912	0.954	0.824	0.939	0.983	1.000	0.948	0.939	1.159	1.018	1.051	0.973	1.066	1.046
LV	0.964	0.997	0.876	0.998	0.998	0.994	0.864	0.950	0.994	0.910	0.871	0.891	1.000	0.999	1.079	0.969	1.089	1.062
LT	0.949	0.992	0.990	0.880	0.983	0.994	0.867	0.932	0.827	0.999	0.861	0.862	1.035	1.002	1.097	0.962	1.133	1.095
PL	0.847	0.919	0.847	0.866	0.819	0.829	0.990	0.998	0.984	0.999	0.983	0.989	1.099	0.993	1.092	1.028	1.059	1.034
SL	0.961	0.995	0.953	0.954	0.863	0.905	0.871	0.967	0.907	0.959	0.947	0.935	1.025	0.996	1.119	0.925	1.073	1.078
SN	0.884	0.943	0.853	0.891	0.839	0.815	0.929	0.974	0.967	0.999	0.996	0.977	1.063	0.996	1.095	0.997	1.099	1.035
Average	*0.922*	*0.964*	*0.843*	*0.835*	*0.812*	*0.910*	*0.942*	*0.980*	*0.966*	*0.990*	*0.970*	*0.967*	*1.062*	*0.998*	*1.092*	*0.990*	*1.080*	*1.033*
Negotiating countries																		
CT	0.933	0.998	0.789	0.812	0.816	0.886	0.856	0.895	0.989	0.999	0.954	0.909	1.066	0.995	1.082	0.935	1.033	1.055
RM	0.938	0.983	0.985	0.999	0.997	0.999	0.986	0.996	0.495	0.746	0.608	0.556	1.022	0.998	1.287	1.019	1.319	1.160
Average	*0.937*	*0.989*	*0.876*	*0.877*	*0.873*	*0.919*	*0.943*	*0.958*	*0.714*	*0.897*	*0.821*	*0.783*	*1.035*	*0.997*	*1.174*	*0.965*	*1.120*	*1.087*
CIS countries																		
ML	0.840	0.986	0.960	0.982	0.999	0.998	0.997	0.978	0.992	0.997	0.963	0.966	1.087	1.002	1.020	0.995	1.014	1.011
RF	0.880	0.956	0.885	0.955	0.906	0.939	0.829	0.949	0.954	0.908	0.840	0.884	1.156	1.007	1.103	1.000	1.137	1.018
UN	0.904	0.999	0.970	0.995	0.980	0.978	0.716	0.842	0.809	0.837	0.765	0.719	1.245	1.010	1.098	0.966	1.025	0.918
Average	*0.882*	*0.961*	*0.898*	*0.962*	*0.919*	*0.947*	*0.818*	*0.936*	*0.931*	*0.896*	*0.828*	*0.847*	*1.164*	*1.007*	*1.101*	*0.994*	*1.116*	*0.996*
Total sample average	**0.918**	**0.966**	**0.854**	**0.858**	**0.836**	**0.918**	**0.923**	**0.970**	**0.935**	**0.966**	**0.928**	**0.923**	**1.073**	**1.000**	**1.101**	**0.988**	**1.090**	**1.030**

Note. Technical efficiency (1-θ) (from eq.4.10) equals the product of efficiency adjusted by the risk and environment *(1-Ω)*, the environmental effect *(1-ρ)/(1-Ω)* and the risk management effect *(1-θ)/(1-ρ)*.

Table 4. 11. Decomposition of non-radial efficiency *(1-θ)* accounted for undesirable outputs and negative outputs for the analysed Eastern European countries banking systems reported by Profit/Revenue-based approach

	Efficiency adj. by risk and env. (1-Ω)						*Env.effect (1-ρ)/(1-Ω)*						*Risk management effect (1-θ)/(1-ρ)*					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
Accessed countries																		
CZ	0.852	0.985	0.964	0.930	0.954	0.981	0.924	0.978	0.786	0.769	0.810	0.965	1.027	0.974	1.086	1.166	1.167	0.954
ES	0.902	0.998	0.824	0.813	0.869	0.983	0.822	0.892	0.964	0.999	0.900	0.958	1.077	1.002	1.002	0.952	1.190	1.035
HU	0.955	0.992	0.898	0.910	0.912	0.939	0.878	0.978	0.991	1.000	0.976	0.961	1.078	1.010	1.014	0.962	1.071	1.049
LV	0.959	0.997	0.828	0.997	0.995	0.994	0.788	0.956	0.991	0.873	0.847	0.868	1.083	1.004	1.109	0.929	1.136	1.096
LT	0.963	0.998	0.987	0.839	0.979	0.998	0.780	0.939	0.804	0.991	0.836	0.843	1.170	1.007	1.120	0.930	1.176	1.137
PL	0.798	0.903	0.858	0.846	0.814	0.847	0.871	0.878	0.969	0.988	0.993	0.990	1.290	1.046	1.015	1.022	1.115	1.047
SL	0.887	0.991	0.858	0.887	0.828	0.879	0.853	0.991	0.929	0.969	0.946	0.925	1.086	0.976	1.081	0.881	1.115	1.141
SN	0.870	0.938	0.812	0.835	0.798	0.800	0.861	0.970	0.984	0.995	0.997	0.996	1.133	1.006	1.061	0.963	1.144	1.059
Average	*0.851*	*0.947*	*0.883*	*0.882*	*0.873*	*0.908*	*0.877*	*0.929*	*0.925*	*0.929*	*0.927*	*0.957*	*1.149*	*1.015*	*1.042*	*1.019*	*1.130*	*1.039*
Negotiating countries																		
CT	0.885	0.999	0.795	0.803	0.791	0.853	0.840	0.895	0.983	0.999	0.977	0.928	1.137	1.002	0.967	0.910	1.094	1.096
RM	0.958	0.991	0.979	0.999	0.994	0.999	0.991	0.994	0.984	0.977	0.700	0.691	1.027	0.998	1.017	0.988	1.431	1.237
Average	*0.947*	*0.993*	*0.919*	*0.913*	*0.891*	*0.918*	*0.968*	*0.973*	*0.984*	*0.986*	*0.821*	*0.809*	*1.042*	*0.999*	*1.002*	*0.955*	*1.260*	*1.161*
CIS countries																		
ML	0.763	0.989	0.943	0.978	0.999	0.997	0.998	0.993	0.995	0.998	0.959	0.973	1.266	1.002	1.049	0.990	1.026	1.014
RF	0.624	0.980	0.848	0.911	0.863	0.949	0.897	0.912	0.960	0.917	0.835	0.895	1.206	1.014	1.076	0.995	1.231	1.037
UN	0.840	0.999	0.944	0.998	0.969	0.959	0.831	0.868	0.835	0.832	0.812	0.822	1.188	1.019	1.014	0.931	1.069	0.901
Average	*0.650*	*0.984*	*0.867*	*0.928*	*0.885*	*0.952*	*0.890*	*0.905*	*0.936*	*0.901*	*0.833*	*0.878*	*1.203*	*1.015*	*1.063*	*0.983*	*1.196*	*1.003*
Total sample average	**0.808**	**0.963**	**0.884**	**0.897**	**0.878**	**0.922**	**0.899**	**0.932**	**0.935**	**0.928**	**0.889**	**0.917**	**1.134**	**1.023**	**1.041**	**1.003**	**1.160**	**1.041**

Note. Technical efficiency (1-θ) (from eq.4.10) equals the product of efficiency adjusted by the risk and environment *(1-Ω)*, the environmental effect *(1-ρ)/(1-Ω)* and the risk management effect *(1-θ)/(1-ρ)*.

However, according to the Intermediation approach, the CIS countries' banks operate in a fairly more favorable environment than the accessed and negotiating countries' banks. Indeed, the competition for market share in the latter banking systems implies that those banks operate in a tougher environment. According to the Production approach, accessed countries had the most favorable environment in the region for banking services provision. However, the Romanian banking system appeared to have been considerably affected by the impact of environmental factors during 2000-2003, and this is likely to be attributable to the effect of the failure of the country's largest investment fund, FNI, in May 2000. This, in turn, was exacerbated by the following instability of the financial system itself (see for example, IMF - Remes and Ghizari (2000)). The Profit/Revenue based approach reports a relatively stable Environmental Effect (EE). However, in the Profit/Revenue approach the EE factor is less than the EE reported by the Intermediation approach for the accessed countries and is roughly the same for the negotiating countries and the CIS. It is interesting to note that the financial distress in Romania, was captured by EE only when the Production approach was utilized. The Intermediation approach did not produce any evidence for that, whereas Profit/Revenue based approach showed the decrease in the EE (i.e., the environmental effect deteriorated) only in 2002-2003.

The Risk Management Effect (RME) reported by the Intermediation approach is also stable and around 1, and external and internal factors affect risk alternately. Although the Production approach reports relatively stable RME, most $RME_{Production}$ are greater than one (i.e., exogenous factors affect the banking risk), and the strongest influence of these factors on risk were on Romanian banks in 2000 and thereafter. $RME_{Profit/Revenue}$ is also evidence of the mostly external economic factors, rather than internal factors, affecting risk during the analyzed period. Furthermore, the EE shows that in 2002-2003 Romania suffered significantly from external environment. Interestingly, both LLP decomposition and RME calculated by the three methodologies suggest that in 2001 the banks in the majority of sampled countries (exceptions include the Czech Republic in the Intermediation case, Romania, Russia and Poland in the Production approach, the Czech Republic and Poland in the Profit/Revenue based modeling) manage risk less effectively than in other years.

4.5. Conclusion

This chapter investigates the risk and efficiency of Eastern European banking systems using the extended three-stage sequential DEA procedure suggested by Pastor (1999a) to decompose the undesirable outputs in banking (risk) into endogenous (due to poor management) and exogenous (due to macroeconomic conditions) components. Five important methodological issues were addressed: undesirable output decomposition, negative data in undesirable output modelling, non-radial efficiency in weak-disposability modelling of undesirable outputs using a piecewise linear representation of the production technology, inclusion of corruption into efficiency analysis and comparison of different bank modelling methodologies.

The results show that the adjustment of the efficiency scores by 'risk' and 'risk and environmental conditions' gives more insight the banking production and risk management. However, the analysis indicates that the adoption of different approaches to the specification of inputs and outputs of banking production can produce significantly different efficiency scores and different technical efficiency decompositions. However, regardless of the input/output modeling methodology adopted, the most technically efficient banks are in the Czech Republic, Hungary and Poland.

The risk decomposition components are relatively stable over the analyzed period, and suggest that banking risk is generally affected by external environmental factors. However, the EE (Environmental Effect) estimated by the Production approach reflects the possible effect of the financial distress of 2000 in Romania on banking efficiency scores, whereas the Intermediation approach does not give any evidence for that and Profit/Revenue approach, only in 2002-2003. However, both LLP decomposition and RME calculated by the three methodologies suggest that in 2001, the banks in most countries managed risk worse than in other years, which is a possible reflection of the 'Disaster myopia' phenomenon.

CHAPTER FIVE: UNDESIRABLE OUTPUT IN BANKING PRODUCTION MODELING METHODOLOGIES: STATISTICAL TESTS AND RETURN ANALYSIS

SUMMARY

This chapter presents a statistical analysis of CEE banking efficiency measures estimated by three input/output methodologies, namely Intermediation, Production and Profit/Revenue based approaches. Along with distribution and inter-distribution mobility analysis of efficiency scores across alternative approaches, a statistical comparison is undertaken for the distributions of the estimated efficiency scores using Kolmogorov-Smirnov and Wilcoxon-Mann-Witney tests, as suggested by Banker and Natarajan (2004), and the distributions of the true efficiency scores utilising bootstrap-based Simar-Zelenyuk-adapted-Li test. Interestingly, the evidence suggests that although the efficiency levels differ across the input/output approaches, the change of the positions of the banks relative to the mean is not substantial across the different approaches. Additionally, I statistically test the returns of the banks and investigate the sensitivity of the returns parameters to the input-output approach adopted. Furthermore, I draw conclusions regarding the banks' returns to scale profiles based on the aforementioned returns parameters. Finally, a comparative analysis based on the distribution and inter-distribution mobility analysis suggested by Tortosa-Ausina (2002a) is performed. The results suggest that Eastern European banks analysed operate with variable returns to scale.

5.1. Introduction

The definition of the banking production process is an important issue in banking efficiency studies and is based primarily on the philosophical understanding of what banks do and why they exist. A variety of Input/Output methodologies describing the banking production process has been proposed, depending upon the perceived bank's goal, and, in so doing measure the different aspects of bank activities. Researchers readily, however, admit that differences in the choice of inputs and outputs can influence the efficiency scores. Recently, Tortosa-Ausina (2002a) suggested a non-parametric density methodology to analyze the difference of efficiency score results estimated by different output specifications. In this chapter this method is applied to examine whether the alternative methodologies have an effect on the estimated efficiency level. Three different approaches to the input/output specification of bank production modeling are considered, namely, the Intermediation, Profit/Revenue and Production approaches.

In order to accurately capture the difference of the distributions of efficiency scores hypothesis testing suggested by Banker and Natarajan (2004) is performed using non-parametric Kolmogorov-Smirnov and Wilcoxon-Mann-Whitney tests. However, these tests are based on the estimated distributions rather than the true distribution of the efficiency scores. Therefore the Simar-Zelenyuk-adapted-Li test is also applied to test the equality of the distributions.

The comparison of univariate distributions of efficiency scores encodes a lot of information, it does not show the transition of efficiency scores levels when alternative approaches are used. Therefore, transition probability matrices and stochastic kernel density analysis of efficiency scores mobility are also used as suggested by Tortosa-Ausina.

Another interesting issue in efficiency and productivity measurement is an analysis of firms' returns, i.e. whether the underlying technology exhibits increasing, constant or decreasing returns. The survey of Banker et al (2004) gives an excellent discussion of the returns to scale measurement in different DEA models. Several studies propose various ways of testing the hypothesis regarding returns to scale, such as non-parametric tests, bootstrap methods etc.[36]

However, no study examines the differences in terms of the conclusions regarding the banking firms' returns profiles based on the returns parameters estimated by alternative input/output methodologies. Therefore, this study attempts to identify how the choice of the production methodology affects the conclusions regarding the banks' returns. In the analysis tests of Banker and Natarajan(2004) and technique based on distribution and inter-distribution methods (Tortosa-Ausina, 2002a, 2002b) are employed.

5.2. Efficiency score dynamics across different Input/Output approaches

5.2.1. Density analysis of efficiency estimators of different Input/Output approaches

Tortosa-Ausina (2002a) suggested a non-parametric technique both univariate and stochastic based on kernel smoothing, to undertake a comparative analysis and mobility estimation of efficiency scores using different output definitions with application to the Spanish banking industry. Although this method was later modified to perform different types of analysis[37], in this chapter the similar visualisation procedures of efficiency scores comparison from the earlier paper are used.

The objective of the process is to investigate the mobility and dependency of the efficiency scores on the input/output specification methodology, via kernel smoothing. Kernel smoothing consists primarily of estimating a density function $f(x)$ evaluated at an arbitrary point x and is given by

[36] For a short survey see Simar and Wilson (2002).

[37] For example, this method was extended by adding ergodic distribution analysis of efficiency scores, to assess the dynamics and long run tendencies of cost efficiency (Totrosa-Ausina, 2002b). In 2003, Tortosa-Ausina performed an analysis of the importance of non-traditional activities in banking performance measurement by utilising a distribution analysis. Stochastic kernels were used to explain efficiency differentials in banking as an impact of specialization, ownership type and the size of banks (Totrosa-Ausina, 2004).

$$\hat{f}(x) = \frac{1}{Nh}\sum_{j=1}^{N} K\left(\frac{x-\hat{\delta}_j}{h}\right), \qquad (5.1)$$

where K is a kernel function and h is a smoothing parameter, or bandwidth.

However, standard kernel density estimators do not take into account the boundary condition of efficiency scores ($EFF_j \leq 1$), therefore, as suggested by Simar and Wilson (1998), the reflection method described by Silverman (1986) and Scott (1992) is used to avoid bias problems near the boundary in estimation of the kernel density of efficiency scores. Accordingly, letting each efficiency estimate EFF_j be reflected by its symmetric image $2 - EFF_j \geq 1, j = 1, \ldots, N$, and the kernel density of the resulting 2N points can be estimated as:

$$\hat{G}(x) = \frac{1}{2Nh}\sum_{j=1}^{N}\left[K\left(\frac{x-\hat{EFF}_j^M}{h}\right) + K\left(\frac{x-(2-\hat{EFF}_j^M)}{h}\right)\right] \qquad (5.2)$$

where N is the number of banks being analysed, Eff_j^M are the efficiency scores computed according to the input/output methodology M, K is a kernel function[38], h is the bandwidth.[39]

Then defining the reflected version of the density function:

$$\hat{f}(x) = \begin{cases} 2\hat{G}(x) & if \quad EFF_j^M \leq 1 \\ 0 & otherwise \end{cases}, \qquad (5.3)$$

formula (5.3) is used to estimate and visualise the density of efficiency scores calculated by different Input/Output methodology.

5.2.2. Statistical tests of the differences between efficiency scores obtained under the alternative methodologies

Since three alternative input/output methodologies are used to construct the banking production process, a statistical assessment of the difference between the

[38] The Gaussian kernel: $K(t) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}t^2}$ is used.

[39] I obtain the bandwidth using Sheather and Jones (1991) solve-the-equation plug-in-approach, which is known as h_{SJPI}. Matlab code obtained from Steve Marron's web page (http://www.stat.unc.edu/faculty/marron.html). Link provided by Tortosa-Ausina (2002b).

estimated efficiency scores by different the approaches is also of interest. Following Banker (1996) and Banker and Natarajan (2004), one can do this by evaluating the null hypothesis of no difference in the efficiency obtained under alternartive methodologies, i.e.

$H_0: F(EFF^{M1}) = F(EFF^{M2})$. *The null hypothesis suggests that the efficiency scores are from the same population, so that efficiency scores are consistent across the methodologies implying that any changes in the choice of the variables do not affect the efficiency scores.*

The alternative hypothesis is

$H_1: F(EFF^{M1}) \neq F(EFF^{M2})$ *– i.e., efficiency scores are from different populations such that efficiency scores are sensitive to the choice of variables.*

where (EFF^{M1}) and (EFF^{M2}) are estimated efficiency scores obtained under the methodology 1 and methodology 2 respectively, and $F^{M1}(EFF^{M1})$ and $F^{M2}(EFF^{M2})$ are corresponding probability distributions.

To test these hypotheses I used parametric Kolmogorov-Smirnov, Wilcoxon-Mann-Whitney and Simar-Zelenyuk-adapted-Li tests.

5.2.3. Non-parametric Kolmogorov-Smirnov and Wilcoxon-Mann-Whitney tests

Non-parametric tests are distribution-free tests, and characterised with assumptions which are less restrictive, "fewer and weaker than those associated with parametric tests" (Siegel and Castellan, 1988, p.34). Therefore, if researchers feel that the assumptions of parametric tests are violated, non-parametric tests are preferred. In the analysis two popular non-parametric tests: the Kolmogorov-Smirnov test for the equality of two distributions and Wilcoxon-Mann-Whitney test which shows whether two independent samples are drawn from the population with the same distributions are applied

Since testing of whether efficiency scores calculated by different input/output methodology are from the same population is of interest, the Kolmogorov-Smirnov two-sample test is employed. This is a test of whether two independent samples are samples from the same but not necessarily known probability density function (the null hypothesis – H_0) or from different probability density functions (the alternative hypothesis – H_1), Young, (1977). Moreover, the two-tailed test is sensitive to any kind of difference of two samples' distributions, such as differences in location (central tendency), dispersion, skewness etc (Siegel and Castellan, 1988). The Kolmogorov-Smirnov test is implemented in the following way. First, a maximum vertical distance between the observed cumulative distributions of the data (in this case, efficiency scores) is calculated:

$$D = \max\left|F^{G_1}\left(\hat{\theta}_j\right) - F^{G_2}\left(\hat{\theta}_j\right)\right| \tag{5.4}$$

where $F^{G_1}\left(\hat{\theta}_j\right)$ and $F^{G_2}\left(\hat{\theta}_j\right)$ are cumulative distributions for group 1 and group 2 respectively. Next, the derived, real scalar statistic D is compared with a critical value which is a function of the confidence interval and the sample size (Young, 1977; Siegel and Castellan, 1988). High values of D statistic indicate significant differences between the experimental groups (in this case, the efficiency scores between the two groups), hence the corresponding probability *(P)* value will be low (i.e. rejection of null hypothesis). Interesting feature of the value of the D statistic (and hence the P value) is that it is not affected by scale changes, for example if logs of the data are used. Therefore

$$D = \max\left|F^{G_1}\left(\ln(\hat{\theta}_j)\right) - F^{G_2}\left(\ln(\hat{\theta}_j)\right)\right| \tag{5.5}$$

is equal to equation (5.4).

The Wilcoxon-Mann-Whitney test, which is also called the Wilcoxon Rank Sum test, investigates whether two independent groups are drawn from the same population by examining location-shift, i.e. the equality of medians or means of the analyzed groups (Rejesus and Lovell, 2003). According to Easton and McColl[40], Wilcoxon-Mann-Whitney test is one of the most powerful of the non-parametric tests available for comparing two populations.

[40] Statistics Glossary. It can be found at http://www.stats.gla.ac.uk/steps/glossary.

In accordance with Hollander and Wolfe (1999), let us consider observations of efficiency score values of commercial banks estimated by two different definitions (population A and B) and denote the observations by $\{X_{1j},..., X_{nj}; j=1,2\}$. Let N present the total number of observations for each methodology, i.e. $N = n_1 + n_2$. Combining all N observations from the two populations A and B $\{X_{1j}, ..., X_{n_j j}; j=1,2\}$ and ranking them from least to greatest:

$$R_j = \sum_{i=1}^{n_j} r_{ij}, \ j=1,2 \tag{5.6}$$

where r_{ij} denote the rank of X_{ij} in the joint ranking sample.

Since the sample of the analysed banks is large ($n_1 = n_2 = 159 \geq 10$), the Wilcoxon Rank Sum Statistics $W=R_j$ can be approximated by a normal distribution, so that

$$W^* = \frac{R_j - [n_2(n_1 + n_2 + 1)/2]}{[n_1 n_2 (n_1 + n_2 + 1)/12]^{1/2}} \tag{5.7}$$

The null hypothesis is tested against the alternative hypothesis at the α-level of significance by comparing the W^* with the critical value $z_{a/2}$ from the standard normal distribution table. The null hypothesis is rejected if $|W^*| \geq z_{a/2}$.

The Wilcoxon-Mann-Whitney test can also be used to examine whether a distribution first-order stochastically dominates the other. To check the statistical significance of the stochastic dominance of efficiency scores calculated using different input/output methodology, the null-hypothesis tested is:

H_0: $F^{M1}(EFF^{M1}) > F^{M2}(EFF^{M2})$ – *efficiency scores estimated using Methodology 1 first order stochastically dominate the efficiency scores calculated using Methodology 2.*

The alternative hypothesis implies that the efficiency scores estimated using Methodology 1 does not first order stochastically dominate efficiency scores calculated using Methodology 2.

5.2.4. Simar-Zelenyuk-adapted-Li test for equality of efficiency distributions

The main problem of efficiency scores analysis is that the true efficiency scores are not observed but estimated via certain non-parametric technique. Recently, Simar and Zelenyuk (2006) proposed a reliable statistical tool for testing the equality of distributions of unobserved DEA-estimated efficiency scores. This approach is based on statistical tests suggested by Li (1996) and adapted by authors to the DEA context.

To evaluate the null hypothesis of no difference in the efficiency scores estimated by different methodologies *(EFF^{MI})*, the Kolmogorov-Smirnov and Mann-Whitney tests is complemented by the Simar-Zelenyuk-adapted-Li test.

To test this hypothesis, the statistic based on the integrated square difference criterion can be used, where unknown distribution functions are replaced by the corresponding empirical (possibly unknown) functions. This means, that they are replaced with the non-parametric kernel density estimators where 'diagonal' terms removed (for details, see Simar and Zelenyuk, 2006):

$$\hat{I}^{nd}_{n_{M1},n_{M2},h} = \left\{ \frac{1}{h\ n_{M1}(n_{M1}-1)} \sum_{j=1}^{n_{M1}} \sum_{k\neq j,k=1}^{n_{M1}} K\left(\frac{EFF^{M1,j}-EFF^{M1,k}}{h}\right) + \frac{1}{h\ n_{M2}(n_{M2}-1)} \sum_{j=1}^{n_{M2}} \sum_{k\neq j,k=1}^{n_{M2}} K\left(\frac{EFF^{M2,j}-EFF^{M2,k}}{h}\right) \right.$$
$$\left. - \frac{1}{h\ n_{M1}(n_{M2}-1)} \sum_{j=1}^{n_{M2}} \sum_{k\neq j,k=1}^{n_{M1}} K\left(\frac{EFF^{M2,j}-EFF^{M1,k}}{h}\right) - \frac{1}{h\ n_{M2}(n_{M1}-1)} \sum_{j=1}^{n_{M1}} \sum_{k\neq j,k=1}^{n_{M2}} K\left(\frac{EFF^{M1,j}-EFF^{M2,k}}{h}\right) \right\}$$

(5. 8)

where K is an appropriate kernel function and h is the smoothing parameter (also called bandwidth or window width).

Letting $\lambda_n = n_{M1}/n_{M2}$, *and assuming* $\lambda_n \to \lambda$, *as* $n_{M1} \to \infty$, where $\lambda \in (0, \infty)$ is a constant, the limiting distribution of equation (5.8) is standard normal (Li, 1996), i.e.

$$\hat{J}^{nd}_{n_{M1},n_{M2},h} \equiv \frac{n_{M1} h^{1/2} \hat{I}^{nd}_{n_{M1},n_{M2},h}}{\hat{\sigma}_{\lambda,h}} \xrightarrow{d} N(0,1) \qquad (5.\ 9)$$

where $\hat{\sigma}_{\lambda,h}$ is a consistent estimator of

$\sigma^2_\lambda = 2\left(\int (F_{M1}(EFF) - \lambda F_{M2}(EFF))^2 dEFF\right)\left(\int K^2(EFF) dEFF\right)$, and can be obtained as

$$\hat{\sigma}^2_{\lambda,h} = 2\left\{ \frac{1}{h\ n^2_{M1}} \sum_{j=1}^{n_{M1}} \sum_{k=1}^{n_{M1}} K\left(\frac{EFF^{M1,j}-EFF^{M1,k}}{h}\right) + \frac{\lambda^2_n}{h\ n^2_{M2}} \sum_{j=1}^{n_{M2}} \sum_{k=1}^{n_{M2}} K\left(\frac{EFF^{M2,j}-EFF^{M2,k}}{h}\right) \right.$$
$$\left. - \frac{\lambda_n}{h\ n_{M1} n_{M2}} \sum_{j=1}^{n_{M2}} \sum_{k=1}^{n_{M1}} K\left(\frac{EFF^{M2,j}-EFF^{M1,k}}{h}\right) - \frac{\lambda_n}{h\ n_{M1} n_{M2}} \sum_{j=1}^{n_{M1}} \sum_{k=1}^{n_{M2}} K\left(\frac{EFF^{M1,j}-EFF^{M2,k}}{h}\right) \right\} \left[\int K^2(EFF) dEFF\right]$$

(5. 10)

The formulas described above use kernel density estimators of DEA efficiency scores, where some estimates (EFF_{Mj}) equal to 1, providing spurious mass at the boundary value 1 in the discrete density to be smoothed. Therefore, the issue of bounded support arises. This can be circumvented either by the reflection method (Silverman, 1986), by ignoring or by smoothing the efficiency scores estimates (Simar and Zelenyuk, 2006). In this chapter latter method is utilized. Because it 'smoothes' away from the bound the DEA-estimates equal to one by adding a small noise within the α -quantile of the empirical distribution of $EF\hat{F}_{Mj}$, ignoring those equal to unity, and of an order smaller than the noise of the estimation. In other words, smoothing is made by

$$EF\hat{F}^{*}_{Mj} = \begin{cases} EF\hat{F}_{Mj} + \varepsilon_{Mj}, & EF\hat{F}_{Mj} = 1 \\ EF\hat{F}_{Mj}, & otherwise \end{cases} \quad (5.\ 11)$$

where $\varepsilon_{Mj} = Uniform\left(0,\ \min\left\{n_{Mj}^{-2/(M+N+1)}, \alpha\right\}\right)$, and α is the α –quantile of the empirical distribution of $EF\hat{F}_{Mj}$ ignoring those equal to unity (where $\alpha = 5\%$).

Since finite samples (a set of DEA estimates) are used here, the performance of the Li-test adapted to the DEA context needs to be improved by a carefully designed bootstrap. A modified version of bootstrapping Algorithm 2, as suggested by Simar and Zelenyuk (2006), is presented in Table 5.1.

Table 5. 1. Algorithm of the Bootstrap for Simar-Zelenyuk-adapted-Li test for equality of the efficiency distributions

1. For each bank in the sample compute EFF_{M1j} $(j=1,...,n)$ using methodology 1 (via DEA) and thus obtaining some sequence of estimated efficiency scores $E\hat{F}F_{M1j}$	For each bank in the sample compute EFF_{M2j} $(j=1,...,n)$ using methodology 2 (via DEA) and thus obtaining some sequence of estimated efficiency scores $E\hat{F}F_{M2j}$

2. Smooth the estimates of the original efficiency scores according to (5.11), and thus obtaining:

$$\left\{EF\hat{F}^{*}_{M1j} : j = 1,...,n_{M1}\right\} \quad (A1)$$

$$\left\{EF\hat{F}^{*}_{M2j} : j = 1,...,n_{M2}\right\} \quad (A2)$$

3. Estimate the Li (1996) statistic (5.9) using the data (A1) and (A2), and bandwidth h^* which is the minimum of the two bandwidths for EFF^*_{M1} and EFF^*_{M2}.

4. Resample from the sample (A1) or (A2) to obtain the bootstrap analogues of (A1) and (A2):

$$\left\{EF\hat{F}^{**}_{M1j} : j = 1,...,n_{M1}\right\} \quad (A3)$$

$$\left\{EF\hat{F}^{**}_{M2j} : j = 1,...,n_{M2}\right\} \quad (A4)$$

5. Estimate the Li (1996) statistic (5.9) using the data (A3) and (A4), and bandwidth h^*

Repeat steps 4-5 B-times $(b=1,...,B)$ to obtain bootstrap estimates of Li-statistics.

5.2.5. The inter-distribution mobility of banks' positions

To identify the mobility of banks' position with regard to the chosen Input/Output approach, transition probability matrices are constructed across the pairs of approaches. Since the change of the position of the bank rather than the absolute efficiency score when different approaches used is of interest, the efficiency scores are normalised relative to the mean as suggested by Tortosa-Ausina (2002a, 2002b):

$$NES_j^M = \frac{EFF_j^M}{\frac{1}{N}\sum_{j=1}^{N} EFF_j^M} \qquad (5.12)$$

The transition probability matrices, based on the *NES* of the banks, show the changes in the relative position of banks when moving from one group to another according to the different banking production models. Unlike Markov models, they do not show transitions over time (Tortosa-Ausina, 2003). A set of six states are considered, which array in increasing order of *NES* according to the pairs of analysed approaches. Each cell in the matrix presents the probability of a bank in this state to transit to another when alternative approach is used, and is calculated as $p_{ij} = N_{ij}/N_i$, where N_{ij} is a number of banks crossing from state i to state j, and N_i is the total number of banks departing from state i.[41]

As argued by Tortosa-Ausina (2002a) in constructing the transition probability matrix, the continuous process is discretised, and, no doubt, this discretization is arguable. Therefore, one can approach a shift of a bank's position from a continuous point of view, i.e. using stochastic kernels. The bivariate kernel density function can be generalised multivariate case as follows:

$$\hat{f}(x;H) = \frac{1}{N}\sum_{j=1}^{N} K_H\left(x - \hat{\delta}_j\right) \qquad (5.13)$$

where H is the bandwidth matrix, and K is the kernel d-function.

For the bivariate case, $x = (x_1, x_2)$, and $H = (h_1, h_2)$, where h_1 and h_2 are the bandwidths for each coordinate direction, and the function to be estimated becomes:

$$\hat{f}(x;H) = \frac{1}{Nh_1h_2}\sum_{j=1}^{N} K\left(\frac{x_1 - NES_j^{M_1}}{h_1}, \frac{x_2 - NES_j^{M_2}}{h_2}\right) \qquad (5.14)$$

Using the bivariate Gaussian kernel, the bandwidths are calculated according to the solve-the-equation plug-in approach for the bivariate Gaussian kernel, based on Wand and Jones (1994).[42]

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[41] In each case N_i is equal to 159.

[42] The computation for the bandwidth is performed using the Matlab code written by Taesam Lee which is available from: http://www.mathworks.com/matlabcentral/fileexchange/loadCategory.do?objectType=category&objectId=6.

5.3. Different banking production modeling methodologies and banks' returns

Examining the existence of economies of scale is an issue of interest in many DEA studies. However, the model defined in the thesis requires presence of the convexity constraint, implying that the determination of local returns to scale suggested by Färe and Grosskopf (1985) is not feasible. Instead, banks' returns are estimated according to Banker and Thrall (1992) and Seiford and Zhu (1999). Therefore, to perform the returns analysis for the discussed banks, the duals to models defined in Chapter 4 are considered[43]:

$$\text{Min } \chi_0 = \sum_{i=1}^{M} u_i x_{i0} - \sum_{r=1}^{R} w_r^g y_{r0}^g + w^b LLP_0 + u_0$$

s.t.

$$\begin{aligned} &\sum_{i=1}^{M} u_i x_{ij} - \sum_{r=1}^{R} w_r^g y_{rj}^g + w^b LLP_j + u_0 \geq 0, \qquad j = 1,\dots,n \\ &w_r^g \geq \frac{1}{sR_{r0}^g}, \qquad r = 1,\dots,R \\ &w^b = \frac{1}{sR_{\gamma_0 LLP_0}} \\ &u_i, w^g \geq 0 \end{aligned} \tag{5. 15}$$

The dual to model (4.6) is written as:

$$\text{Min } \iota_0 = \sum_{i=1}^{M} u_i x_{i0} - \sum_{r=1}^{R} w_r^g y_{r0}^g + w^b \gamma_0 LLP_0 + u_0$$

s.t.

$$\begin{aligned} &\sum_{i=1}^{M} u_i x_{ij} - \sum_{r=1}^{R} w_r^g y_{rj}^g + w^b \gamma_j LLP_j + u_0 \geq 0, \qquad j = 1,\dots,n \\ &w_r^g \geq \frac{1}{sR_{r0}^g}, \qquad r = 1,\dots,R \\ &w^b = \frac{1}{sR_{\gamma_0 LLP_0}} \\ &u_i, w^g \geq 0 \end{aligned} \tag{5. 16}$$

[43] The derivation of dual in the case of eq.4.8 is given in Appendix G.

And the dual to model (4.8) is the following program:

$$\text{Min } \xi_0 = \sum_{i=1}^{M} u_i x_{i0} - \sum_{r=1}^{R} w_r^g y_{r0}^g + w^b \gamma_0 LLP_0 + \sum_{p=1}^{P} v_p^+ Q_{p0}^+ - \sum_{q=1}^{Q} v_q^- Q_{q0}^- + u_0$$

s.t.

$$\sum_{i=1}^{M} u_i x_{ij} - \sum_{r=1}^{R} w_r^g y_{rj}^g + w^b \gamma_j LLP_j + \sum_{p=1}^{P} v_p^+ Q_{pj}^+ - \sum_{q=1}^{Q} v_q^- Q_{qj}^- + u_0 \geq 0, \qquad j = 1,\dots,n$$

$$w_r^g \geq \frac{1}{sR_{r0}^g}, \qquad r = 1,\dots,R$$

$$w^b = \frac{1}{sR_{\gamma_0 LLP_0}}$$

$$u_i, w^g \geq 0$$

(5. 17)

The multipliers of discretionary inputs (u_i), non-discretionary inputs (v_p^+ and v_q^-), desirable outputs (w_r^g) and undesirable output (w^b) can be interpreted as shadow prices of the corresponding variable.[44]

To investigate returns of a particular bank at a point on the efficient frontier constructed using the defined models (4.5, 4.6 and 4.8), the intercept term u_0 is examined in models (5.15-5.17). In the analysis, the RTS analysis presented in Hua et al (2007) and Banker et al. (1984) is applied, according to which bank operates increasing returns (IR) if and only if $u_0^* < 0$, decreasing returns (DR) if and only if $u_0^* > 0$, and constant returns (CR) if and only if $u_0^* = 0$.

This approach is suitable for efficient banks only, i.e. banks which are on the frontier as calculated by models 4.5, 4.6 and 4.8. Furthermore, the models 5.15-5.17 can produce more than one optimal solution for u_0. Following Hua et al. (2007) and Seiford and Zhu (1999) for general cases where banks are not efficient or alternative u_0 exist, modified versions of models 5.15-5.17 are used. To characterise a bank's returns with $u_0^* > 0$ in model 5.15, the following modified model can be used:

[44] In the analysis, I am assuming that the shadow prices of desirable outputs are assumed to equal to their market prices, therefore the obtained 'bad' output multiplier is its absolute shadow price. For more details, see Fare et al (1993).

$$\text{Min } u_0$$

s.t.

$$\begin{aligned}
&\sum_{i=1}^{M} u_i x_{i0} - \sum_{r=1}^{R} w_r^g y_{r0}^g + w^b LLP_0 + u_0 = \theta_0^* \\
&\sum_{i=1}^{M} u_i x_{ij} - \sum_{r=1}^{R} w_r^g y_{rj}^g + w^b LLP_j + u_0 \geq 0, \qquad j = 1,\dots,n \\
&w_r^g \geq \frac{1}{sR_{r0}^g}, \qquad r = 1,\dots,R \\
&w^b = \frac{1}{sR_{\gamma_0 LLP_0}} \\
&u_i, w^g, \hat{u}_0 \geq 0
\end{aligned} \tag{5. 18}$$

To investigate a bank's returns with $u_0^* > 0$ in model 5.16, the model is subsequently modified as:

$$\text{Min } u_0$$

s.t.

$$\begin{aligned}
&\sum_{i=1}^{M} u_i x_{i0} - \sum_{r=1}^{R} w_r^g y_{r0}^g + w^b \gamma_0 LLP_0 + u_0 = \rho_0^* \\
&\sum_{i=1}^{M} u_i x_{ij} - \sum_{r=1}^{R} w_r^g y_{rj}^g + w^b \gamma_j LLP_j + u_0 \geq 0, \qquad j = 1,\dots,n \\
&w_r^g \geq \frac{1}{sR_{r0}^g}, \qquad r = 1,\dots,R \\
&w^b = \frac{1}{sR_{\gamma_0 LLP_0}} \\
&u_i, w^g, \hat{u}_0 \geq 0
\end{aligned} \tag{5. 19}$$

To characterise a bank's returns with $u_0^* > 0$ in model 5.17, the following modified model is used:

Min u_0

s.t.

$$\sum_{i=1}^{M} u_i x_{i0} - \sum_{r=1}^{R} w_r^g y_{r0}^g + w^b \gamma_0 LLP_0 + \sum_{p=1}^{P} v_p^+ Q_{p0}^+ - \sum_{q=1}^{Q} v_q^- Q_{q0}^- + u_0 = \Omega_0^*$$

$$\sum_{i=1}^{M} u_i x_{ij} - \sum_{r=1}^{R} w_r^g y_{rj}^g + w^b \gamma_j LLP_j + \sum_{p=1}^{P} v_p^+ Q_{pj}^+ - \sum_{q=1}^{Q} v_q^- Q_{qj}^- + u_0 \geq 0, \qquad j = 1,\ldots,n$$

$$w_r^g \geq \frac{1}{sR_{r0}^g}, \qquad r = 1,\ldots,R$$

$$w^b = \frac{1}{sR_{\gamma_0 LLP_0}}$$

$$u_i, w^g, \hat{u}_0 \geq 0$$

(5. 20)

In the cases where models 5.15-5.17 yield $u_0^* < 0$, the $\hat{u}_0 \geq 0$ in models 5.18-5.20 are interchanged for $\hat{u}_0 \leq 0$, and the objective functions of models 5.18-5.20 are changed from minimisation to maximisation. Then, following Hua et al (2007), and Seiford and Zhu (1999), the following proposition can be stated: [45]

Proposition 1. Given the existence of an optimal solution with $u_0^* > 0$ in model (5.15) [or (5.16) or (5.17)], (i) the returns of a bank$_0$ are CR if and only if the optimal value which model (5.18) [or (5.19) or (5.20) respectively] achieves is zero, i.e., $u_0^* = 0$ and DR if and only if $u_0^* > 0$. Given the existence of an optimal solution with $u_0^* < 0$ in model (5.15) [or (5.16) or (5.17)], (ii) the returns of a bank$_0$ are CR if and only if the optimal value which the modified form of model (5.18) [or (5.19) or (5.20) respectively] achieves is zero, i.e., $u_0^* = 0$ and IR if and only if $u_0^* < 0$.

5.3.1. An analysis of the existence of scale economies

To evaluate the returns to scale of the banks using u_0^* values, the following hypothesis is tested:

H_0 : $F(u_0^*) = F(O)$ – *No scale inefficiency (or equivalently, banks operate with constant returns to scale production)*

against the alternative hypothesis

[45] I state this Proposition without formal proof, although the proof of Proposition 1 is similar to that of Proposition 1 in the survey of Hua et al (2007), and Theorem 7 in the study of Seiford and Zhu (1999).

$H_1 : F(u_0^*) \neq F(O)$ – *Banks are not scale efficient (or equivalently, they operate with variable returns to scale production)*

where O is the null vector and u_0^* is estimated using formula (5.15 and/or – 5.20).

5.3.2. Density and inter-distribution mobility of returns parameter u_0 across different Input/Output approaches

As per the efficiency density and inter-distribution mobility analysis, densities of the returns parameter u_0 can be visualized across different input/output methodologies over the analyzed time period for three different methods of efficiency calculation, namely technical efficiency, technical efficiency adjusted for risk and technical efficiency adjusted for risk and the environment. The univariate Gaussian kernel is used to obtain the bandwidth using the solve-the-equation plug-in-approach by Sheather and Jones (1991).

Then, the correlation coefficients are considered to compare the returns parameter of the banks in the sample. However, these figures would not give any information about the changes of the banks' returns parameter when different modelling methodologies are used. Therefore, a transition probability matrix (in the same manner as for the relative efficiency analysis) is constructed for three groups (or states): IR (where the upper endpoint is -∞, i.e. negative return parameters), CR (where the upper endpoint is equal to zero, i.e. return parameters are zero) and DR (with an upper endpoint of +∞, i.e. positive return parameters). In sum, the transition probability matrix shows the probability of reporting different returns when alternative approaches are used.

Again, as in the analysis of relative efficiency, I can consider continuous counterpart of these transition probability matrices and use stochastic kernels. As before, I utilize bivariate Gaussian kernel and calculate the bandwidths according to solve-the-equation plug-in approach for bivariate Gaussian kernel, based on Wand and Jones (1994).

5.4. Results

5.4.1. An analysis of Efficiency scores density and inter-distribution mobility

Figure 5.1 shows the distributions of the estimated individual efficiency scores for each method used to calculate technical efficiency (i.e. pure technical efficiency, adjusted for risk and adjusted for risk and the environment) across input/output modelling methodologies. As can be seen from the Figure 5.1, the estimated distributions appear to be different among the modelling approaches. The most significant discrepancy in the densities of the efficiency scores reported by the different input/output approaches was observed in 1998 by all three methods used to calculate technical efficiency. This divergence of densities is clear not only from the shape of the densities but also in their modes and modality, meaning that the levels of efficiency observed most frequently for the different approaches are at different levels. For instance, in the case of pure technical efficiency estimation, multi-modality exists in the density of the intermediation approach efficiency scores and, moderately, the density of the profit-revenue approach.

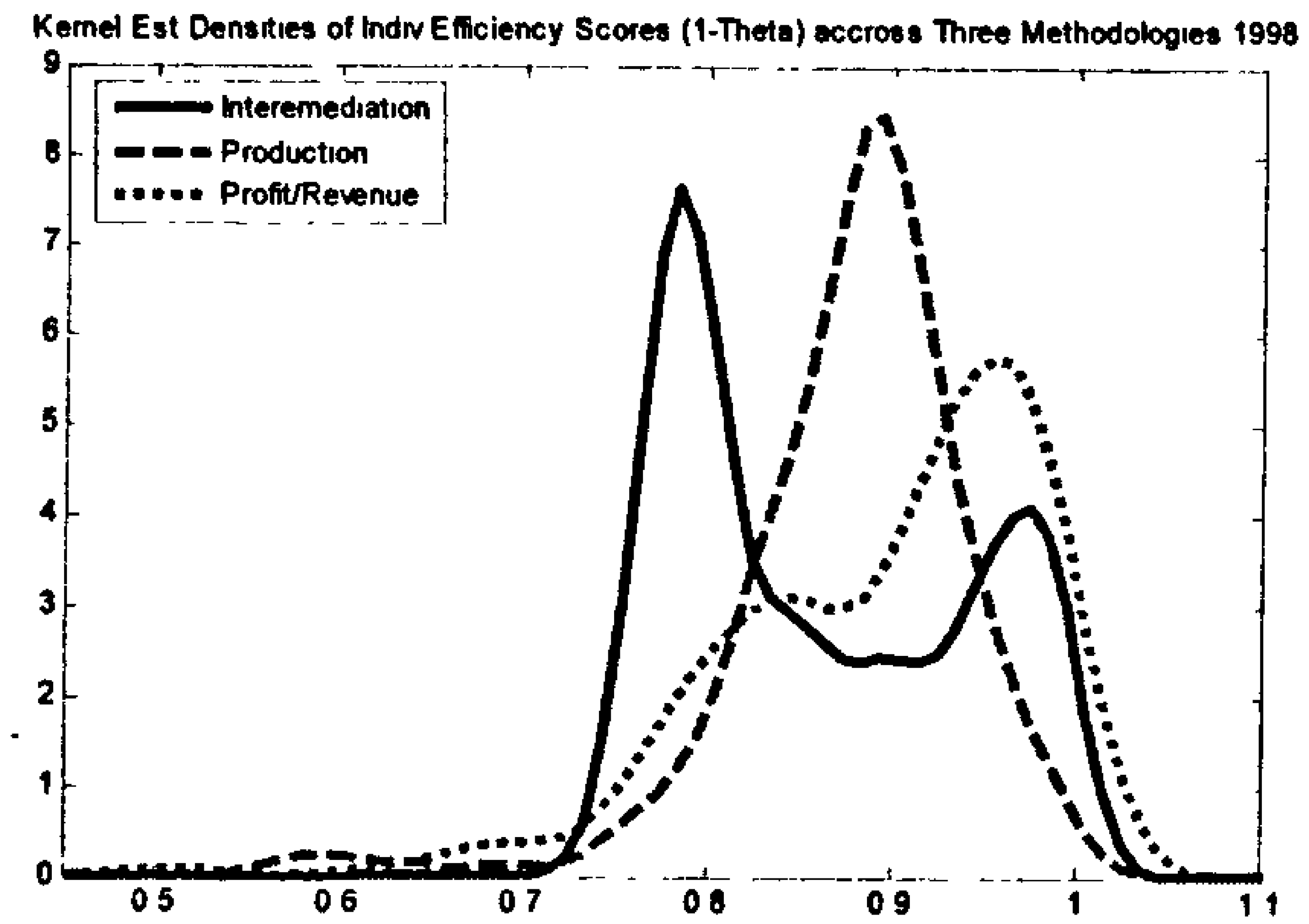
Although the shape of the densities of efficiencies estimated by the different approaches is fairly different for the rest of the years, the estimated modes are roughly at the same level and multi-modality has almost vanished by 2003. Interestingly, the patterns of the densities are not mirrored across pure technical efficiency, yet they are very similar for efficiency adjusted for risk and adjusted for risk and environment. As is well known, different input/output approaches can sometimes give a similar pattern although the pattern dynamics can be different (e.g. 2003 *(1-Ω)* graph), or even reverse (e.g. 2001 *(1-Ω)* graph). Nevertheless, a common pattern emerges across all the efficiency estimation methods and the input/output approaches; over the analysed period the estimated density distributions become increasingly compact by end of the period.

As distribution analysis suggests, the efficiency scores calculated by different input/output modelling specifications in some cases are not stable and can vary across the efficiency evaluation methods. Statistical tests for the equality of distribution between the efficiency scores calculated utilizing different input/output approaches across the years are of particular interest in this study. Table 5.2 presents the results for the Kolmogorov-Smirnov and Wilcoxon-Mann-Whitney tests on consistency of efficiency scores obtained under the alternative methodologies. Equalities for most of the comparisons of the *(1-ρ)* efficiency results are rejected with 95% confidence. However, if the equality (1-*θ*) and (1-Ω) efficiency results are considered then the null hypothesis (at 5% and 10% levels of significance) are rejected in fewer cases. Except for the year 1998 (for all efficiency measurement cases) and 2000 (for the efficiency measures *(1-ρ)* and *(1-Ω)*), the rejection/or acceptance of the null hypothesis is not consistent across the measurement models.

Table 5. 2. Tests on consistency of efficiency scores obtained under the alternative methodologies

		Efficiency measure *(1-θ)*			Efficiency measure *(1-ρ)*			Efficiency measure *(1-Ω)*		
		I vs. P	I vs. PR	P vs. PR	I vs. P	I vs. PR	P vs. PR	I vs. P	I vs. PR	P vs. PR
1998	KS	0.301* (0.000)	0.245* (0.000)	0.276* (0.000)	0.345* (0.000)	0.786* (0.000)	0.761* (0.000)	0.276* (0.000)	0.283* (0.000)	0.333* (0.000)
	WMW	2.306* (0.021)	-3.233* (0.001)	-2.390* (0.016)	2.943* (0.003)	10.956* (0.000)	10.033* (0.000)	3.403* (0.001)	1.507 (0.131)	3.423* (0.001)
1999	KS	0.176* (0.014)	0.100 (0.397)	0.157* (0.039)	0.176* (0.014)	0.106* (0.000)	0.132 (0.125)	0.195* (0.005)	0.220* (0.001)	0.063 (0.912)
	WMW	-2.553* (0.011)	0.930 (0.352)	-1.805** (0.071)	-2.540* (0.011)	1.235 (0.216)	-1.354 (0.175)	2.114* (0.034)	-2.486* (0.012)	-0.266 (0.791)
2000	KS	0.100 (0.397)	0.138** (0.095)	0.125 (0.162)	0.201* (0.003)	0.333* (0.000)	0.195* (0.005)	0.150** (0.053)	0.270* (0.000)	0.138** (0.095)
	WMW	-0.470 (0.638)	1.782** (0.074)	-1.313 (0.189)	-3.070* (0.002)	5.419* (0.000)	2.350* (0.018)	-1.860** (0.062)	3.744* (0.000)	1.828** (0.067)
2001	KS	0.100 (0.397)	0.176* (0.014)	0.176* (0.014)	0.056 (0.961)	0.163* (0.000)	0.188* (0.007)	0.150** (0.053)	0.138** (0.095)	0.151** (0.053)
	WMW	0.793 (0.427)	2.047* (0.041)	-2.664* (0.007)	-0.502 (0.615)	2.985* (0.003)	2.430* (0.015)	1.728** (0.083)	0.260 (0.795)	1.515 (0.129)
2002	KS	0.144** (0.072)	0.056 (0.961)	0.138** (0.095)	0.119 (0.206)	0.226* (0.001)	0.132 (0.125)	0.106 (0.323)	0.094 (0.479)	0.132 (0.125)
	WMW	-1.466 (0.142)	0.026 (0.979)	-1.608 (0.107)	-2.158* (0.031)	3.956* (0.000)	1.684** (0.092)	1.132 (0.257)	0.365 (0.714)	1.316 (0.188)
2003	KS	0.100 (0.397)	0.075 (0.756)	0.100 (0.397)	0.188* (0.007)	0.195* (0.005)	0.094 (0.479)	0.119 (0.206)	0.138 (0.095)	0.088 (0.569)
	WMW	-1.700** (0.089)	0.687 (0.492)	-1.006 (0.314)	-3.078* (0.002)	3.539* (0.004)	0.478 (0.632)	1.713 (0.086)	-1.108 (0.268)	0.491 (0.623)

Notes. (I) Intermediation Approach, (PR) Profit/Revenue Approach, (P) Production Approach. (KS) Kolmogorov-Smirnov test (D-value, p-value in brackets), (WMW) Wilcoxon-Mann-Whitney test (W* value, p-value in brackets). Statistical significance: * statistically significant at 5% level, ** statistically significant at 10% level.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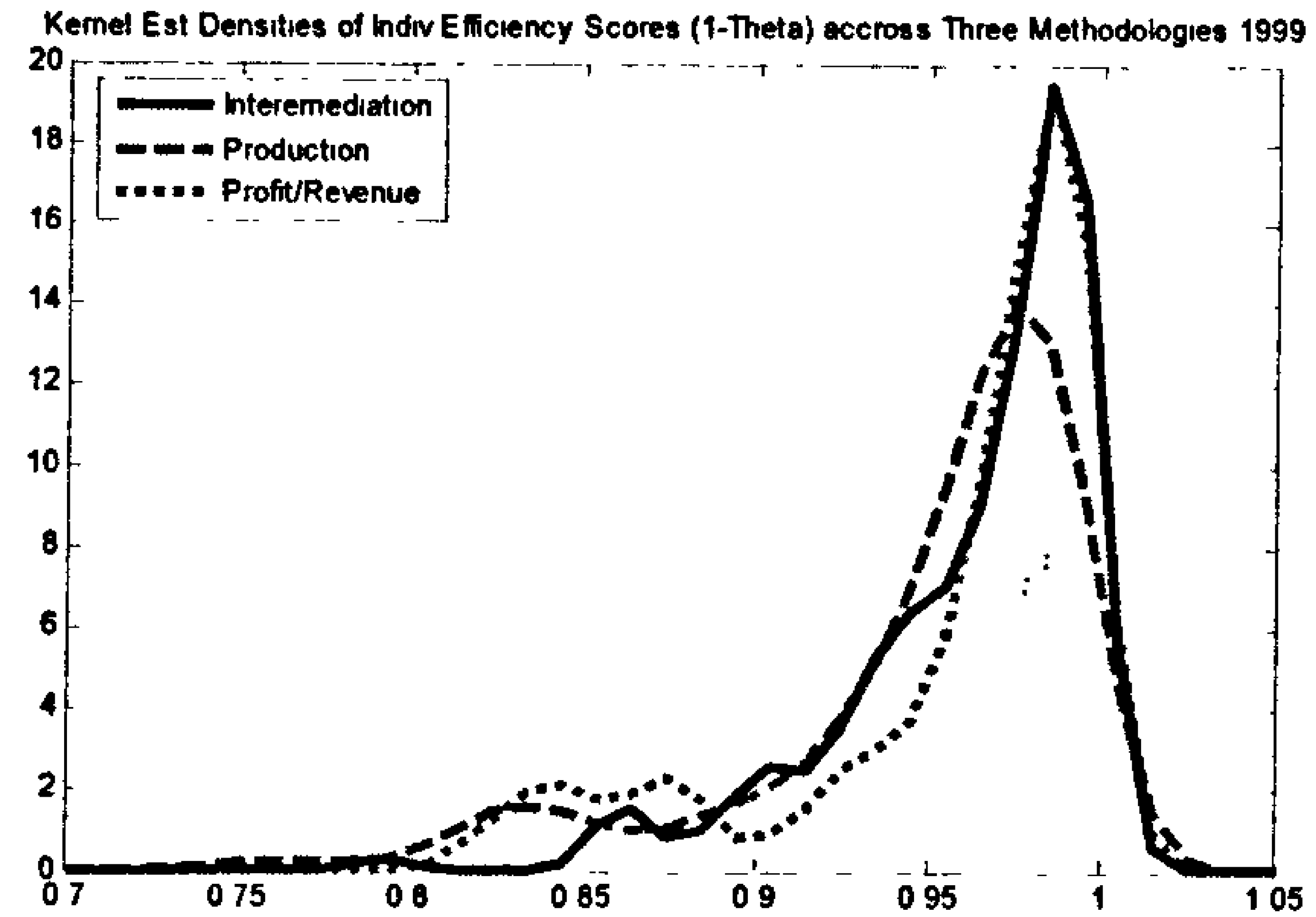
Interemediation
Production
Profit/Revenue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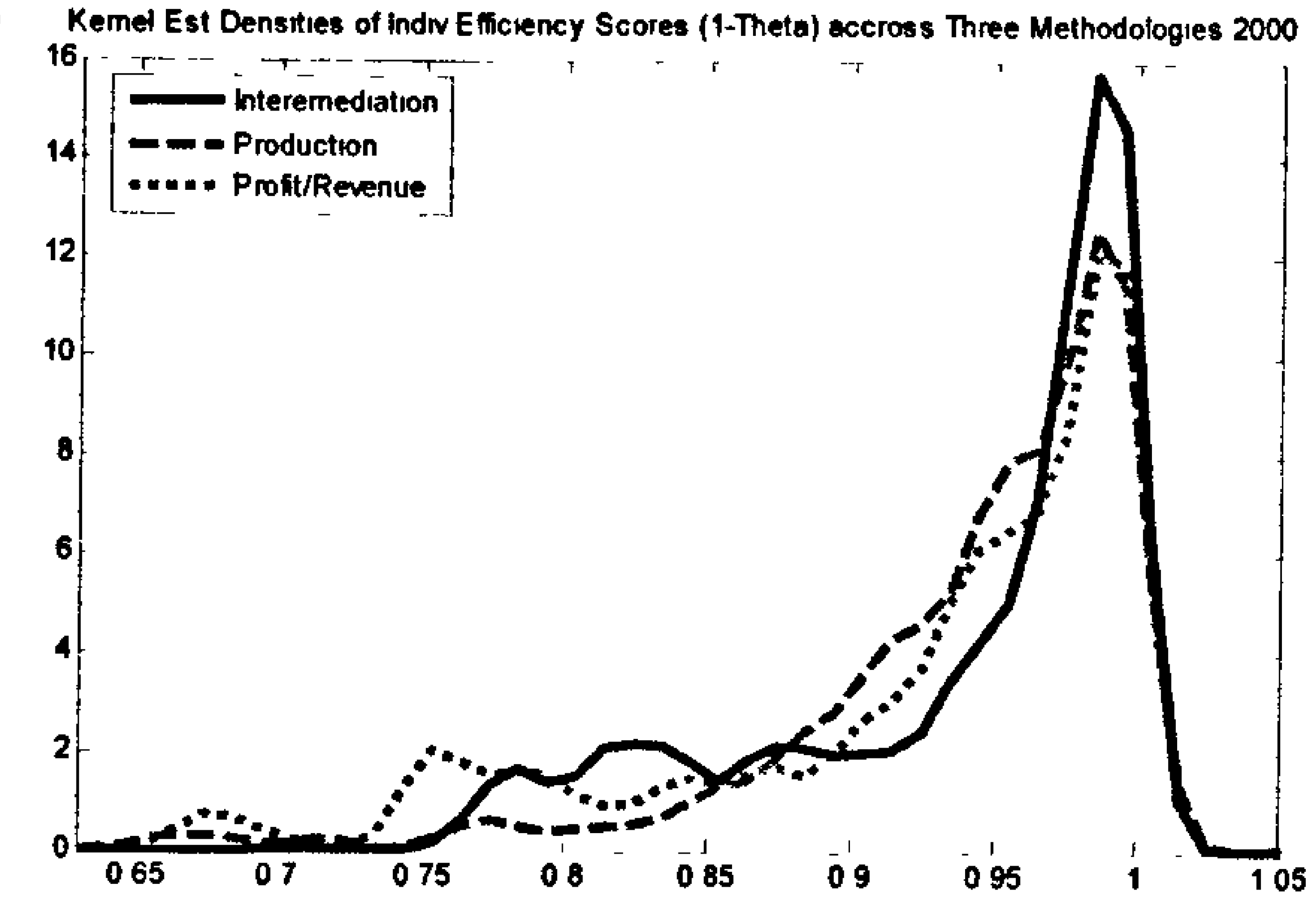
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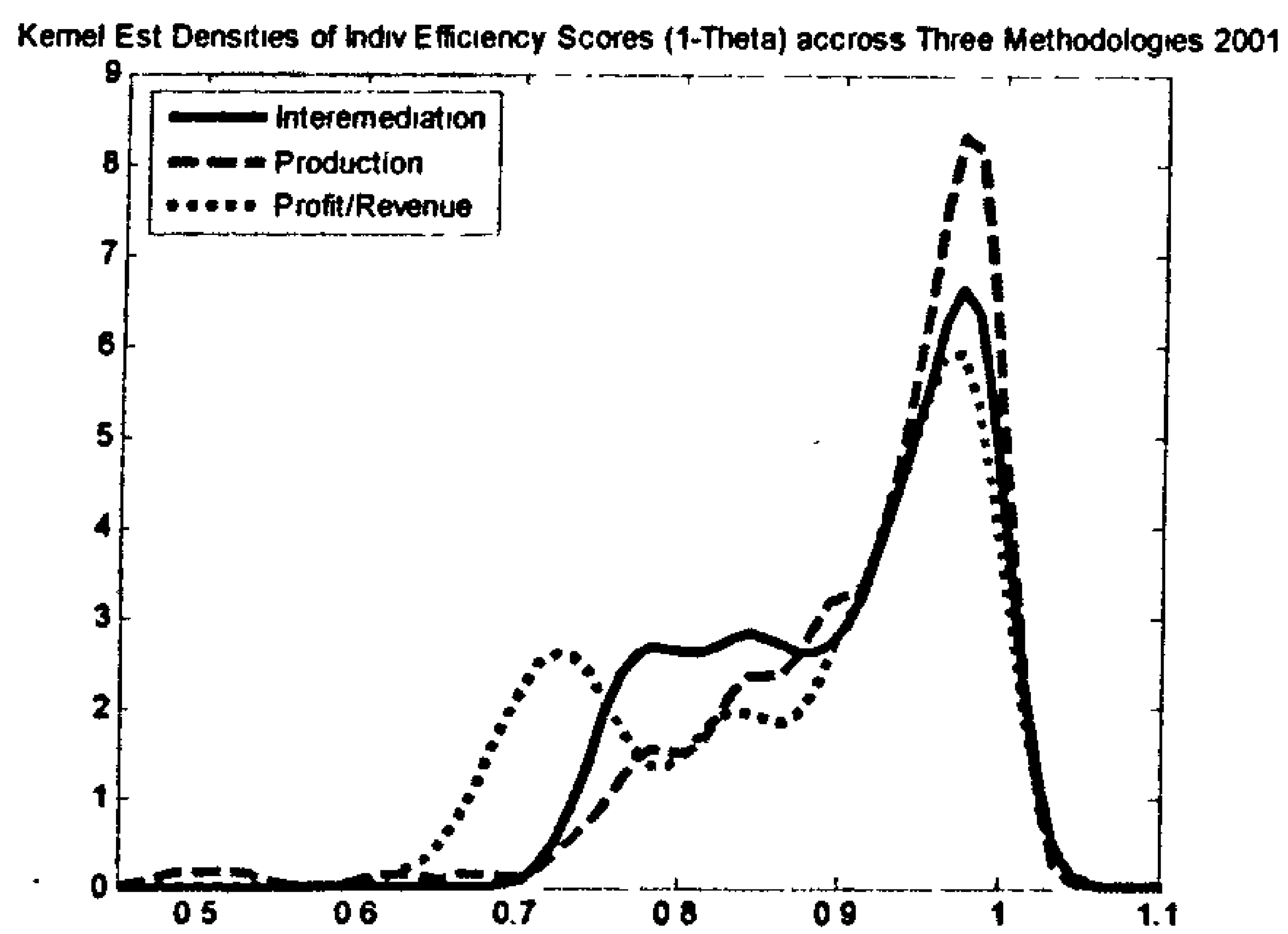
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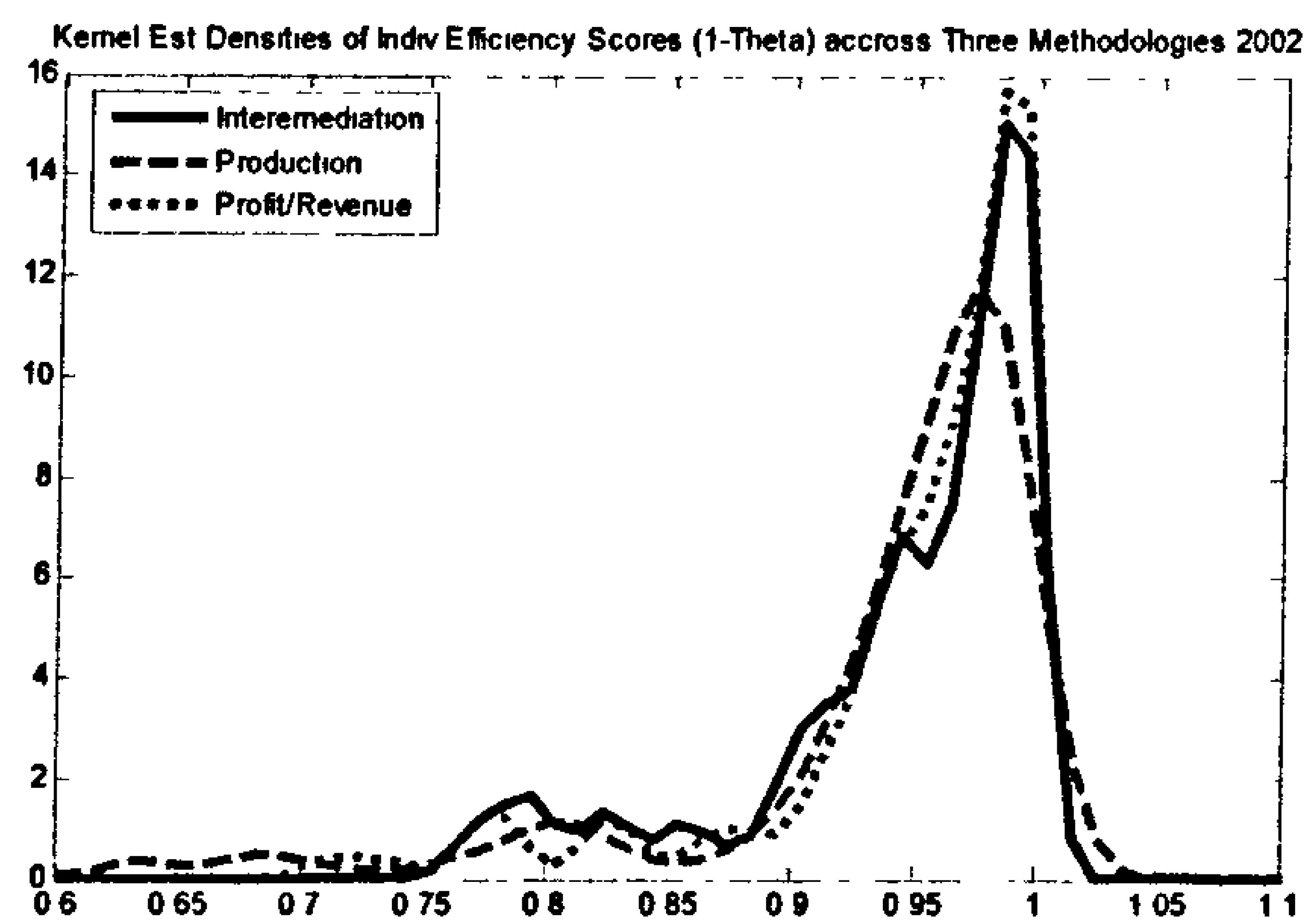
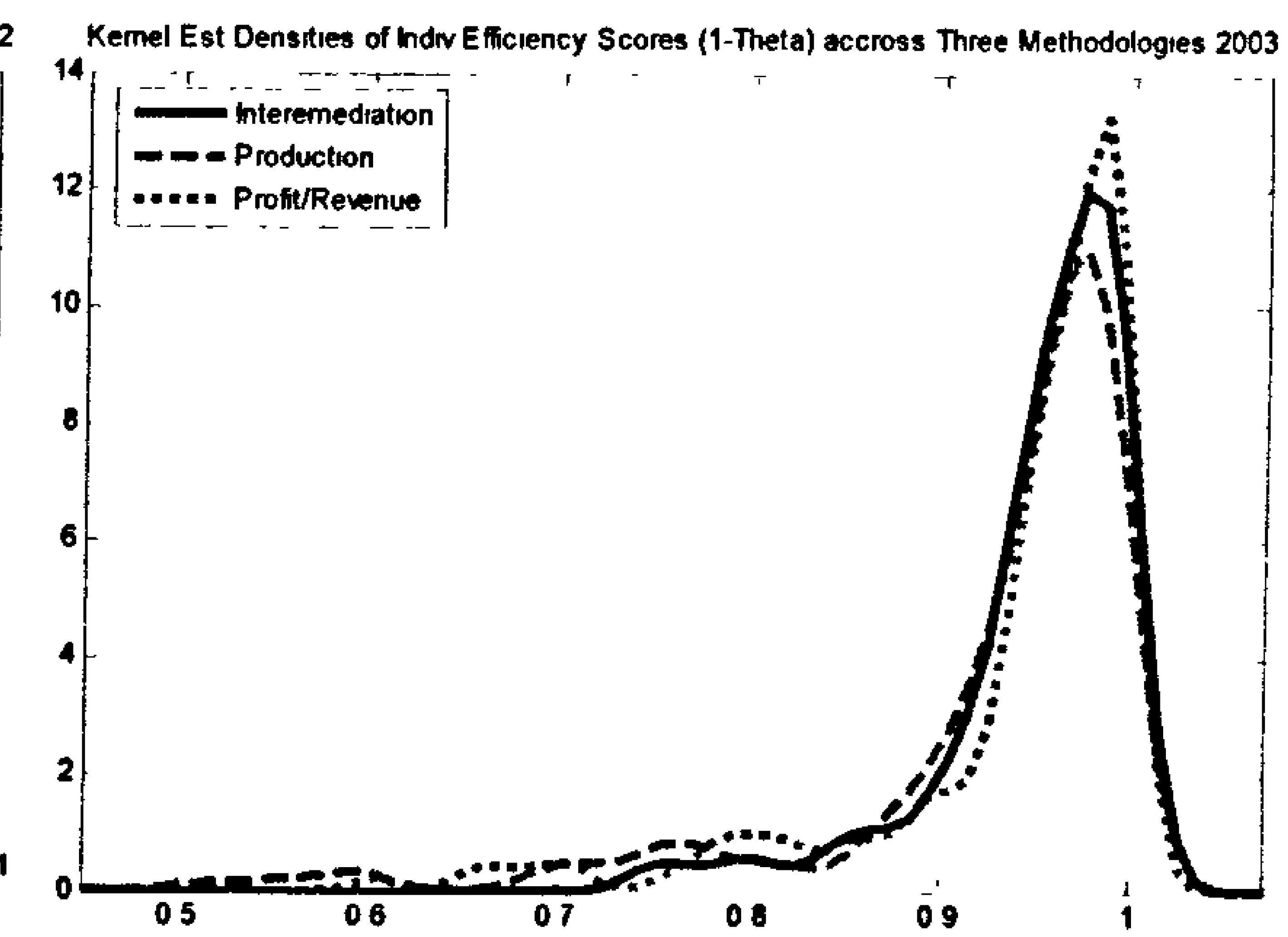
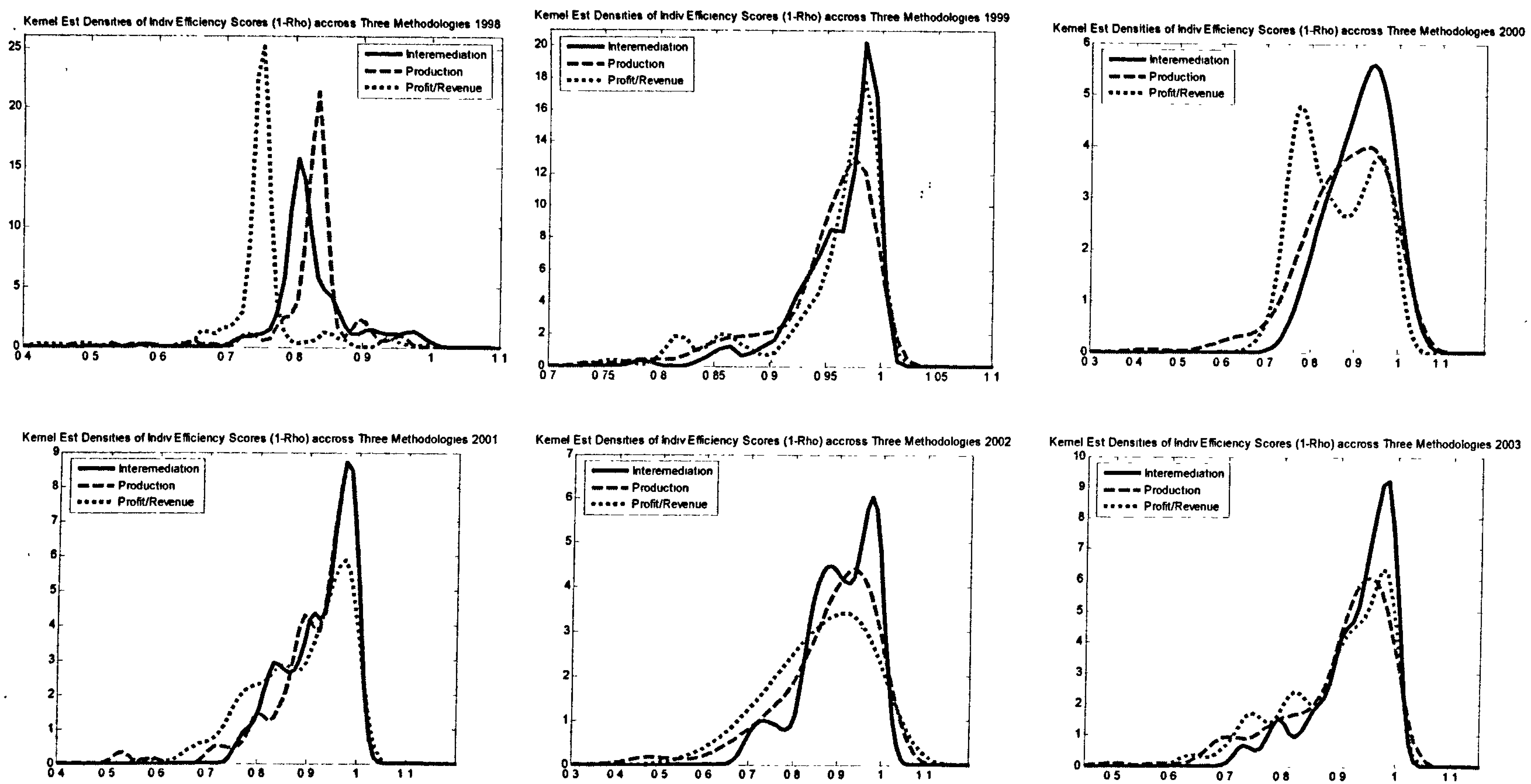
Profit/Revenue


Kernel Est Densities of Indiv Efficiency Scores (1-Theta) accross Three Methodologies 2002
Interemediation
Production
Profit/Revenue


Kernel Est Densities of Indiv Efficiency Scores (1-Theta) accross Three Methodologies 2003
Interemediation
Production
Profit/Revenue



Kernel Est Densities of Indiv Efficiency Scores (1-Rho) accross Three Methodologies 1998
Interemediation
Production
Profit/Revenue
Kernel Est Densities of Indiv Efficiency Scores (1-Rho) accross Three Methodologies 1999
Interemediation
Production
Profit/Revenue
Kernel Est Densities of Indiv Efficiency Scores (1-Rho) accross Three Methodologies 2000
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Kernel Est Densities of Indiv Efficiency Scores (1-Rho) accross Three Methodologies 2001
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Kernel Est Densities of Indiv Efficiency Scores (1-Rho) accross Three Methodologies 2002
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Kernel Est Densities of Indiv Efficiency Scores (1-Rho) accross Three Methodologies 2003
Interemediation
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Profit/Revenue

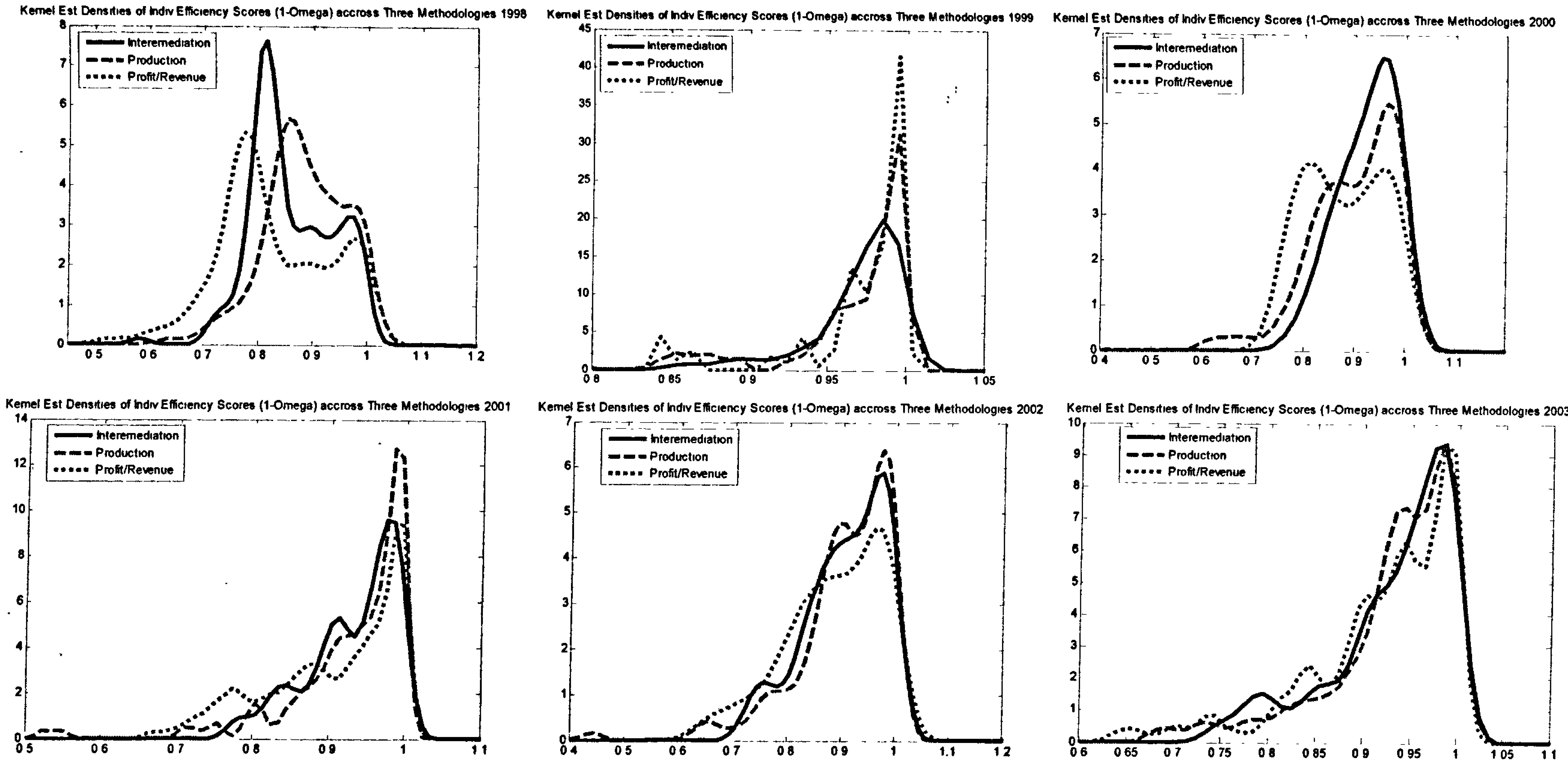


Figure 5. 1. Distributions of Efficiency Scores (three types of efficiency measure) across Three Alternative Methodologies.

Note. Vertical axis refers to (estimated) probability density function of the distribution of efficiency scores and horizontal axis refers to efficiency scores (reflected).

The non-parametric KS and WMW tests are based on the estimated but not the *true* efficiency scores. Hence, the results are complemented by the equality test of efficiency scores using the Simar-Zelenyuk-adapted-Li test for equality of efficiency distributions, presented in Table 5.3. A comparison of the true efficiency results suggest that efficiency, the distribution of efficiency scores are drawn from different populations, i.e. in most cases the equality of distributions is rejected (at 5% and 10% levels of significance).

Table 5. 3. Simar-Zelenyuk-adapted-Li test for equality of efficiency distributions

Null Hypothesis		Efficiency measure $(1-\theta)$		Efficiency measure $(1-\rho)$		Efficiency measure $(1-\Omega)$	
		Test statistics	Bootstrap p-value	Test statistics	Bootstrap p-value	Test statistics	Bootstrap p-value
1998	$f(eff^{INT})=f(eff^{P})$	26.4544	0.000*	33.5101	0.000*	6.0966	0.000*
	$f(eff^{INT})=f(eff^{PR})$	11.7704	0.000*	67.9844	0.000*	6.9777	0.000*
	$f(eff^{PR})=f(eff^{P})$	16.3593	0.000*	63.2521	0.000*	14.4112	0.000*
1999	$f(eff^{INT})=f(eff^{P})$	2.5003	0.009*	2.7023	0.008*	2.3597	0.009*
	$f(eff^{INT})=f(eff^{PR})$	0.7607	0.198	0.9313	0.095**	2.4663	0.012*
	$f(eff^{PR})=f(eff^{P})$	2.9932	0.004*	2.7425	0.005*	0.3434	0.537
2000	$f(eff^{INT})=f(eff^{P})$	1.9008	0.017*	1.9236	0.026*	1.3160	0.054**
	$f(eff^{INT})=f(eff^{PR})$	1.1484	0.052**	12.1761	0.000*	8.4651	0.000*
	$f(eff^{PR})=f(eff^{P})$	0.4193	0.518	4.9559	0.000*	2.7179	0.006*
2001	$f(eff^{INT})=f(eff^{P})$	1.0839	0.083**	0.0817	0.918	0.4834	0.490
	$f(eff^{INT})=f(eff^{PR})$	2.7043	0.008*	1.5669	0.042*	2.6570	0.006*
	$f(eff^{PR})=f(eff^{P})$	3.3166	0.003*	2.3260	0.012	1.4181	0.053**
2002	$f(eff^{INT})=f(eff^{P})$	1.7330	0.031*	0.6491	0.319	-0.0948	0.893
	$f(eff^{INT})=f(eff^{PR})$	0.0466	0.943	2.8917	0.006	1.3133	0.064**
	$f(eff^{PR})=f(eff^{P})$	1.2321	0.061**	1.4258	0.051	1.3729	0.062**
2003	$f(eff^{INT})=f(eff^{P})$	0.4298	0.527	1.7380	0.028	0.6819	0.264
	$f(eff^{INT})=f(eff^{PR})$	0.0774	0.918	1.6637	0.028	1.2969	0.059**
	$f(eff^{PR})=f(eff^{P})$	1.1443	0.064**	0.9348	0.103	0.1565	0.828

Notes: (INT) Intermediation Approach, (PR) Profit/Revenue Approach, (P) Production Approach. The number of bootstrap iterations is 5000. For these tests, the Gaussian density, $K(t)=\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}t^2}$ is used, and h is the minimum of the two bandwidths for EFFM1 and EFFM2, which are calculated according to Silverman (1986) and equal to $h_M = 1.06A_M n_M^{-1/5}$, where $A=\min\left(\sqrt{\operatorname{var}(u)}, iqr(u)/1.349\right)$, and *iqr(u)* is the interquartile range of the random variable *u*, for which the density is estimated. Statistical significance: * statistically significant at 5% level, ** statistically significant at 10% level.

The analysis of the distribution of efficiency scores do not provide any information about the banks' relative positions, therefore the transition probability matrices of normalised efficiency scores are estimated. Table 5.4 shows the transition probabilities from Intermediation to Production, from Intermediation to Profit and from Production to Profit-Revenue for the normalised pure technical efficiency *(1-θ)*; Table 5.5 for risk adjusted technical efficiency *(1-ρ)* and Table 5.6 – for risk and environment adjusted efficiency *(1-Ω)*. The upper limits indicate the endpoints for each relative efficiency state. The interpretation for each cell in each matrix indicates the probability of the bank remaining in this state or moving to another according to the relative efficiency estimated by different approaches.

Thus, according to Table 5.4, entry a_{11} for the Intermediation/Production transition probability matrix shows that according to relative efficiency scores *(1-θ)*, the least efficient 16.7% of banks according to Intermediation approach with relative efficiency of less than 92.1%, remained with relative efficiency score in that range with probability 0.52 when Production approach was used. The remaining 0.48 transited vastly to state 2 – (0.29) and state 3 - (0.12), whereas 7% moved to states of most efficient banks (state 4, 5 and 6). Since this is a transition probability matrix, the sum of the probabilities in each row of the matrix sum to one.

Table 5. 4. Transition probability matrices of relative efficiency *(1-θ)* across different approaches

Intermediation/Production						**Intermediation/ Profit-Revenue based**						**Production/Profit-Revenue based**					
Upper Limit						Upper Limit						Upper Limit					
0.921	0.989	1.019	1.035	1.052	∞	0.921	0.989	1.019	1.035	1.052	∞	0.946	0.998	1.022	1.041	1.059	∞
0.52	0.29	0.12	0.04	0.01	0.02	0.65	0.14	0.05	0.05	0.04	0.07	0.91	0.08	0.00	0.00	0.01	0.01
0.11	0.43	0.32	0.08	0.04	0.03	0.20	0.39	0.27	0.05	0.03	0.07	0.21	0.45	0.28	0.04	0.03	0.00
0.06	0.13	0.39	0.30	0.08	0.04	0.07	0.08	0.45	0.29	0.06	0.04	0.04	0.14	0.40	0.26	0.11	0.04
0.01	0.05	0.08	0.27	0.48	0.11	0.04	0.06	0.04	0.30	0.48	0.08	0.00	0.00	0.17	0.59	0.11	0.13
0.01	0.07	0.08	0.04	0.27	0.54	0.01	0.03	0.06	0.05	0.45	0.40	0.03	0.01	0.01	0.19	0.39	0.38
0.03	0.04	0.11	0.05	0.11	0.66	0.06	0.04	0.03	0.05	0.06	0.77	0.04	0.03	0.01	0.02	0.24	0.65

Note. Entries in the table show the probability of a bank's relative efficiency transition when alternative approaches are used.

Table 5. 5. Transition probability matrices of relative efficiency *(1-ρ)* across different approaches

Intermediation/Production						**Intermediation/ Profit-Revenue based**						**Production/Profit-Revenue based**					
Upper Limit						Upper Limit						Upper Limit					
0.939	0.973	1.012	1.034	1.066	∞	0.939	0.973	1.012	1.034	1.066	∞	0.928	0.991	1.015	1.044	1.081	∞
0.73	0.16	0.08	0.01	0.01	0.01	0.88	0.08	0.04	0.01	0.00	0.00	0.93	0.04	0.01	0.01	0.00	0.01
0.14	0.16	0.57	0.09	0.01	0.02	0.22	0.17	0.57	0.03	0.01	0.00	0.35	0.56	0.08	0.01	0.00	0.01
0.13	0.14	0.35	0.27	0.11	0.01	0.20	0.12	0.38	0.23	0.06	0.02	0.00	0.51	0.38	0.10	0.00	0.01
0.06	0.01	0.15	0.31	0.40	0.08	0.06	0.02	0.09	0.31	0.41	0.11	0.01	0.07	0.14	0.64	0.15	0.01
0.01	0.01	0.06	0.06	0.34	0.52	0.02	0.01	0.05	0.06	0.22	0.64	0.01	0.01	0.02	0.11	0.48	0.37
0.05	0.01	0.04	0.04	0.04	0.82	0.06	0.02	0.09	0.00	0.01	0.82	0.01	0.03	0.01	0.00	0.01	0.94

Note. Entries in the table show the probability of a bank's relative efficiency transition when alternative approaches are used.

Table 5. 6. Transition probability matrices of relative efficiency *(1-Ω)* across different approaches

Intermediation/Production						**Intermediation/ Profit-Revenue based**						**Production/Profit-Revenue based**					
Upper Limit						Upper Limit						Upper Limit					
0.927	0.981	1.015	1.036	1.062	∞	0.927	0.981	1.015	1.036	1.062	∞	0.932	0.987	1.021	1.046	1.068	∞
0.61	0.25	0.01	0.05	0.04	0.04	0.84	0.07	0.01	0.01	0.01	0.06	0.91	0.06	0.02	0.01	0.00	0.01
0.19	0.45	0.16	0.07	0.10	0.03	0.33	0.41	0.07	0.06	0.04	0.10	0.42	0.47	0.09	0.01	0.01	0.00
0.06	0.15	0.38	0.27	0.07	0.08	0.08	0.11	0.43	0.24	0.03	0.12	0.04	0.18	0.72	0.04	0.01	0.00
0.00	0.04	0.20	0.50	0.20	0.07	0.01	0.05	0.21	0.42	0.13	0.17	0.03	0.02	0.43	0.28	0.22	0.03
0.04	0.03	0.04	0.10	0.59	0.20	0.04	0.03	0.03	0.07	0.26	0.57	0.00	0.01	0.01	0.01	0.47	0.51
0.03	0.05	0.02	0.03	0.22	0.65	0.04	0.04	0.01	0.01	0.06	0.84	0.01	0.02	0.00	0.01	0.01	0.96

Note. Entries in the table show the probability of a bank's relative efficiency transition when alternative approaches are used.

Although, the probability mass is, in general, concentrated along the positively sloped diagonal, in some cases banks have a rather low probability of remaining in the same state when another approach is used (e.g. according state 2 in the Intermediation/Production and Intermediation/Profit-Revenue based approaches transition probability matrices shown in Table 5.5). Surprisingly, and in contrast to the results by Tortosa-Ausina (2002a), transition mainly occurs to a higher efficiency state and a transition to lower states occurs with fairly small amount of probability. Another interesting detail is that if a bank is identified in the least efficient or the most efficient state, it has a very high probability of remaining in the same state. These tendencies are similar in the case of risk adjusted technical efficiency *(1-ρ)* and risk and environment adjusted efficiency *(1-Ω)*, but in the *(1-Ω)* case, transition occurs at a more modest rate than *(1-θ)* while the *(1-ρ)* case is the most moderate for such transitions.

The continuous counterparts to transition probability matrices are stochastic kernels and are displayed on the three dimensional graphs in Figures 5.2 – 5.4. As observed in the univariate kernel graphs, most of the densities become more constricted. The upper endpoints of the limits in the transition probability matrices point the same conclusion by virtue of having taut ranges of efficiency scores in the state. This is also displayed by the sharp peaks in the stochastic kernels graphs.

Conclusions regarding the transition of the banks' positions can be more accurately drawn from contour plots, shown in the Figures 5.2 – 5.4. The positive slope diagonal line in every contour plot graph represents the continuous counterpart of the transition matrix's diagonal. This diagonal line helps to visualise whether the banks will change their position relative to the mean when different approaches are used. For instance, if concentration takes place along this diagonal the banks' positions relative to the mean do not vary. On the other hand, if concentration abandons the diagonal, then the banks' position change with the change of approach. According to Figures 5.2 – 5.4, it may be inferred that the inter-distribution mobility is not high for either input/output specification, however it is noticeable that dispersion seems skewed to the left and is much higher between the Production and Profit-Revenue approaches efficiency scores and the Intermediation and Profit-Revenue approaches.

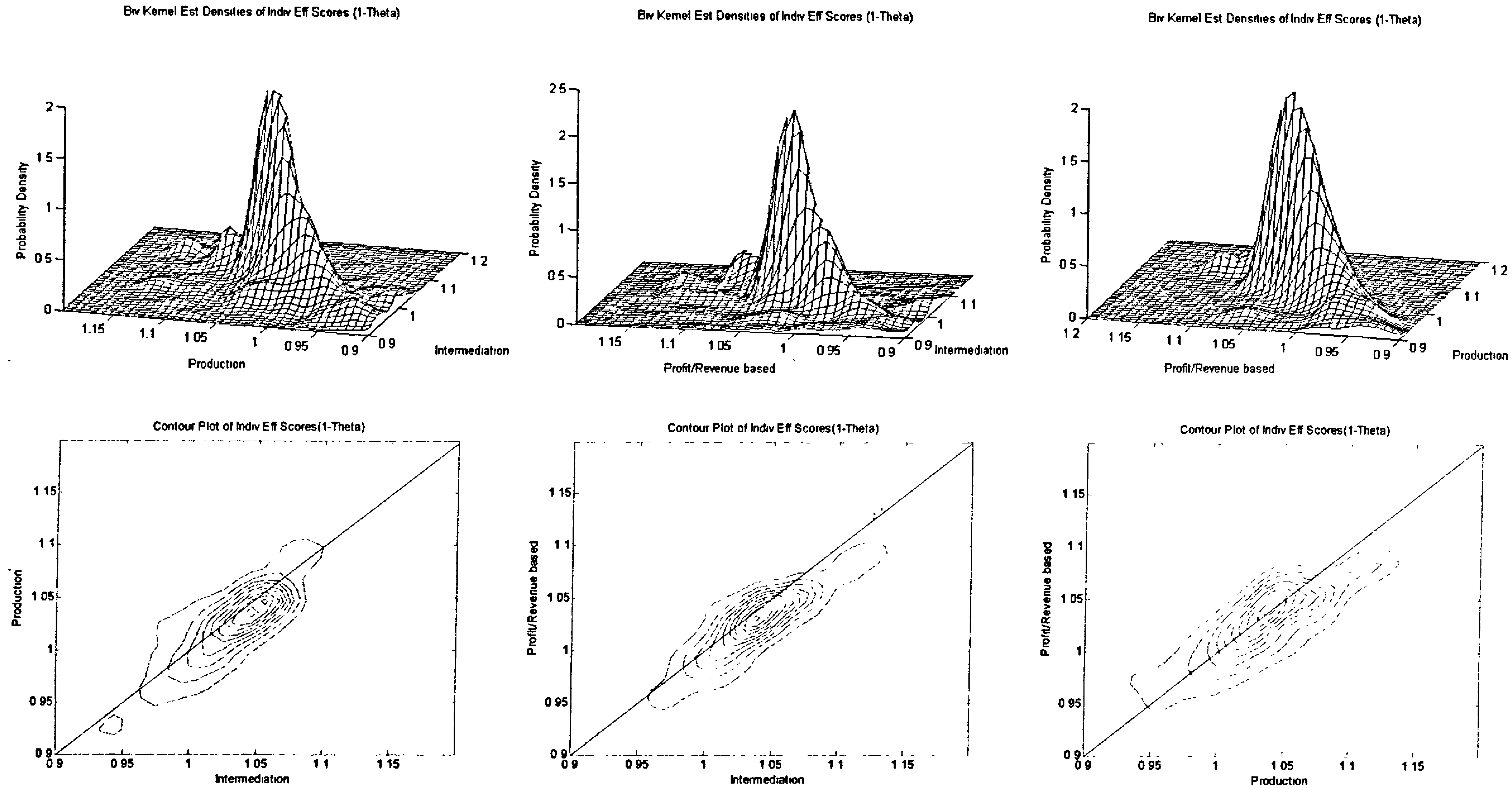


Figure 5. 2. Normalised efficiency *(1-θ)* transition across different input/output definitions.

Note. The above diagrams show the stochastic probability of the normalised efficiency scores across the two alternative approaches. The contour plots visualise the probability mass of the stochastic kernels of the two approaches.

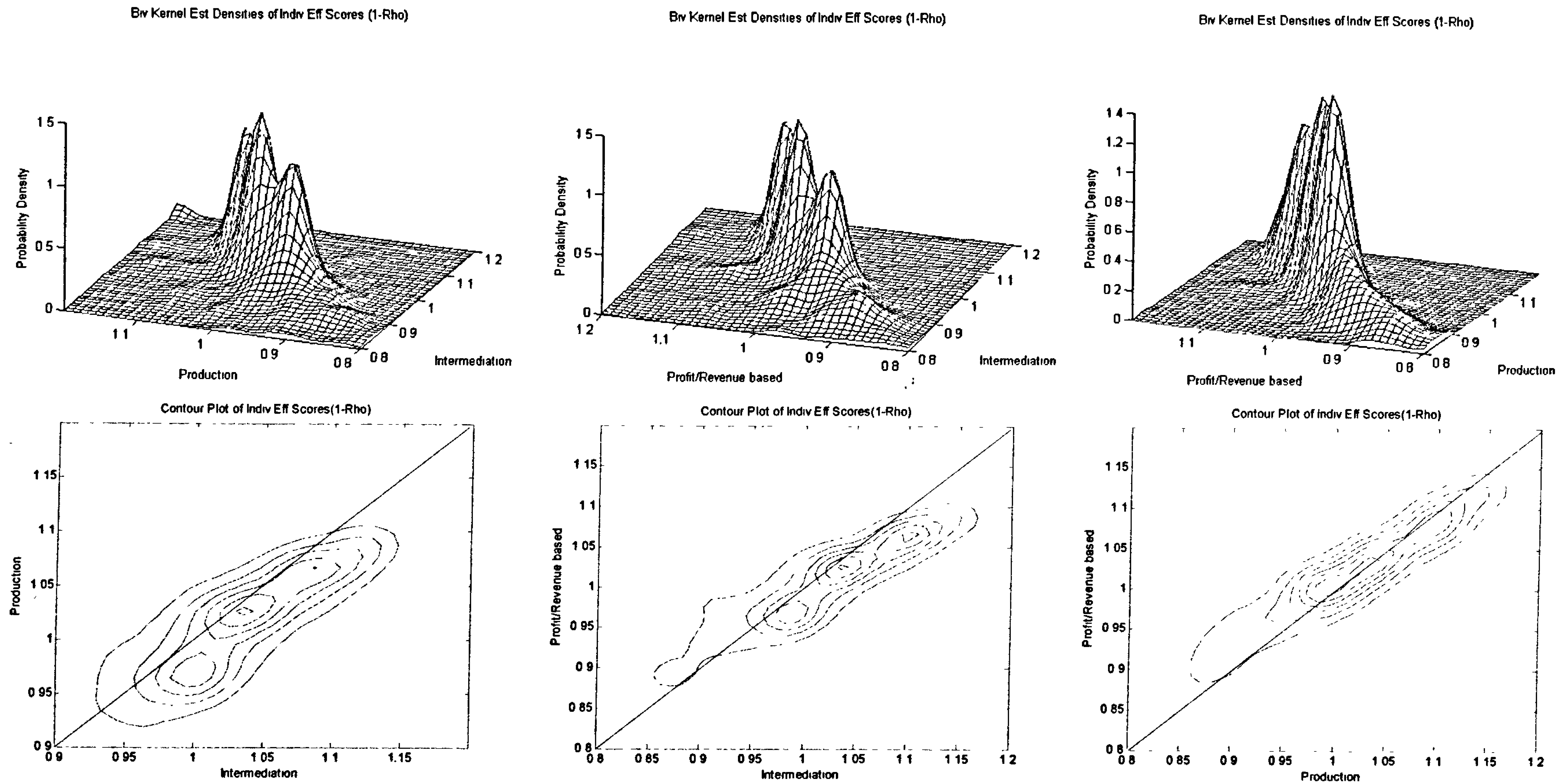


Figure 5. 3. Normalised efficiency *(1-ρ)* transition across different input/output definitions.
Note. The above diagrams show the stochastic probability of the normalised efficiency scores across the two alternative approaches. The contour plots visualise the probability mass of the stochastic kernels of the two approaches.

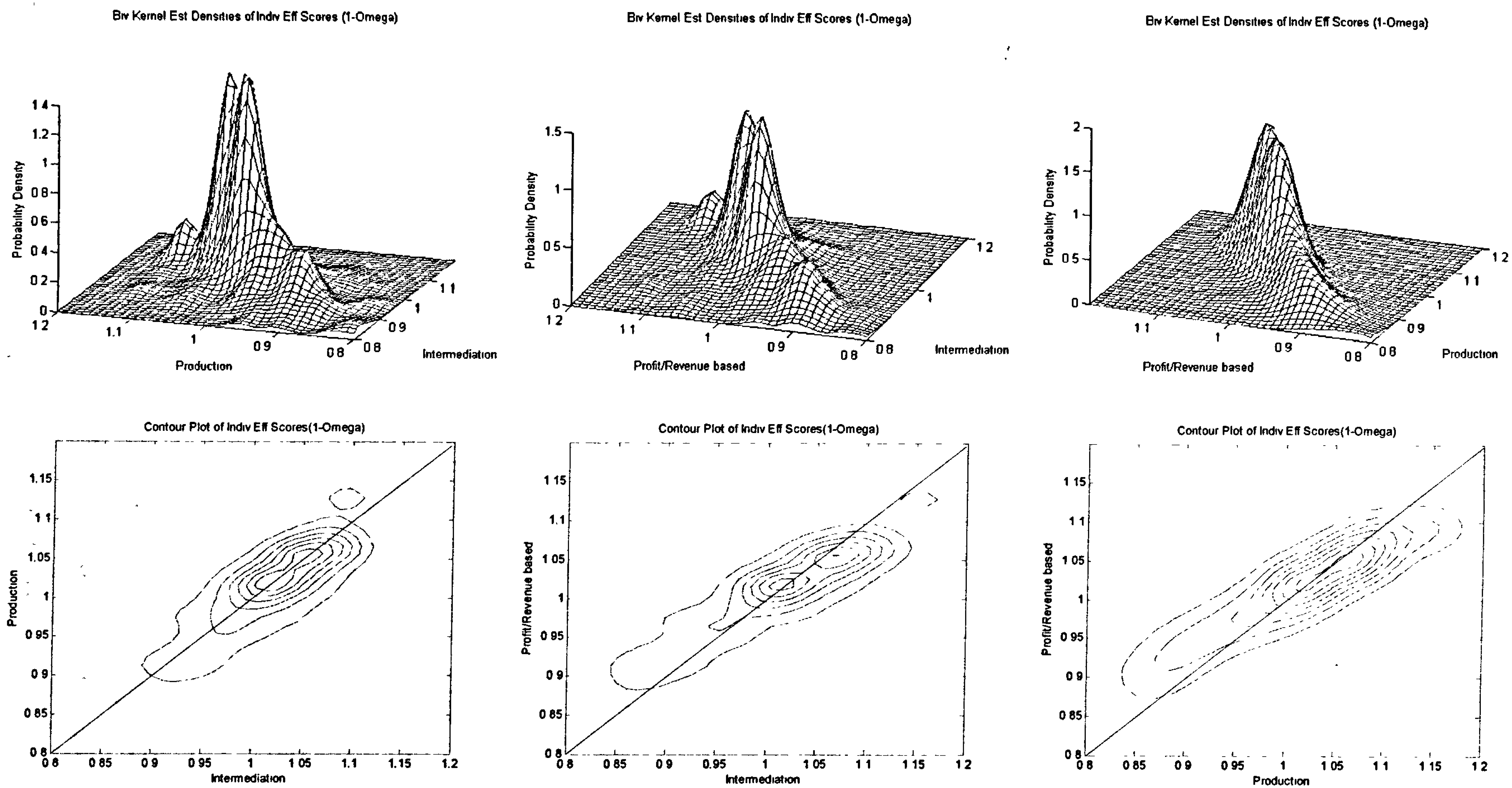


Figure 5. 4. Normalised efficiency *(1-Ω)* transition across different input/output definitions.

Note. The above diagrams show the stochastic probability of the normalised efficiency scores across the two alternative approaches. The contour plots visualise the probability mass of the stochastic kernels of the two approaches.

5.4.2. *An analysis of banks' returns*

The returns characteristics of the banking production process reported by the DEA efficiency results are now discussed. Following Banker and Natarajan (2004), a test of whether the banks operate at constant or variable returns to scale is analysed by comparing the distribution of the returns parameter of the banks with the null vector. Table 5.7 reports the test results obtained by Kolmogorov-Smirnov and Wilcoxon-Mann-Whitney tests. As can be seen, the KS test rejects the null hypothesis in all cases suggesting that banks operate variable returns to scale. These results are consistent with the WMW test, which fails to reject the null hypothesis at the 5% level of significance in six cases only.

Table 5. 7. Test of Returns to Scale of Eastern European banks (1998-2003

		Efficiency measure *(1-θ)*			Efficiency measure *(1-ρ)*			Efficiency measure *(1-Ω)*		
		I	P	PR	I	P	PR	I	P	PR
1998	KS	0.6981	08428	0.6604	0. 7421	0.8491	0.8742	0.6164	0.5094	0.7170
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	WMW	6.531	11.300	-5.287	7.983	11.508	12.458	3.836	-0.311	-7.267
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.755)	(0.000)
1999	KS	0.8805	.8805	0.8742	0. 8616	0.8805	0.8868	0.6667	0.5283	0.5660
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	WMW	12.544	12.544	12.337	11.923	12.544	12.752	5.495	-0.933	-2.177
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.350)	(0.029)
2000	KS	0.5094	0.7358	0.7170	0.7421	0.6164	0.7296	0.6101	0.6038	0.5283
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	WMW	-0.311	7:776	7.154	7.983	3.836	7.568	3.629	3.421	0.933
		(0.755)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.350)
2001	KS	0.5220	0.6981	0.7610	0.5031	0.6164	0.5912	0.5220	0.5535	0.6667
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	WMW	-0.726	-6.531	-8.605	0.104	4.054	-3.007	0.726	-1.869	-5.495
		(0.468)	(0.000)	(0.000)	(0.917)	(0.000)	(0 000)	(0.468)	(0.061)	(0.000)
2002	KS	0.8553	0.7987	0.9748	0.7799	0.7233	0.7170	0.6415	0.6289	0.5220
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	WMW	11.715	9.849	15.655	9.229	7.361	7.153	4.665	4.251	0.726
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.468)
2003	KS	0.7799	0.8113	0.7987	0.7673	0.7799	0.7610	0.7421	0.5660	0.5094
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	WMW	9.227	10.264	9.849	8.812	9.227	8.605	7.983	2.177	0.311
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.029)	(0.755)

Note. (I) Intermediation Approach, (PR) Profit/Revenue Approach, (P) Production Approach. (KS) Kolmogorov-Smirnov test (D-value, p-value in brackets), (WMW) Wilcoxon-Mann-Whitney test (W* value, p-value in brackets).

Table 5.8 gives an overview of the banks' returns reported by the alternative Input/Output approaches across the efficiency estimation methodology. Accordingly, in most cases, the majority of the banks operate at decreasing returns to scale with only a few banks operate at increasing returns. Surprisingly, virtually no banks operate at constant returns to scale. Bearing in mind that operating at decreasing returns suggest that these banks produce services at a higher average cost, this result can be interpreted as a signal of the difficulty of most banks to absorb a new technology and new management strategy into their production process since they could have inherited an old production technology from the pre-transition period.

Table 5. 8. Overview of banks' returns reported by different approaches across three efficiency estimation cases

	Efficiency measure (1-θ) Case								
	Intermediation			Production			Profit/Revenue-based		
	IR	CR	DR	IR	CR	DR	IR	CR	DR
1998	0.30	0.00	0.70	0.16	0.00	0.84	0.66	0.00	0.34
1999	0.12	0.00	0.88	0.12	0.00	0.88	0.13	0.00	0.87
2000	0.51	0.00	0.49	0.26	0.00	0.74	0.28	0.01	0.71
2001	0.52	0.00	0.48	0.69	0.01	0.30	0.76	0.00	0.24
2002	0.14	0.00	0.86	0.20	0.00	0.80	0.03	0.00	0.97
2003	0.22	0.08	0.70	0.19	0.00	0.81	0.20	0.00	0.80
	Efficiency measure (1-ρ) Case								
	Intermediation			Production			Profit/Revenue-based		
	IR	CR	DR	IR	CR	DR	IR	CR	DR
1998	0.26	0.00	0.74	0.15	0.00	0.85	0.12	0.01	0.87
1999	0.14	0.00	0.86	0.12	0.00	0.88	0.11	0.00	0.89
2000	0.26	0.00	0.74	0.38	0.00	0.62	0.27	0.00	0.73
2001	0.50	0.00	0.50	0.37	0.08	0.55	0.59	0.00	0.41
2002	0.22	0.00	0.78	0.28	0.00	0.72	0.28	0.00	0.72
2003	0.23	0.08	0.69	0.22	0.00	0.78	0.24	0.00	0.76
	Efficiency measure (1-Ω) Case								
	Intermediation			Production			Profit/Revenue-based		
	IR	CR	DR	IR	CR	DR	IR	CR	DR
1998	0.38	0.00	0.62	0.51	0.00	0.49	0.72	0.01	0.28
1999	0.33	0.00	0.67	0.53	0.00	0.47	0.57	0.00	0.43
2000	0.39	0.00	0.61	0.40	0.00	0.60	0.47	0.00	0.53
2001	0.48	0.00	0.52	0.55	0.02	0.43	0.67	0.00	0.33
2002	0.36	0.01	0.64	0.37	0.00	0.63	0.48	0.01	0.52
2003	0.26	0.00	0.74	0.43	0.01	0.56	0.49	0.00	0.51

Note: IR refers to increasing returns, CR refers to constant returns, DR refers to decreasing returns. Figures are measured by the share of each return to scale characteristic to the total number of banks (159). For the analysis return parameter (u_0) rounded to four decimal points.

Figures 5.5 - 5.7 show the distributions of the estimated individual returns parameters (u_0) for three alternative Input/Output approaches across *(1-θ)*, *(1- ρ)* and *(1-Ω)* efficiency measuring models. As can be seen from Figure 5.5, measuring efficiency by the Intermediation and Production approaches report approximately similar returns for the analysed banks whereas the density of returns parameters estimated by the Profit/Revenue-based approach is radically different from the other two approaches. However, the modes for all three densities are close to zero.

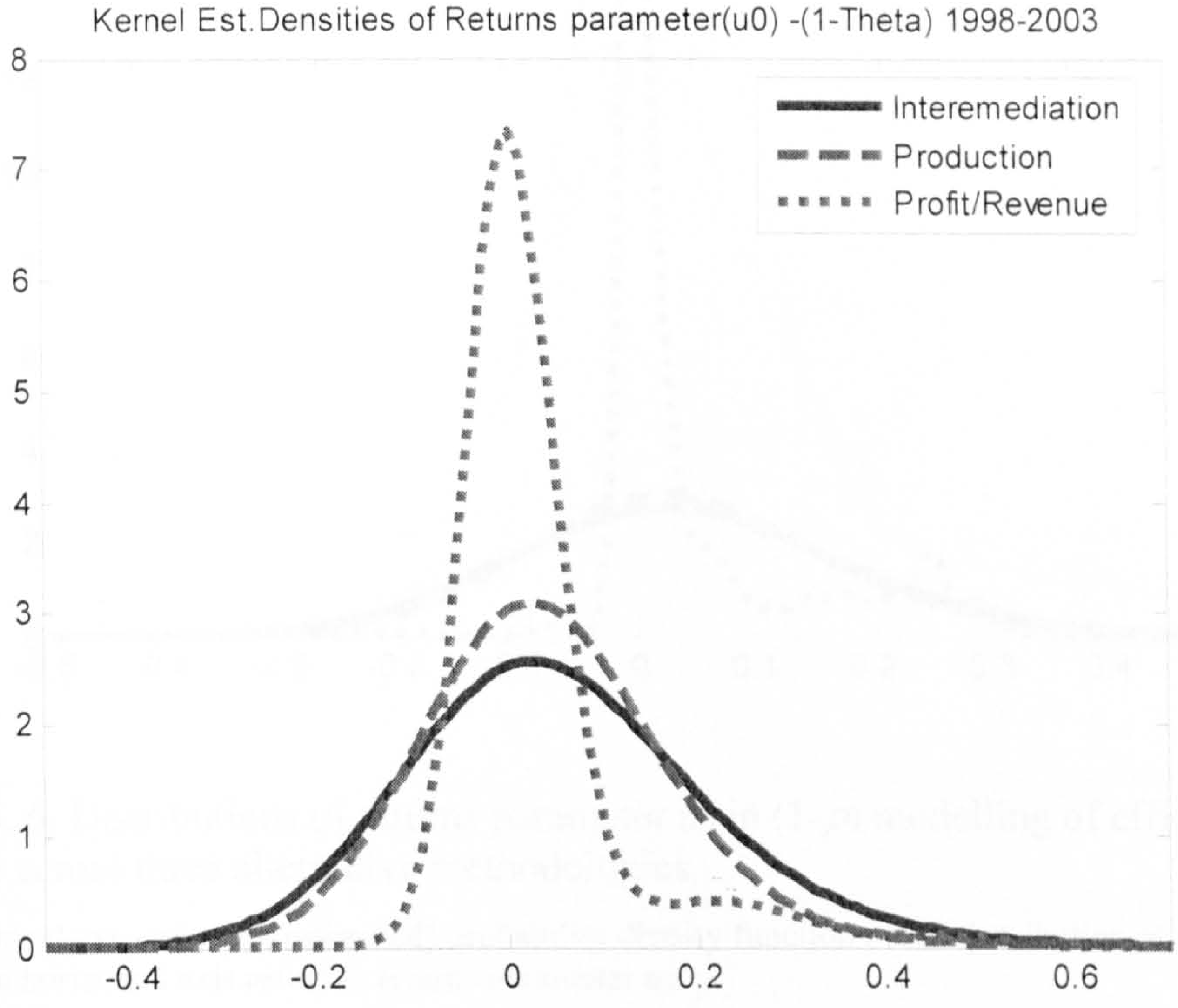


Figure 5. 5. Distributions of returns parameter u_0 in (1-θ) modelling of efficiency measure across three alternative methodologies.

Note. Vertical axis refers to (estimated) probability density function of the distribution of efficiency scores and horizontal axis refers to returns parameter

In measuring returns estimates according to the (1-ρ) modelling, the densities for the returns parameters using the Intermediation and Production approaches are almost identical, albeit wide that the that of (1-θ) (Figure 5.6). The density for the returns parameters using the Profit/Revenue-based approach is extremely tight and has a very high estimated density probability at its mode.

In both graphs (Figure 5.5 and 5.6) the densities are skewed to the left, suggesting that according to (1-ρ) and (1-θ) returns estimates, banks tend to operate at decreasing returns.

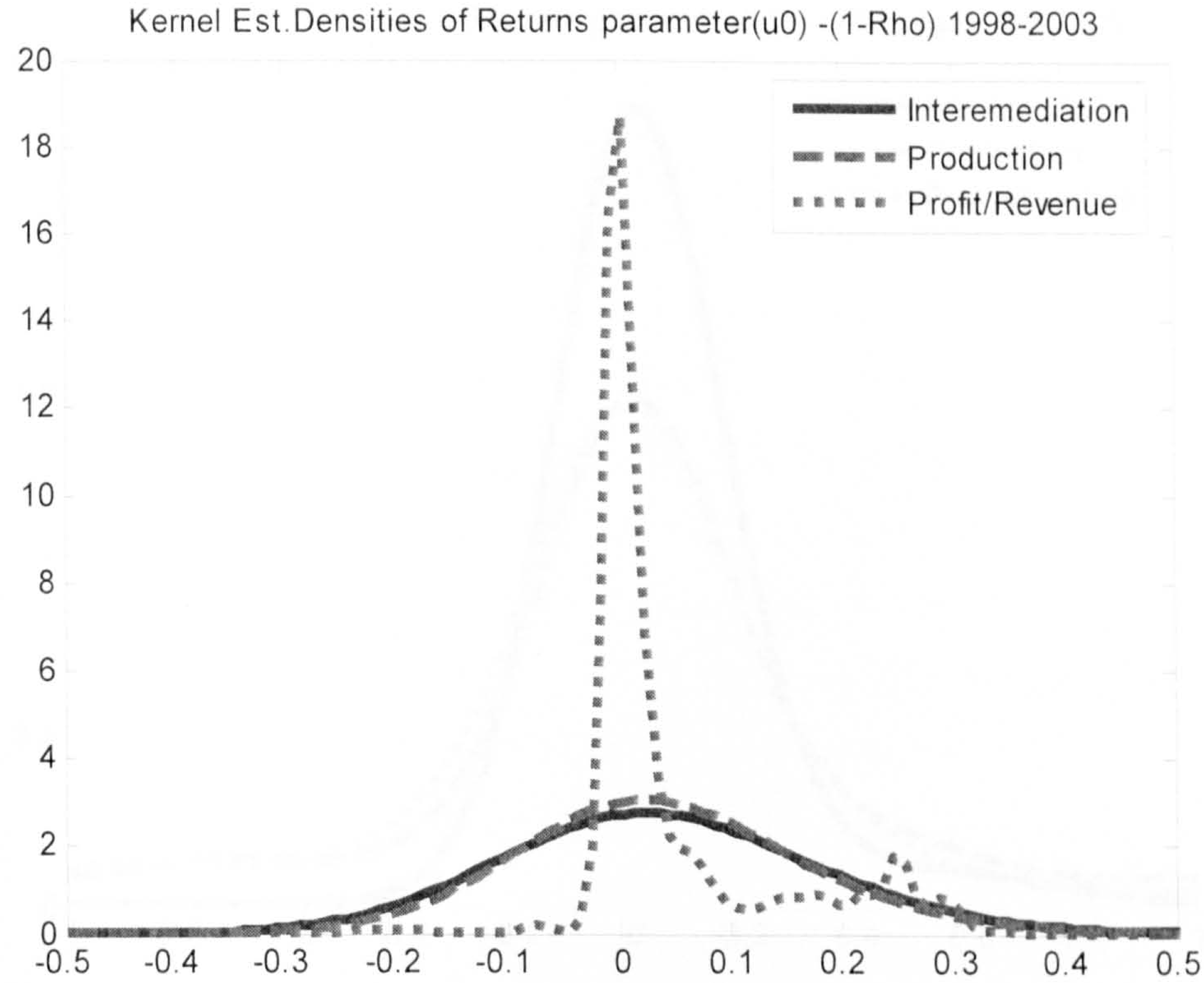


Figure 5. 6. Distributions of returns parameter u_0 in (1-ρ) modelling of efficiency measure across three alternative methodologies.

Note. Vertical axis refers to (estimated) probability density function of the distribution of efficiency scores and horizontal axis refers to returns parameter u_0.

In Figure 5.7 the densities for the (1- Ω) returns parameters are illustrated. In contrast to the two previous efficiency measurement models (1-θ) and (1-ρ), the densities for the Production and Profit/Revenue approaches are similar. The density for the Intermediation approach is dissimilar to the other two approaches since it is tighter and has a higher density probability estimate at its mode. Although the density of Production and Profit/Revenue-based returns parameters are rather symmetric, the density for the Intermediation approach is skewed to the right.

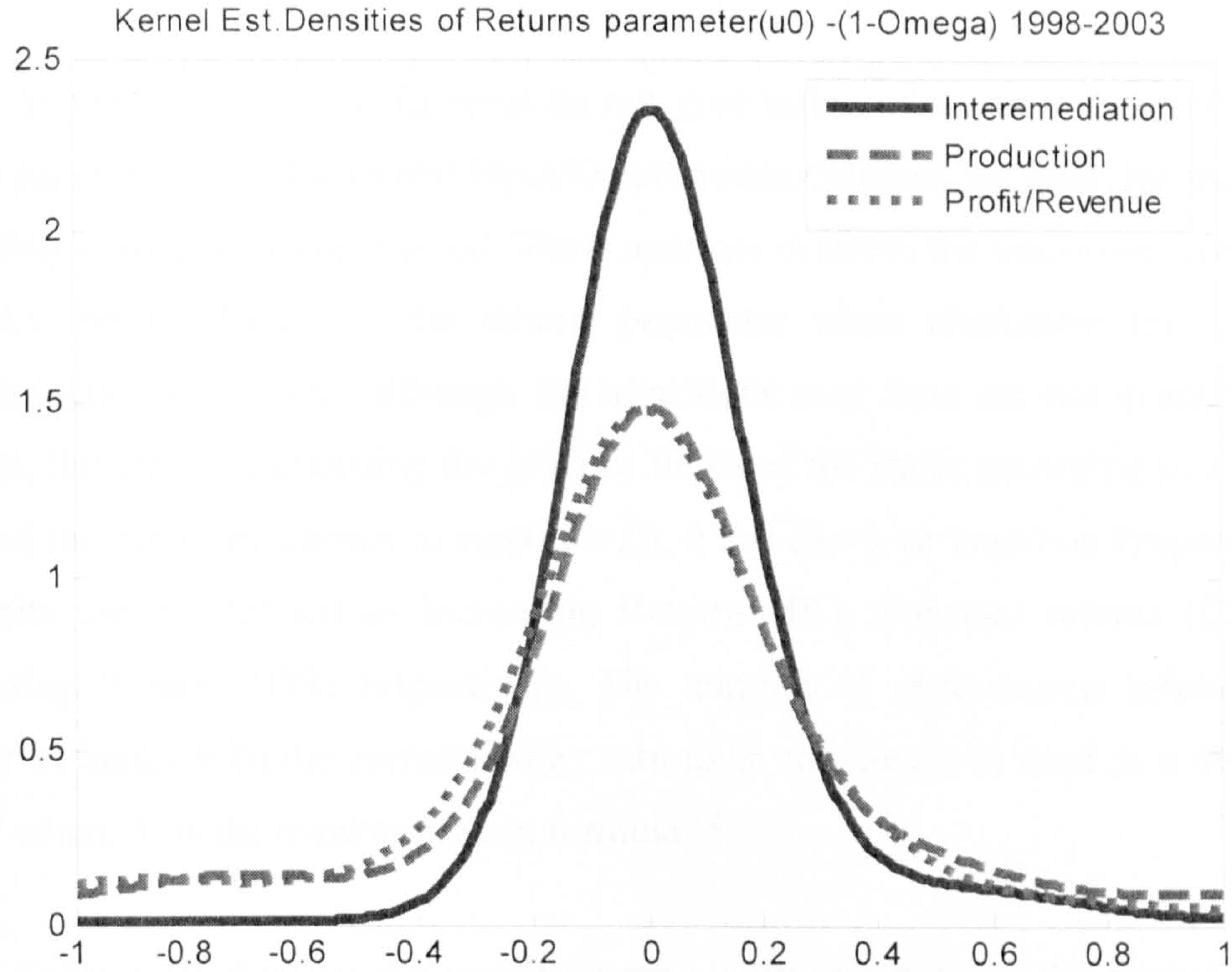


Figure 5. 7. Distributions of returns parameter u_0 in (1-Ω) modelling of efficiency measure across three alternative methodologies.

Note. Vertical axis refers to (estimated) probability density function of the distribution of efficiency scores and horizontal axis refers to returns parameter u_0.

Table 5.9 reports the correlation coefficients for the returns parameters using three measurements models across alternative Input/Output approaches over the analysed period. As can be seen, in some cases the returns parameters extremely highly correlate (e.g. 2001 *(1-θ)* efficiency measurement model) while in other cases a low correlation is found (e.g. 1999 *(1-ρ)* efficiency measurement model). However, in most cases the two approaches are correlated strongly with each other and their correlation with the third one is roughly at the same level for both.

Table 5. 9. Correlation matrices of returns parameter (u_0) across different approaches (three efficiency estimation cases)

	Efficiency measure (1-θ) Case			*Efficiency measure (1-ρ) Case*			*Efficiency measure (1-Ω) Case*		
	Inter/Prof	Inter/Prod	Prof/Prod	Inter/Prof	Inter/Prod	Prof/Prod	Inter/Prof	Inter/Prod	Prof/Prod
1998	0.5013	0.9652	0.5274	0.1348	0.9653	0.1953	0.0839	0.6032	0.3728
1999	0.4873	0.7563	0.4367	0.4851	0.5137	0.3198	0.0685	0.1315	0.8081
2000	0.6729	0.2330	0.2111	0.9580	0.2693	0.244	0.3798	0.1654	0.3083
2001	0.9995	0.9921	0.9938	0.8978	0.5492	0.5754	-0.0330	-0.0369	0.9131
2002	0.5208	0.8668	0.7575	0.4919	0.9433	0.3394	0.2339	0.4768	0.7517
2003	0.0308	0.9997	0.0469	0.0425	0.9997	0.0541	0.13400	0.9972	0.1842

As the correlation coefficients do not give information about the mobility of returns parameters when different Input/Output methodologies are used, the transition probability matrices are constructed. These matrices describe the transition probability of banks' returns based on the returns parameter when alternative Input/Output methodologies are utilised; although the transitions over time are not quantified. In addition, this involves choosing the grids or limits of the states according to a certain rule, and the limits are chosen to equal (-∞,0), 0 and (0,∞), or based on Proposition 1, the limits can be defined as Increasing Returns (IR), Constant returns (CR) and Decreasing Returns (DR) respectively. The number of observations refers to the number of banks with the corresponding returns in the approach used as a departing point[46] where N_i is the number used in formula (5.12).

Table 5.10 displays the transition probability matrices of the banks' returns parameter. It is clear that the transition probabilities abandon the constant returns state completely in all cases. For the constant returns cases, transition occurs mostly to the decreasing returns state and rarely to the increasing returns state. Interestingly, the diagonal of the matrices suggest that if a bank reported increasing or decreasing returns in one approach, in most cases it has a relatively high probability of being reported with the same returns when an alternative approach is used. These transition matrices present transitions in a discrete way; therefore I also present their continuous counterparts in the form of stochastic kernels.

Table 5. 10. Transition probability matrices of returns parameter across different approaches (three efficiency estimation cases) 1998-2003.

	Efficiency measure (1-θ) Case											
	Intermediation vs. Production				Intermediation vs. Profit				Production vs. Profit			
	No of observ.	IR	CR	DR	No of observ.	IR	CR	DR	No of observ.	IR	CR	DR
IR	289	0.72	0.00	0.28	289	0.75	0.00	0.25	259	0.84	0.00	0.16
CR	13	0.08	0.00	0.92	13	0.08	0.00	0.92	1	1.00	0.00	0.00
DR	652	0.08	0.00	0.92	652	0.17	0.00	0.83	694	0.16	0.00	0.84

[46] In Intermediation vs. Production and Intermediation vs. Profit this approach is Intermediation, and in Production vs. Profit approach this is Production approach.

	Efficiency measure (1-ρ) Case											
	Intermediation vs. Production				Intermediation vs. Profit				Production vs. Profit			
	No of observ.	IR	CR	DR	No of observ.	IR	CR	DR	No of observ.	IR	CR	DR
IR	255	0.71	0.01	0.28	255	0.79	0.00	0.21	242	0.89	0.00	0.11
CR	13	0.08	0.00	0.92	13	0.08	0.00	0.92	12	1.00	0.00	0.00
DR	686	0.09	0.00	0.91	686	0.08	0.00	0.92	700	0.04	0.00	0.96
	Efficiency measure (1-Ω) Case											
	Intermediation vs. Production				Intermediation vs. Profit				Production and Profit			
	No of observ.	IR	CR	DR	No of observ.	IR	CR	DR	No of observ.	IR	CR	DR
IR	350	0.59	0.00	0.41	350	0.69	0.00	0.31	444	0.96	0.00	0.04
CR	1	0.00	0.00	1.00	1	0.00	0.00	1.00	4	1.00	0.00	0.00
DR	603	0.40	0.00	0.60	603	0.49	0.00	0.51	506	0.22	0.00	0.78

Note: For the analysis return parameter (u_0) rounded to four decimal points.

Figures 5.8-5.10 report the results for the three dimensional plots of the stochastic kernels; to make the conclusions drawn more accurate, the contour plots are also presented. As said before, the positive diagonal line in contour plots refers to the diagonal of the relative transition probability matrix. If the probability abandons the diagonal line, banks are reported with different returns according to different Input/Output modelling. Alternatively, if the concentration of probability mass is along this diagonal, it suggests that banks report the same returns according to the alternative approaches.

As can be seen from the figures for the (1-θ) and (1-ρ) efficiency measurement models returns, the banks transit in Intermediation/Profit and Production/Profit cases and in (1-Ω) Intermediation/Production and Intermediation/Profit.

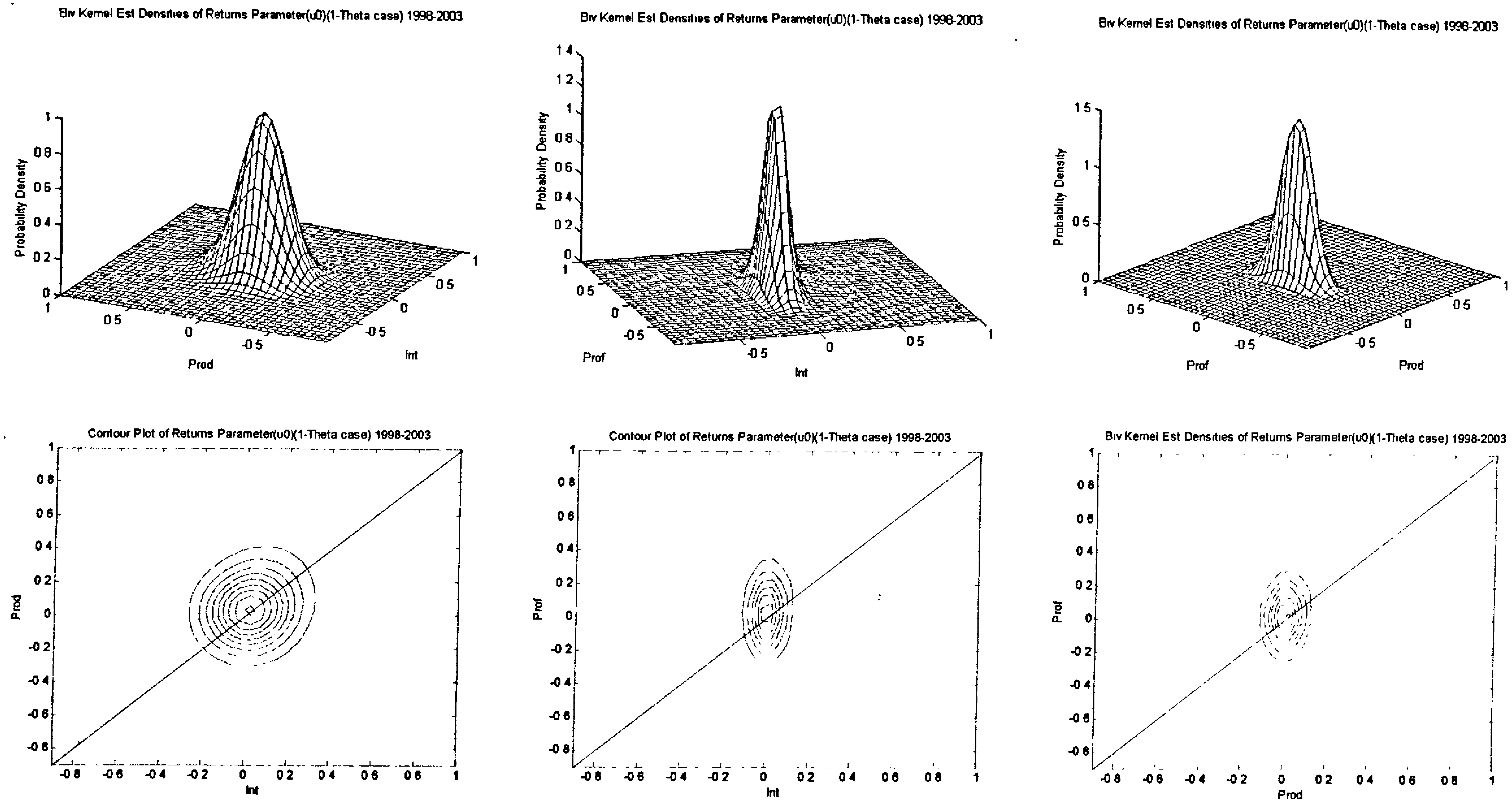


Figure 5. 8. Transition of returns parameter u_0 across different output definitions in (1-θ) modelling.

Notes. The above diagrams show the stochastic probability of the n returns parameter u_0 across the two alternative approaches. The contour plots visualise the probability mass of the stochastic kernels of the two approaches. 'Prod' – Production approach, 'Int' – Intermediation approach, 'Prof' – Profit/Revenue based approach.

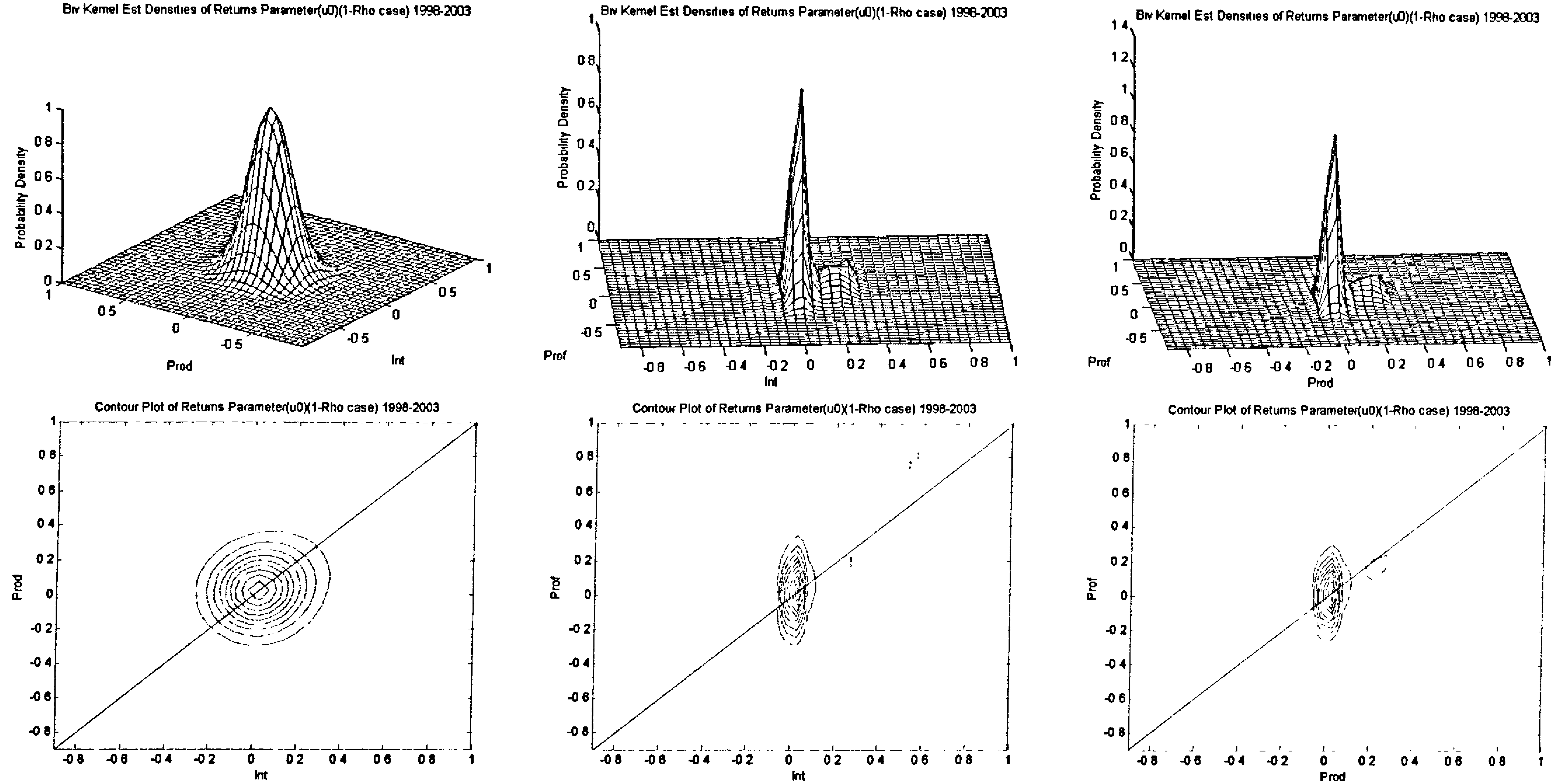


Figure 5. 9. Transition of returns parameter u_0 across different output definitions in (1-ρ) modelling.
Notes. The above diagrams show the stochastic probability of the n returns parameter u_0 across the two alternative approaches. The contour plots visualise the probability mass of the stochastic kernels of the two approaches. 'Prod' – Production approach, 'Int' – Intermediation approach, 'Prof' – Profit/Revenue based approach.

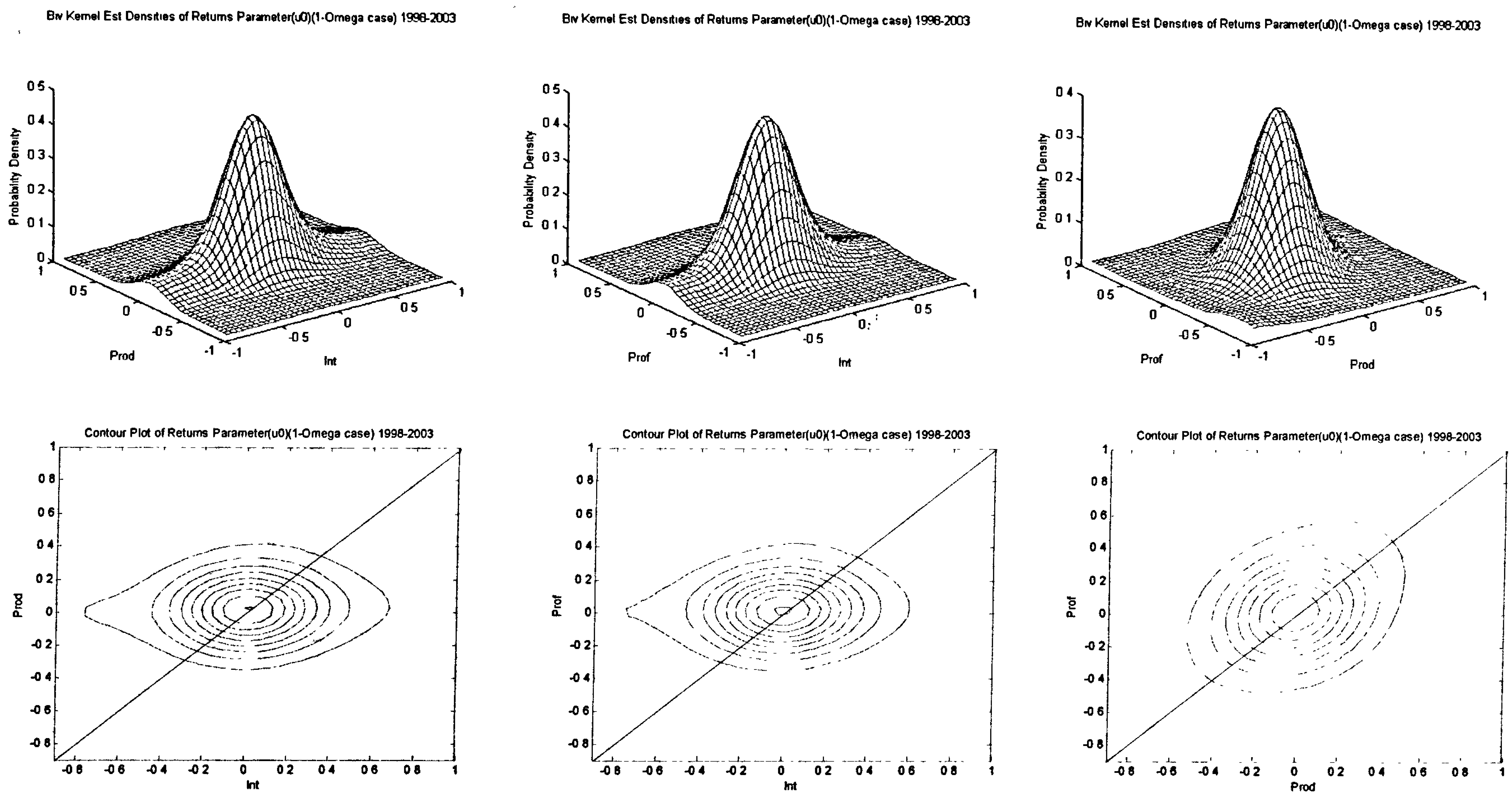


Figure 5. 10. Transition of returns parameter u_0 across different output definitions in (1-Ω) modelling.

Notes. The above diagrams show the stochastic probability of the n returns parameter u_0 across the two alternative approaches. The contour plots visualise the probability mass of the stochastic kernels of the two approaches. 'Prod' – Production approach, 'Int' – Intermediation approach, 'Prof' – Profit/Revenue based approach.

5.5. Conclusion

The research presented has analyzed and statistically tested the influence of the choice of different input/output methodologies on DEA efficiency scores and banks' returns estimated for Eastern European banks. The non-parametric Kolmogorov-Smirnov, Wilcoxon-Man-Whitney and the Simar-Zelenyuk-adapted-Li tests are applied to test the equality of the efficiency scores distributions. These distributions were plotted using the kernel density estimates. An analysis of the distributions of *true* efficiency scores using the Simar-Zelenyuk-adapted-Li test reports their inequality in most comparisons than the Kolmogorov-Smirnov and Wilcoxon-Man-Whitney tests. In general, the statistical test and density analysis indicate that different approaches to the specification of inputs and outputs of banking production can produce significantly different efficiency scores.

The Tortosa-Ausina (2002a, 2002b) methodology was also applied to analyze the inter-density mobility of relative efficiency using stochastic kernel analysis. This analysis suggests that although the efficiency scores differ from approach to approach, according to the stochastic kernels of the relative efficiency scores banks do not change their relative position to the mean.

An analysis of the returns parameters of the banks suggest that they operate at variable returns to scale. Close look at the share of the banks with increasing, constant and decreasing returns suggest that in most cases the majority of the banks operate at decreasing returns to scale, few banks operate at increasing returns and virtually no banks operate at constant returns to scale. Bearing in mind that decreasing returns suggest that these banks produce services at a higher average cost, this result can be interpreted as a signal of the difficulty for most banks to absorb new technology or a new management strategy into their production process since they might have inherited an old production technology from the pre-transition period. However, the stochastic analysis of the returns parameters of the banks implies that the conclusion regarding the returns of the banks is sensitive to the choice of particular approaches.

CHAPTER SIX: A NON-RADIAL LUENBERGER PRODUCTIVITY ANALYSIS OF EASTERN EUROPEAN BANKS: RISK AS UNDESIRABLE OUTPUT

SUMMARY

This chapter develops a Luenberger productivity index applicable to the technology where the desirable and undesirable outputs are jointly produced and are possibly negative. The components of the Luenberger productivity index – the efficiency change and the technological shift are decomposed into the factors determined by technology adjusted for risk and the environment, environmental and risk management effects. Additionally, the comparative analysis of the sensitivity of the productivity indexes to the choice of the modelling methodology is done using statistical tests and kernel density estimates (both univariate and bivariate). It is found that the main driver of productivity change in the Central and Eastern European banks is technological improvement. The tests for the stochastic dominance show that the productivity indexes reported by the Production approach in most cases stochastically dominate the Intermediation and Profit/Revenue based results. Additionally, the stochastic kernel density estimates of the productivity results show that a moderate transition of the productivity levels takes place when the alternative input/output methodology are utilised.

6.1. *Introduction*

The measurement and analysis of productivity growth received paid increased interest among researchers studying firm performance. A Malmquist index of productivity change, initially defined by Caves, Christensen and Diewert (1982) and extended by Färe et al. (1992) by merging it with Farrell's (1957) efficiency measurement, has become increasingly popular.[47] However, if the technology has as a feature the joint production of desirable and undesirable outputs, the Malmquist index may not be computable (Chung et al. 1997). Therefore, I use the Luenberger productivity index to measure the productivity change of the banking firm's technology where the undesirable outputs are produced together with desirable outputs.

The Luenberger productivity index is defined by Chambers et al. (1996) as the difference in values of the directional distance functions. In primal Luenberger productivity index the shortage function (directional distance function), which accounts for both input contractions and output improvement (Luenberger 1992a, b), is used. In this study, however, the output-oriented range directional technology, initially defined by Silva Portela (2004), is used modified to allow for weak-disposable undesirable outputs (Färe et al, 1989 and Färe and Grosskopf, 2004). Moreover, measures for a non-radial Luenberger productivity index are obtained since the non-radial measures have a higher discriminating power and they do not allow for non-zero slacks (input and/or output slacks, depending on the way of defining the technology).[48]

The research effort in this study has focused not only on measuring the productivity change, but also on the factors determining better performance. Therefore, to get a greater insight into the determinants of better performance and valuable information about the bank's management, the Luenberger productivity decompositions suggested by Boussemart et al. (2003) are extended by decomposing the efficiency change and the components of the technological shift into the factors determined by the technology adjusted for the risk and

[47] For a short survey, see Maniadakis and Thanassoulis (2004). Several extensions and applications of the Malmquist index can be found in Färe et al. (1998).

[48] There are several studies measuring the non-radial Malmquist productivity index, for example, Chen (2003), Zhou et al. (2006)

environment, environmental and risk management effects. The method is applied to measure the productivity of the Central and Eastern European banks operating during 1998 – 2003. In addition, three alternative methodologies for defining the banking production process are utilised, namely Intermediation, Production and Profit/Revenue based. Although, there are several studies investigating the sensitivity of efficiency results to the choice of the input/output modelling (Tortosa-Ausina, 2002a, 2002b, 2003 and Silva Portela and Thanassoulis, 2007) to my knowledge, this chapter is the first attempt to analyse how the productivity change results have been affected by the different specifications of the banking production process. In this analysis, along with non-parametric tests of the productivity indexes distributions, the kernel density estimators technique (both univariate and bivariate) suggested by Tortosa-Ausina in the aforementioned papers are used.

The chapter proceeds as follows. Section 6.2 gives an overview of the banking productivity literature. In Section 6.3 the non-radial banking technology is redefined by incorporating undesirable outputs and allowing for the negative data in outputs proposed in Chapter 4. Section 6.4 presents the procedure of the Luenberger productivity index measurement and its decomposition. The productivity results and the comparative analysis of the productivity indexes reported by the alternative approach are presented in Section 6.5. Finally, Section 6.6 provides conclusions.

6.2. Overview of literature on banking productivity analysis

There is a broad literature that addresses the theoretical and methodological issues on measurement of productivity and its decomposition.[49] Within the substantial economic literature investigating productivity change in the banking industry, most empirical studies focus on the analysis of banking industries in the developed economies (see, for example a survey by Berger and Humphrey, 1997 and a short review by Casu et al, 2004). The overview of the banking productivity studies presented in Table 6.1 supplements the review given in the Casu et al. survey.

[49] An excellent survey of non-parametric studies on productivity and its decomposition can be found in Grosskopf (1993, 2003).

Table 6. 1. Overview of banking productivity studies

	Authors	Methodology for productivity analysis	Productivity Index	Approach	Analysed country	Sample details	Findings
1	Rezitis (2006)	DEA	Malmquist index	Intermediation	Greece	1982 – 1997, 6 banks	- Survey findings indicate a productivity growth on average by 2.4% per year over the entire period. - The average level of overall technical efficiency is high.
2	Lozano – Vivas and Pastor (2006)	DEA	Global Malmquist index		1980 – 1997, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, the UK and the USA		- Banking and economic performance are considerably similar. - There is convergence within banking sector and economy. - Technical progress seems positively influence banking productivity, but not the economy as a whole. - The banking performance, technical change particular, has a significant affect on economic productivity and its convergence.
3	Casu, Girardone and Molyneux (2004)	DEA Translog cost function (cost change analysis)	Malmquist index (TFP)	Intermediation	France, Germany, Italy, Spain, UK	1994 – 2000 357 French banks, 518 German banks, 413 Italian banks, 448 Spanish banks and 350 UK banks	- Productivity growth in the Italian and Spanish banking; - Mixed trends in French and German banking; - Both methodologies give consistent result on main components of productivity growth; - Technological change is main component of productivity growth

4	Havrylchyk (2004)	DEA	Malmquist index (TFP)	Intermediation	Poland	1995 – 2001 9 M&A	- Decrease of total factor productivity after mergers and acquisitions; - Positive efficiency change for merged and acquired banks, which in some cases was offset by negative frontier shift.
5	Sturm and Williams (2004)	DEA	Malmquist index (TFP)	Intermediation (4 alternative specification)	Australia	Malmquist index: Model 1. 1989 – 1995, 15 banks Model 1a. 1990 – 1995, 16 banks Model 1b. 1989 – 1995, 15 banks Model 2. 1989 – 1995, 13 banks	- Productivity improvement post-deregulation, mainly due to technological change. - Foreign banks provided a source of technological efficiency changes. - Domestic banks improved their scale of operations
6	Isik and Hassan (2003a)	DEA	Malmquist index (TFP)	Intermediation	Turkey	1981 – 1990 458 observations	- Performance was significantly improved after deregulation. - Main driver of productivity growth is efficiency increases. - Exclusion of off-balance sheet items deteriorates the average efficiency and productivity scores
7	Isik and Hassan (2003b)	DEA	Malmquist index (TFP)	Intermediation	Turkey	1992 – 1996 54 annual bank observations	- Turkish banks experienced 17% productivity loss following the 1994 financial crisis. - Foreign banks suffered the most from 1994 crisis, whereas the state banks passed crisis relatively unharmed. - The crisis shock on small banks was overwhelming.
8	Tsionas, Lolos and Christopoulos (2003)	DEA	Malmquist index (TFP)	Intermediation	Greece	1993 – 1998	- Performance of Greek banks is mainly attributed to technical change of larger banks and increase of technical efficiency medium sized banks.

9	Lozano-Vivas and Humphrey (2002)	DEA Parametric stochastic cost function	- A symmetric Malmquist index; - A stochastic frontier (composed error) cost function; - A growth accounting measure	Inputs and outputs defined as assets and liabilities according to coverage levels	Spain	1986 - 1991	- Productivity estimates compared to the corresponding asset/liability index. - Productivity estimates are biased to the coverage level of assets and liabilities. - Survey findings show decline in productivity (the level downward change of productivity is different depending on the level of coverage)
10	Leightner and Lovell (1998)	DEA	Malmquist index	2 approaches depending on objective (Thai banks or Bank of Thailand)	Thailand	1989 - 1994	- Financial liberalisation impacts the growth of bank. - Objectives, size of the banks and whether it is foreign/domestic affect the productivity measures. - Strong growth needs to be monitored to prevent growth based on speculation.
11	Gilbert and Wilson (1998)	DEA	Malmquist index (bootstrapping confidence intervals)	Intermediation	Korea	1980 - 1994	- The nationwide banks had large productivity gains over 1980 – 1994. - The regional banks: 2 had significant gains, 2 – significant productivity decrease, remaining banks – insignificant changes. - Changes in scale and pure efficiency were insignificantly different from unity (except for 4 cases of latter one), and change in pure technology was significantly different from 1 in most cases.

12	Grifell-Tatjé and Lovell (1997)	DEA	Malmquist and Generalised Malmquist index	Value added	Spain	1986 – 1993 Savings banks (77 – 50) Commercial banks (61 – 67)	- The separate calculation of productivity change within banking sectors show an evidence of 2% excess per year. - Deregulation enhanced productivity. - Although scale economies have made only a minor contribution to overall productivity growth, it influences the performance of very large and very small banks. - Savings banks have more efficient organisational structure.
13	Pastor, Pérez and Quesada (1997)	DEA	Malmquist index	Value added	1992, the USA (168 banks), Spain (59), Germany (22), Italy (31), Austria (45), the UK (18), France (67), Belgium (17)		- Austria, Italy, Germany and Belgium have more productive banks. - The USA, the UK, France and Spain are less productive. - Spain and France show relatively high efficiency and relatively low technology level. - Austria and Germany have very productive technology with a low level of efficiency. - Efficiency measures are more homogeneous across the countries than productivity and technology.
14	Grifell-Tatjé and Lovell (1996)	DEA	Malmquist index	Value added	Spain	1986 – 1991 56 – 77 savings banks	- The results show evidence of the productivity decline. - There is no apparent evidence between size and performance. - Fast branching saving banks experienced slower productivity decline than low-branching. - No productivity gains following mergers and acquisitions.

The majority of the studies on banking productivity analysis investigate the impact of different regulatory and environmental factors on the development of the banking market. For example, post-deregulation banking productivity performance in developed countries is assessed by Sturm and Williams (2004) in the case of the Australian banking industry; Tsionas et al (2003) and Rezitis (2006) investigate post-deregulation productivity of Greek banking; and the impact of deregulation in the Spanish banking system on banking efficiency and productivity is analysed by Lozano-Vivas and Humphrey (2002) and Grifell-Tatje and Lovell (1996, 1997).

In the case of Australian banks, Sturm and Williams (2004) also considered the impact of foreign bank entry on post-deregulation banking efficiency and productivity. Additionally, they apply four different types of the banking production process specifications based on the Intermediation approach and, according to Malmquist indexes results, all of them excepting one input/output specification suggest post-deregulation productivity improvement. The productivity decomposition in their study shows that the major source of post-deregulation productivity gain of Australian banks is technological change, which is mainly attributed to foreign banks, rather than the efficiency improvement. Although Tsionas et al. (2003) found an improvement in performance in the case of Greek banking, it was mainly attributed to larger banks' technical change, the medium sized banks improved their TFP owing to positive (yet not substantial) improvement of technical efficiency.

Spanish banking was assessed by Grifell-Tatjé and Lovell in 1996 who investigated post-deregulation productivity of savings banks and in the 1997 paper they examined the pattern of productivity change in both commercial and savings banking. The earlier analysis suggested that Spanish savings banks experienced productivity decline, mainly attributed to the deterioration in production possibilities (technical change). To explain the nature of the productivity decline, the authors examined the effect of branching and consolidation on the performance of the savings banks. However, neither the expansion of branching network nor mergers and acquisitions had been found as a source of productivity decline. As the authors suggested, Spanish savings banks had difficulties in adapting to a new environment with more open competition brought by deregulation and liberalisation. Additionally, the latter study found that the productivity performance of the two sectors differ substantially, the best-practice banks in each sector improved their post-deregulation performance.

Lozano-Vivas and Humphrey (2002) also assess the Spanish banking system using parametric (stochastic cost frontier) and nonparametric (Malmquist index) techniques and found evidence of a downward change in banking productivity during 1986 – 1991. However, the main objective of the paper relates to the bias problem in banking productivity studies due the nature of the data. In analysing the banking production process, the authors consider five coverage levels of balance sheet assets and liabilities referred to as inputs and outputs. The core finding of the study is that the higher the coverage level of inputs and outputs is, the more of the bias is eliminated.

Further support of the importance of the input/output methodology in production analysis can be found in Leightner and Lovell (1998). The authors consider two different specifications of the banking production process derived from the objectives of the banks themselves (profit maximizing) and of the central bank – The Bank of Thailand (fostering economic growth along with preserving safety and soundness of banking system). They performed two separate analyses of the Thai banking system, one which investigates the ability of the banks to pursue their own objectives and another which examines the ability of banks to satisfy the objectives of The Bank of Thailand. The analysis shows that the majority of the banks adapted well to financial liberalisation and improved their performance in meeting their own objectives. Overall, the financial liberalisation had a positive impact on the Thai banking system; in particular it led to an increase in the banks' ability to raise their profits and to finance economic growth.

An assessment of banking productivity in the emerging countries after liberalisation and deregulation is also available. Gilbert and Wilson (1998) conduct a case study of the Korean banking industry. Isik and Hassan consider productivity development of the Turkish banking industry: the authors carry out a study of post-deregulation performance of Turkish banks (2003a) while a survey examines the impact of the financial crisis on the Turkish banking industry productivity (2003b).[50] The productivity assessment of Polish banks in transition is investigated by Havrylchyk (2004). The aim was an analysis of post-merger and post-acquisition productivity, so the study considered only merged and acquired banks in the Polish banking industry.

The results of Gilbert and Wilson (1998) on Korean banks were consistent with the view that privatisation and deregulation enhance potential output and productivity. Similar evidence was found for the Turkish banking analysis by Isik and Hassan (2003a). Interestingly, Turkish banks improved their efficiency, providing the main source of productivity growth, as technical progress was found not to be improved. Furthermore, it has been shown that the inclusion of OBS items produced some evidence of technical progress of Turkish banks. The importance of OBS items is highlighted by the fact that their exclusion significantly deteriorated the average efficiency and productivity measures of the entire industry. This gives further support to the importance of the appropriate definition of inputs and outputs in the analysis of banking efficiency and productivity. As expected, financial distress leads to a considerable productivity decline (Isik and Hassan, 2003b). Moreover, they show that foreign banks suffered the most from the crisis followed by domestic private banks. Regarding the size of the banks, small sized banks received a disproportionately negative impact of the shock.

Although several studies undertake a cross-country analysis of banking productivity performance, in general, they concentrate on the banking industry of developed countries (Lozano – Vivas and Pastor, 2006; Casu et al., 2004; Pastor et al., 1997). In particular, Pastor et al. (1997) compared the efficiency and productivity of different European and US banking systems whereas a comparative cross-country productivity assessment (both parametric and nonparametric) of European banking is presented in Casu et al. (2004). According to the former study, the most productive banking systems are located in Austria, Italy, Germany and Belgium, and the least productive are in the USA, the UK, France and Spain. Similar results are found in the latter study. For example, the results show that productivity improved in the Italian

[50] An interesting aspect of their study is that although the financial crisis has a significant negative impact on productivity, state-owned banks as well as the small-sized banks suffered the most from the crisis, whereas the state banks passed the crisis relatively unharmed.

and Spanish banking industries while German and French banks exhibit mixed results. However, the combination of the technological and efficiency changes is very different in different banking systems, as in Austrian and German banking, where a major part of productivity change is due to technological change whereas in Spain and France it is efficiency catching-up.

The study of Lozano – Vivas and Pastor (2006) differs from all other studies as it investigates the synergy between banking and economic productivity. The analysis is based on the construction of an overall banking and economic frontiers and estimation of a global Malmquist productivity index. More recently, authors examine the relationship between economic and banking performance; determining the components of banking productivity are examined since they play a fundamental role in explaining economic growth. The analysis of the paper suggests that banking performance and technical change in particular has a (positive) effect on economic productivity and its convergence.

On the whole, the aforementioned surveys suggest that liberalisation and de-regulation of the banking industry enhances efficiency and productivity[51] in both the developed and emerging economies. Moreover, some studies show that the performance of the banks is mainly attributed to technological change, and factors such as size, ownership and objectives of the banks affect productivity measures. This result is supported by most cross-country and single country analysis studies, which suggest that the improvement of banking productivity is mainly due to the technological change. Although several non-parametric and parametric methods are employed in the productivity studies, the most popular method of banking productivity measurement is the non-parametric Malmquist index.

The main contributions of this chapter to the existing literature are as follows. First, a cross-country analysis of banking productivity in the transition economies is performed. Second, in assuming undesirable output production, negative data is incorporated in the range direction methodology. The Luenberger productivity measure is estimated and decomposed into several risk management and

[51] As has been noted before, the exception is the Spanish banking industry where the findings suggest that there was little or no change in productivity (Lozano-Vivas and Humphrey, 2002) or even a productivity decline (Grifell-Tatjé and Lovell, 1996).

environmental factors. Finally, a comparative analysis of productivity measurement estimated using three alternative input/output methodologies is performed.

6.3. Modelling technology

Let us redefine the models proposed in Chapter 4 in terms of directional distance function notations in formulating the Luenberger productivity indexes and its decomposition. Hence, let $D_j(x_j, y_j, b_j)$ be the maximising objective function of the following linear program which is identical to (4.5):

$$D_j(x_j, y_j, b_j) = \arg\max\left\{ \theta = \frac{1}{s}\sum_{r=1}^{R}\alpha_r + \frac{1}{s}\beta \middle| \begin{array}{l} \sum_{j=1}^{n}\lambda_j x_{ij} \le x_{i0}; \sum_{j=1}^{n}\lambda_j y_{rj}^g \ge y_{r0}^g + \alpha_r R_{r0}^g; \\ \sum_{j=1}^{n}\lambda_j LLP_j = LLP_0 - \beta_0 R_{LLP_0}; \sum_{j=1}^{n}\lambda_j = 1; \\ \lambda_j \ge 0; \quad \forall j = 1, \dots, n \end{array} \right\} \tag{6. 1}$$

where $R_{LLP_0} = LLP_0 - \min_j\{LLP_j\}$ and $R_{r0}^g = \max_j\{y_{rj}^g\} - y_{r0}^g$, r = *1*, ..., *R*, are range directional vectors of undesirable output (risk in banking) and desirable outputs respectively.

Let us refer to the risk management banking technology defined in Model (4.6) as $DRM\ (x\ ,y\ ,b\ )$:

$$DRM\ (x\ ,y\ ,b\ ) = \arg\max\left\{ \rho = \frac{1}{s}\sum_{r=1}^{R}\alpha_r + \frac{1}{s}\beta \middle| \begin{array}{l} \sum_{j=1}^{n}\lambda_j x_{ij} \le x_{i0}; \sum_{j=1}^{n}\lambda_j y_{rj}^g \ge y_{r0}^g + \alpha_r R_{r0}^g; \\ \sum_{j=1}^{n}\lambda_j \gamma_j LLP_j = \gamma_0 LLP_0 - \beta_0 R_{\gamma_0 LLP_0}; \\ \sum_{j=1}^{n}\lambda_j = 1; \lambda_j \ge 0; \forall j = 1, \dots, n \end{array} \right\} \tag{6. 2}$$

where $R_{\gamma_j LLP_0} = \gamma_0 LLP_0 - \min_j\{\gamma_j LLP_j\}$, and the parameter γ is found from (4.4).

The environment and risk adjusted technology output directional technology redefined as $DER\ (x,y,b)$ (Model 4.8):

$$DER\ (x\ ,y\ ,b\ ) = \arg\max \left\{ \Omega = \frac{1}{s}\sum_{r=1}^{R}\alpha_r + \frac{1}{s}\beta \left| \begin{array}{l} \sum_{j=1}^{n}\lambda_j x_{ij} \le x_{i0}; \sum_{j=1}^{n}\lambda_j y_{rj}^{g} \ge y_{r0}^{g} + \alpha_r R_{r0}^{g}; \\ \sum_{j=1}^{n}\lambda_j \gamma_j LLP_j = \gamma_0 LLP_0 - \beta_0 R_{\gamma_0 LLP_0}; \\ \sum_{j=1}^{n}\lambda_j Q_{pj}^{+} \le Q_{p0}^{+}, p = 1,\dots,P; \sum_{j=1}^{n}\lambda_j Q_{qj}^{-} \ge Q_{q0}^{-}, q = 1,\dots,Q \\ \sum_{j=1}^{n}\lambda_j = 1; \lambda_j \ge 0; \forall j = 1,\dots,n \end{array} \right. \right\} \quad (6.3)$$

where $Q_j^{+} = (Q_{1j}^{+}, Q_{2j}^{+}, \dots, Q_{Pj}^{+})$ and $Q_j^{-} = (Q_{1j}^{-}, Q_{2j}^{-}, \dots, Q_{Qj}^{-})$ are the vectors of banking system specific variables with positive or negative influence.

The $D_j(x_j, y_j, b_j)$, $DRM_j(x_j, y_j, b_j)$ and $DER_j(x_j, y_j, b_j)$ are the measures of technical inefficiency of the firm *j*. The output range directional distance function $D\ (x\ ,y\ ,b\ )$ can be additively decomposed as follows[52]:

$$D\ (x\ ,y\ ,b\ ) = \\ DER\ (x\ ,y\ ,b\ ) + (DRM\ (x\ ,y\ ,b\ ) - DER\ (x\ ,y\ ,b\ )) + (D\ (x\ ,y\ ,b\ ) - DRM\ (x\ ,y\ ,b\ )) \quad (6.4)$$

The summation in the first brackets can be interpreted as the environmental effect (EE) on technology $D_j(x_j, y_j, b_j)$ while the risk management effect (RME) – the second brackets:

$$D_j(x_j, y_j, b_j) = DER_j(x_j, y_j, b_j) + EE_j(x_j, y_j, b_j) + RME_j(x_j, y_j, b_j) \quad (6.5)$$

6.4. Productivity measurement

According to Chambers (2002), the productivity indicator can be directly constructed from the technology directional distance function, and the technology *t* Luenberger productivity indicator is defined by:

$$L^t(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = D_j^t(x_j^t, y_j^t, b_j^t) - D_j^t(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) \quad (6.6)$$

while the technology *t+1* Luenberger productivity indicator is:

[52] This decomposition has been suggested by Pastor (1999a, 2002); but the decomposition in this paper is additive rather than multiplicative.

$$L^{t+1}(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = D_j^{t+1}(x_j^t, y_j^t, b_j^t) - D_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) \ . \tag{6.7}$$

The two indexes yield the same values if, and only if, the output distance function is of the form

$$D_j^\tau(x_j^\tau, y_j^\tau, b_j^\tau) = A(\tau)\hat{D}_j(x_j^\tau, y_j^\tau, b_j^\tau), \ \ \tau = t, \ \ t+1 \tag{6.8}$$

Although this statement is analogous to the statement given in Fare et al. (1999) for Malmquist indices, it is also true for Luenberger productivity indices (the proof is given in the Appendix H).

The output Luenberger productivity index in the case of output range directional distance functions is defined as an arithmetic mean of (6.6) and (6.7) as follows:

$$\begin{aligned} L(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = \frac{1}{2}\Big[&\big(D_j^t(x_j^t, y_j^t, b_j^t) - D_j^t(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\big) \\ &+ \big(D_j^{t+1}(x_j^t, y_j^t, b_j^t) - D_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\big)\Big] \end{aligned} \tag{6.9}$$

Productivity growth is indicated by a positive value of the Luenberger productivity index whereas a negative Luenberger productivity index is evidence of productivity decline of the firm between the considered time periods.

The output Luenberger productivity index (6.9) can be additively decomposed into two components (Boussemart et al, 2003):

$$\begin{aligned} L(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) &= \big[D_j^t(x_j^t, y_j^t, b_j^t) - D_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\big] \\ &+ \frac{1}{2}\Big[\big(D_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - D_j^t(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\big) + \big(D_j^{t+1}(x_j^t, y_j^t, b_j^t) - D_j^t(x_j^t, y_j^t, b_j^t)\big)\Big] \end{aligned} \tag{6.10}$$

The first difference captures technical efficiency change of the output range directional functions between periods *t* and *t+1* while the arithmetic mean of the last two differences measures the technological change, i.e. the shift of the technology between two periods.

Using the additive decomposition of $D\ (x\ ,y\ ,b\ )$ defined in formula (6.5), the technical efficiency change can be decomposed as follows:

$$EFFCH(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = \left[DER_j^t(x_j^t, y_j^t, b_j^t) + EE_j^t(x_j^t, y_j^t, b_j^t) + RME_j^t(x_j^t, y_j^t, b_j^t)\right]$$
$$-\left[DER_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) + EE_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) + RME_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right]$$

(6. 11)

Rearranging (6.11) gives the following decomposition:

$$EFFCH(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = \left[DER_j^t(x_j^t, y_j^t, b_j^t) - DER_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right]$$
$$+\left[EE_j^t(x_j^t, y_j^t, b_j^t) - EE_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right]$$
$$+\left[RME_j^t(x_j^t, y_j^t, b_j^t) - RME_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right]$$

(6. 12)

whereby the first difference (inside the first square brackets) measures the change of efficiency adjusted for risk and the environment, while the second and third differences captures the change in the environmental effect and risk management effect respectively.

Technological change can be decomposed into two components – the magnitude of technological change and the bias of technological change as follows:

$$TECH(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = \left[D_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - D_j^t(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right]$$
$$+\frac{1}{2}\left[\left(D_j^{t+1}(x_j^t, y_j^t, b_j^t) - D_j^t(x_j^t, y_j^t, b_j^t)\right) + \left(D_j^t(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - D_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right)\right]$$

(6. 13)

or, alternatively, as

$$TECH(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = \left[D_j^{t+1}(x_j^t, y_j^t, b_j^t) - D_j^t(x_j^t, y_j^t, b_j^t)\right]$$
$$+\frac{1}{2}\left[\left(D_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - D_j^t(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right) + \left(D_j^t(x_j^t, y_j^t, b_j^t) - D_j^{t+1}(x_j^t, y_j^t, b_j^t)\right)\right]$$

(6. 14)

where the difference in the first square brackets measures the magnitude of technological change and the arithmetic mean of the last two differences measures the bias of technical change between period *t* and *t+1*. The bias index makes no contribution to productivity change if the magnitude of technical change is the same when measured along the two rays. In other word, if, and only if, the distance functions are of the form (6.8), the bias index is equal to zero.

It is possible to gain additional insight into the nature of the magnitude and the bias of technological change with respect to the environment and risk management of the banks by decomposing it into the magnitude and bias indices of changes of environment and risk adjusted efficiency and environmental and risk management effects. Formula (6.13) is used for the decompositions. The magnitude of technological change can be decomposed as follows:

$$
\begin{aligned}
& MTECH(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = \\
& \qquad \left[DER_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) + EE_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) + RME_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right] \\
& \qquad - \left[DER_j^{t}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) + EE_j^{t}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) + RME_j^{t}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right]
\end{aligned}
\tag{6.15}
$$

Rearrangement of (6.15) gives three components for the technological change magnitude:

$$
\begin{aligned}
MTECH(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = & \left[DER_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - DER_j^{t}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right] \\
& + \left[EE_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - EE_j^{t}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right] \\
& + \left[RME_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - RME_j^{t}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right]
\end{aligned}
\tag{6.16}
$$

where the difference in the first brackets represents the magnitude of efficiency adjusted for environment and risk, the second brackets provide a measure of the magnitude of the environmental effect, and the difference in the last brackets is the magnitude of the risk management effect.

Analogously, the decomposition of the bias of technological change is as follows:

$$
\begin{aligned}
& BTCH(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = \\
& \qquad \frac{1}{2}\Big[\Big[\Big(DER_j^{t+1}(x_j^t, y_j^t, b_j^t) + EE_j^{t+1}(x_j^t, y_j^t, b_j^t) + RME_j^{t+1}(x_j^t, y_j^t, b_j^t)\Big) \\
& \qquad - \Big(DER_j^{t}(x_j^t, y_j^t, b_j^t) + EE_j^{t}(x_j^t, y_j^t, b_j^t) + RME_j^{t}(x_j^t, y_j^t, b_j^t)\Big)\Big] \\
& \qquad + \Big[\Big(DER_j^{t}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) + EE_j^{t}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) + RME_j^{t}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\Big) \\
& \qquad - \Big(DER_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) + EE_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) + RME_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\Big)\Big] \Big]
\end{aligned}
\tag{6.17}
$$

which can be rearranged into the following:

$$
\begin{aligned}
& BTCH(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = \\
& \qquad \frac{1}{2}\Big[\Big(DER_j^{t+1}(x_j^t, y_j^t, b_j^t) - DER_j^{t}(x_j^t, y_j^t, b_j^t)\Big) + \Big(DER_j^{t}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - DER_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\Big)\Big] \\
& \qquad + \frac{1}{2}\Big[\Big(EE_j^{t+1}(x_j^t, y_j^t, b_j^t) - EE_j^{t}(x_j^t, y_j^t, b_j^t)\Big) + \Big(EE_j^{t}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - EE_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\Big)\Big] \\
& \qquad + \frac{1}{2}\Big[\Big(RME_j^{t+1}(x_j^t, y_j^t, b_j^t) - RME_j^{t}(x_j^t, y_j^t, b_j^t)\Big) + \Big(RME_j^{t}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - RME_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\Big)\Big]
\end{aligned}
\tag{6.18}
$$

The arithmetic mean of the differences in the first square brackets compares the difference in the magnitude of technological change adjusted for risk and environment along the two rays, the arithmetic mean of the differences in the second brackets, the magnitude of the environmental effect; and the arithmetic of the differences in the last brackets is the magnitude of the risk management effect. Alternatively, the bias index of technological change can be decomposed into input bias and output bias indexes. Four alternative decompositions of this type are given in the Appendix H.

The assumption of variable returns to scale is maintained in the defining and decomposing all indexes, as it is a necessary condition to deal with negative data for modelling technology (see Silva Portela, 2004). Therefore, the productivity indexes estimated in this study are not total factor productivity indexes, since a total factor productivity index assumes the constant returns to scale technology (Färe and Grosskopf, 1996).

6.5. Estimation results

Productivity changes are measured and decomposed for the Eastern European banking industry using the same panel data as in previous sections based on three alternative approaches, namely Intermediation, Production and Profit/Revenue. Next, a general description of the productivity results and its decomposition is provided; a detailed analysis will be presented in the latter part of the section.

Tables 6.2-6.4 report the Luenberger index (LI) results obtained from (6.9) averaged across the analysed countries' banking systems, sub-groups' and the total sample.[53] The decompositions into efficiency change (EFFCH) and technological change (TECH) components (6.10) are also presented. A positive (negative) value of the index indicates productivity growth (decline), while an index equal to zero indicates no change in productivity between period t and $t+1$.

[53] Briec et al. (2003) and Färe and Primont (2003) define the aggregate Luenberger productivity index. This aggregation is inappropriate in the modelling technology used here since the directional vector is not constant for all the DMUs but varies for each DMU according to the range of the possibilities for improvement. For that reason, Tables 6.2-6.4 and Tables 6.5-6.7 report the decomposition of the Luenberger productivity index provide the corresponding arithmetic averages.

Table 6. 2. Luenberger index decomposition of commercial banking productivity in Eastern European countries (Intermediation approach)

	1998-99			1999-2000			2000-2001			2001-2002			2002-2003		
	LI[a]	EffCH	TECH	LI[a]	EffCH	TECH	LI[a]	EffCH	TECH	LI[a]	EffCH	TECH	LI[a]	EffCH	TECH
Accessed countries															
CZ	-0.179	0.033	-0.212	-0.093	0.012	-0.105	-0.159	-0.040	-0.119	-4.516	0.021	-4.537	-0.164	0.024	-0.187
ES	0.016	0.131	-0.115	0.003	-0.044	0.047	-0.002	-0.041	0.039	0.014	0.077	-0.062	0.012	0.012	0.000
HU	3.108	0.043	3.065	-0.010	-0.016	0.006	-0.154	-0.032	-0.122	0.215	0.056	0.159	0.082	0.006	0.076
LV	0.003	0.108	-0.105	-0.003	-0.010	0.007	-0.007	-0.024	0.017	-0.003	0.032	-0.035	-0.003	-0.002	-0.001
LT	-0.003	0.145	-0.147	-0.008	-0.035	0.027	-0.014	-0.032	0.017	0.001	0.067	-0.066	0.006	0.004	0.001
PL	-0.040	0.064	-0.104	-0.103	-0.037	-0.067	-0.084	-0.014	-0.070	-0.017	0.013	-0.029	0.048	0.008	0.040
SL	-0.254	0.130	-0.384	0.797	-0.040	0.838	0.035	-0.076	0.111	-0.059	0.086	-0.145	0.014	0.018	-0.004
SN	-0.007	0.091	-0.097	0.000	-0.029	0.029	-0.003	-0.057	0.053	0.011	0.074	-0.062	0.006	0.015	-0.009
Average	*0.157*	*0.091*	*0.066*	*0.066*	*-0.024*	*0.091*	*-0.046*	*-0.036*	*-0.010*	*-0.468*	*0.045*	*-0.513*	*0.003*	*0.009*	*-0.007*
Negotiating countries															
CT	-0.001	0.135	-0.136	-0.003	-0.019	0.016	-0.003	-0.025	0.022	-0.002	0.032	-0.034	0.001	0.004	-0.003
RM	0.175	0.119	0.055	-1.581	-0.009	-1.572	-0.010	-0.017	0.007	-0.002	0.025	-0.027	-0.008	-0.017	0.009
Average	*0.053*	*0.130*	*-0.077*	*-0.489*	*-0.016*	*-0.473*	*-0.005*	*-0.023*	*0.018*	*-0.002*	*0.030*	*-0.032*	*-0.002*	*-0.003*	*0.001*
CIS countries															
ML	0.012	0.186	-0.174	0.000	0.000	0.000	-0.005	-0.012	0.007	-0.004	0.012	-0.016	-0.001	-0.002	0.001
RF	0.034	0.146	-0.112	0.165	-0.025	0.190	-0.005	-0.033	0.028	-0.017	0.039	-0.056	-0.001	-0.003	0.002
UN	0.008	0.125	-0.117	-0.009	-0.039	0.031	-0.014	-0.038	0.024	-0.006	0.036	-0.043	-0.011	0.002	-0.013
Average	*0.027*	*0.146*	*-0.120*	*0.114*	*-0.025*	*0.139*	*-0.007*	*-0.032*	*0.025*	*-0.013*	*0.036*	*-0.049*	*-0.003*	*-0.002*	*-0.001*
Total sample average	**0.101**	**0.114**	**-0.012**	**-0.010**	**-0.023**	**0.013**	**-0.027**	**-0.033**	**0.005**	**-0.257**	**0.040**	**-0.297**	**0.000**	**0.004**	**-0.004**

[a] LI = EffCH + TECH

Note: LI – Luenberger productivity index, EffCH – Efficiency Change, TECH – Technological Change

Table 6. 3. Luenberger index decomposition of commercial banking productivity in Eastern European countries (Production approach)

	1998-99			1999-2000			2000-2001			2001-2002			2002-2003		
	LI[a]	EffCH	TECH	LI[a]	EffCH	TECH	LI[a]	EffCH	TECH	LI[a]	EffCH	TECH	LI[a]	EffCH	TECH
Accessed countries															
CZ	-0.079	0.063	-0.142	0.000	-0.010	0.010	-0.027	-0.007	-0.020	-3.661	0.092	-3.753	-0.046	0.082	-0.127
ES	0.108	0.132	-0.024	0.100	0.057	0.043	0.088	0.039	0.050	0.083	0.059	0.024	0.114	0.065	0.049
HU	2.550	0.104	2.446	0.054	0.010	0.044	-0.053	0.050	-0.104	0.285	0.088	0.197	0.143	0.081	0.062
LV	0.081	0.098	-0.018	0.087	0.022	0.065	0.078	0.015	0.063	0.081	0.038	0.042	0.086	0.018	0.068
LT	0.084	0.080	0.004	0.080	0.035	0.045	0.080	0.028	0.053	0.091	0.059	0.032	0.093	0.027	0.066
PL	0.070	0.104	-0.034	-0.001	0.065	-0.066	0.044	0.042	0.002	0.000	0.042	-0.042	0.168	0.082	0.085
SL	-0.141	0.149	-0.290	0.756	0.041	0.715	0.368	0.551	-0.184	0.018	0.043	-0.025	0.102	0.055	0.046
SN	0.089	0.111	-0.022	0.087	0.046	0.041	0.090	0.024	0.066	0.077	0.048	0.030	0.081	0.029	0.052
Average	*0.208*	*0.104*	*0.104*	*0.141*	*0.036*	*0.105*	*0.089*	*0.093*	*-0.004*	*-0.323*	*0.053*	*-0.376*	*0.099*	*0.053*	*0.045*
Negotiating countries															
CT	0.078	0.097	-0.019	0.080	0.026	0.054	0.083	0.012	0.071	0.075	0.037	0.038	0.091	0.040	0.051
RM	0.154	0.113	0.041	-1.176	0.005	-1.181	0.117	0.078	0.039	0.084	0.054	0.030	0.095	0.037	0.058
Average	*0.101*	*0.102*	*-0.001*	*-0.306*	*0.020*	*-0.326*	*0.093*	*0.032*	*0.061*	*0.078*	*0.042*	*0.036*	*0.092*	*0.039*	*0.053*
CIS countries															
ML	0.085	0.075	0.010	0.084	0.023	0.062	0.083	0.015	0.067	0.081	0.011	0.070	0.085	0.014	0.071
RF	0.102	0.129	-0.028	0.170	0.055	0.115	0.090	0.029	0.061	0.054	0.049	0.006	0.110	0.070	0.040
UN	0.097	0.098	-0.001	0.093	0.056	0.037	0.077	0.012	0.065	0.057	0.025	0.032	0.077	0.048	0.029
Average	*0.099*	*0.118*	*-0.019*	*0.146*	*0.052*	*0.094*	*0.087*	*0.024*	*0.062*	*0.058*	*0.040*	*0.018*	*0.101*	*0.060*	*0.041*
Total sample average	**0.158**	**0.108**	**0.050**	**0.069**	**0.038**	**0.031**	**0.089**	**0.063**	**0.026**	**-0.145**	**0.047**	**-0.192**	**0.098**	**0.053**	**0.045**

[a] LI = EffCH + TECH

Note: LI – Luenberger productivity index, EffCH – Efficiency Change, TECH – Technological Change

Table 6. 4. Luenberger index decomposition of commercial banking productivity in Eastern European countries (Profit-Revenue based approach)

	1998-99			1999-2000			2000-2001			2001-2002			2002-2003		
	LI[a]	EffCH	TECH	LI[a]	EffCH	TECH	LI[a]	EffCH	TECH	LI[a]	EffCH	TECH	LI[a]	EffCH	TECH
Accessed countries															
CZ	0.027	0.068	-0.041	0.040	-0.014	0.053	-0.032	-0.027	-0.005	-5.815	0.055	-5.871	-0.536	-0.009	-0.527
ES	0.022	0.099	-0.077	-0.004	-0.060	0.056	0.010	-0.031	0.042	0.011	0.089	-0.078	0.003	-0.011	0.014
HU	3.919	0.097	3.822	-0.027	-0.097	0.071	-0.217	-0.091	-0.126	0.290	0.150	0.139	0.089	-0.007	0.097
LV	0.214	0.056	0.158	-0.003	-0.004	0.001	-0.007	-0.034	0.027	0.002	0.034	-0.032	-0.002	0.000	-0.002
LT	-0.007	0.028	-0.035	-0.009	-0.025	0.016	0.000	-0.049	0.049	0.020	0.066	-0.046	0.010	0.016	-0.006
PL	-0.086	0.022	-0.108	0.056	-0.049	0.105	0.017	-0.038	0.056	0.027	0.057	-0.030	0.135	-0.008	0.143
SL	-0.353	0.115	-0.468	0.989	-0.053	1.042	0.012	-0.058	0.070	-0.067	0.092	-0.158	0.015	0.010	0.005
SN	-0.001	0.069	-0.071	-0.007	-0.042	0.034	-0.005	-0.064	0.059	0.004	0.086	-0.082	-0.005	-0.011	0.007
Average	*0.256*	*0.061*	*0.195*	*0.139*	*-0.037*	*0.176*	*-0.014*	*-0.046*	*0.032*	*-0.587*	*0.068*	*-0.656*	*-0.017*	*-0.003*	*-0.014*
Negotiating countries															
CT	-0.003	0.042	-0.046	-0.004	-0.025	0.021	-0.003	-0.033	0.031	-0.011	0.044	-0.055	0.003	-0.002	0.005
RM	0.001	0.054	-0.053	-1.949	-0.014	-1.935	0.484	-0.019	0.503	-0.020	0.052	-0.072	-0.028	-0.027	-0.001
Average	*-0.002*	*0.046*	*-0.048*	*-0.603*	*-0.022*	*-0.581*	*0.147*	*-0.029*	*0.176*	*-0.014*	*0.046*	*-0.060*	*-0.007*	*-0.010*	*0.003*
CIS countries															
ML	0.002	0.024	-0.022	-0.001	-0.003	0.002	-0.003	-0.017	0.014	-0.002	0.013	-0.015	0.001	0.002	-0.001
RF	0.028	0.083	-0.055	0.199	-0.018	0.217	0.013	-0.054	0.067	-0.028	0.061	-0.089	0.007	-0.011	0.019
UN	0.008	0.056	-0.048	-0.004	-0.038	0.034	-0.009	-0.044	0.035	-0.017	0.039	-0.056	-0.019	-0.029	0.010
Average	*0.021*	*0.072*	*-0.050*	*0.139*	*-0.020*	*0.159*	*0.007*	*-0.048*	*0.055*	*-0.023*	*0.051*	*-0.075*	*0.002*	*-0.013*	*0.015*
Total sample average	**0.145**	**0.062**	**0.083**	**0.018**	**-0.030**	**0.047**	**0.018**	**-0.044**	**0.062**	**-0.327**	**0.060**	**-0.387**	**-0.010**	**-0.007**	**-0.003**

[a] LI = EffCH + TECH

Note: LI – Luenberger productivity index, EffCH – Efficiency Change, TECH – Technological Change

Looking at the Luenberger index, the highest average productivity growth rate is in the period 1998 – 99 for all three approaches. For instance, Intermediation LI reports average productivity growth rate of 10.1%, which is mainly explained by the efficiency change (the technological change had a negative impact on productivity growth of -1.2% level). For the rest of the considered period, the Intermediation approach reports a productivity decline which is mainly due to the negative efficiency change. However, the lowest level of productivity decline was due to the negative technological change and occurred between the years 2001-02. Indeed, according to the risk decomposition the risk management technology in that particular time period in virtually all banks was very inefficient, primarily as a result of the internal factors. The results also suggest that productivity does not change in the period 2002-03, and a closer look shows that the positive efficiency change was outweighed by the negative technological change at the absolute level of 0.04%.

As was mentioned before, the LI productivity results reported by the production approach also suggest that the highest average productivity growth occurred in the period between 1998-99, and this level of productivity growth (15.8%) is the highest across the input/output modelling approaches. The Profit/Revenue-based productivity index for that period is slightly lower, 14.5%, but still fairly high compared to the one reported by the Intermediation approach. The productivity indexes in the next two time periods 1999-00 and 2000-01 (Production and Profit approaches) show that the average productivity of the sample continued to improve but at a slightly lower rate (6.9% - 8.9% and 1.8% respectively). However, both components of the average LI decomposition (EFFCH and TECH) are positive in the production approach, whereas the profit approach shows that, although, technical change was positive, the efficiency change contributed negatively to LI at those periods.

Table 6. 5. Efficiency change (EFFCH) decomposition of commercial banking productivity in Eastern European countries (Intermediation approach)

	1998-99				1999-2000				2000-2001				2001-2002				2002-2003			
	EFF CH[a]	ENR EffCh	EE CH	RME CH	EFF CH[a]	ENR EffCh	EE CH	RME CH	EFF CH[a]	ENR EffCh	EE CH	RME CH	EFF CH[a]	ENR EffCh	EE CH	RME CH	EFF CH[a]	ENR EffCh	EE CH	RME CH
Accessed countries																				
CZ	0.033	0.068	0.045	-0.080	0.012	-0.010	-0.014	0.035	-0.040	-0.007	-0.003	-0.030	0.021	-0.005	0.024	0.001	0.024	0.021	0.001	0.001
ES	0.131	0.093	0.036	0.002	-0.044	-0.002	-0.046	0.004	-0.041	0.001	0.010	-0.052	0.077	-0.005	-0.001	0.083	0.012	0.008	0.017	-0.012
HU	0.043	-0.007	0.069	-0.020	-0.016	-0.010	0.003	-0.009	-0.032	-0.013	0.001	-0.020	0.056	-0.014	0.001	0.069	0.006	0.009	0.002	-0.005
LV	0.108	0.063	0.039	0.006	-0.010	-0.018	-0.003	0.011	-0.024	0.003	0.003	-0.030	0.032	-0.002	-0.006	0.040	-0.002	0.001	0.008	-0.011
LT	0.145	0.012	0.120	0.012	-0.035	-0.021	-0.024	0.011	-0.032	-0.004	0.010	-0.037	0.067	-0.015	0.014	0.068	0.004	0.012	0.011	-0.019
PL	0.064	0.086	0.008	-0.029	-0.037	-0.034	-0.015	0.012	-0.014	-0.016	0.016	-0.015	0.013	-0.048	-0.010	0.070	0.008	0.027	0.010	-0.029
SL	0.130	0.060	0.068	0.002	-0.040	-0.045	-0.032	0.037	-0.076	0.013	0.033	-0.122	0.086	-0.070	0.007	0.148	0.018	0.033	0.007	-0.022
SN	0.091	0.055	0.046	-0.010	-0.029	-0.052	0.012	0.011	-0.057	0.003	-0.005	-0.055	0.074	0.000	-0.004	0.077	0.015	0.017	0.014	-0.016
Average	*0.091*	*0.059*	*0.047*	*-0.015*	*-0.024*	*-0.027*	*-0.012*	*0.015*	*-0.036*	*-0.003*	*0.009*	*-0.042*	*0.045*	*-0.023*	*0.001*	*0.068*	*0.009*	*0.017*	*0.008*	*-0.016*
Negotiating countries																				
CT	0.135	0.072	0.060	0.004	-0.019	-0.025	-0.002	0.007	-0.025	0.001	0.003	-0.030	0.032	-0.017	0.001	0.048	0.004	0.011	0.003	-0.009
RM	0.119	0.069	0.062	-0.012	-0.009	-0.038	-0.003	0.033	-0.017	0.035	-0.005	-0.047	0.025	-0.025	0.010	0.040	-0.017	0.012	-0.011	-0.019
Average	*0.130*	*0.071*	*0.060*	*-0.001*	*-0.016*	*-0.029*	*-0.002*	*0.015*	*-0.023*	*0.012*	*0.000*	*-0.035*	*0.030*	*-0.020*	*0.004*	*0.046*	*-0.003*	*0.011*	*-0.001*	*-0.012*
CIS countries																				
ML	0.186	0.150	-0.002	0.038	0.000	-0.023	0.002	0.022	-0.012	0.019	0.001	-0.032	0.012	-0.002	0.000	0.014	-0.002	0.003	0.000	-0.004
RF	0.146	0.165	0.019	-0.037	-0.025	-0.059	0.000	0.034	-0.033	0.011	0.000	-0.044	0.039	-0.022	0.000	0.061	-0.003	0.030	0.000	-0.033
UN	0.125	0.170	-0.002	-0.043	-0.039	-0.075	-0.007	0.042	-0.038	0.038	0.005	-0.081	0.036	-0.008	0.005	0.039	0.002	0.020	-0.002	-0.015
Average	*0.146*	*0.164*	*0.012*	*-0.030*	*-0.025*	*-0.058*	*-0.001*	*0.034*	*-0.032*	*0.017*	*0.001*	*-0.050*	*0.036*	*-0.017*	*0.001*	*0.052*	*-0.002*	*0.025*	*-0.001*	*-0.027*
Total sample average	**0.114**	**0.092**	**0.039**	**-0.017**	**-0.023**	**-0.037**	**-0.007**	**0.021**	**-0.033**	**0.005**	**0.005**	**-0.043**	**0.040**	**-0.021**	**0.001**	**0.060**	**0.004**	**0.019**	**0.004**	**-0.019**

[a] EFFCH = ENREffCh + EECH +RMECH

Note: EFFCH – Efficiency Change, ENREffCh – Environment and Risk adjusted efficiency change, EECH – Environmental effect change, RMECH – Risk management effect change

Table 6. 6. Efficiency change (EFFCH) decomposition of commercial banking productivity in Eastern European countries (Production approach)

	1998-99				1999-2000				2000-2001				2001-2002				2002-2003			
	EFF CH[a]	ENR EffCh	EE CH	RME CH	EFF CH[a]	ENR EffCh	EE CH	RME CH	EFF CH[a]	ENR EffCh	EE CH	RME CH	EFF CH[a]	ENR EffCh	EE CH	RME CH	EFF CH[a]	ENR EffCh	EE CH	RME CH
Accessed countries																				
CZ	0.063	0.124	0.025	-0.085	-0.010	0.160	-0.197	0.027	-0.007	0.003	0.022	-0.032	0.092	0.060	-0.006	0.038	0.082	0.136	-0.026	-0.029
ES	0.132	0.122	0.056	-0.046	0.057	-0.033	0.020	0.070	0.039	0.085	0.013	-0.059	0.059	0.094	-0.021	-0.014	0.065	0.117	-0.059	0.007
HU	0.104	0.057	0.131	-0.085	0.010	-0.038	0.064	-0.016	0.050	0.092	0.028	-0.070	0.088	0.050	-0.034	0.073	0.081	0.115	0.047	-0.082
LV	0.098	0.033	0.087	-0.021	0.022	-0.030	0.021	0.031	0.015	0.063	-0.036	-0.012	0.038	0.013	-0.016	0.041	0.018	0.013	0.033	-0.029
LT	0.080	0.029	0.070	-0.018	0.035	0.004	-0.027	0.058	0.028	-0.032	0.081	-0.021	0.059	0.047	-0.059	0.071	0.027	0.014	0.012	0.001
PL	0.104	0.089	0.039	-0.023	0.065	-0.008	-0.029	0.102	0.042	0.064	0.011	-0.032	0.042	0.002	-0.002	0.043	0.082	0.059	0.039	-0.015
SL	0.149	0.072	0.075	0.003	0.041	-0.060	0.032	0.068	0.551	0.127	0.085	0.340	0.043	-0.010	0.034	0.020	0.055	0.057	-0.008	0.006
SN	0.111	0.087	0.056	-0.032	0.046	-0.045	0.014	0.077	0.024	0.070	0.020	-0.065	0.048	0.020	0.035	-0.007	0.029	0.068	0.008	-0.047
Average	*0.104*	*0.072*	*0.064*	*-0.032*	*0.036*	*-0.008*	*-0.014*	*0.058*	*0.093*	*0.060*	*0.021*	*0.013*	*0.053*	*0.023*	*-0.005*	*0.035*	*0.053*	*0.061*	*0.015*	*-0.022*
Negotiating countries																				
CT	0.097	0.065	0.088	-0.055	0.026	-0.035	0.023	0.039	0.012	0.054	-0.012	-0.029	0.037	0.005	0.029	0.002	0.040	0.061	0.003	-0.023
RM	0.113	0.109	0.056	-0.052	0.005	0.027	0.084	-0.107	0.078	0.034	0.089	-0.045	0.054	0.017	-0.003	0.039	0.037	0.064	0.030	-0.057
Average	*0.102*	*0.079*	*0.078*	*-0.054*	*0.020*	*-0.016*	*0.042*	*-0.006*	*0.032*	*0.047*	*0.019*	*-0.034*	*0.042*	*0.008*	*0.020*	*0.014*	*0.039*	*0.062*	*0.011*	*-0.034*
CIS countries																				
ML	0.075	0.132	-0.002	-0.054	0.023	0.004	-0.007	0.026	0.015	0.032	0.001	-0.017	0.011	0.013	-0.013	0.011	0.014	0.002	0.011	0.000
RF	0.129	0.116	0.079	-0.066	0.055	-0.031	0.027	0.059	0.029	0.084	-0.008	-0.046	0.049	-0.008	0.018	0.039	0.070	0.057	0.022	-0.010
UN	0.098	0.081	0.117	-0.100	0.056	-0.002	-0.011	0.069	0.012	0.049	0.048	-0.084	0.025	-0.002	0.036	-0.008	0.048	0.028	0.040	-0.020
Average	*0.118*	*0.111*	*0.078*	*-0.071*	*0.052*	*-0.022*	*0.016*	*0.058*	*0.024*	*0.071*	*0.003*	*-0.050*	*0.040*	*-0.005*	*0.018*	*0.027*	*0.060*	*0.046*	*0.025*	*-0.010*
Total sample average	**0.108**	**0.085**	**0.070**	**-0.047**	**0.038**	**-0.014**	**0.004**	**0.048**	**0.063**	**0.061**	**0.015**	**-0.013**	**0.047**	**0.012**	**0.006**	**0.029**	**0.053**	**0.057**	**0.017**	**-0.021**

[a] EFFCH = ENREffCh + EECH +RMECH
Note: EFFCH – Efficiency Change, ENREffCh – Environment and Risk adjusted efficiency change, EECH – Environmental effect change, RMECH – Risk management effect change

Table 6. 7. Efficiency change (EFFCH) decomposition of commercial banking productivity in Eastern European countries (Profit/Revenue based approach)

	1998-99				1999-2000				2000-2001				2001-2002				2002-2003			
	EFF CH[a]	ENR EffCh	EE CH	RME CH	EFF CH[a]	ENR EffCh	EE CH	RME CH	EFF CH[a]	ENR EffCh	EE CH	RME CH	EFF CH[a]	ENR EffCh	EE CH	RME CH	EFF CH[a]	ENR EffCh	EE CH	RME CH
Accessed countries																				
CZ	0.068	0.129	0.052	-0.113	-0.014	-0.012	-0.063	0.062	-0.027	-0.012	0.023	-0.039	0.055	0.027	0.009	0.019	-0.009	0.000	0.028	-0.037
ES	0.099	0.120	0.095	-0.115	-0.060	-0.078	0.009	0.009	-0.031	-0.004	0.017	-0.044	0.089	0.025	-0.014	0.078	-0.011	0.030	-0.025	-0.017
HU	0.097	0.024	0.149	-0.076	-0.097	-0.153	0.016	0.040	-0.091	0.000	0.009	-0.100	0.150	0.016	-0.029	0.164	-0.007	0.048	-0.023	-0.032
LV	0.056	0.041	0.142	-0.127	-0.004	-0.015	-0.023	0.034	-0.034	0.017	0.003	-0.054	0.034	-0.001	0.001	0.033	0.000	-0.001	0.005	-0.004
LT	0.028	0.023	0.137	-0.132	-0.025	-0.004	-0.054	0.034	-0.049	-0.037	0.051	-0.063	0.066	0.021	-0.017	0.062	0.016	0.021	0.010	-0.015
PL	0.022	0.105	0.057	-0.139	-0.049	-0.081	-0.012	0.044	-0.038	-0.003	0.012	-0.047	0.057	-0.038	0.003	0.092	-0.008	0.043	-0.003	-0.048
SL	0.115	0.088	0.111	-0.083	-0.053	-0.090	-0.026	0.063	-0.058	0.033	0.028	-0.119	0.092	-0.056	0.000	0.149	0.010	0.053	-0.009	-0.034
SN	0.069	0.099	0.100	-0.129	-0.042	-0.104	0.006	0.056	-0.064	0.004	0.008	-0.077	0.086	-0.014	0.001	0.098	-0.011	0.013	-0.001	-0.023
Average	*0.061*	*0.078*	*0.102*	*-0.119*	*-0.037*	*-0.062*	*-0.020*	*0.045*	*-0.046*	*0.003*	*0.016*	*-0.065*	*0.068*	*-0.011*	*-0.002*	*0.082*	*-0.003*	*0.025*	*0.000*	*-0.028*
Negotiating countries																				
CT	0.042	0.078	0.134	-0.170	-0.025	-0.065	0.009	0.030	-0.033	0.014	0.006	-0.054	0.044	-0.014	0.000	0.057	-0.002	0.014	-0.010	-0.006
RM	0.054	0.126	0.065	-0.137	-0.014	-0.029	-0.038	0.053	-0.019	0.046	0.008	-0.073	0.052	-0.026	-0.012	0.090	-0.027	0.024	-0.026	-0.025
Average	*0.046*	*0.093*	*0.113*	*-0.160*	*-0.022*	*-0.054*	*-0.005*	*0.037*	*-0.029*	*0.024*	*0.007*	*-0.060*	*0.046*	*-0.017*	*-0.004*	*0.067*	*-0.010*	*0.017*	*-0.015*	*-0.012*
CIS countries																				
ML	0.024	0.192	0.000	-0.168	-0.003	-0.035	-0.001	0.033	-0.017	0.027	0.001	-0.045	0.013	0.011	-0.016	0.018	0.002	-0.001	0.002	0.001
RF	0.083	0.173	0.055	-0.145	-0.018	-0.086	0.010	0.058	-0.054	0.034	-0.005	-0.083	0.061	-0.029	-0.011	0.100	-0.011	0.047	-0.024	-0.034
UN	0.056	0.115	0.099	-0.157	-0.038	-0.049	-0.051	0.062	-0.044	0.049	0.012	-0.106	0.039	-0.015	-0.017	0.071	-0.029	0.000	0.003	-0.032
Average	*0.072*	*0.164*	*0.058*	*-0.150*	*-0.020*	*-0.073*	*-0.003*	*0.056*	*-0.048*	*0.036*	*-0.001*	*-0.083*	*0.051*	*-0.022*	*-0.013*	*0.086*	*-0.013*	*0.033*	*-0.016*	*-0.030*
Total sample average	**0.062**	**0.106**	**0.090**	**-0.135**	**-0.030**	**-0.064**	**-0.013**	**0.047**	**-0.044**	**0.016**	**0.010**	**-0.070**	**0.060**	**-0.015**	**-0.006**	**0.081**	**-0.007**	**0.026**	**-0.007**	**-0.026**

[a] EFFCH = ENREffCh + EECH +RMECH

Note: EFFCH – Efficiency Change, ENREffCh – Environment and Risk adjusted efficiency change, EECH – Environmental effect change, RMECH – Risk management effect change

The decomposition of the changes in technical efficiency, i.e. the "catch-up" part of the productivity index, estimated by the three alternative input/output approaches is given in Table 6.5 – 6.7. According to the Intermediation approach, the decomposition of the technical efficiency catching-up for the years 1998-99, 2000-01 and 2002-03, the change in risk management effect on the technical efficiency in most countries was negative, i.e. it lessened the efficiency change. However, the negative impact of the change in risk management effect was offset by the positive impact of the environment and risk adjusted efficiency change and the environmental effect change resulting in an overall positive efficiency change. The exception is the period 2000-01 when all banks had a negative technical efficiency change, caused not only by the negative changes in the risk management effect, but also, in some cases, by the worsening environmental effect and negative environment and risk adjusted efficiency change.

Like in the Intermediation approach decomposition, the production approach decomposition of technical efficiency change shows that in virtually all countries throughout the analysed time period the technical efficiency change positively contributed productivity. The change of risk management effect was negative in 1998-99, 2000-01 and 2002-03. The change in the environment and risk adjusted efficiency negatively contribute the overall change of the technical efficiency change in the period 1999-00. The Profit/Revenue based decomposition of the technical change exhibits similar trends as in Intermediation approach, however the elements of technical efficiency change are somewhat superior to the Intermediation decomposition (except for period 1998-99 when it is the reverse).

The part of productivity change which appears in the form of technological change (or frontier-shift) and its decomposition into magnitude and bias components across the alternative methodologies is shown in the Tables 6.8-6.10. Tables 6.11-6.13 show the decomposition of the magnitude of the technological change across the different input/output specification, while the Tables 6.14-6.16 provide the decomposition of the bias index of technological change. As per the previous tables, the efficiency change component of the Luenberger productivity index is relatively stable for the country averages and averages of the country sub-groups. However, the technological change index is rather heterogeneous and volatile across the countries, implying that in differences the productivity changes across the countries reflect the divergence of technological change among them.

For instance, all three approaches suggest that the average productivity in the Hungarian banking system was extremely high in the period 1998-99, and the major factor of this productivity growth was attributed to the substantial technological shift. Looking at individual Hungarian banks, the results show that, the most productive bank at that period was Orszagos Takarekpenztar es Kereskedelmi - Bank-National Savings and Commercial Bank Ltd (OTP) – the largest bank in the Hungary, which achieved substantial productivity growth primarily as a result of significant technological change. Looking further at the decomposition of technological change, the shift of the technology is a result of the bias index, i.e. the difference of the magnitudes, particularly the bias index of the environment and risk adjusted efficiency. Indeed, according to Global Finance (2001), the OTP was the only bank among the large Hungarian banks to significantly improve its profits, while at the same time conducting its activities in a rapidly changing market environment. In fact, to maintain its dominant position in retail banking, in the second half of the 1990s, the OTP's strategy focused on increasing the profitability and productivity of its retail business by investing heavily in information technology (Bonin and Ábel, 2000). As a result, according to the aforementioned study, in 1999 OTP owned 43% of all the ATMs in Hungary and the value of its bank card transactions was 71% of the total volume of the bank card business.

At the same time many banks in the sample, as given by the negative Luenberger index, experienced a productivity decline, possibly as a result of the financial distress caused by the Russian financial crisis of 1998. Hence, the productivity performance of the OTP bank was outstanding when compared to the other analyzed banks. However, for the subsequent time periods the productivity performance of the OTP bank was fairly comparable to the other banks. A possible reason for this might be that these banks carefully monitored the risk in their activities taking into account the changes in the environment (possibly, the effect of 'disaster myopia'). Moreover, the strong competition from other banks - large and foreign- and competition policy[54] may also contribute to this finding.

[54] For example, in the changes to competition law and policy propose or envisaged, which is available at
http://www.oecd.org/dataoecd/45/22/2409112.pdf#search=%22hungary%20otp%20competition%20la w%22, it was stated that the market conduct of OTP with regard to the 'New Home' a five-year building deposit campaign, is abusive and the bank was imposed a fine amounting to HUF 10 million (about USD 48 thousand).

Table 6. 8. Technological change (TECH) decomposition of commercial banking productivity in Eastern European countries (Intermediation approach)

	1998-99			1999-2000			2000-2001			2001-2002			2002-2003		
	TECH[a]	MTECH	BTECH	TECH[a]	MTECH	BTECH	TECH[a]	MTECH	BTECH	TECH[a]	MTECH	BTECH	TECH[a]	MTECH	BTECH
Accessed countries															
CZ	-0.212	-0.375	0.164	-0.105	-0.252	0.147	-0.119	-0.160	0.041	-4.537	-9.167	4.631	-0.187	-1.488	1.300
ES	-0.115	-0.114	-0.001	0.047	0.040	0.008	0.039	0.043	-0.004	-0.062	-0.058	-0.005	0.000	-0.001	0.001
HU	3.065	-0.006	3.071	0.006	-0.035	0.041	-0.122	-0.283	0.161	0.159	-0.071	0.230	0.076	0.076	0.000
LV	-0.105	-0.105	0.000	0.007	0.008	-0.002	0.017	0.018	-0.001	-0.035	-0.035	0.000	-0.001	-0.001	0.000
LT	-0.147	-0.144	-0.003	0.027	0.031	-0.004	0.017	0.011	0.006	-0.066	-0.075	0.009	0.001	0.002	-0.001
PL	-0.104	-0.150	0.046	-0.067	-0.295	0.229	-0.070	-0.170	0.101	-0.029	-0.050	0.021	0.040	0.004	0.036
SL	-0.384	-0.666	0.281	0.838	0.037	0.801	0.111	0.070	0.041	-0.145	-0.105	-0.040	-0.004	0.000	-0.004
SN	-0.097	-0.099	0.002	0.029	0.029	0.000	0.053	0.051	0.002	-0.062	-0.069	0.006	-0.009	-0.006	-0.002
Average	*0.066*	*-0.212*	*0.278*	*0.091*	*-0.083*	*0.174*	*-0.010*	*-0.054*	*0.045*	*-0.513*	*-1.014*	*0.502*	*-0.007*	*-0.150*	*0.144*
Negotiating countries															
CT	-0.136	-0.135	-0.001	0.016	0.014	0.002	0.022	0.022	0.000	-0.034	-0.034	0.000	-0.003	-0.003	0.000
RM	0.055	0.136	-0.081	-1.572	-3.249	1.677	0.007	0.007	0.001	-0.027	-0.033	0.006	0.009	0.011	-0.001
Average	*-0.077*	*-0.052*	*-0.026*	*-0.473*	*-0.990*	*0.517*	*0.018*	*0.017*	*0.000*	*-0.032*	*-0.034*	*0.002*	*0.001*	*0.001*	*-0.001*
CIS countries															
ML	-0.174	-0.161	-0.013	0.000	0.000	0.000	0.007	0.008	-0.002	-0.016	-0.019	0.003	0.001	0.001	-0.001
RF	-0.112	-0.093	-0.019	0.190	0.357	-0.167	0.028	0.025	0.003	-0.056	-0.045	-0.011	0.002	0.011	-0.008
UN	-0.117	-0.112	-0.005	0.031	0.031	0.000	0.024	0.024	0.000	-0.043	-0.045	0.003	-0.013	-0.010	-0.003
Average	*-0.120*	*-0.104*	*-0.016*	*0.139*	*0.257*	*-0.117*	*0.025*	*0.023*	*0.002*	*-0.049*	*-0.043*	*-0.007*	*-0.001*	*0.006*	*-0.007*
Total sample average	**-0.012**	**-0.154**	**0.141**	**0.013**	**-0.131**	**0.144**	**0.005**	**-0.020**	**0.025**	**-0.297**	**-0.567**	**0.270**	**-0.004**	**-0.079**	**0.076**

[a] TECH = MTECH + BTECH

Note: TECH – Technological change, MTECH – Magnitude of technological change, BTECH – Bias index of technological change

Table 6. 9. Technological change (TECH) decomposition of commercial banking productivity in Eastern European countries (Production approach)

	1998-99			1999-2000			2000-2001			2001-2002			2002-2003		
	TECH[a]	MTE CH	BTE CH	TECH[a]	MTE CH	BTE CH	TECH[a]	MTE CH	BTE CH	TECH[a]	MTE CH	BTE CH	TECH[a]	MTE CH	BTE CH
Accessed countries															
CZ	-0.142	-0.375	0.232	0.010	-0.201	0.211	-0.020	-0.132	0.112	-3.753	-7.686	3.933	-0.127	-1.321	1.194
ES	-0.024	-0.110	0.086	0.043	-0.069	0.113	0.050	-0.050	0.100	0.024	-0.065	0.090	0.049	-0.067	0.117
HU	2.446	-0.103	2.550	0.044	-0.126	0.169	-0.104	-0.356	0.252	0.197	-0.106	0.303	0.062	-0.119	0.181
LV	-0.018	-0.095	0.077	0.065	-0.026	0.091	0.063	-0.022	0.085	0.042	-0.044	0.087	0.068	-0.025	0.092
LT	0.004	-0.090	0.094	0.045	-0.045	0.090	0.053	-0.039	0.092	0.032	-0.057	0.089	0.066	-0.026	0.092
PL	-0.034	-0.182	0.148	-0.066	-0.352	0.287	0.002	-0.183	0.186	-0.042	-0.212	0.169	0.085	-0.101	0.186
SL	-0.290	-0.604	0.313	0.715	-0.035	0.750	-0.184	-0.590	0.406	-0.025	-0.089	0.064	0.046	-0.056	0.102
SN	-0.022	-0.122	0.100	0.041	-0.057	0.098	0.066	-0.037	0.102	0.030	-0.068	0.098	0.052	-0.058	0.110
Average	*0.104*	*-0.213*	*0.317*	*0.105*	*-0.136*	*0.240*	*-0.004*	*-0.172*	*0.167*	*-0.376*	*-0.898*	*0.522*	*0.045*	*-0.195*	*0.240*
Negotiating countries															
CT	-0.019	-0.111	0.091	0.054	-0.036	0.090	0.071	-0.024	0.095	0.038	-0.053	0.091	0.051	-0.046	0.096
RM	0.041	-0.063	0.104	-1.181	-2.582	1.401	0.039	-0.055	0.094	0.030	-0.055	0.086	0.058	-0.056	0.113
Average	*-0.001*	*-0.096*	*0.095*	*-0.326*	*-0.819*	*0.493*	*0.061*	*-0.034*	*0.095*	*0.036*	*-0.054*	*0.090*	*0.053*	*-0.049*	*0.102*
CIS countries															
ML	0.010	-0.074	0.084	0.062	-0.023	0.085	0.067	-0.016	0.083	0.070	-0.015	0.085	0.071	-0.013	0.084
RF	-0.028	-0.106	0.078	0.115	0.084	0.030	0.061	-0.047	0.108	0.006	-0.073	0.079	0.040	-0.063	0.103
UN	-0.001	-0.094	0.093	0.037	-0.059	0.096	0.065	-0.029	0.095	0.032	-0.060	0.093	0.029	-0.078	0.108
Average	*-0.019*	*-0.100*	*0.082*	*0.094*	*0.046*	*0.049*	*0.062*	*-0.040*	*0.102*	*0.018*	*-0.064*	*0.082*	*0.041*	*-0.061*	*0.102*
Total sample average	**0.050**	**-0.161**	**0.211**	**0.031**	**-0.194**	**0.225**	**0.026**	**-0.110**	**0.136**	**-0.192**	**-0.513**	**0.321**	**0.045**	**-0.131**	**0.177**

[a] TECH = MTECH + BTECH

Note: TECH – Technological change, MTECH – Magnitude of technological change, BTECH – Bias index of technological change

Table 6. 10. Technological change (TECH) decomposition of commercial banking productivity in Eastern European countries (Profit/Revenue based approach)

	1998-99			1999-2000			2000-2001			2001-2002			2002-2003		
	TECH[a]	MTE CH	BTE CH	TECH[a]	MTE CH	BTE CH	TECH[a]	MTE CH	BTE CH	TECH[a]	MTE CH	BTE CH	TECH[a]	MTE CH	BTE CH
Accessed countries															
CZ	-0.041	-0.014	-0.027	0.053	0.056	-0.002	-0.005	0.060	-0.065	-5.871	-11.75	5.881	-0.527	-1.092	0.565
ES	-0.077	-0.072	-0.004	0.056	0.055	0.000	0.042	0.034	0.008	-0.078	-0.072	-0.006	0.014	0.012	0.003
HU	3.822	-0.050	3.873	0.071	0.025	0.046	-0.126	-0.326	0.200	0.139	-0.084	0.223	0.097	0.089	0.008
LV	0.158	-0.036	0.194	0.001	0.002	-0.001	0.027	0.030	-0.003	-0.032	-0.031	-0.001	-0.002	-0.002	0.000
LT	-0.035	-0.038	0.003	0.016	0.019	-0.004	0.049	0.052	-0.003	-0.046	-0.035	-0.010	-0.006	-0.004	-0.002
PL	-0.108	-0.196	0.088	0.105	0.025	0.080	0.056	0.057	-0.002	-0.030	-0.140	0.110	0.143	0.051	0.092
SL	-0.468	-0.815	0.347	1.042	0.077	0.964	0.070	0.031	0.039	-0.158	-0.115	-0.043	0.005	0.009	-0.004
SN	-0.071	-0.071	0.000	0.034	0.037	-0.002	0.059	0.057	0.002	-0.082	-0.092	0.010	0.007	0.003	0.003
Average	*0.195*	*-0.178*	*0.373*	*0.176*	*0.032*	*0.144*	*0.032*	*0.020*	*0.012*	*-0.656*	*-1.307*	*0.651*	*-0.014*	*-0.095*	*0.081*
Negotiating countries															
CT	-0.046	-0.048	0.003	0.021	0.024	-0.003	0.031	0.028	0.002	-0.055	-0.061	0.006	0.005	0.004	0.001
RM	-0.053	-0.220	0.168	-1.935	-4.076	2.141	0.503	0.084	0.419	-0.072	-0.029	-0.043	-0.001	0.020	-0.021
Average	*-0.048*	*-0.101*	*0.054*	*-0.581*	*-1.238*	*0.657*	*0.176*	*0.046*	*0.130*	*-0.060*	*-0.051*	*-0.009*	*0.003*	*0.009*	*-0.006*
CIS countries															
ML	-0.022	-0.019	-0.003	0.002	0.003	0.000	0.014	0.016	-0.001	-0.015	-0.016	0.001	-0.001	-0.001	0.000
RF	-0.055	-0.042	-0.014	0.217	0.406	-0.189	0.067	0.068	-0.002	-0.089	-0.075	-0.013	0.019	0.023	-0.004
UN	-0.048	-0.051	0.003	0.034	0.036	-0.001	0.035	0.033	0.002	-0.056	-0.056	-0.001	0.010	0.021	-0.011
Average	*-0.050*	*-0.041*	*-0.010*	*0.159*	*0.292*	*-0.133*	*0.055*	*0.056*	*-0.001*	*-0.075*	*-0.065*	*-0.009*	*0.015*	*0.020*	*-0.005*
Total sample average	**0.083**	**-0.125**	**0.208**	**0.047**	**-0.099**	**0.146**	**0.062**	**0.035**	**0.027**	**-0.387**	**-0.735**	**0.348**	**-0.003**	**-0.044**	**0.041**

[a] TECH = MTECH + BTECH

Note: TECH – Technological change, MTECH – Magnitude of technological change, BTECH – Bias index of technological change

Table 6. 11. Magnitude of technological change decomposition of commercial banking productivity in Eastern European countries (Intermediation approach)

	1998-99				1999-2000				2000-2001				2001-2002				2002-2003			
	MTE CH[a]	MEN REFF CH	MEE CH	MRM ECH	MTE CH[a]	MEN REFF CH	MEE CH	MRM ECH	MTE CH[a]	MEN REFF CH	MEE CH	MRM ECH	MTE CH[a]	MEN REFF CH	MEE CH	MRM ECH	MTE CH[a]	MEN REFF CH	MEE CH	MRM ECH
Accessed countries																				
CZ	-0.375	-0.030	-0.498	0.153	-0.252	-0.002	-0.236	-0.014	-0.160	0.015	-0.209	0.035	-9.167	-0.059	0.100	-9.208	-1.488	-0.012	-0.467	-1.008
ES	-0.114	-0.044	-0.066	-0.004	0.040	-0.036	0.080	-0.004	0.043	-0.067	0.060	0.050	-0.058	-0.013	0.020	-0.065	-0.001	-0.032	0.017	0.014
HU	-0.006	0.060	-0.077	0.012	-0.035	-0.051	-0.007	0.023	-0.283	-0.269	-0.003	-0.011	-0.071	0.002	-0.003	-0.070	0.076	0.047	-0.008	0.037
LV	-0.105	0.002	-0.098	-0.009	0.008	0.018	0.000	-0.010	0.018	-0.005	-0.013	0.035	-0.035	0.004	-0.001	-0.038	-0.001	-0.006	-0.011	0.017
LT	-0.144	-0.004	-0.133	-0.008	0.031	0.013	0.029	-0.011	0.011	-0.021	0.009	0.023	-0.075	0.009	-0.014	-0.070	0.002	-0.002	-0.019	0.023
PL	-0.150	0.183	-0.276	-0.057	-0.295	-0.289	0.007	-0.013	-0.170	-0.151	-0.038	0.019	-0.050	-0.117	0.011	0.055	0.004	-0.018	-0.006	0.027
SL	-0.666	-0.051	-0.272	-0.342	0.037	0.053	0.015	-0.031	0.070	0.051	-0.357	0.376	-0.105	0.021	0.004	-0.130	0.000	-0.098	-0.063	0.162
SN	-0.099	0.006	-0.110	0.005	0.029	0.047	-0.008	-0.011	0.051	-0.011	0.000	0.063	-0.069	0.015	-0.005	-0.078	-0.006	-0.013	-0.014	0.020
Average	*-0.212*	*0.036*	*-0.205*	*-0.042*	*-0.083*	*-0.055*	*-0.016*	*-0.011*	*-0.054*	*-0.053*	*-0.076*	*0.074*	*-1.014*	*-0.028*	*0.012*	*-0.999*	*-0.150*	*-0.019*	*-0.064*	*-0.067*
Negotiating countries																				
CT	-0.135	-0.054	-0.071	-0.010	0.014	0.017	0.003	-0.006	0.022	-0.008	-0.005	0.035	-0.034	0.014	-0.001	-0.048	-0.003	-0.012	-0.002	0.011
RM	0.136	0.190	-0.023	-0.030	-3.249	-3.357	0.135	-0.027	0.007	-0.013	-0.005	0.025	-0.033	0.009	-0.004	-0.038	0.011	-0.022	0.009	0.025
Average	*-0.052*	*0.021*	*-0.057*	*-0.016*	*-0.990*	*-1.021*	*0.044*	*-0.012*	*0.017*	*-0.009*	*-0.005*	*0.032*	*-0.034*	*0.013*	*-0.002*	*-0.045*	*0.001*	*-0.015*	*0.002*	*0.015*
CIS countries																				
ML	-0.161	-0.841	-0.136	0.816	0.000	0.022	-0.001	-0.021	0.008	-0.015	-0.001	0.025	-0.019	-0.001	0.000	-0.018	0.001	-0.013	-0.002	0.017
RF	-0.093	0.003	-0.053	-0.043	0.357	0.052	0.000	0.305	0.025	-0.235	-0.017	0.278	-0.045	0.019	0.000	-0.064	0.011	-0.019	0.000	0.030
UN	-0.112	-0.143	0.000	0.031	0.031	0.064	0.007	-0.041	0.024	-0.015	0.001	0.038	-0.045	0.004	-0.005	-0.045	-0.010	-0.037	0.001	0.027
Average	*-0.104*	*-0.114*	*-0.052*	*0.062*	*0.257*	*0.051*	*0.001*	*0.204*	*0.023*	*-0.170*	*-0.012*	*0.205*	*-0.043*	*0.014*	*-0.001*	*-0.056*	*0.006*	*-0.022*	*0.000*	*0.028*
Total sample average	**-0.154**	**-0.011**	**-0.136**	**-0.007**	**-0.131**	**-0.182**	**-0.001**	**0.052**	**-0.020**	**-0.080**	**-0.045**	**0.106**	**-0.567**	**-0.009**	**0.006**	**-0.564**	**-0.079**	**-0.019**	**-0.034**	**-0.026**

[a] MTECH = MENREFFCH + MEECH+MRMECH

Note: MTECH – Magnitude of the technological change, MENREFFCH– Magnitude of the efficiency adjusted for environment and risk change, MEECH – Magnitude of the environmental effect change, MRMECH – Magnitude of the risk management effect change

Table 6. 12. Magnitude of technological change decomposition of commercial banking productivity in Eastern European countries (Production approach)

	1998-99				1999-2000				2000-2001				2001-2002				2002-2003			
	MTECH[a]	MENREFFCH	MEECH	MRMECH	MTECH[a]	MENREFFCH	MEECH	MRMECH	MTECH[a]	MENREFFCH	MEECH	MRMECH	MTECH[a]	MENREFFCH	MEECH	MRMECH	MTECH[a]	MENREFFCH	MEECH	MRMECH
Accessed countries																				
CZ	-0.375	-0.188	-0.370	0.184	-0.201	0.123	-0.288	-0.036	-0.132	0.086	-0.280	0.061	-7.686	-0.018	-0.004	-7.664	-1.321	-0.031	-0.481	-0.809
ES	-0.110	0.058	-0.230	0.061	-0.069	-0.033	0.034	-0.070	-0.050	-0.087	-0.012	0.049	-0.065	-0.105	0.021	0.019	-0.067	-0.109	0.061	-0.019
HU	-0.103	-0.036	-0.136	0.068	-0.126	-0.109	-0.026	0.009	-0.356	-0.384	0.045	-0.017	-0.106	-0.051	0.006	-0.061	-0.119	-0.133	-0.064	0.078
LV	-0.095	0.026	-0.124	0.003	-0.026	0.007	-0.001	-0.031	-0.022	-0.078	0.042	0.015	-0.044	-0.057	0.053	-0.040	-0.025	-0.065	0.010	0.030
LT	-0.090	-0.026	-0.090	0.026	-0.045	-0.027	0.042	-0.060	-0.039	-0.361	0.290	0.031	-0.057	-0.047	0.059	-0.069	-0.026	-0.045	0.022	-0.003
PL	-0.182	0.253	-0.467	0.032	-0.352	-0.244	-0.023	-0.085	-0.183	-0.235	-0.019	0.070	-0.212	-0.177	0.007	-0.042	-0.101	-0.061	-0.072	0.032
SL	-0.604	-0.084	-0.248	-0.272	-0.035	0.033	-0.001	-0.066	-0.590	-0.501	0.038	-0.127	-0.089	-0.062	-0.019	-0.007	-0.056	-0.146	-0.019	0.109
SN	-0.122	-0.035	-0.110	0.023	-0.057	0.031	-0.009	-0.079	-0.037	-0.088	-0.024	0.075	-0.068	-0.034	-0.038	0.004	-0.058	-0.087	-0.009	0.039
Average	*-0.213*	*0.028*	*-0.246*	*0.005*	*-0.136*	*-0.046*	*-0.033*	*-0.056*	*-0.172*	*-0.201*	*0.007*	*0.023*	*-0.898*	*-0.080*	*0.012*	*-0.831*	*-0.195*	*-0.078*	*-0.068*	*-0.048*
Negotiating countries																				
CT	-0.111	-0.008	-0.146	0.044	-0.036	-0.005	0.008	-0.039	-0.024	-0.068	0.009	0.035	-0.053	-0.017	-0.029	-0.007	-0.046	-0.061	-0.009	0.024
RM	-0.063	0.212	-0.240	-0.035	-2.582	-0.098	-2.203	-0.281	-0.055	-0.072	-0.006	0.024	-0.055	-0.071	0.039	-0.024	-0.056	-0.111	0.003	0.052
Average	*-0.096*	*0.059*	*-0.175*	*0.019*	*-0.819*	*-0.034*	*-0.672*	*-0.113*	*-0.034*	*-0.069*	*0.004*	*0.032*	*-0.054*	*-0.033*	*-0.008*	*-0.012*	*-0.049*	*-0.076*	*-0.005*	*0.033*
CIS countries																				
ML	-0.074	-7.821	-1.079	8.826	-0.023	-0.004	0.007	-0.026	-0.016	-0.030	0.002	0.012	-0.015	-0.026	0.022	-0.012	-0.013	-0.028	0.006	0.009
RF	-0.106	0.664	-0.785	0.014	0.084	0.012	-0.021	0.093	-0.047	-0.204	-0.064	0.221	-0.073	-0.032	-0.003	-0.038	-0.063	-0.050	-0.024	0.011
UN	-0.094	-0.059	-0.107	0.072	-0.059	-0.160	0.169	-0.068	-0.029	-0.098	0.012	0.056	-0.060	-0.023	-0.039	0.001	-0.078	-0.107	0.005	0.023
Average	*-0.100*	*-0.377*	*-0.686*	*0.963*	*0.046*	*-0.022*	*0.018*	*0.050*	*-0.040*	*-0.165*	*-0.042*	*0.167*	*-0.064*	*-0.029*	*-0.007*	*-0.027*	*-0.061*	*-0.058*	*-0.015*	*0.013*
Total sample average	**-0.161**	**-0.087**	**-0.365**	**0.291**	**-0.194**	**-0.037**	**-0.122**	**-0.034**	**-0.110**	**-0.169**	**-0.008**	**0.067**	**-0.513**	**-0.057**	**0.003**	**-0.459**	**-0.131**	**-0.072**	**-0.042**	**-0.017**

[a] MTECH = MENREFFCH + MEECH+MRMECH

Note: MTECH – Magnitude of the technological change, MENREFFCH– Magnitude of the efficiency adjusted for environment and risk change, MEECH – Magnitude of the environmental effect change, MRMECH – Magnitude of the risk management effect change

Table 6. 13. Magnitude of technological change decomposition of commercial banking productivity in Eastern European countries (Profit/Revenue based approach)

	1998-99				1999-2000				2000-2001				2001-2002				2002-2003			
	MTECH[a]	MENREFFCH	MEECH	MRMECH	MTECH[a]	MENREFFCH	MEECH	MRMECH	MTECH[a]	MENREFFCH	MEECH	MRMECH	MTECH[a]	MENREFFCH	MEECH	MRMECH	MTECH[a]	MENREFFCH	MEECH	MRMECH
Accessed countries																				
CZ	-0.014	0.135	-0.259	0.110	0.056	0.575	-0.478	-0.042	0.060	0.032	-0.016	0.044	-11.75	-0.077	0.127	-11.80	-1.092	0.003	-0.663	-0.431
ES	-0.072	0.053	-0.244	0.118	0.055	0.060	0.005	-0.010	0.034	0.004	-0.008	0.038	-0.072	-0.006	0.010	-0.075	0.012	-0.013	0.026	-0.002
HU	-0.050	0.046	-0.185	0.088	0.025	0.045	0.023	-0.044	-0.326	-0.392	0.051	0.014	-0.084	0.036	0.022	-0.143	0.089	0.056	0.030	0.003
LV	-0.036	0.030	-0.200	0.133	0.002	0.013	0.022	-0.033	0.030	-0.079	0.047	0.062	-0.031	-0.011	0.011	-0.031	-0.002	-0.015	0.008	0.004
LT	-0.038	-0.011	-0.170	0.144	0.019	-0.006	0.060	-0.035	0.052	-0.047	0.024	0.075	-0.035	0.000	0.008	-0.043	-0.004	-0.008	0.002	0.002
PL	-0.196	-0.169	-0.152	0.125	0.025	0.086	-0.021	-0.039	0.057	0.093	-0.060	0.024	-0.140	0.099	0.001	-0.240	0.051	0.025	-0.010	0.036
SL	-0.815	-0.053	-0.412	-0.350	0.077	0.087	0.054	-0.063	0.031	-0.356	-0.070	0.457	-0.115	0.015	0.012	-0.141	0.009	-0.146	-0.025	0.181
SN	-0.071	-0.026	-0.167	0.122	0.037	0.092	-0.001	-0.055	0.057	-0.024	-0.015	0.096	-0.092	0.023	-0.007	-0.108	0.003	0.000	-0.003	0.006
Average	*-0.178*	*-0.024*	*-0.216*	*0.063*	*0.032*	*0.110*	*-0.036*	*-0.042*	*0.020*	*-0.071*	*-0.011*	*0.102*	*-1.307*	*0.019*	*0.019*	*-1.346*	*-0.095*	*-0.013*	*-0.070*	*-0.012*
Negotiating countries																				
CT	-0.048	1.123	-1.332	0.160	0.024	0.046	0.007	-0.029	0.028	-0.014	-0.017	0.059	-0.061	0.010	-0.003	-0.068	0.004	-0.006	0.010	0.001
RM	-0.220	-0.161	-0.137	0.078	-4.076	-0.060	-3.639	-0.377	0.084	-0.080	0.109	0.056	-0.029	-0.033	0.062	-0.059	0.020	-0.036	0.039	0.017
Average	*-0.101*	*0.728*	*-0.964*	*0.135*	*-1.238*	*0.013*	*-1.115*	*-0.136*	*0.046*	*-0.035*	*0.022*	*0.058*	*-0.051*	*-0.003*	*0.017*	*-0.065*	*0.009*	*-0.015*	*0.019*	*0.006*
CIS countries																				
ML	-0.019	-0.109	-2.358	2.447	0.003	0.034	0.001	-0.033	0.016	-0.022	0.001	0.037	-0.016	-0.040	0.042	-0.018	-0.001	-0.026	0.012	0.014
RF	-0.042	1.948	-2.054	0.065	0.406	0.050	0.027	0.329	0.068	-0.127	-0.137	0.333	-0.075	0.011	0.018	-0.105	0.023	-0.021	0.011	0.033
UN	-0.051	-0.044	-0.125	0.118	0.036	-0.113	0.210	-0.061	0.033	-0.060	0.047	0.047	-0.056	-0.012	0.029	-0.073	0.021	-0.062	0.054	0.028
Average	*-0.041*	*1.348*	*-1.717*	*0.328*	*0.292*	*0.017*	*0.059*	*0.216*	*0.056*	*-0.103*	*-0.088*	*0.246*	*-0.065*	*0.001*	*0.023*	*-0.090*	*0.020*	*-0.029*	*0.019*	*0.030*
Total sample average	**-0.125**	**0.504**	**-0.782**	**0.153**	**-0.099**	**0.067**	**-0.184**	**0.019**	**0.035**	**-0.075**	**-0.028**	**0.138**	**-0.735**	**0.010**	**0.020**	**-0.765**	**-0.044**	**-0.018**	**-0.029**	**0.004**

[a] MTECH = MENREFFCH + MEECH+MRMECH

Note: MTECH – Magnitude of the technological change, MENREFFCH– Magnitude of the efficiency adjusted for environment and risk change, MEECH – Magnitude of the environmental effect change, MRMECH – Magnitude of the risk management effect change

Table 6. 14. Bias of technological change decomposition of commercial banking productivity in Eastern European countries (Intermediation approach)

	1998-99				1999-2000				2000-2001				2001-2002				2002-2003			
	BTECH[a]	BENR EFF	BEE	BRME	BTECH[a]	BENR EFF	BEE	BRME	BTECH[a]	BENR EFF	BEE	BRME	BTECH[a]	BENR EFF	BEE	BRME	BTECH[a]	BENR EFF	BEE	BRME
Accessed countries																				
CZ	0.164	0.012	0.190	-0.039	0.147	0.014	0.119	0.014	0.041	-0.010	0.091	-0.040	4.631	0.101	-0.017	4.547	1.300	0.601	0.281	0.418
ES	-0.001	0.000	-0.005	0.003	0.008	0.076	-0.073	0.004	-0.004	0.076	-0.080	0.000	-0.005	0.054	-0.053	-0.005	0.001	0.060	-0.060	0.000
HU	3.071	3.017	0.052	0.002	0.041	0.057	0.001	-0.018	0.161	0.149	-0.009	0.021	0.230	0.249	-0.014	-0.005	0.000	0.020	0.005	-0.026
LV	0.000	-0.029	0.028	0.002	-0.002	-0.001	-0.001	0.000	-0.001	0.000	0.003	-0.003	0.000	-0.002	0.001	0.001	0.000	0.000	0.001	-0.001
LT	-0.003	0.000	-0.001	-0.002	-0.004	0.028	-0.027	-0.004	0.006	0.022	-0.027	0.010	0.009	0.001	-0.004	0.012	-0.001	-0.003	0.001	0.001
PL	0.046	-0.123	0.127	0.041	0.229	0.224	-0.014	0.019	0.101	0.091	0.000	0.010	0.021	0.099	-0.024	-0.054	0.036	0.077	-0.004	-0.037
SL	0.281	-0.001	0.105	0.177	0.801	-0.034	0.076	0.759	0.041	-0.018	0.158	-0.100	-0.040	0.130	0.036	-0.206	-0.004	0.052	0.016	-0.072
SN	0.002	-0.028	0.028	0.002	0.000	0.005	-0.006	0.000	0.002	0.007	-0.007	0.003	0.006	0.011	-0.005	0.000	-0.002	0.005	-0.007	-0.001
Average	*0.278*	*0.174*	*0.075*	*0.029*	*0.174*	*0.060*	*0.012*	*0.102*	*0.045*	*0.035*	*0.023*	*-0.013*	*0.502*	*0.071*	*-0.007*	*0.438*	*0.144*	*0.092*	*0.028*	*0.024*
Negotiating countries																				
CT	-0.001	-0.007	0.003	0.003	0.002	0.012	-0.011	0.000	0.000	0.005	-0.004	-0.001	0.000	0.004	-0.005	0.001	0.000	0.004	-0.005	0.001
RM	-0.081	-0.047	-0.064	0.030	1.677	1.737	-0.071	0.011	0.001	-0.006	-0.007	0.013	0.006	0.019	-0.022	0.008	-0.001	0.010	-0.009	-0.003
Average	*-0.026*	*-0.019*	*-0.017*	*0.011*	*0.517*	*0.543*	*-0.029*	*0.003*	*0.000*	*0.002*	*-0.005*	*0.004*	*0.002*	*0.009*	*-0.010*	*0.003*	*-0.001*	*0.006*	*-0.006*	*0.000*
CIS countries																				
ML	-0.013	0.350	0.064	-0.427	0.000	0.010	-0.001	-0.010	-0.002	-0.003	0.000	0.001	0.003	0.001	0.000	0.003	-0.001	0.003	0.001	-0.004
RF	-0.019	-0.073	0.019	0.035	-0.167	-0.001	-0.008	-0.158	0.003	0.113	0.002	-0.111	-0.011	0.128	-0.017	-0.122	-0.008	-0.001	-0.005	-0.002
UN	-0.005	-0.003	-0.007	0.005	0.000	0.000	-0.009	0.008	0.000	-0.005	-0.011	0.016	0.003	0.004	-0.005	0.004	-0.003	0.005	-0.003	-0.005
Average	*-0.016*	*-0.015*	*0.019*	*-0.020*	*-0.117*	*0.000*	*-0.007*	*-0.110*	*0.002*	*0.078*	*-0.001*	*-0.075*	*-0.007*	*0.091*	*-0.013*	*-0.084*	*-0.007*	*0.000*	*-0.004*	*-0.003*
Total sample average	**0.141**	**0.087**	**0.043**	**0.011**	**0.144**	**0.121**	**0.000**	**0.023**	**0.025**	**0.042**	**0.011**	**-0.028**	**0.270**	**0.067**	**-0.009**	**0.212**	**0.076**	**0.051**	**0.013**	**0.012**

[a] BTECH = BENREFF + BEE + BRME

Note: BTECH – Bias index of technological change, BENREFF – Environment and risk adjusted efficiency bias, BEE – Environmental effect bias, BRME– Risk management effect bias

Table 6. 15. Bias of technological change decomposition of commercial banking productivity in Eastern European countries (Production approach)

	1998-99				1999-2000				2000-2001				2001-2002				2002-2003			
	BTECH[a]	BENR EFF	BEE	BRME	BTECH[a]	BENR EFF	BEE	BRME	BTECH[a]	BENR EFF	BEE	BRME	BTECH[a]	BENR EFF	BEE	BRME	BTECH[a]	BENR EFF	BEE	BRME
Accessed countries																				
CZ	0.232	0.127	0.165	-0.060	0.211	0.033	0.153	0.025	0.112	0.014	0.128	-0.029	3.933	0.176	-0.002	3.759	1.194	0.544	0.307	0.343
ES	0.086	0.018	0.082	-0.013	0.113	0.145	-0.048	0.015	0.100	0.103	-0.012	0.009	0.090	0.125	0.008	-0.043	0.117	0.127	-0.035	0.025
HU	2.550	2.765	-0.222	0.006	0.169	0.209	-0.019	-0.020	0.252	0.247	-0.038	0.043	0.303	0.329	-0.044	0.017	0.181	0.201	0.017	-0.038
LV	0.077	0.124	-0.058	0.011	0.091	0.021	0.067	0.003	0.085	0.101	-0.025	0.008	0.087	0.064	0.023	0.000	0.092	0.036	0.065	-0.009
LT	0.094	0.082	0.003	0.009	0.090	0.020	0.066	0.003	0.092	0.280	-0.188	0.000	0.089	0.030	0.052	0.007	0.092	0.038	0.048	0.005
PL	0.148	-0.092	0.221	0.019	0.287	0.267	-0.012	0.031	0.186	0.173	0.006	0.007	0.169	0.167	0.004	-0.001	0.186	0.145	0.050	-0.008
SL	0.313	0.085	0.083	0.145	0.750	0.014	0.113	0.623	0.406	0.322	-0.035	0.119	0.064	0.300	-0.032	-0.205	0.102	0.119	0.030	-0.047
SN	0.100	0.064	0.023	0.012	0.098	0.090	0.000	0.007	0.102	0.104	0.000	-0.002	0.098	0.114	0.014	-0.031	0.110	0.125	-0.008	-0.007
Average	*0.317*	*0.238*	*0.059*	*0.021*	*0.240*	*0.106*	*0.044*	*0.091*	*0.167*	*0.164*	*-0.016*	*0.019*	*0.522*	*0.154*	*0.005*	*0.363*	*0.240*	*0.151*	*0.064*	*0.024*
Negotiating countries																				
CT	0.091	0.062	0.023	0.006	0.090	0.106	-0.015	-0.001	0.095	0.094	-0.007	0.008	0.091	0.092	0.015	-0.015	0.096	0.099	0.006	-0.008
RM	0.104	-0.108	0.170	0.043	1.401	0.141	1.137	0.123	0.094	0.055	0.034	0.004	0.086	0.043	0.055	-0.012	0.113	0.125	-0.009	-0.003
Average	*0.095*	*0.010*	*0.068*	*0.018*	*0.493*	*0.117*	*0.340*	*0.037*	*0.095*	*0.082*	*0.006*	*0.007*	*0.090*	*0.077*	*0.027*	*-0.014*	*0.102*	*0.107*	*0.001*	*-0.007*
CIS countries																				
ML	0.084	3.929	0.538	-4.384	0.085	0.062	0.028	-0.005	0.083	0.014	0.069	0.000	0.085	0.077	0.007	0.001	0.084	0.099	-0.011	-0.004
RF	0.078	-0.007	0.067	0.019	0.030	0.062	0.033	-0.065	0.108	0.112	0.068	-0.073	0.079	0.169	0.054	-0.144	0.103	0.071	0.026	0.006
UN	0.093	0.071	0.002	0.019	0.096	0.182	-0.108	0.022	0.095	0.212	-0.121	0.003	0.093	0.089	0.024	-0.021	0.108	0.119	-0.003	-0.008
Average	*0.082*	*0.427*	*0.105*	*-0.449*	*0.049*	*0.085*	*0.006*	*-0.042*	*0.102*	*0.121*	*0.032*	*-0.051*	*0.082*	*0.144*	*0.043*	*-0.105*	*0.102*	*0.084*	*0.016*	*0.002*
Total sample average	**0.211**	**0.256**	**0.074**	**-0.119**	**0.225**	**0.101**	**0.081**	**0.043**	**0.136**	**0.138**	**0.002**	**-0.004**	**0.321**	**0.138**	**0.020**	**0.163**	**0.177**	**0.124**	**0.040**	**0.013**

[a] BTECH = BENREFF + BEE + BRME

Note: BTECH – Bias index of technological change, BENREFF – Environment and risk adjusted efficiency bias, BEE – Environmental effect bias, BRME– Risk management effect bias

Table 6. 16. Bias of technological change decomposition of commercial banking productivity in Eastern European countries (Profit/Revenue based approach)

	1998-99				1999-2000				2000-2001				2001-2002				2002-2003			
	BTECH[a]	BENREFF	BEE	BRME	BTECH[a]	BENREFF	BEE	BRME	BTECH[a]	BENREFF	BEE	BRME	BTECH[a]	BENREFF	BEE	BRME	BTECH[a]	BENREFF	BEE	BRME
Accessed countries																				
CZ	-0.027	-0.122	0.098	-0.003	-0.002	-0.289	0.259	0.028	-0.065	-0.010	-0.009	-0.045	5.881	0.083	-0.072	5.870	0.565	-0.016	0.350	0.231
ES	-0.004	-0.072	0.067	0.001	0.000	0.005	-0.001	-0.004	0.008	0.006	-0.009	0.011	-0.006	0.022	-0.019	-0.010	0.003	0.008	-0.011	0.005
HU	3.873	3.573	0.127	0.173	0.046	0.076	-0.031	0.000	0.200	0.197	-0.044	0.047	0.223	0.316	-0.098	0.006	0.008	0.023	-0.028	0.012
LV	0.194	0.136	0.061	-0.003	-0.001	0.005	-0.006	0.000	-0.003	0.041	-0.038	-0.006	-0.001	0.041	-0.037	-0.004	0.000	0.008	-0.007	-0.001
LT	0.003	-0.004	0.013	-0.006	-0.004	0.004	-0.008	0.000	-0.003	0.047	-0.044	-0.006	-0.010	0.013	-0.017	-0.007	-0.002	0.013	-0.019	0.004
PL	0.088	0.040	0.044	0.004	0.080	0.063	-0.007	0.024	-0.002	-0.040	0.015	0.023	0.110	0.033	0.010	0.067	0.092	0.070	0.015	0.007
SL	0.347	-0.023	0.144	0.226	0.964	-0.044	0.083	0.926	0.039	0.177	0.015	-0.153	-0.043	0.228	-0.023	-0.248	-0.004	0.053	0.019	-0.076
SN	0.000	-0.028	0.026	0.002	-0.002	0.004	-0.008	0.001	0.002	0.006	-0.003	-0.001	0.010	0.006	-0.005	0.009	0.003	-0.005	-0.006	0.014
Average	*0.373*	*0.264*	*0.068*	*0.041*	*0.144*	*-0.014*	*0.031*	*0.127*	*0.012*	*0.040*	*-0.011*	*-0.017*	*0.651*	*0.079*	*-0.026*	*0.598*	*0.081*	*0.026*	*0.036*	*0.019*
Negotiating countries																				
CT	0.003	-0.591	0.590	0.004	-0.003	0.010	-0.011	-0.003	0.002	0.000	0.003	0.000	0.006	0.001	-0.001	0.006	0.001	0.001	-0.003	0.003
RM	0.168	0.107	0.024	0.037	2.141	0.158	1.827	0.156	0.419	0.038	0.380	0.001	-0.043	0.022	-0.054	-0.010	-0.021	0.046	-0.067	0.000
Average	*0.054*	*-0.377*	*0.416*	*0.014*	*0.657*	*0.056*	*0.555*	*0.046*	*0.130*	*0.012*	*0.119*	*0.000*	*-0.009*	*0.007*	*-0.017*	*0.001*	*-0.006*	*0.015*	*-0.023*	*0.002*
CIS countries																				
ML	-0.003	-0.042	1.179	-1.140	0.000	0.005	0.007	-0.013	-0.001	0.001	-0.003	0.001	0.001	0.022	-0.021	0.000	0.000	0.053	-0.048	-0.005
RF	-0.014	-0.895	0.851	0.030	-0.189	-0.010	0.001	-0.180	-0.002	0.041	0.078	-0.120	-0.013	0.069	0.010	-0.093	-0.004	-0.019	0.017	-0.002
UN	0.003	-0.029	0.015	0.017	-0.001	0.100	-0.112	0.011	0.002	0.122	-0.143	0.023	-0.001	0.012	-0.013	0.000	-0.011	0.010	-0.013	-0.008
Average	*-0.010*	*-0.638*	*0.726*	*-0.097*	*-0.133*	*0.013*	*-0.020*	*-0.126*	*-0.001*	*0.052*	*0.027*	*-0.080*	*-0.009*	*0.053*	*0.003*	*-0.065*	*-0.005*	*-0.006*	*0.004*	*-0.003*
Total sample average	**0.208**	**-0.107**	**0.319**	**-0.004**	**0.146**	**0.005**	**0.102**	**0.039**	**0.027**	**0.039**	**0.021**	**-0.033**	**0.348**	**0.060**	**-0.016**	**0.304**	**0.041**	**0.015**	**0.017**	**0.010**

[a] BTECH = BENREFF + BEE + BRME

Note: BTECH – Bias index of technological change, BENREFF – Environment and risk adjusted efficiency bias, BEE – Environmental effect bias, BRME– Risk management effect bias

Taking another example, in the period 1999-2000 the banking industry of Slovakia appeared to be remarkably productive, where again the productivity growth is gained as a consequence of a technological shift, but this time is due to increase of the bias index – risk management efficiency bias in particular. The main driver of the technological change, and as a consequence of the high average productivity growth, in that period is the second largest bank in the Slovak Republic - Vseobecna Uverova Banka (VUB). In 2000 the first phase of the privatization of this bank was completed, and an agreement was entered into with EBRD and IFC on the sale of approximately 25% of the shares in VUB in February 2001. Moreover, in 2000 the bank established a new organizational structure with a focus on strengthening the risk management system and reducing the number of management levels. These initiatives resulted in a 10% decrease in the bank's general operating costs and improved its financial performance. Besides the restructuring of the bank, VUB achieved the technological shift as a result of developing electronic distribution channels which facilitated e-banking communication, such as home banking, a wide network of ATMs, EFT POS terminals and internet banking. And, according to the VUB 2000 Annual Report, by activating such services, VUB has become one of the leaders in electronic banking in Slovakia.

The Romanian banking industry also experienced a notable productivity change in three input/output methodologies in the period 1999-2000. However, unlike the Slovakian banks, they experienced a productivity decline. The decomposition of productivity suggests that the cause of the productivity decline is a negative technological shift caused by the high negative magnitude of environmental effect changes, mainly in the largest Romanian bank – Romanian Commercial Bank (BCR). Also in 2000, the largest Romanian investment fund Fondul Naţional de Investiţii (FNI) collapsed as a result of gross mismanagement, fraudulent practices and poor regulatory oversight. This triggered a decline in the confidence in the Romanian financial sector (IMF, Remes and Ghizari, 2000), amplified by the panic among the people trying to withdraw their funds from the BCR branches (BBC, 2000).

The banking system in the Czech Republic experienced a serious productivity decline in the period 2001-2002. The results suggest that main cause of the average productivity decline is the negative technological shift of Ceskoslovenska Obchodni Banka (CSOB). The decomposition of the technological change shows that the bias index positively contributed the productivity growth, although the substantial negative magnitude of the technological change had a significant influence on the technological change and, as a result, on the productivity change. A detailed decomposition of the magnitude and bias indexes of technological change suggest that the core elements of the change in technology are related to the risk management effect. Indeed, the magnitude of the risk management effect had a considerable negative impact which was not sufficiently offset by the positive bias of the risk management effect. A rigorous look at the Czech banking industry for that period and the productivity decomposition results gives a detailed picture about the country's banking system and the CSOB in particular. In 2000 the third largest bank of the Czech Republic - Investment and Postal Bank (Investiční a Poštovní banka or IPB), bailed out causing a major corporate governance scandal (World Bank, 2002). In June 2001 IPB was sold to CSOB, which was the fourth largest bank at the time with a strong background in corporate banking and a sound risk management system, making it the largest Czech bank. The reorganization of the bank's structure following the acquisition, which Anderson (2001) called a 'shotgun marriage', is captured by the technological process. The positive bias index suggests that the risk management reorganization was improved. Yet, the negative magnitude of the risk management effect indicates that there was still scope for further improvement for this period (comparing the risk management technology of the CSOB before the acquisition).

In taking a more detailed look at the productivity growth and its decomposition results for the individual banking sub-groups, it is clear from Figures 6.1 to 6.3 that, while the average Luenberger productivity indexes for different sub-groups are typically very different, the average efficiency change across the sub-groups often exhibits similar trends over time. This is particularly true with respect to the Intermediation and Profit/Revenue based approaches. Figure 6.1 and 6.2, for example, illustrate very clearly that, according to these approaches, the banking subgroups exhibit a clear improvement in technical efficiency levels in the periods 1998-99 and 2001-02, whereas in the period between 1999 and 2001 the efficiency change was negative. Although there is a considerable degree of convergence between the efficiency change results estimated using these two approaches, these figures highlight the greater variation of the efficiency change levels produced using the

Profit/Revenue based methodology. The Production approach efficiency change results also show considerable variation, both through time and across the different country sub-groups as well as for the sample average. However, the Production efficiency change also contrasts with the corresponding change for the Intermediation and Profit-Revenue based approaches with respect to the level of the changes, which is positive throughout the analysed period, suggesting that the banks gradually improved their Production efficiency.

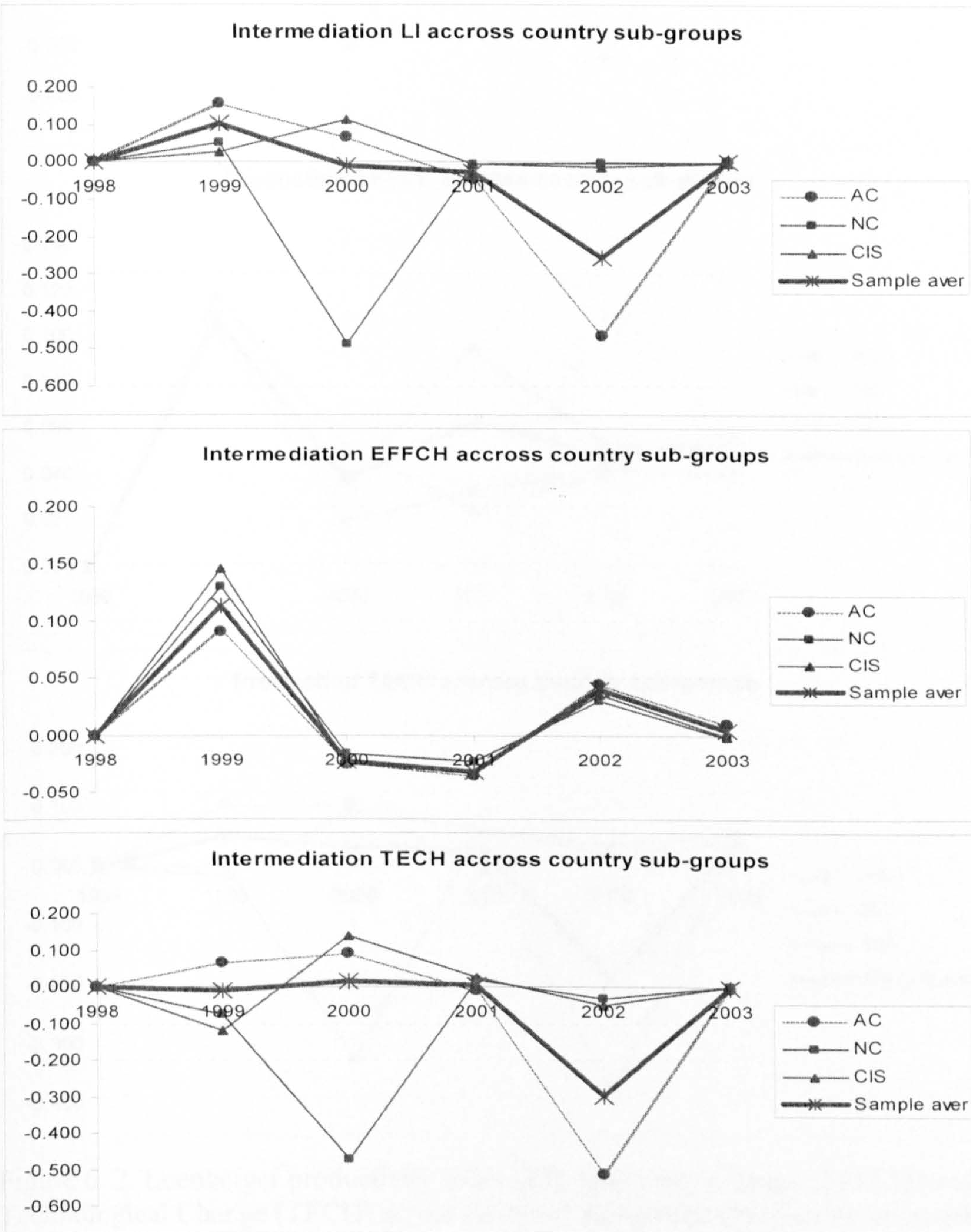


Figure 6. 1. Luenberger productivity index (LI), Efficiency Change (EFFCH) and Technological Change (TECH) across counties' sub-groups (Intermediation approach).

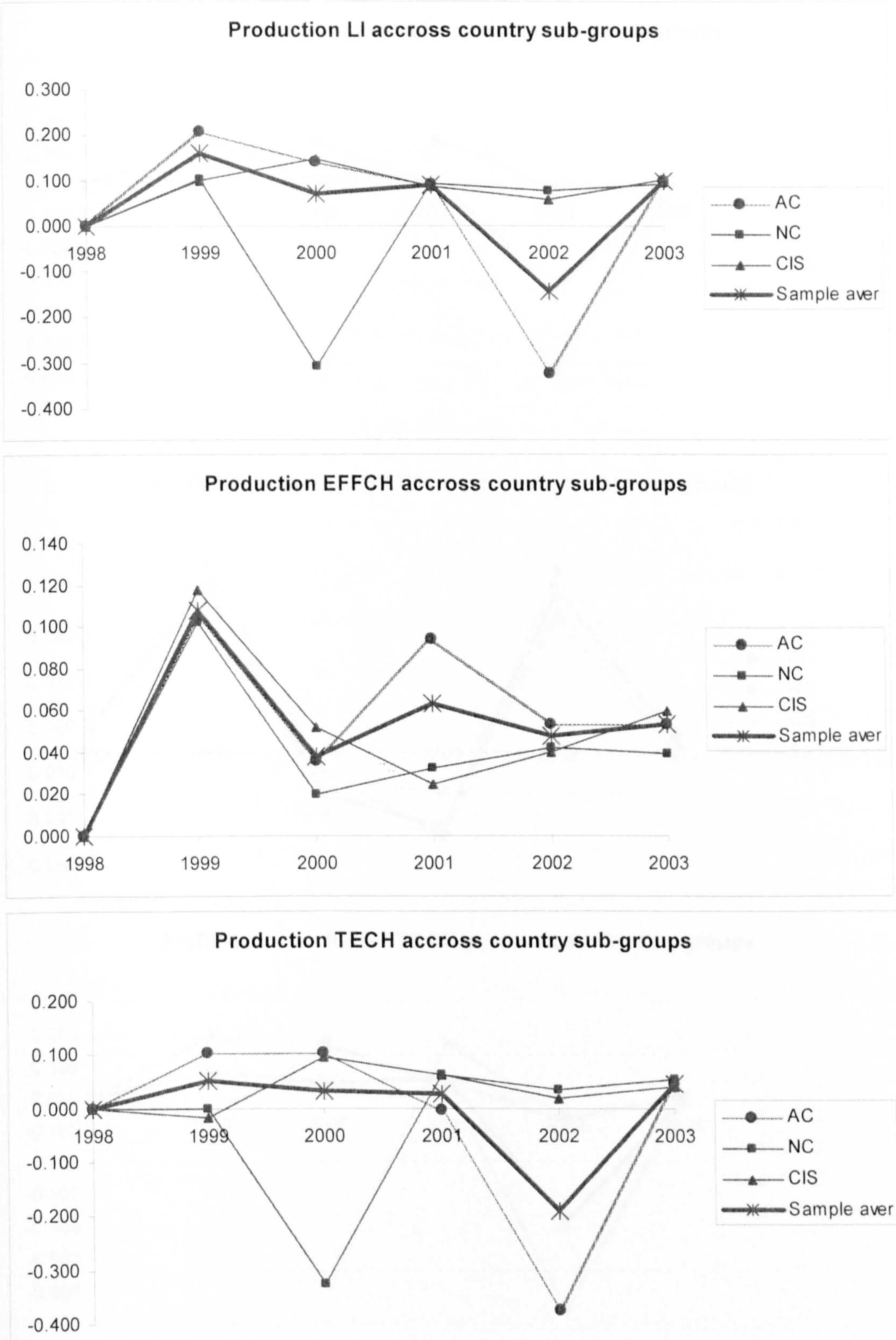
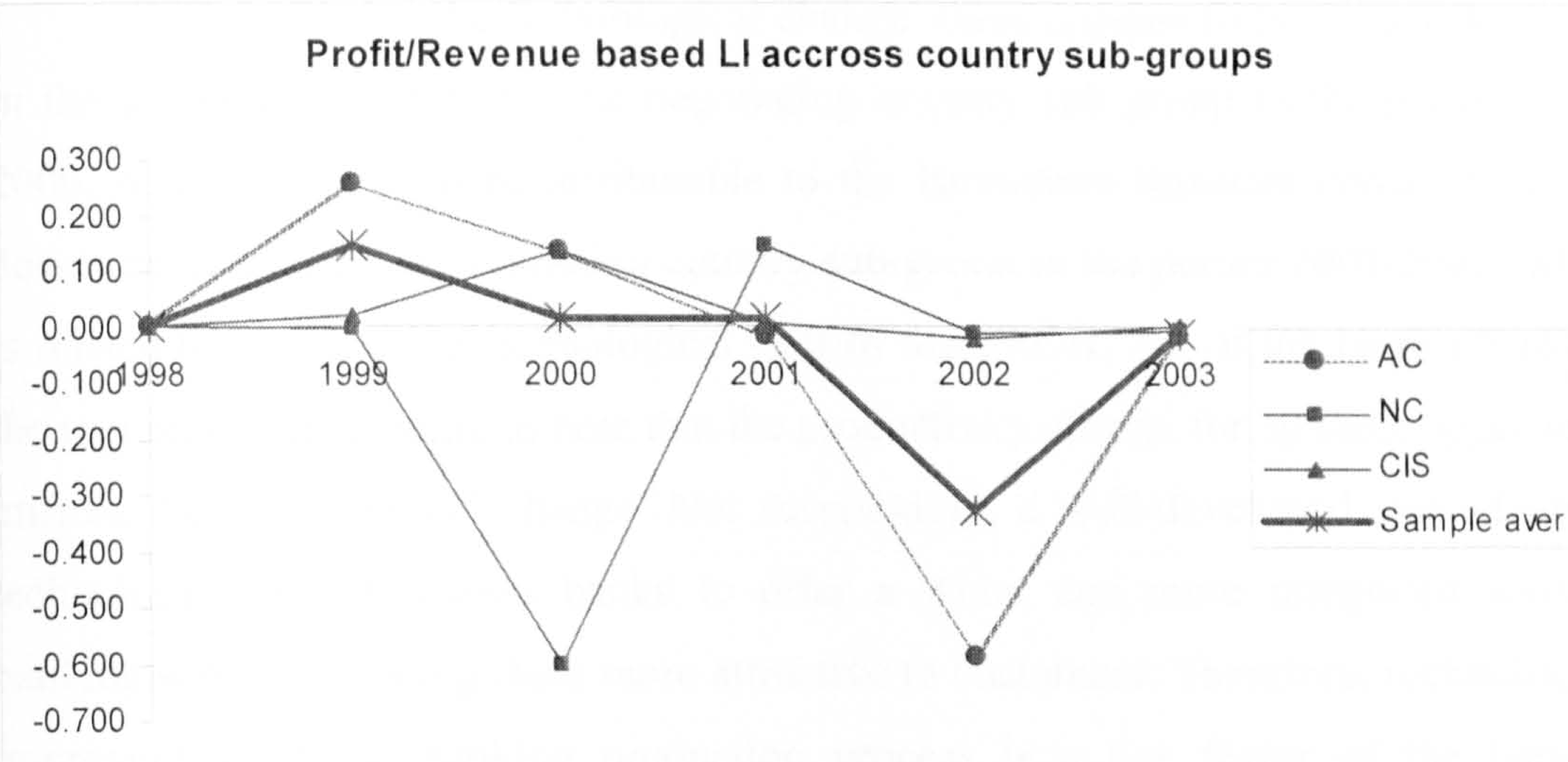
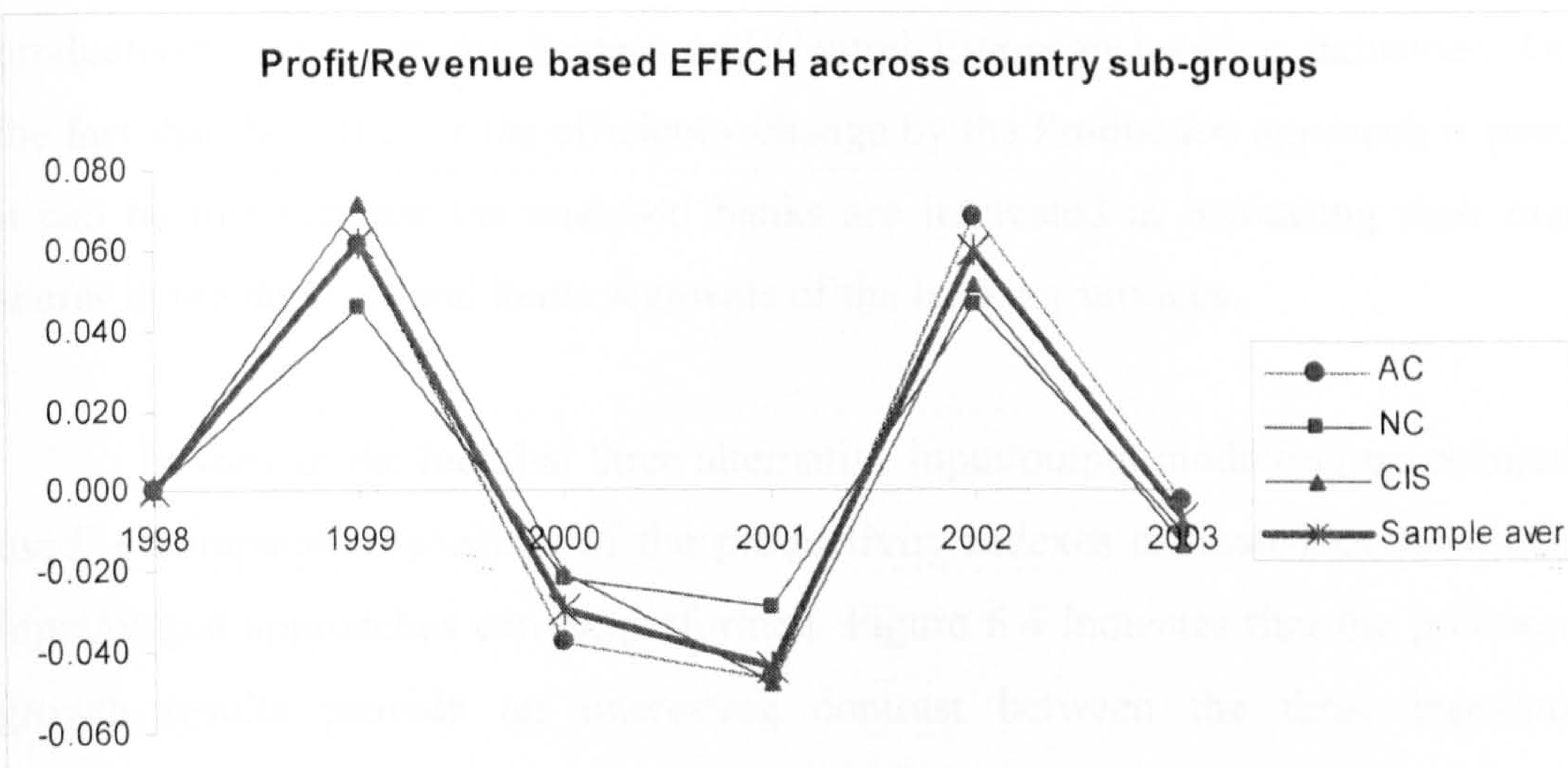


Figure 6. 2. Luenberger productivity index (LI), Efficiency Change (EFFCH) and Technological Change (TECH) across counties' sub-groups (Production approach).





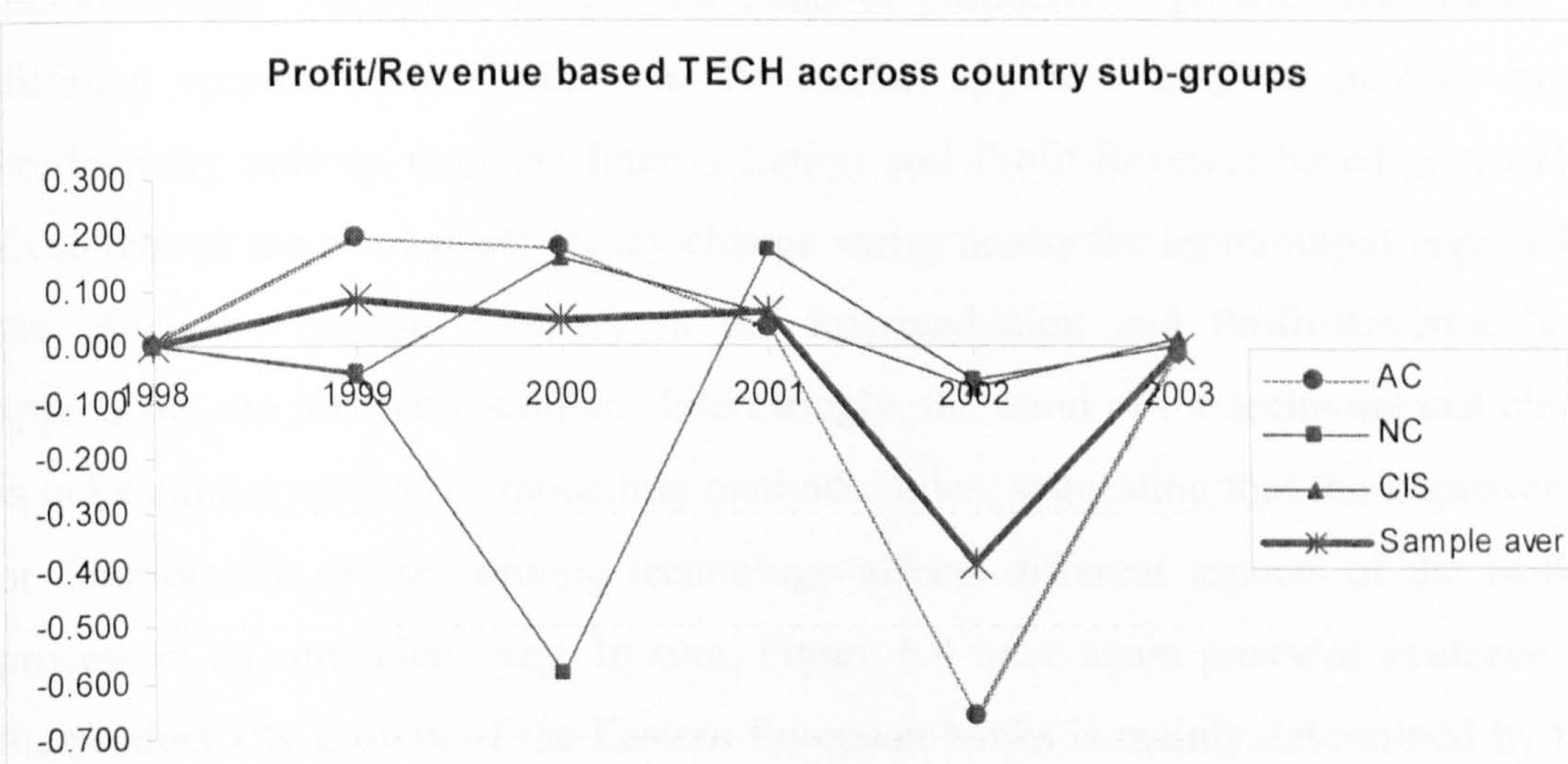


Figure 6. 3. Luenberger productivity index (LI), Efficiency Change (EFFCH) and Technological Change (TECH) across counties' sub-groups (Profit/Revenue-based approach).

With respect to the technological change, there appears to be a clear downturn in the technological shift for the negotiating country sub-group in the period 1999-2000, which is likely to be attributable to the Romanian financial crisis. A similar downturn is seen for the accession country sub-group in the period 2001-2002, which is related to the negative technological shift of the CSOB, one of the largest banks in the region. It is interesting to note that the productivity change for all three approaches mirrors the technological change. Not surprisingly, a well-developed and advanced technology platform allows banks to offer a wider and more integrated level of banking services, making them more attractive to customers. Therefore, technological improvement of the banking production process is a key factor of the banking productivity growth in the Eastern and Central European banking industries. Given the fact that the trend for the efficiency change by the Production approach is positive it can be inferred that the analysed banks are interested in increasing their market shares in the deposits and loans segments of the banking services.

In view of the fact that three alternative input/output modelling procedures are used, a comparative analysis of the productivity indexes estimated by the different input/output approaches can be performed. Figure 6.4 indicates that the productivity growth results provide an interesting contrast between the three input/output methodologies. Although the general trend of productivity growth reported by the different approaches is similar, the Production approach tends to produce higher productivity indexes than the Intermediation and Profit/Revenue based approaches. Even though the average efficiency change varies across the input/output approaches, the efficiency change tendency in the Intermediation and Profit/Revenue based approaches are relatively similar. Interestingly, the trend of the technological change is quite similar across the modelling methodologies, suggesting that the improvement or deterioration of the banking technology affects different aspects of the banking process in an equivalent way. In sum, Figure 6.4 once again provides evidence that the productivity growth of the Eastern European banks is mainly determined by their technological advancement.

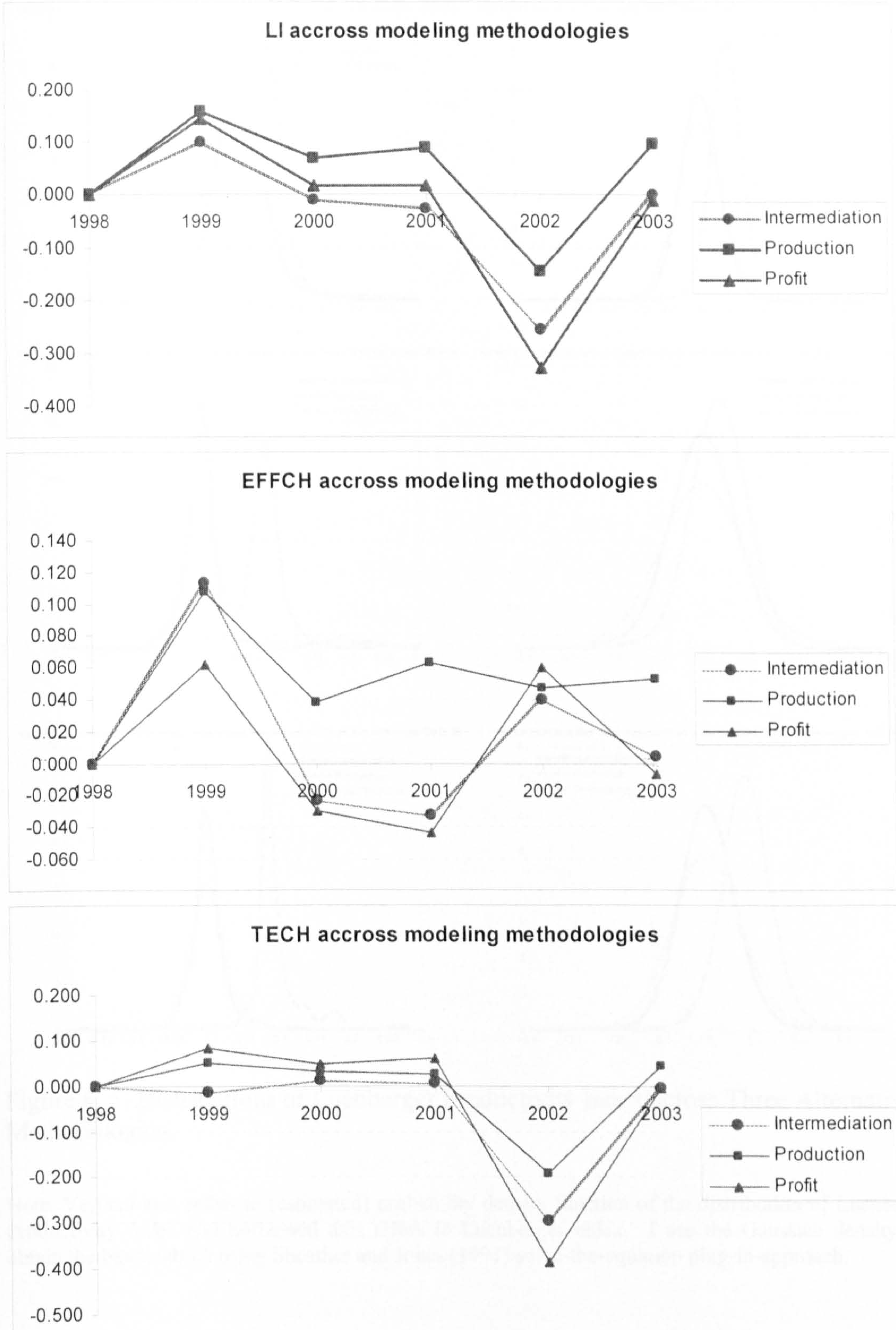


Figure 6. 4. Luenberger productivity index (LI), Efficiency Change (EFFCH) and Technological Change (TECH) across modelling methodologies.

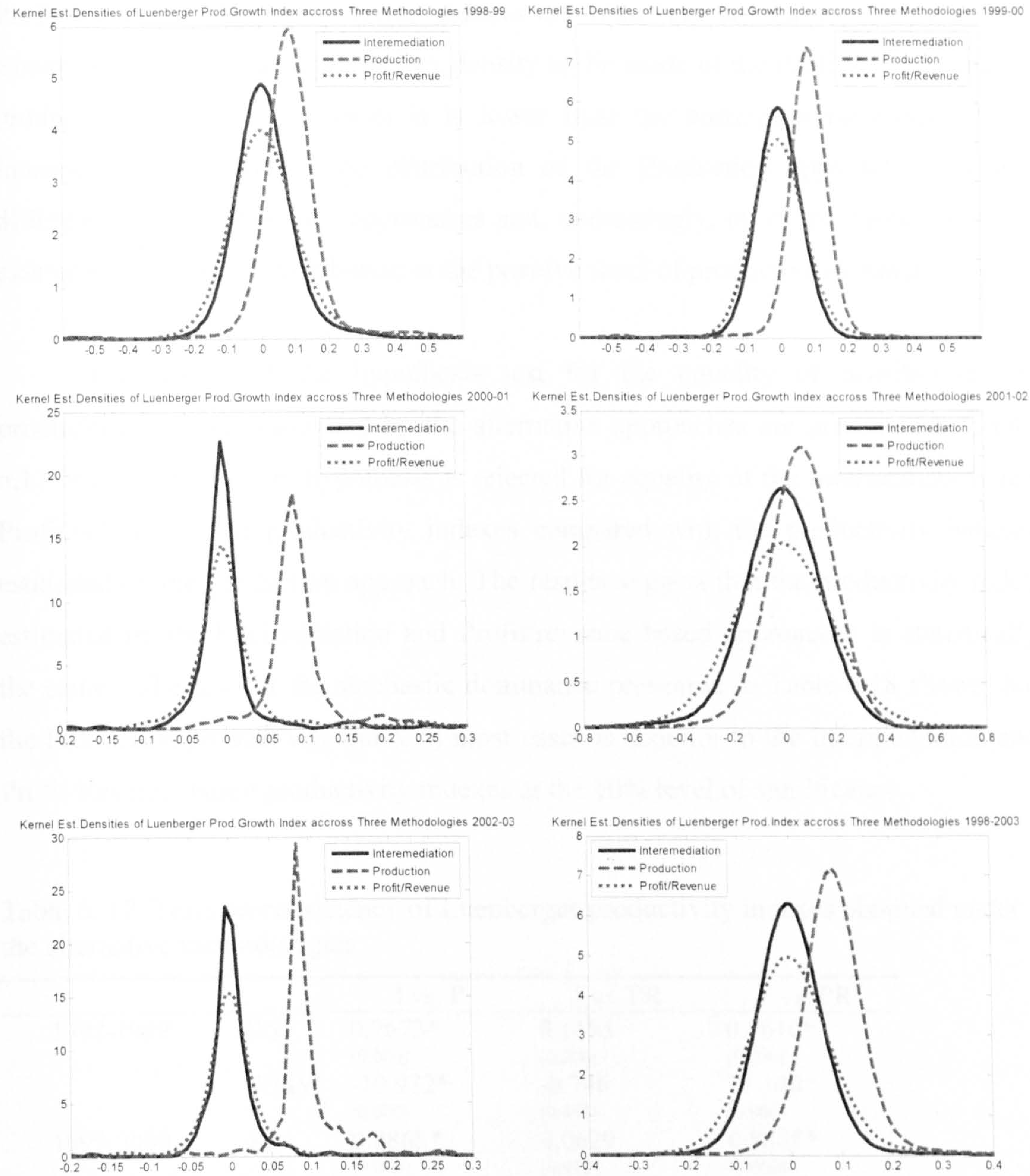


Figure 6. 5. Distributions of Luenberger Productivity Index across Three Alternative Methodologies.

Note. Vertical axis refers to (estimated) probability density function of the distribution of Luenberger Productivity Index and horizontal axis refers to Luenberger index. I use the Gaussian density and obtain the bandwidth h using Sheather and Jones (1991) solve-the-equation plug-in-approach.

In statistically analysing the consistency of the Luenberger productivity index across the alternative modelling methodologies, an analysis of the distributions is also undertaken. Figure 6.5 shows the kernel density estimators which are used to approximate the distributions of the Luenberger productivity index for the different input/output approaches. The estimated distributions of the Intermediation and

Profit/Revenue based productivity indexes are relatively similar for all years. An exception is the estimated probability density at the mode of the Profit/Revenue based productivity index; in all cases it is lower than the corresponding mode of the Intermediation approach. The distribution of the Production approach is clearly different from the other two approaches and, interestingly, in all the cases it has the estimated mode of the distribution at the positive level of productivity change.

The results of the hypothesis test for the equality of distributions of productivity indexes estimated by the alternative approaches are presented in Table 6.17. As shown, the null hypothesis is rejected for equality of the Intermediation and Profit/revenue based productivity indexes compared with the productivity indexes estimated by the Production approach. The results suggest that the productivity index estimated by the Intermediation and Profit/revenue based approaches is statistically the same. The test for the stochastic dominance presented in Table 6.18 shows that the Production productivity index in most cases is superior to the Intermediation and Profit/Revenue based productivity indexes at the 10% level of significance.

Table 6. 17. Tests on consistency of Luenberger productivity indexes obtained under the alternative methodologies

		I vs. P	I vs. PR	P vs. PR
1998-1999	KS	0.7673* (0.000)	0.1195 (0.206)	0.7610* (0.000)
	WMW	-10.972* (0.000)	-0.746 (0.455)	11.140* (0.000)
1999-2000	KS	0.8868* (0.000)	0.0629 (0.912)	0.8868* (0.000)
	WMW	-13.547* (0.000)	-0.564 (0.573)	13.004* (0.000)
2000-2001	KS	0.8616* (0.000)	0.1132 (0.260)	0.8113* (0.000)
	WMW	-13.011* (0.000)	0.901 (0.367)	11.926* (0.000)
2001-2002	KS	0.8302* (0.000)	0.0755 (0.756)	0.8050* (0.000)
	WMW	-12.438* (0.000)	-0.825 (0.409)	11.939* (0.000)
2002-2003	KS	0.8994* (0.000)	0.0943 (0.479)	0.8742* (0.000)
	WMW	-13.785* (0.000)	0.202 (0.840)	13.596* (0.000)

Notes. (I) Intermediation Approach, (PR) Profit/Revenue Approach, (P) Production Approach. (KS) Kolmogorov-Smirnov test (D-value, p-value in brackets), (WMW) Wilcoxon-Mann-Whitney test (W* value, p-value in brackets). Statistical significance: * statistically significant at 5% level.

Table 6. 18. Probabilities of stochastic dominance of productivity indexes calculated by different input/output methodologies (Wilcoxon-Mann-Whitney test)

	$H_0 - F^I(LI^I) > F^P(EFF^P)$ $H1$ – not $H0$	$H_0 - F^{PR}(LI^{PRI}) > F^I(EFF^I)$ $H1$ – not $H0$	$H_0 - F^{PR}(LI^{PRI}) > F^P(EFF^P)$ $H1$ – not $H0$
1998-1999	0.144	0.476	0.139
1999-2000	0.061*	0.482	0.078*
2000-2001	0.078*	0.529	0.113
2001-2002	0.097*	0.473	0.113
2002-2003	0.053*	0.507	0.059*

Note. (I) Intermediation Approach, (PR) Profit/Revenue Approach, (P) Production Approach.
Statistical significance: * statistically significant at 10% level.

The stochastic kernel results, describing the intra-distribution mobility, are shown in Figure 6.6. Specifically, the graphs represent bivariate density functions estimates for the productivity indexes estimated using different input/output approaches. Each coordinate direction represents a Luenberger index estimated by the particular modelling methodology and the stochastic kernels attempt to describe the transition of the productivity level from one modelling methodology to another. Looking at the graphs and their contour plots, it can be inferred that moderate mobility takes place across the approaches, since the probability mass is not concentrated along the positively sloped diagonal in the contour plots. Although the stochastic kernel of the Intermediation and Profit/Revenue based productivity indexes ignore the positive sloped diagonal, its mode is located on it. Intuitively, this means that if the bank reported for the level of the Intermediation productivity index has the highest frequency (roughly in the range -0.05 and 0.05), the Profit/Revenue based productivity index has a very high probability of being in the same range.

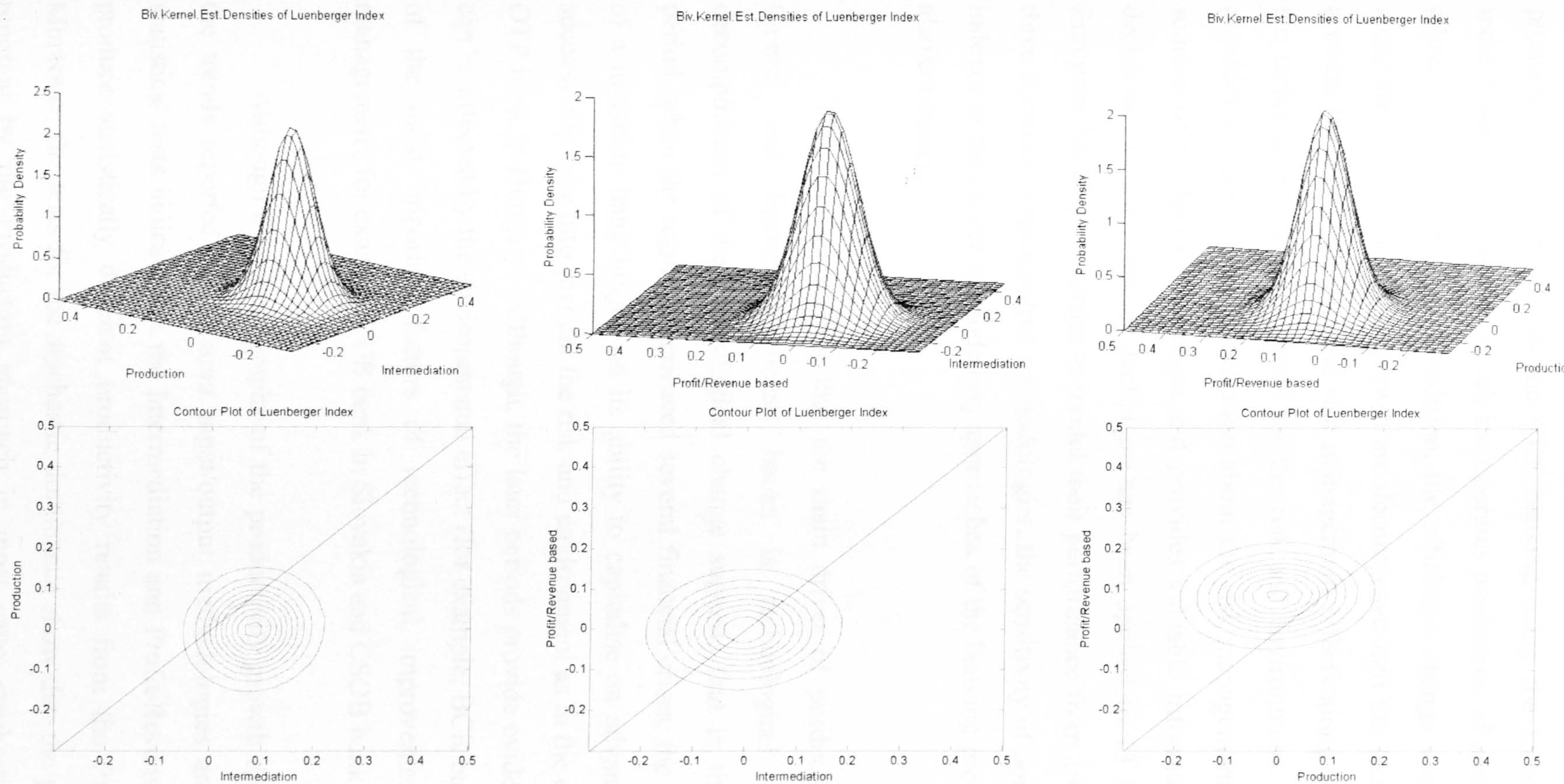


Figure 6. 6. Luenberger productivity transition across different input/output definitions.
Note. The bivariate Gaussian kernels are used and the bandwidths are calculated according to the solve-the-equation plug-in approach for bivariate Gaussian kernel, based on Wand and Jones (1994).

6.6. Conclusions

This chapter presents a non-radial DEA approach to measuring the productivity performance of the CEE banking using the Luenberger productivity index based on technology which incorporates production of undesirable outputs and allows for negative data. In addition, the efficiency change and technological shift components of productivity growth are decomposed into the factors which take into account the environmental and risk management effects along with the variation of the technical efficiency adjusted for the risk and environment. This decomposition provides complementary information about the risk management and environmental sources of productivity changes and provides valuable information for managerial decisions. As the proposed technique has been applied to 13 Central and Eastern European banking industries to model their performance from 1998 to 2003 utilising three alternative input/output methodologies, the sensitivity of non-radial productivity indexes to the choice of modelling approaches of the banking production process was also conducted.

The findings suggest that the main driver of productivity change in the Central and Eastern European banks is technological improvement. The decomposition of the technological change suggests that in the beginning of the period, when the region experienced several financial crises, the productivity growth of a transition bank hinged on its ability to capitalise on advanced technology and successfully take into account the risk and environment as in the case, for instance, of OTP bank in Hungary. Although, the later periods provide evidence that technology can be affected by the environmental effect (for example, BCR bank in Romania) one of the most important factors of technological improvement/ decline is risk management, for example VUB bank in Slovakia and CSOB bank in Czech Republic.

Although the visual graphs of the productivity growth dynamics suggest that the trends reported by different input/output methodologies are quite similar, the statistical tests indicate that the Intermediation and Profit/Revenue based approaches produce statistically different productivity results from the Production approach. Moreover, the tests for the stochastic dominance show that the productivity indexes reported by the Production approach in most cases stochastically dominate the

Intermediation and Profit/Revenue based results with 90% confidence. In addition, the stochastic kernel density estimates of the productivity results, which attempt to identify the changes in the levels of the productivity growth/decline when different approaches are used, show that a moderate transition of the productivity levels takes place when the alternative input/output methodology are utilised.

CHAPTER SEVEN: CONCLUSIONS

The analysis of this thesis is aimed at filling a major gap in both the theoretical and empirical literature on banking efficiency and productivity analysis. It focuses on the risk and environmental dimensions of bank efficiency and productivity and their sensitivity to the choice of the input/output methodology used. In particular, the main contributions of this thesis are as follows. First, undesirable output technologies can be classified according to two categories: technological and behavioural. Second, a non-radial efficiency measurement model of production technology with undesirable output(s) is developed, where the outputs (both desirable and undesirable) can be negative. Third, a new way of incorporating banking risk into the efficiency and productivity analysis as an undesirable output and its decomposition is provided. Fourth, the Luenberger productivity index for undesirable output technology with negative outputs and a decomposition of productivity components into the factors determined by the risk management and environmental factors are suggested. Fifth, a meta-analysis of input/output variables and approaches in banking efficiency and productivity studies is given. Sixth, statistical tests of the sensitivity of efficiency measures, return parameters and productivity indexes to the choice of input/output methodology are analysed. However, perhaps the main value of the thesis is its application to the Eastern European transition banking.

Before outlining the directions for further work, unambiguous conclusions have emerged with regard to the modelling methodologies in the banking efficiency and productivity analysis. First, as meta-analysis showed, the chosen approach and the definition of the input and output variables mainly rely on theoretical concepts of and the choice of a particular approach in describing the banking production process is not affected by the availability of particular input or output variable information. However, the empirical literature uses different specifications for the inputs and outputs within the same input/output approach. Here, the efficiency and productivity measures and the return parameters in the defined models for the undesirable output technology with negative outputs estimated utilising three alternative methodologies, namely Intermediation, Production and Profit/Revenue, are statistically compared. In general, the statistical test and density analysis indicate that different approaches in the specification of inputs and outputs of banking production can produce significantly different efficiency scores, although the inter-density mobility analysis of relative efficiency using stochastic kernels suggests banks do not change their relative position to the mean. On the other hand, the stochastic analysis of the returns parameters and productivity indexes of the banks implies that the conclusions regarding the returns of the banks is sensitive to the choice of particular approaches.

The empirical results also suggest that of the Central and Eastern European countries analysed Czech, Hungarian and Polish banks are the most technically efficient banks. The risk decomposition suggests that banking risk is generally affected by external environmental factors. The environmental effect component of banking efficiency estimated by the Production approach reflects possible effects of financial distress on banking efficiency scores in Romania for the year 2000. This is not supported by the Intermediation approach and is supported empirically by the Profit/Revenue approach for the years 2002-2003. Furthermore, both the LLP decomposition and Risk Management effect component of banking efficiency calculated by three methodologies suggest that in 2001 banks in most countries manage risk worse than in other years, which is a possible reflection of the 'Disaster myopia' phenomenon in banking. The productivity analysis implies that the main driver of productivity change in the Central and Eastern European banks is technological improvement. The decomposition of the technological change suggests that one of the most important factors of technological improvement/decline in CEE transition banking relates to risk management.

The analysis presented in this thesis offers considerable opportunities for further research. The non-radial efficiency technique defined in the thesis reduces the impact of slacks on the efficiency measure. It would also be interesting to consider the Slack Based Model suggested by Tone (2001) in the analysis of CEE banking with a theoretical discussion of important properties of SBM measures: continuity and commensurability. Another research direction could include constructing the CEE regional frontier in order to see the relationship between economic growth and banking sector development in transition following the recent discussion in the economic theory literature (Rajan and Zingales, 2003; and Sylla, 2006). Finally, a theoretical area of research also deserving additional attention concerns the comparison of efficiency scores. Simar and Zelenyuk (2006) suggested a bootstrap methodology to test the equality of efficiency scores' distribution. However, there is a considerable lack of statistical methodologies to test the stochastic dominance of efficiency scores of two groups of DMUs or efficiency measures estimated using alternative input/output approaches.

APPENDIX A. PRUDENTIAL REQUIREMENTS IN THE ANALYZED CENTRAL AND EASTERN EUROPEAN BANKING INDUSTRIES

This Appendix gives an analytical overview of the evolution of the prudential regulations in the thirteen analyzed banking sectors on the Central and Eastern Europe, namely Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, the Moldova, Poland, Romania, Russia, Slovakia, Slovenia and Ukraine. The survey focuses on the overview of the countries' banking regulations and supervisions with a particular emphasis on the regulations on the minimum capital requirement, capital adequacy, credit requirements, loan classification, foreign currency open position, required reserves, investment regulations and other requirements. The countries' banking regulations and supervisions are discussed in the alphabetical order.

A.1. Banking regulation in Croatia

Central bank: The HNB (Hrvatska Narodna Banka - Croatian National Bank) is the central bank of the Republic of Croatia. It is responsible for the issuing/revoking licenses for the banks and supervision of banks. The Banking Law, which is available at http://www.hnb.hr/propisi/zakoni-htm-pdf/ezbanke-7-2002.pdf, sets out the broad principles underlying the HNB's supervision of the banking system. Supervision is carried out through on-site inspections and by the provision of relevant financial and other data by banks to the HNB. The Management and Supervisory Boards of a bank may challenge the findings set out in the resulting HNB report.

Minimum Capital: The minimum capital requirement for a bank is HRK 20mn. Depending on the amount of capital, banks may carry out a wider range of banking activities.

Capital Adequacy: Banks are required to maintain their liable capital above 10% of risk-weighted assets as defined by the BIS, and are obliged to submit to the HNB quarterly reports on this capital ratio.

Credit Requirement: Exposure to a single borrower may not exceed 25% of capital. Exposure to a shareholder owning more than 3% of the bank's capital may not exceed 5% of capital. Aggregate exposure to shareholders owning more than 5% of the bank's capital and to associates of those shareholders must not exceed 25% of capital. Aggregate large exposures (those which individually exceed 10% of capital) must not exceed 400% of capital. Exposures to the Republic of Croatia, the HNB and the Croatian Guarantee Agency are exempt from the limits set out above.

Credit provision: The loan classification is given in Table A1.

Table A1. The loan classification by Croatian banking regulation.

Loan Categories	Days Overdue	Provision rate
"A"	Current	0%
"B"	30-60 days overdue	10%-20%
"C"	61-180 days overdue	50%
"D"	181-365 days overdue	60%-90%
"E"	Over 365 days overdue	100%

Source: World Bank.

Liquidity: The regulation requires 87% of all liabilities with maturity of less than one year be invested in assets maturing within one year (World Bank).

Foreign currency open position: Banks must keep a ratio of short-term foreign exchange assets to short-term foreign exchange liabilities at the level least than 53%. Additionally, the net open foreign exchange position must not exceed 30% of liable capital.

Required reserves: According to the HNB Banks Bulletin, in 2000 the reserve requirements are 23.5% and reduced from the level of 28.5%.

Investment regulations: A bank must notify the NHB of all shareholders with an individual equity holding exceeding 10% of total voting shares. A bank must seek approval from the CNB before acquiring or ceding a stake in another bank or company that is greater than 10 percent of the bank's liable capital. A bank's investments in land, buildings, equipment, and office facilities may not exceed 30% of liable capital. The sum of a bank's total investments in land, buildings, plant, office equipment, and owner's equity in banks and other companies may not exceed 70% of liable capital.

Other requirements: According to World Bank, the State Agency for Savings Deposit Insurance and Bank Rehabilitation set up a deposit insurance scheme in July 1997. According to the scheme, all banks were obliged to contribute an initial 0.6% of total retail deposits and an initial 0.3% of their equity to the fund. Thereafter, quarterly contributions are made at 0.2% of the average balance of insured retail deposits. Retail deposits were insured, fully up to HRK 30,000, whereas amounts between HRK 30,000 and HRK 50,000 were 75% covered. Balances exceeding HRK 50,000 were not covered under this scheme. The summary of prudential regulation in Croatian banking industry is given in Table A2.

Table A2. Summary of prudential regulations in Croatia

	1996	1997	1998	1999	2000
Minimum capital (Depending on the license, i.e. limited or fully licensed)	DM 5 mln DM 10mln	DM 5 mln DM 10 mln	DM 5 mln DM 15 mln	HRK 20 bln HRK 40 bln HRK 60 bln	HRK 20 bln HRK 40 bln HRK 60 bln
Minimum capital adequacy ratio, %	8	8	8	10	10
Maximum exposure to single borrower, % of capital	30	30	30	25	25
Maximum total large exposures, % of capital	200	200	200	400	400
Maximum related party lending, % of capital			30	25	
Max. Open foreign exchange position, % of capital			30	30	
Maximum investment in one non-financial enterprise, % of capital				10	
Maximum investment in non-financial enterprises, % of capital				70	
Minimum reserve with the National bank, % of deposits	31	31	30	29.5	23.5

Source: World Bank, HNB.

A.2. Banking regulation in Czech Republic

The central bank of Czech Republic is Czech National Bank (CNB), and it defines the prudential framework for banking business and banks' activities are governed by Act No. 21/1992. From 2002, banks required to have their internal risk management systems audited. Additionally, CNB has instructed each bank to disclose a quarterly survey of its activities and results. Moreover, in 2002 CNB introduced minimum requirements for disclosure of information by banks and foreign bank branches in order to promote the safety and soundness of the banking system by increasing its transparency.

The consent of the CNB is required for foreign capital participation in an existing bank, for merger, amalgamation or split of the bank or reduction in the bank's authorised capital unless it results from a loss, and for transfer of more than 15% of the bank's equity through one or more transactions to any one or more parties.

Minimum Capital: The minimum regulatory capital requirements for banks and foreign bank branches was raised in January 1994 from CZK 300mn to CZK 500mn necessary for the granting of a banking license, which payable to the CNB in cash to ensure the capital is real.

Capital Adequacy: The law on solvency requirements was amended in 1991, requiring banks to have 8% BIS solvency ratios by end-1996. Moreover, according to 2005 Annual report on banking supervision, banks will be allowed to use special approaches based on advanced mathematical models for calculating the capital requirements for credit risk (IRB approach) and the newly introduced operational risk (AMA approach) under the revised capital adequacy framework (Basel II, or the revised EU directives 2001/12/EC and 93/6/EEC). However, the implementation of these approaches is still on earlier stages: pre-validation of the IRB approach was conducted in four banks, while the AMA approach was addressed by CNB staff in three banks. Nevertheless, a capital ratio of 8% of the value of risk-weighted assets is still considered as an absolute minimum.

Credit Requirement: According to the Provision of the CNB No.2 of 3.07.2002, the large credit exposure limits are subject to the following guidelines:

a) Credit risk exposure to one person or to any group of connected counterparties is limited to 25% of the bank's capital.

b) Credit risk exposure of all counterparties connected to a bank, may not exceed 20% of the bank's capital.

Credit provision: The loan classification is given in Table A3.

Table A3. The loan classification by Czech banking regulation.

Loan Categories for Loss Provisioning	Days Overdue	Provision rate
Standard	less than 1 month overdue	0%
Watch	1-3 months overdue, rescheduled before 6 months	5%
Substandard	3-6 months overdue, rescheduled within the last 6 months	20%
Doubtful	6 months to 1 year overdue	50%
Loss	overdue for over 1 year; debtor under bankruptcy or settlement	100%

Source: World Bank.

Foreign currency open position: An amendment to the CNB Provision, effective from January 1996, increased the total limit for the open foreign currency position for banks and branches of foreign banks to 20% from 15% of bank capital. Additionally a 15% of capital limit was introduced for open bank positions in individual convertible currencies.

Required reserves: At the start of 1997, the CNB cut the ratio from 11.5% to 9.5%, and in mid-1998 it formulated a medium-term programme to reduce it further. This was done in three steps: to 7.5% effective 30 July 1998; to 5.0% effective 28 January 1999; and to 2.0% effective 7 October 1999. Simultaneously, the preferential 4% ratio for building societies and Českomoravská záruční a rozvojová banka (the Czech-Moravian Guarantee and Development Bank) was abolished. A uniform ratio applies to all the credit institutions in the reserve requirement regime (CNB)[55].

Investment regulations: Equity investment in an enterprise cannot exceed 15% of the bank's capital, and the aggregate of such investments cannot exceed 60% of the bank's capital. The consent of the CNB is required to buy shares, or acquire interests which total more than 10% of the equity of any legal person which is not a bank; or to buy shares, or acquire other interests, in legal persons of a non-bank nature which total more than 25% of the bank's equity and reserves (World Bank).

The summary of prudential regulation in Czech Republic banking system is given in Table A4.

[55] More details can be found at http://www.cnb.cz/www.cnb.cz/en/monetary_policy/inflation_reports/boxes_annexes/zpinflace_01_april_a2.html.

Table A4. Summary of prudential regulation in Czech Republic

	1995	1996	1997	1998	1999
Minimum Capital	CZK 500 mln				
Minimum capital adequacy ratio, %	6.25	6.25	8	8	8
Minimum Liquidity ratios, %					
Maximum exposure to single borrower, % of capital	40	25	25	25	25
Maximum total large exposures, % of capital		230	230	230	230
Maximum related party lending, % of capital		20	20	20	20
Max. Open foreign exchange position, % of capital		20	20	20	20
Maximum investment in one non-financial enterprise, % of capital		10	10	15	15
Maximum investment in non-financial enterprises, % of capital		25	25	60	60
Minimum reserve with the National bank, % of deposits		11.5	9.5	7.5	2.0

Source: World Bank.

A.3. Banking regulation in Estonia

Under the "Eesti Pank Act" (Eesti Pank – the central bank of Estonia)[56], the EP is responsible for regulating financial institutions in Estonia. Off-site inspection is carried out constantly, based on financial analysis carried out using reports presented by banks. On-site inspections are conducted as often as needed, but at least once every two years and prudential regulations are strictly enforced (Credit Institutions Act).

According to World Bank, the EP exercises the supervision of all credit institutions in Estonia. A Supervisory Committee was established at EP in October 1993, and new reporting procedures and forms for banks were introduced. Banking supervision, in particular, is responsible for monitoring adherence by banks to EP prudential regulations in the following areas:

- loan classifying and provisioning
- the minimum size of own funds
- liquidity
- foreign exchange risks
- high customer risk concentration
- money laundering
- internal audit systems and procedures
- capital adequacy
- reserve requirement
- transactions with the related persons
- investment restrictions

[56] The "Eesti Pank Act" is available at http://www.legaltext.ee/text/en/X70022.htm.

Prudential regulations in Estonia have been amended to follow corresponding EU directives, for instance, the **Minimum Capital** requirement for a bank is the Kroon equivalent of EUR 5mn, payable only in cash. The previous requirement was EEK 60mn until 1 January 1998, EEK 75mn thereafter until 1 January 2000.

Capital Adequacy: The minimum ratio was raised on October 1, 1997 to 10% (from 8%). Four months earlier the risk weighting of loans to local government was raised to 100% from 50%. As from July 1998, the 10% capital adequacy ratio applies to banks on a consolidated basis. In Feb 2005 (Decree No 2), the minimum ratio of capital requirement is set at the level of 8%.

Credit Requirement: According to Appendix 3 of Decree No 12 (July 2002) of the Governor of EP:

- Exposure to a single borrower, or any group of connected borrowers, cannot exceed 25% of a bank's capital;
- Exposure to a bank's own subsidiary, its parent company, or other subsidiary of the parent cannot exceed 20% of the bank's capital;
- Total large exposures (those exceeding 10% of capital) should not exceed 800% of capital.

Credit Provision: Credit institutions should establish internal methodologies and policies regarding classifying overdue loans and the appropriate allocation of reserves for losses. Established internal polices and methodologies are subject to regulatory review as well as reviewed as part of the external audit.

Liquidity: Three liquidity levels are monitored: Liquidity I is the ratio of cash and assets convertible to cash within two banking days to liabilities which can be met within two banking days. Liquidity II is the ratio of highly liquid assets to short term liabilities. The minimum Liquidity II ratio is set at 35%. Liquidity III is the ratio of highly liquid assets to total balance sheet and certain off-balance sheet liabilities. Liquidity should also be monitored based on cash flow. Assets and liabilities should be structured according to the remaining maturity, and the net positions monitored (World Bank).

Foreign currency open position: Under the guidelines of EP (Decree No 8, May 2005), the net open position of a single freely convertible currency must not exceed 15% (soft currencies must not exceed 5%) of bank's own funds. However, these limits dot not apply to the currencies of the countries joined to the European Monetary System's exchange rate mechanism ERM II.

Required reserves: In order to increase liquidity buffers, following the tight liquidity situation at the end of 1997, the central bank decided to raise the reserve requirement to 13% from 10% of demand, time and savings deposits and other liabilities of the same character (including securities). According to EP Governor's Decree No 6 (July 2006), the new general reserve requirement rate is 15%.

Investment regulations: A credit institution cannot invest in an unlimited liability entity. Equity investment in an enterprise cannot exceed 15% of the bank's capital, and the aggregate of such investments cannot exceed 60% of the bank's capital. These restrictions do not apply to holdings in other credit or financial institutions. Total investments based on balance sheet value cannot exceed the bank's capital.

Summary of prudential regulations is given in the Table A5.

Table A5. Summary of prudential regulation in Estonia

	1995	*1996*	*1997*	*1998*	*1999*	*2006*
Minimum Capital	EEK 25 mln	EEK 50 mln	EEK 60 mln	EEK 75 mln	EUR 5 mln	EUR 5 mln
Minimum capital adequacy ratio, %	8	8	10	10	10	8
Maximum exposure to single borrower, % of capital	25	25	25	25	25	25
Maximum total large exposures, % of capital	800	800	800	800	800	800
Maximum related party lending, % of capital	25	25	25	25	25	25
Max. Open foreign exchange position, % of capital			30	30	30	30
Maximum investment in one non-financial enterprise, % of capital	15	15	15	15	15	15
Maximum investment in non-financial enterprises, % of capital	60	60	60	60	60	60
Minimum reserve with the National bank, % of deposits	10	10	10	13	13	15

Source: World Bank, EP web-site.

A.4. Banking regulation in Hungary

The Magyar Nemzeti Bank (MNB), as according to Act LVIII of 2001, is the central bank of the Republic of Hungary. It will promote the stability of the financial system and development and smooth conduct of policies related to the prudential supervision of the financial system.

In accordance with Grigorian and Manole (2006), licensing requirements and regulations were tightened in the Hungarian banking sector. The law introduced stricter requirements for bank managers and members of the board, doubled the minimum registered capital for banks from Ft1 billion to Ft 2 billion, and added a second step to the approval process at the Hungarian Banking and Capital Markets Supervision Agency (HBCMS). Agency is also responsible for licensing securities firms.

Minimum Capital: The Credit Institutions Act raised the minimum registered capital upon establishment as follows: for Banks - HUF 2bn; Co-operatives - HUF100mn; Financial undertakings - HUF20mn.

Capital Adequacy: The requirements set the minimum capital adequacy ratio of a credit institution at 8%.

Credit Requirement: No single exposure may exceed 25% of bank's capital. The total value of all large exposures, explicitly those which are exceeding 10% of bank's capital, cannot exceed eight times bank's capital.

Liquidity: At least 10% of average monthly total assets must be. It remains flexible as to the way of provisioning for liquidity: there are no portfolio liquidity requirements, whilst the obligation to maintain liquidity resides in an "adequate" matching of the maturity and amounts of assets and liabilities. This leaves it to the HBCMS to assess the "adequacy" of institutions' individual liquidity management (World Bank)

The summary of prudential regulation in Hungarian banking system is presented in the Table A6.

Table A6. Summary of prudential regulation in Hungary

	1995	*1996*	*1997*	*1998*	*1999*
Minimum Capital	HUF 1 bn	HUF 1 bn	HUF 2 bn	HUF 2 bn	HUF 2 bn
Minimum capital adequacy ratio, %	8	8	8	8	8
Minimum Liquidity ratios, %		10	10	10	10

Maximum exposure to single borrower, % of capital	25	25	25	25	25
Maximum total large exposures, % of capital	800	800	800	800	800
Max. Open foreign exchange position, % of capital		30	30	30	30
Maximum investment in one non-financial enterprise, % of capital	40	15	15	15	15
Maximum investment in non-financial enterprises, % of capital		100	100	100	60

Source: World Bank.

A.5. Banking regulation in Latvia

The principal basis of banking legislation is the Law "On Credit Institutions", adopted in 1995. The legislative framework for banking meets EU requirements and in some respects exceeds them (World Bank). The Bank of Latvia (the central of the Republic of Latvia) had already started to implement the most important EU directives concerning the banking sector. As in Article 10 of the Law "On the Bank of Latvia" (May 1992), the Bank of Latvia performs supervision as well as on-site and off-site examinations of credit

Minimum Capital: The banks must have a minimum capital base of at least 5mn Euros in the LVL equivalent in accordance with the exchange rate established by the Bank of Latvia.

Credit Requirement: A credit institution's exposure is considered large if it exceeds 10% of own funds. According to the regulation, the total of large exposures may not exceed 800% of own funds while exposure to a single client or a group of connected clients may not exceed 25% of own funds. Moreover, any credit exposure to a non-related entity or group of non-related entities may not exceed 25% of credit institution's equity and the total credit exposure to all related parties may not exceed 15% equity. Table A7 reports the loan classification and the provision rate in Latvian banking. The summary of prudential regulation is given in Table A8.

Table A7. Loan classification in Latvia

Loan Categories for Loss Provisioning	Days Overdue	Provision rate
Standard	Performing	0%
Close-watch	Overdue < 30 days	10%
Substandard	Overdue 30 – 90 days	30%
Doubtful	Overdue > 90 days	60%
Loss	Lost loans	100%

Source: World Bank.

Table A8. Summary of prudential regulation in Latvia

	1996	*1997*	*1998*	*1999*
Minimum Capital	LVL 1 mln	LVL 1 mln	LVL 2 mln	EUR 5 mln
Minimum capital adequacy ratio, %	10	10	10	10
Minimum Liquidity ratios, %			30	30
Maximum exposure to single borrower, % of capital		25	25	25
Maximum total large exposures, % of capital		800	800	800
Maximum related party lending, % of capital		15	15	15
Max. Open foreign exchange position, % of capital		20	20	20
Maximum investment in one non-financial enterprise, % of capital		15	15	15
Maximum investment in non-financial enterprises, % of capital		60	60	60
Minimum reserve with the National bank, % of deposits	8	8		

Source: World Bank.

A.6. Banking regulation in Lithuania

The Bank of Lithuania (BOL) is the central bank of the Republic of Lithuania. According to World Bank, the BOL inspects banks, requires reports, issues rules and instructions, and applies various sanctions to banks violating any banking laws and regulations. However, according to the U.S. Department of Commerce, "Government policies do not interfere in the free flow of financial resources or the allocation of credit."[57]

Minimum Capital: The minimum capital requirement for all banks is EUR 5.0mn in LTL equivalent as of January 1, 1998, and increased from ECU 3.8mn ($4.6mn) as in line with EU rules.

Capital Adequacy: The capital adequacy requirement specifies that the ratio of eligible bank capital and risk-weighted assets and off-balance sheet liabilities may not be less than 8%.

Credit Requirement: The BOL lending requirements state that the maximum exposure to one borrower may not exceed 25% of the bank's capital. Amount of loans granted by the bank to its parent enterprise, other subsidiaries of the parent enterprise

[57] 2006 Index of Economic Freedom, http://www.heritage.org/research/features/index/country.cfm?id=Lithuania

or of the bank, may not exceed 75 per cent of bank capital for each borrower, if the BOL carries out consolidated supervision of the financial group as a whole. If the BOL does not carry out consolidated supervision of the financial group as a whole, the loan amount granted by the bank to its parent enterprise, other subsidiaries of the parent enterprise or of the bank, may not exceed 20 per cent of bank capital for each borrower. . In addition, lending to connected persons is limited to 20% of bank capital. Moreover, the large exposure ratio may not exceed 800 per cent of bank capital. The loan classification and their provision is given in Table A9.

Table A9. Loan classification in Lithuania

Loan Categories for Loss Provisioning	***Days Overdue***	***Provision rate***
Standard loans	Timely repayment, reliable financial position, adequately secured	0%
Watched loan	Overdue < 30 days, unstable/unknown financial position, not adequately secured	0%
Substandard loans	Overdue 31-90 days, deteriorating financial position, not adequately secured	20%
Doubtful loans	Overdue 91-180 days, not secured	40%
Bad loans	Overdue > 181 days, going bankrupt or in liquidation, collateral pledged to other creditor	100%

Source: World Bank.

Liquidity: Commercial banks are required to ensure at least a 30% liquidity ratio. This is calculated by dividing the bank's liquid assets by liabilities on each claim. This constrains banks' assets according to their liability allocations.

The maximum open position in foreign currency and precious metals: the overall open position in foreign currency (Euro position is excluded) may not exceed 25% of bank capital, and the ratio of the open position in one currency (Euro position is excluded) or precious metals may not exceed 15% of bank capital.

Required reserves: The reserve requirement rate is 6%. Zero reserve requirement rate is applied to the following: 1) deposits with initial maturity of over two years or with the redemption notice term specified in a relevant agreement of over two years; 2) debt securities issued with an initial maturity of over two years; and 3) repurchase agreements.

Investment regulations: The Law on Banks requires that total bank investment in the shares or capital of other companies may not exceed 60% of bank's capital, while investment in an individual company is limited to 15% of bank capital. These provisions are not applicable to investment in the shares and capital of such companies that are attributed to the type of enterprises engaged in credit and financial activities in the laws of the Republic of Lithuania and the legislation of the Bank of Lithuania. Banks are prohibited from acquiring shares in a company that holds a controlling interest in the bank, or become a co-owner of such a company.

The summary of prudential regulation in Lithuania is given in Table A10.

Table A10. Summary of prudential regulation in Lithuania

	1996	*1997*	*1998*	*1999*	*2006*
Minimum Capital		ECU 3.8 mln	ECU 5 mln	ECU 5 mln	ECU 5 mln
Minimum capital adequacy ratio, %		10	10	10	8
Minimum Liquidity ratios, %		30	30	30	30
Maximum exposure to single borrower, % of capital		25	25	25	25
Maximum total large exposures, % of capital					800
Maximum related party lending, % of capital		10	10	10	
Max. Open foreign exchange position, % of capital		30	30	30	25
Maximum investment in one non-financial enterprise, % of capital		10	10	10	15
Maximum investment in non-financial enterprises, % of capital					60
Minimum reserve with the National bank, % of deposits	6	10	10	10	6

Source: World Bank, LOB.

A.7. Banking regulation in Moldova

The National Bank of Moldova (NBM) is the central bank of the Republic of Moldova.

Minimum Capital: The central bank has increased the minimum capital requirement, which is expected to contribute to consolidation in the banking sector. Current requirement for the minimum capital of the banks is set at MDL50 mn, MDL 100 mn and MDL 150 mn according to the license (last amendment June 2006).

Capital Adequacy: From January 1, 2000 all banks must have and maintain a ratio of Total Regulatory Capital to Risk-Weighted Assets of at least 12 percent, an increase from previous requirement of 10%.

Credit Requirement: The net credit exposure of the bank to a person or group of interrelated persons should not exceed 25 percent of the bank's Total Regulatory Capital.

The sum large credits (a "large credit" defined as the net credit exposure of the bank to any person or group of interrelated persons equal to 10 percent or more of Total Regulatory Capital) shall not exceed 5 times the bank's Total Regulatory Capital.

Credit Provision: In accordance with the Regulation on credit classification and allowance for loan losses ("Risk Fund") (last amendment June 2006), all loans are subdivided into five categories: standard, under supervision, substandard, doubtful and loss (Table A11).

Table A11. Loan classification in Moldova

Loan Categories for Loss Provisioning	*Provision rate*
Standard loans	2
Loans under supervision	5
Substandard loans	30
Doubtful loans	75
Loss	100

Source: NBM.

Liquidity: the liquidity ratio requires the ratio of liquid assets to deposits with maturity of less than 30 days to be no less than 30% (World Bank).

Foreign currency open position: According to the Regulation on bank's open foreign exchange position (last amendment June, 2006), the following limits were set:

- the long open foreign exchange position ratio for each foreign currency shall not exceed "+10%";
- the short open foreign exchange position ratio for each foreign currency shall not be less than "-10%" (USD – "-15%");
- the sum of long open foreign exchange position ratios for all currencies shall not exceed "+20%";
- the sum of short open foreign exchange position ratios for all currencies shall not be less than "-20%";
- ratio of the sum of balance-sheet assets in foreign currency and the sum of balance-sheet liabilities in foreign currency shall not exceed "+25%" or be less than "-25%".

However, the limit stipulated in this point shall not have any impact upon banks whose both the sum of balance sheet assets in foreign currency and the one of balance –sheet liabilities in foreign currency will not exceed, separately for each of them, 10% of the total regulatory capital.

Investment regulations: A written authorization from the National Bank of Moldova for a bank to hold an equity interest in legal entities shall be obtained prior to entering into purchase transaction or transferring equity interest in legal entities. Banks shall inform the National Bank about any equity investment in legal entities, and shall present the decision of competent body, within 10 days after the investment took place (Regulation on equity investments of banks in legal entities, last amendment Jan 2006).

The summary of prudential regulation in Moldova is given in Table A12.

Table A12. Summary of prudential regulation in Moldova

	1995	*1996*	*1997*	*1998*	*1999*	*2006*
Minimum Capital in MDL (Three types of licenses)	1 mln 4 mln 8 mln	4 mln 8 mln 12 mln	4 mln 8 mln 12 mln	8 mln 16 mln 24 mln	8 mln 16 mln 24 mln	50 mln 100 mln 150 mln
Minimum capital adequacy ratio, %	4	4	6	8	10	
Minimum Liquidity ratios, %				30	30	
Maximum exposure to single borrower, % of capital			30	30	30	25
Maximum total large exposures, % of capital				500	500	
Maximum related party lending, % of capital				20	20	
Maximum investment in one non-financial enterprise, % of capital				15	15	
Maximum investment in non-financial enterprises, % of capital				50	50	

Source: World Bank, NBM.

A.8. Banking regulation in Poland

The National Bank of Poland (NBP) is the central bank of the Polish Republic. In accordance with the 1997 Banking Law and The Act of the National Bank of Poland, supervision is to be exercised by the Commission for Banking Supervision (CBS). The executive body of the Commission is the General Inspectorate of Banking Supervision (GIBS). The CBS is responsible for: i) regulating banks, in order to safeguard the security of funds accumulated by banks; ii) supervision of banks in terms of compliance with the Banking Law and the NBP Law, permits granted for formation, and bank's Articles of Association; iii) periodical controlling of banks' financial performance and reporting the results to the Council of Monetary Policy; iv) execution of supervision duties through the GIBS.

Minimum Capital: The minimum capital for domestic banks has been lifted several times and now stands at EUR 5mn, reflecting the requirements of the European Second Banking Coordination Directive. Foreign banks' capital requirement is set at the equivalent of $6mn to be held in local currency (World Bank).

Capital Adequacy: The Banking Law requires banks to maintain a solvency ratio of at least 8%. However, all banks, which began operations, are obliged to maintain a solvency ratio of 15% during the first twelve months of activity and 12% during the second year. The calculation of the solvency ratio is broadly in line with the Basle Capital Accord and the European Own Funds and Solvency Ratio Directives (World Bank).

Credit Requirement: Under NBP rules, banks are subject to credit exposure limits similar to those specified in the European Large Exposures Directive:

- the sum of credits and contingent liabilities (excluding those guaranteed by the State or international financial institutions or cash-secured) to a single entity or group can-not exceed 25% of a bank's own funds:
- each single credit exceeding 10% of a bank's own funds has to be reported to the CBS;
- The aggregate amount of the bank's exposure to a single party or a group of interconnected parties must not exceed 800 percent of the bank's capital.

The classification of loans is given in Table A13.

Table A13. Loan classification in Poland

Loan Categories for Loss Provisioning	*Days Overdue*	*Provision rate*
Standard	There are no major delinquencies in payments, and the economic and financial situation of the debtors does not arouse particular doubts.	(0%)
Watchlist	Loans where payments are < 30 days overdue; financial standing of the debtor is good, but the risk of country, region, industry or debtor's customers is "being watched".	(0.5%)
Substandard	Payments are between thirty and ninety days overdue.	(20%)
Doubtful	Debt service is overdue between 90 and 180 days; or, loans from debtors whose economic and financial situation considerably deteriorates and losses affect equity.	(50%)
Loss	Overdue loans exceeding 180 days; or, borrowers under liquidation or bankruptcy proceedings; or, loans from debtors	(100%)

	against whom the bank has had recourse to the law; or, loans contested by debtors.

Source: World Bank

Foreign currency open position: Each bank must limit its net open position in individual convertible currencies to 15% of its own funds, and in individual non-convertible currencies to 2% of its own funds.

Investment regulations: The total value of equity and bond investments (excluding State and NBP bonds) cannot exceed 15% of a bank's own funds.

Summary of prudential regulation is given in Table A14.

Table A14. Summary of prudential regulation in Poland

	1995	*1996*	*1997*	*1998*	*1999*
Minimum Capital			ECU 5 mln	ECU 5 mln	EUR 5 mln
Minimum capital adequacy ratio, %	8	12	12	12	12
Minimum Liquidity ratios, %					
Maximum exposure to single borrower, % of capital		15	25	25	25
Maximum total large exposures, % of capital	800	800	800	800	800
Maximum related party lending, % of capital		15	10	10	
Max. Open foreign exchange position, % of capital		30	30	30	
Maximum investment in one non-financial enterprise, % of capital			15	15	15
Maximum investment in non-financial enterprises, % of capital	25	25	60	60	60
Minimum reserve with the National bank, % of deposits			20/11/5*	20/11/5	5

* - Demand / Time / Foreign

Source: World Bank.

A.9. Banking regulation in Romania

The National Bank of Romania (NBR) is the country's central bank and is responsible for authorizing and supervising banks in Romania. To bring the legal framework to EU standards, the Romanian legal framework on banking underwent a comprehensive review process. Amendments to the Banking Law strengthen the power and independence of NBR, set forth clear procedures for declaring insolvent banks bankrupt and tighten banking supervision.

Minimum Capital: The minimum level of the initial capital is established through regulations issued by the National Bank of Romania and may not be less than the equivalent in domestic currency of EUR 5 million.

Capital Adequacy: According to World Bank, From April 30, 2000, banks must maintain a capital adequacy ratio of at least 12% which is an increase from 8%.

Credit Provision: Credit provision matrix given in Table A15, is defined by quality of the borrower and debt service history. Quality of the borrower is classified as:

A: Very good & not expected to decline. Permits payment of debt at maturity

B: Very good or good though long-term performance is somewhat questionable

C: Satisfactory, but there is a clear negative trend

D: Deteriorating. Financial crises occur within short intervals

E: Shows losses. Clear evidence that debt cannot be repaid

The debt service history of the debtor is evaluated and classified as follows:

Good: Principal & interest paid at maturity within 7 days of maturity

Weak: Principal and interest paid within 7-30 days

Inadequate: Principal and interest paid after 30 days

Table A15. Romania: loan classification matrix

	Good	*Weak*	*Inadequate*
A	Standard (0%)	Watch (5%)	Substandard (20%)
B	Watch (5%)	Substandard (20%)	Doubtful (50%)
C	Substandard (20%)	Doubtful (50%)	Loss (100%)
D	Doubtful (50%)	Loss (100%)	Loss (100%)
E	Loss (100%)	Loss (100%)	Loss (100%)

Source: World Bank.

The summary of prudential regulation in Romania is given in Table A16.

Table A16. Summary of prudential regulation in Romania

	1995	*1996*	*1997*	*1998*	*1999*	*2006*
Minimum Capital, ROL	25 bln	25 bln	50 bln	50 bln	50 bln	EUR 5mn
Minimum capital adequacy ratio, %	8	8	8	8	8	
Minimum Liquidity ratios, %						
Maximum exposure to single borrower, % of capital	20	20	20	20	20	
Maximum total large exposures, % of capital	800	800	800	800	800	
Maximum related party lending, % of capital	20	20	20	20	20	
Max. Open foreign exchange position, % of capital			10	10	10	
Maximum investment in one non-financial enterprise, % of capital	20	20	20	20	10	
Maximum investment in non-financial						

enterprises, % of capital					
Minimum reserve with the National bank, % of deposits*	7.5 / 40	9 / 20	25 / 20	25 / 20	25 / 20

* - % of domestic and % of foreign deposits respectively
Source: World Bank.

A.10. Banking regulation in Russia

According to the Federal Law "On the Central Bank of the Russian Federation (Bank of Russia)" of June 2002, the Bank of Russia is the central bank of Russian Federation.

Minimum Capital: The authorized capital minimum requirements set for newly established credit organizations is EUR 5 mn in ruble equivalent.

Capital Adequacy: The capital adequacy ratio has been set at 10%-11% as of Feb 2004.

Credit Provision: According to Bank of Russia, before August 1, 2004, loan loss reserves were calculated for four credit risk groups and a fixed percentage of deductions was set for each group (Bank of Russia Instruction No. 62a, dated June 30, 1997, "On the Procedure for Making and Using Loan Loss Provisions"). After August 1, 2004, calculations have been made for five loan categories. Provisions have been cancelled for (the highest) Category I loans and minimum and maximum provisions have been established for Category II, III and IV loans, depending on the collateral of Category I and II quality (Bank of Russia Regulation No. 254_P, dated March 26, 2004, "On the Procedure for Making by Credit Institutions Loan Loss Provisions and Provisions for Loan Debts and Similar Debts").Classification and their provisions are given in Table A17.

Table A17. Loan classification in Russia

Loan Categories for Loss Provisioning	*Provision rate*
I (Standard)	0
II (Substandard)	1-20
III (Doubtful loans)	21-50
IV (Problem loans)	51-100
V (Bad loans)	100

Source: Bank of Russia.

Liquidity: According to Instruction No 5529 as Feb 2004, the instant liquidity ratio has been set at 15% of the balance. The current liquidity ratio has been set at no less than 70% of the balance and the long-term liquidity ratio has been set at no more than 120%. The share of liquid assets in the total assets of a credit organization has been set at no less than 20% of the balance.

Foreign currency open position: the percentage ratio of the total value of the open currency positions to equity capital equals or exceeds 2%

Required reserves: According to the decision of the Bank of Russia Board of Directors, since July 8, 2004, the required reserves for obligations to households were lowered from 7% to 3.5% and for other obligations of credit institutions in rubles and in foreign currency from 7% to 3.5%.

Summary of prudential regulation in Russia is given in Table A18.

Table A18. Summary of prudential regulation in Russia

	1995	*1996*	*1997*	*1998*	*1999*	*2006*
Minimum Capital, ECU		2 mln	3 mln	5 mln		5 mn EUR
Minimum capital adequacy ratio, %	4.5	5	6	7	8-9	10-11
Minimum Liquidity ratios, %		20	30	50	70	
Maximum exposure to single borrower, % of capital	50-100	60	40	25	25	25
Maximum total large exposures, % of capital		1200	1000	800	800	800
Maximum related party lending, % of capital		60	20	20		
Max. Open foreign exchange position, % of capital			30			
Maximum investment in one non-financial enterprise, % of capital	Not regulated		10	10		
Maximum investment in non-financial enterprises, % of capital	Not regulated	45	25	25		
Minimum reserve with the National bank, % of deposits						3.5

Source: World Bank, Bank of Russia.

A.11. Banking regulation in Slovakia

The National Bank of Slovakia (NBS) is the central bank of the Slovak Republic and was established in Jan 1993 the National Bank of Slovakia Act No. 566/1992 Zb. According to World Bank, the Banking Supervision Division of NBS consists of three departments: On-Site Supervision, Off-Site Supervision Departments and Licensing Department. The duties of the banking supervision department include both the monitoring of performance and the adherence to banking regulations, as well as the imposition of sanctions in cases of non-compliance. Moreover, the NBS may ask auditors – all large banks must be audited by a "big 6" audit firm –to provide it with additional prudential information when necessary.

Minimum Capital: Act on Banks (last amendment in 2006) specifies a minimum monetary deposit towards a bank's registered capital of SKK 500 mn and a minimum monetary deposit towards the registered capital of a bank performing mortgage transactions of SKK 1bn.

Capital Adequacy: By the prudential regulation, banks should achieve a minimum adequacy ratio of 8%.

Credit Requirement: The NBS's Decree No 2/2004, which amends Decree No 8/2002 of the National Bank of Slovakia on large exposures of banks, is effective from 31 January 2004. Pursuant to Article 31 paragraph 9 and Article 32 paragraph 5 of Act No 483/2001 on banks as amended, a bank is obliged to observe the limits on large exposure as follows:

- The limit on a bank's large exposure to a parent company or subsidiary or to a group of economically connected persons, of which the bank is a member (20% of own funds);
- The limit on a bank's large exposure to another person, a group of economically connected persons, or to countries and central banks (25% of own funds;
- The limit on the sum of a bank's large exposures (800% of own funds;
- The ratio between large exposure to a natural person and own funds set at the level of no more than 2%;
- The ratio of large exposure to a legal person, except for a bank with its registered office in a Zone A country to own funds, set at a maximum level of 10%;
- The ratio of large exposure to all related persons to the bank to the bank's own funds, set at a maximum level of 40%.

The loan classification and the provisions in Slovakia are presented in Table A19.

Table A19. Loan classification and provision

Loan Categories for Loss Provisioning	Days Overdue	Provision rate
Standard	Client solvent, overdue < 30 days	0%
Special Mention	Temporary financial difficulties, 30 days < overdue >90 days	5%
Substandard	Degenerating financial position, 90 days < overdue > 180 days, restructured claims	20%
Doubtful & Litigious	Borrower insolvent, 180 days < overdue > 360 days, restructured several times	50%
Loss	Client bankrupt or in liquidation, overdue > 360 days	100%

Source: World Bank.

Liquidity: According to The Decrees 3/2004 and 2/2002, the liquidity indicator of a bank for a time period of up to and including seven days is the ratio of the sum of assets and the sum of specified liabilities. Liquidity indicator of a bank or liquidity of a branch office of a foreign bank for a period of up to and including seven days shall be at least 1.00. The liquidity indicator of fixed assets and non-liquid assets of a bank is the ratio of the sum of balances in accounts of fixed assets reduced by balances of accounts of assets that the bank received as a guarantee transfer of rights and balances of accounts of non-liquid assets of the bank to the sum of balances of accounts of capital and reserves of the bank. Liquidity indicator of permanent and non-liquid assets of a bank shall not be higher than 1.00.

The summary of prudential regulation in Slovakia is given in Table A20.

Table A20. Summary of prudential regulation in Slovakia

	1995	*1996*	*1997*	*1998*	*2006*
Minimum Capital, SKK	500 mln	500 mln	500 mln	500 mln	500 mln 1 bn
Minimum capital adequacy ratio, %	7.25	8	8	8	
Minimum Liquidity ratios, %					
Maximum exposure to single borrower, % of capital	40	25	25	25	
Maximum total large exposures, % of capital		800	800	800	
Maximum related party lending, % of capital		25	25	25	
Max. Open foreign exchange position, % of capital			25	25	
Maximum investment in one non-financial enterprise, % of capital					
Maximum investment in non-financial enterprises, % of capital	25	25	25	10	
Minimum reserve with the National bank, % of deposits	3 and 9*	9	9	9	

* - Time and Demand deposits

Source: World Bank, NBS.

A.12. Banking regulation in Slovenia

Under the Bank of Slovenia Act (July 2002), Banka Slovenije (Bank of Slovenia – BoS) is the central bank of the Republic of Slovenia. The BoS establishes and oversees the implementation of minimum capital requirement rules, licensing procedures, auditing and reporting procedures and loan classification guidelines as well as consolidation and mergers regulations.

Minimum Capital: Under Regulation on the harmonization of the amounts of the minimum initial capital of a bank and a savings bank (Jan 2004) , the minimum capital requirement for a commercial bank is set at SIT 1.22 bln.

Capital Adequacy: Banks must adhere to a capital adequacy ratio of 8 %.

Credit Requirement: Banking regulation shall be considered the large exposure where its value is equal to or exceeds 10% of bank's funds. The bank's exposure to a single client does not exceed 25% of bank's funds. Exposures to entities connected to the reporting bank must not exceed 20% of capital. The bank should not incur large exposures, which in aggregate exceed 800% of its own funds.

Credit Provision: The BoS has provided the following guidelines for the classification of assets by banks (Table A21).

Table A21. Loan classification and provision in Slovenia

Loan Categories for Loss Provisioning	*Days Overdue*	*Provision rate*
Standard	Very good and no difficulties expected. Pay obligations on time	1%
Watch	Good even though current financial position weak. Not expected to worsen	5-15%
Substandard	Expected that cash flow will not be sufficient to regularly repay due liabilities	15-40%
Doubtful	Great chance of losses, or under rehabilitation or bankruptcy procedures.	40-99%
Loss	Shows losses, or customers not expected to repay debts.	100%

Source: World Bank.

The summary of prudential regulation is given in Table A22.

Table A22. Summary of prudential regulation in Slovenia

	1995	*1996*	*1997*	*1998*	*1999*	*2006*
Minimum Capital, SIT						1.22
Minimum capital adequacy ratio, %	8	8	8	8	8	
Maximum exposure to single borrower, % of capital	25	25	25	25	25	
Maximum total large exposures, % of				100	800	

capital					
Maximum related party lending, % of capital				5	20
Max. Open foreign exchange position, % of capital					20
Maximum investment in one non-financial enterprise, % of capital	15	15	15	15	15
Maximum investment in non-financial enterprises. % of capital	60	60	60	60	60

Source: World Bank, BoS.

A.13. Banking regulation in Ukraine

The National Bank of Ukraine (NBU), the central bank of Ukraine, exercises the functions of the banking regulation and the supervision over the business of banks. It also exercises the the permanent supervision of the compliance of banks with the banking legislation, regulation and the economic norms.

Minimum Capital: According to the Law of Ukraine on Banks and Banking, the minimum size of the bank-authorized capital at moment of registration cannot be less than

1) 1 million EURO - for local cooperative banks;

2) 3 million EURO - for banks that carry out their activity on the territory of a certain oblast (region);

3) 5 million EURO - for banks that carry out their activity on the entire territory of Ukraine.

Capital Adequacy and Solvency: Minimum capital adequacy ratio is 8%.

Credit Requirement: Maximum Large Credit Exposure benchmark (the ratio between total large credit exposures and bank capital) is maximum 10% for all Ukrainian banks. Maximum Exposure per Single Borrower is 25%. The bank should not incur large exposures, which in aggregate exceed 800% of its own funds.

Loan classification and the rate of provision for loans is given in Table A23.

Table A23. Loan classification and provision in Ukraine

Loan Categories	*Days Overdue*	*Provision rate*
Standard (Class A)	Financial performance is very good and permits the payment of loan principal and interest at maturity. At the same time, it is judged that the financial performance will continue at the same high level.	2%
Watch (Class B)	Financial performance is good or very good, but cannot	5%

	be maintained at this level over a longer period.	
Substandard (Class C)	Financial performance is satisfactory, but shows a clear tendency of deterioration.	20%
Doubtful (Class D)	Financial performance is poor and shows clear cyclicality over short periods of time.	50%
Loss (Class E)	Financial performance shows losses and clear evidence that neither loan principal nor interest can be paid.	100%

Source: World Bank.

Liquidity: Quick Liquidity is set at minimum 20%.

Foreign currency open position: The General Bank Open FX Position Limitation is calculated as a ratio of general open FX position to bank capital. The benchmark for General Bank Open FX Position is no more than 30%. The benchmark for Long (Short) Open FX Position in Hard Currency is no more than 20%. The benchmark for Long (Short) Open FX Position in Soft Currency is be no more than 10%.

The summary of prudential regulation in Ukrainian banking regulation is given in Table A24.

Table A24. Summary of prudential regulations in Ukraine

	1995	*1996*	*1997*	*1998*	*1999*	*2006*
Minimum Capital, ECU (EUR)		0.75 bln	1 mln	2 mln	3 mln	1 mln 3 mln 5mln
Minimum capital adequacy ratio, %		8	8	8	8	
Minimum Liquidity ratios, %					20	
Maximum exposure to single borrower, % of capital	45	25	25	25	25	
Maximum total large exposures, % of capital	800	800	800	800	800	
Maximum related party lending, % of capital			40	40	40	
Max. Open foreign exchange position, % of capital			40	30		30
Maximum investment in non-financial enterprises, % of capital			50	50	50	
Minimum reserve with the National bank, % of deposits	15	15	15	15	15	

Source: World Bank, NBU.

APPENDIX B. MULTINOMIAL LOGISTIC META-REGRESSIONS WITH PRODUCTION APPROACH AS A BASE APPROACH

Table B3. Results of Multinomial Logistic Meta-Regressions with Production approach as a base approach

	Intermediation	Value-Added	Unspecified
X_{labour}	-0.08 (0.932)	1.09 (0.929)	-0.09 (0.929)
D_{publ}	1.91 (0.056)	1.02 (0.309)	0.13 (0.893)
Year	0.09 (0.932)	-1.09 (0.274)	0.07 (0.942)
$X_{deposit}$	-0.13 (0.896)	-0.74 0.462	0.18 0.860
D_{publ}	1.98 (0.048)	0.78 0.436	0.23 0.822
Year	0.73 (0.465)	0.15 0.880	-0.26 0.794
$X_{capital}$	-0.46 0.642	-0.46 0.642	-0.45 0.651
D_{publ}	1.67 0.094	0.50 0.616	0.19 0.851
Year	0.47 0.642	0.46 0.643	0.44 0.661
$X_{int\text{-}exp}$	-0.39 0.696	-0.00 1.000	-0.00 1.000
D_{publ}	1.96 0.050	0.29 0.770	0.23 0.820
Year	0.96 0.337	0.68 0.499	-0.19 0.847
X_{nonint}	20.93 0.000	17.67 0.000	. .
D_{publ}	1.76 0.078	0.52 0.600	0.21 0.832
Year	0.30 0.762	-0.79 0.427	-0.20 0.844
$X_{quality}$	0.00 1.000	-0.00 1.000	-0.00 1.000
D_{publ}	1.94 0.053	0.68 0.496	0.24 0.811
Year	0.89 0.372	-0.38 0.706	-0.21 0.831

	Intermediation	Value-Added	Unspecified
Y_{loans}	1.08 0.280	1.54 0.963	-0.44 0.659
D_{publ}	1.94 0.052	1.06 0.291	0.52 0.605
Year	-0.678 0.500	-1.54 0.124	-0.52 0.606
Y_{invest}	0.09 0.931	0.05 0.963	-0.03 0.974
D_{publ}	1.98 0.047	0.68 0.495	0.20 0.843
Year	0.67 0.502	-0.33 0.739	-0.18 0.859
Y_{earn}	0.39 (0.699)	0.51 0.612	-0.16 0.871
D_{publ}	1.76 (0.078)	0.51 0.612	0.23 0.818
Year	0.70 (0.483)	-0.54 0.590	-0.20 0.839
Y_{obs}	-0.14 (0.888)	0.10 0.919	-0.00 1.000
D_{publ}	1.95 (0.051)	0.69 0.492	0.20 0.845
Year	0.87 (0.386)	-0.38 0.702	-0.17 0.863
Y_{nonrev}	0.00 (1.000)	-0.00 1.000	0.00 1.000
D_{publ}	1.95 (0.052)	0.68 0.496	0.24 0.807
Year	0.63 (0.530)	-0.38 0.706	-0.22 0.828
Y_{intrev}	0.19 (0.850)	1.27 0.203	-0.46 0.647
D_{publ}	1.97 (0.049)	0.71 0.476	0.20 0.842
Year	0.68 (0.497)	-1.27 0.203	0.45 0.652
Y_{depos}	-0.46 (0.646)	0.05 0.963	-0.03 0.974
D_{publ}	2.21 (0.027)	0.68 0.495	0.20 0.843
Year	14.94 (0.00)	-0.33 0.739	-0.18 0.859

Note: Table presents estimated parameter Z statistics with p – value in brackets.

APPENDIX C. LIST OF ANALYZED CENTRAL AND EASTERN EUROPEAN BANKS

CROATIA

1 Zagrebacka Banka dd
2 Privredna Banka Zagreb
3 Raiffeisenbank Austria d.d., Zagreb
4 HVB Splitska Banka dd
5 OTP banka Hrvatska dd
6 Hrvatska Postanska Bank DD
7 Medimurska banka dd
8 Jadranska Banka dd
9 Podravska Banka
10 Partner Banka dd
11 Kreditna Banka Zagreb
12 Gospodarsko Kreditna Banka d.d., Zagreb
13 Istarska Kreditna Bank Umag d.d.
14 Slavonska Banka dd, Osijek
15 Varazdinska Bank d.d.
16 Centar Banka dd
17 StedBanka d.d.
18 Hypo Alpe-Adria-Bank dd

CZECH REPUBLIC

19 Ceskoslovenska Obchodni Banka - CSOB
20 Ceska Sporitelna a.s.
21 Komercni Banka
22 HVB Bank Czech Republic AS
23 Ceska Exportni Banka-Czech Export Bank
24 Calyon Bank Czech Republic as
25 J&T Banka as
26 eBanka as
27 PPF banka a.s.

ESTONIA

28 HansaPank-HansaBank
29 SEB Eesti Ühispank
30 AS Sampo Pank
31 Eesti Krediidipank-Estonian Credit Bank

HUNGARY

32 Orszagos Takarekpenztar es Kereskedelmi - OTP Bank-National Savings and Commercial Bank Ltd
33 K&H Bank-Kereskedelmi es Hitelbank RT
34 MKB Bank Rt
35 CIB Közép-europai Nemzetközi Bank Rt-Central-European International Bank Ltd. - CIB Bank
36 Raiffeisen Bank Rt
37 Inter-Europa Bank Ltd

LATVIA

38 Hansabanka
39 SEB Latvijas Unibanka
40 Parekss Banka-JSC Parex Bank
41 NORD/LB Latvija
42 Latvijas Hipoteku un zemes banka-Mortgage and Land Bank of Latvia
43 Rietumu Banka
44 Aizkraukles Banka A/S
45 Latvian Savings Bank-Latvijas KrajBanka
46 Latvian Economic Commercial Bank-LATEKO Banka
47 Baltijas Tranzitu Bank-Baltic Trust Bank
48 Multibanka
49 Sampo Banka
50 Baltijas Starptautiska Banka-Baltic International Bank
51 Trust Commercial Bank-Trasta Komercbanka
52 Paritate Bank
53 Ogres Komercbanka A/S
54 Latvijas Tirdzniecibas Banka-Latvian Trade Bank
55 VEF Banka

LITHUANIA

56 SEB Vilniaus Bankas
57 AB Bankas Hansabankas
58 AB Bankas NORD/LB Lietuva
59 Bankas Snoras
60 Siauliu Bankas
61 AB Ukio Bankas
62 UAB Medicinos Bankas
63 AB Parex Bankas

MOLDOVA REP. OF

64 Moldindconbank SA
65 Victoriabank
66 Moldova Agroindbank SA
67 JSCB Banca Sociala SA
68 EuroCreditBank

POLAND

69 Bank Pekao SA-Bank Polska Kasa Opieki SA
70 Bank Zachodni WBK S.A.
71 Kredyt Bank SA
72 BRE Bank SA
73 Bank Saski S.A.
74 ING Bank Slaski S.A.
75 Bank Handlowy w Warszawie S.A.
76 Bank Millennium
77 Raiffeisen Bank Polska SA
78 Bank Ochrony Srodowiska SA - BOS SA

79 Fortis Bank Polska SA
80 Getin Bank SA
81 BNP Paribas Bank (Polska) SA
82 Gospodarczy Bank Wielkopolski S.A.
83 ABN Amro Bank (Polska) SA
84 WestLB Bank Polska SA
85 Deutsche Bank Polska S.A.
86 Kredyt Bank SA
87 East European Bank-Bank Wspolpracy Europejskiej SA
88 AIG Bank Polska SA

ROMANIA

89 Romanian Commercial Bank SA-Banca Comerciala Romana SA
90 Banca Tiriac-Commercial Bank Ion Tiriac
91 UniCredit Romania SA
92 Banca Romaneasca S.A.
93 Finansbank (Romania) SA
94 Emporiki Bank - Romania SA
95 Daewoo Bank (Romania) SA
96 Banca de Credit si Dezvoltare Romexterra SA-Romexterra Bank S.A.

RUSSIAN FEDERATION

97 ABH Financial Limited
98 AK Bars Bank
99 Aljba Alliance
100 Avtobank-Nikoil
101 Baltiyskiy Bank
102 Bank of Investments and Novation-B.I.N. Bank
103 Bank Petrocommerce
104 Bank Zenit
105 Chelindbank - Chelyabinsk Joint Stock Commercial Bank-Chelindbank Group
106 Commercial Bank of Regional Development - RegioBank
107 Credit Bank of Moscow
108 Evrofinance Mosnarbank
109 Far Eastern Bank
110 Gazprombank Group
111 Industry & Construction Bank - ICB
112 International Moscow Bank - IMB
113 Joint Stock Bank Avangard
114 Joint Stock Commercial Bank - Bank of Moscow
115 KMB Bank / Small Business Credit Bank
116 Lanta Bank
117 MBRD-Moscow Bank for Reconstruction & Development
118 MDM-Bank Saint Petersburg
119 National Bank Trust
120 NIKoil IBG Bank
121 NOMOS-Bank-Joint-Stock Investment Commercial Bank Novaya Moskva
122 Novosibirsk Bank for Foreign Trade-Novosibirskvneshtorgbank
123 Probusiness Bank
124 Rossiysky Capital Bank (The)
125 SDM Bank
126 Urals Transport Joint-Stock Bank - UralTransBank
127 UralSib-Ural-Siberian Bank, OJSC
128 Vozrozhdeniye Bank
129 Yapi Kredi Bank Moscow

SLOVAKIA

130 Vseobecna Uverova Banka a.s.
131 Slovak Savings Bank-Slovenska sporitel'na as
132 OTP Banka Slovensko, as
133 Dexia banka Slovensko a.s
134 Ludova Banka, as
135 Istrobanka
136 Postova Banka, A.S.-Post Bank JSC
137 Komercni Banka Bratislava a.s.
138 Tatra Banka a.s.
139 UniBanka, a.s.
140 Ludva Banka, as

SLOVENIA

141 Nova Ljubljanska Banka d.d.
142 Abanka Vipa dd
143 SKB Banka DD
144 Banka Celje dd
145 Raiffeisen Krekova Banka dd
146 Factor Banka d.d.
147 Gorenjska Banka d.d. Kranj
148 Banka Koper d.d.
149 SB Banka DD
150 Nova Kreditna Banka Maribor d.d.

UKRAINE

151 PrivatBank
152 Joint Stock Post-Pension Bank Aval
153 Nadra Bank
154 First Ukrainian International Bank
155 Kredyt Bank (Ukraine)
156 Vseukrainsky Aktsionerny Bank-VABank
157 Industrialbank
158 Ukrgazprombank
159 Credit Dnepr Joint Stock Bank

APPENDIX D. SUMMARY STATISTICS FOR ANALYZED BANKS GROUPED BY INDIVIDUAL COUNTRIES

Croatia

Variable	Mean	Std.Dev.	Minimum	Maximum
Inputs				
Deposits and short term funding (I)	1292008	2310464	12060	11100000
Personnel expenses (I), (PR), (P)	26468.59	49283.7	623	232670
Total Fixed assets (I)	61395	124642	1651	620325
Other non-interest expenses (PR), (P)	29012	51474	423	265357
Outputs				
Desirable outputs				
Total customer loans (I), (P)	915395	1531352	22507	7953245
Total other earning assets (I), (P)	709602	1322885	7944	6466599
Net Interest Revenue (PR)	58228	98852	3156	517782
Other Income (I), (P), (PR)	4106	11136	-9138	94106
Net commission, net fee and net trading income (I), (PR), (P)	27073	49580	-5004	238719
Deposits and short term funding (P)	1292008	2310464	12060	11100000
Undesirable outputs				
Loan Loss Provisions (I), (PR), (P)	14533	23027	-8622	125628

Czech Republic

Variable	Mean	Std.Dev.	Minimum	Maximum
Inputs				
Deposits and short term funding (I)	9710988	12500000	23542	34400000
Personnel expenses (I), (PR), (P)	132373.5	179004	2216	462535
Total Fixed assets (I)	343850	488150	587	1424472
Other non-interest expenses (PR), (P)	86303	134731	0	564958
Outputs				
Desirable outputs				
Total customer loans (I), (P)	4169763	5168333	1328	15700000
Total other earning assets (I), (P)	6545412	8551041	36643	25400000
Net Interest Revenue (PR)	328861	435351	-2624	1214219
Other Income (I), (P), (PR)	54301	92721	100	371653
Net commission, net fee and net trading income (I), (PR), (P)	180645	240903	-3569	684221
Deposits and short term funding (P)	9710988	12500000	23542	34400000
Undesirable outputs				
Loan Loss Provisions (I), (PR), (P)	102349	319981	-166251	1504579

Estonia

Variable	Mean	Std.Dev.	Minimum	Maximum

Inputs				
Deposits and short term funding (I)	2571453	3249926	73512	11300000
Personnel expenses (I), (PR), (P)	51911	63715	3509	215112
Total Fixed assets (I)	110775	107731	6375	338245
Other non-interest expenses (PR), (P)	66020	70424	3664	223896
Outputs				
Desirable outputs				
Total customer loans (I), (P)	2112040	2668332	47403	10100000
Total other earning assets (I), (P)	854062	1168886	27296	3755047
Net Interest Revenue (PR)	124726	160169	4716	500925
Other Income (I), (P), (PR)	1791	8968	-22071	17321
Net commission, net fee and net trading income (I), (PR), (P)	67683	90823	447	292494
Deposits and short term funding (P)	2571453	3249926	73512	11300000
Undesirable outputs				
Loan Loss Provisions (I), (PR), (P)	23784	28427	602	93791

Hungary

Variable	Mean	Std.Dev.	Minimum	Maximum
Inputs				
Deposits and short term funding (I)	6723179	5629747	1211941	22100000
Personnel expenses (I), (PR), (P)	115743	115642	18456	476414
Total Fixed assets (I)	204079	237940	6692	913045
Other non-interest expenses (PR), (P)	292782	397834	27371	1443558
Outputs				
Desirable outputs				
Total customer loans (I), (P)	4432343	3067341	769178	15900000
Total other earning assets (I), (P)	2653350	2444324	302808	8431270
Net Interest Revenue (PR)	320866	338733	40123	1371919
Other Income (I), (P), (PR)	130376	266054	-32540	980210
Net commission, net fee and net trading income (I), (PR), (P)	87356	164608	-425512	472108
Deposits and short term funding (P)	6723179	5629747	1211941	22100000
Undesirable outputs				
Loan Loss Provisions (I), (PR), (P)	30671	29260	-4830	106567

Latvia

Variable	Mean	Std.Dev.	Minimum	Maximum
Inputs				
Deposits and short term funding (I)	584760	780660	8772	3782329
Personnel expenses (I), (PR), (P)	11674	14179	439	69076
Total Fixed assets (I)	23672	29251	341	146988
Other non-interest expenses (PR), (P)	17297	21545	402	121491
Outputs				
Desirable outputs				
Total customer loans (I), (P)	318778	552859	412	2758233
Total other earning assets (I), (P)	286751	368421	4825	2100408

Net Interest Revenue (PR)	21405	28438	-412	128112
Other Income (I), (P), (PR)	1867	2682	-2349	13569
Net commission, net fee and net trading income (I), (PR), (P)	16535	28593	-96491	151406
Deposits and short term funding (P)	584760	780660	8772	3782329
Undesirable outputs				
Loan Loss Provisions (I), (PR), (P)	5148	13215	-3292	116228

Lithuania

Variable	Mean	Std.Dev.	Minimum	Maximum
Inputs				
Deposits and short term funding (I)	949662	1217233	16064	5111481
Personnel expenses (I), (PR), (P)	25601	25390	2105	81850
Total Fixed assets (I)	71542	66619	5489	210135
Other non-interest expenses (PR), (P)	27721	29937	1447	114465
Outputs				
Desirable outputs				
Total customer loans (I), (P)	577406	820132	15395	4026648
Total other earning assets (I), (P)	345075	447298	7898	1456537
Net Interest Revenue (PR)	37948	44784	2168	156329
Other Income (I), (P), (PR)	2904	3325	-1639	13243
Net commission, net fee and net trading income (I), (PR), (P)	25667	28192	1491	112869
Deposits and short term funding (P)	949662	1217233	16064	5111481
Undesirable outputs				
Loan Loss Provisions (I), (PR), (P)	3590	12114	-28059	52168

Moldova

Variable	Mean	Std.Dev.	Minimum	Maximum
Inputs				
Deposits and short term funding (I)	159297	111479	2634	456515
Personnel expenses (I), (PR), (P)	7954	5934	741	20941
Total Fixed assets (I)	20648	12368	7450	56605
Other non-interest expenses (PR), (P)	8175	4686	439	17420
Outputs				
Desirable outputs				
Total customer loans (I), (P)	123525	86341	1373	375266
Total other earning assets (I), (P)	60387	45910	3301	153578
Net Interest Revenue (PR)	19578	14906	584	59924
Other Income (I), (P), (PR)	1936	2980	100	16125
Net commission, net fee and net trading income (I), (PR), (P)	10982	6288	247	24894
Deposits and short term funding (P)	159297	111479	2634	456515
Undesirable outputs				
Loan Loss Provisions (I), (PR), (P)	4423	5043	-2341	18603

Poland

Variable	Mean	Std.Dev.	Minimum	Maximum
Inputs				
Deposits and short term funding (I)	5727031	6758524	43135	31800000
Personnel expenses (I), (PR), (P)	126667	155099	2004	733651
Total Fixed assets (I)	217317	276289	522	1185106
Other non-interest expenses (PR), (P)	121550	127045	943	515705
Outputs				
Desirable outputs				
Total customer loans (I), (P)	3667491	4133443	24985	18800000
Total other earning assets (I), (P)	2692876	3455629	3247	16200000
Net Interest Revenue (PR)	243391	314412	-4514	1542730
Other Income (I), (P), (PR)	3717	13926	-9996	118014
Net commission, net fee and net trading income (I), (PR), (P)	190775	225672	-37552	1003864
Deposits and short term funding (P)	5727031	6758524	43135	31800000
Undesirable outputs				
Loan Loss Provisions (I), (PR), (P)	83278	139157	-14751	783944

Romania

Variable	Mean	Std.Dev.	Minimum	Maximum
Inputs				
Deposits and short term funding (I)	2565229	5614535	26277	23800000
Personnel expenses (I), (PR), (P)	104450	227846	1251	963459
Total Fixed assets (I)	357663	822597	2316	3792885
Other non-interest expenses (PR), (P)	83144	144371	2290	551854
Outputs				
Desirable outputs				
Total customer loans (I), (P)	1231865	2698442	6282	12700000
Total other earning assets (I), (P)	1639608	3702135	28779	14900000
Net Interest Revenue (PR)	293334	739508	3063	4015469
Other Income (I), (P), (PR)	27202	79301	-6054	438841
Net commission, net fee and net trading income (I), (PR), (P)	116750	245650	340	1183182
Deposits and short term funding (P)	2565229	5614535	26277	23800000
Undesirable outputs				
Loan Loss Provisions (I), (PR), (P)	97867	322083	-15163	2025190

Russia

Variable	Mean	Std.Dev.	Minimum	Maximum
Inputs				
Deposits and short term funding (I)	1946978	2767663	52504	14200000
Personnel expenses (I), (PR), (P)	62296	92330	528	428940
Total Fixed assets (I)	95182	119463	785	712269
Other non-interest expenses (PR), (P)	72619	97961	4511	636280

Outputs				
Desirable outputs				
Total customer loans (I), (P)	1201289	1774236	1580	10300000
Total other earning assets (I), (P)	906048	1567587	1030	9134146
Net Interest Revenue (PR)	88939	126532	-141163	695721
Other Income (I), (P), (PR)	15246	40657	-280331	198734
Net commission, net fee and net trading income (I), (PR), (P)	72648	188353	-1419131	714423
Deposits and short term funding (P)	1946978	2767663	52504	14200000
Undesirable outputs				
Loan Loss Provisions (I), (PR), (P)	41241	216846	-1017627	2707264

Slovakia

Variable	Mean	Std.Dev.	Minimum	Maximum
Inputs				
Deposits and short term funding (I)	3395022	3659395	176227	12000000
Personnel expenses (I), (PR), (P)	44806	52755	3553	173535
Total Fixed assets (I)	150530	170434	3746	630254
Other non-interest expenses (PR), (P)	217904	266944	8964	1135569
Outputs				
Desirable outputs				
Total customer loans (I), (P)	1660411	1878491	113235	8702248
Total other earning assets (I), (P)	2034053	2648089	88345	10500000
Net Interest Revenue (PR)	100302	122816	-109042	478017
Other Income (I), (P), (PR)	28999	38907	-41500	210443
Net commission, net fee and net trading income (I), (PR), (P)	29736	43761	0	156985
Deposits and short term funding (P)	3395022	3659395	176227	12000000
Undesirable outputs				
Loan Loss Provisions (I), (PR), (P)	-3738	173566	-1033022	537707

Slovenia

Variable	Mean	Std.Dev.	Minimum	Maximum
Inputs				
Deposits and short term funding (I)	2264433	2644437	102626	12100000
Personnel expenses (I), (PR), (P)	43453	51181	1801	234265
Total Fixed assets (I)	97420	112243	648	465227
Other non-interest expenses (PR), (P)	49777	54675	2268	238082
Outputs				
Desirable outputs				
Total customer loans (I), (P)	1481060	1684228	93875	8333072
Total other earning assets (I), (P)	1127025	1366057	33227	6131282
Net Interest Revenue (PR)	97137	102133	3364	435054
Other Income (I), (P), (PR)	6112	11246	-6084	50697
Net commission, net fee and net trading income (I), (PR), (P)	42245	47471	3020	246847

Deposits and short term funding (P)	2264433	2644437	102626	12100000
Undesirable outputs				
Loan Loss Provisions (I), (PR), (P)	25205	30555	1016	144019

Ukraine

Variable	Mean	Std.Dev.	Minimum	Maximum
Inputs				
Deposits and short term funding (I)	1405610	2061139	18312	8985620
Personnel expenses (I), (PR), (P)	51301	80748	1436	369765
Total Fixed assets (I)	117750	150922	898	661063
Other non-interest expenses (PR), (P)	75639	105625	857	386190
Outputs				
Desirable outputs				
Total customer loans (I), (P)	1025499	1765519	11670	8556351
Total other earning assets (I), (P)	461789	513036	17483	2668528
Net Interest Revenue (PR)	101635	139496	1846	628427
Other Income (I), (P), (PR)	4733	9658	100	55457
Net commission, net fee and net trading income (I), (PR), (P)	94473	131175	-1714	467044
Deposits and short term funding (P)	1405610	2061139	18312	8985620
Undesirable outputs				
Loan Loss Provisions (I), (PR), (P)	39600	69548	-6449	270867

APPENDIX E. ENVIRONMENTAL VARIABLES DESCRIPTION USED IN THE ANALYSIS

Table E1. PPP US dollar exchange rate in the analysed CEE countries (1998-2003)

	1998	1999	2000	2001	2001	2003
Croatia	3.69	3.78	3.88	3.90	3.97	4.02
the Czech Republic	13.87	14.08	13.93	14.47	14.68	14.83
Estonia	5.81	5.99	6.26	6.44	6.64	6.81
Hungary	92.65	98.89	106.42	112.87	123.54	128.68
Latvia	0.23	0.24	0.24	0.24	0.25	0.25
Lithuania	1.52	1.49	1.48	1.44	1.42	1.41
Moldova	1.70	2.35	2.93	3.21	3.42	3.65
Poland	1.70	1.79	1.87	1.91	1.92	1.91
Romania	3063.31	4460.17	6301.54	8454.99	10329.64	11713.82
Russia	3.02	5.13	6.91	7.95	9.06	10.24
Slovakia	13.57	14.23	14.83	15.27	15.70	16.42
Slovenia	113.11	118.84	123.07	131.19	140.10	145.54
Ukraine	0.56	0.70	0.84	0.91	0.93	0.99

Source: IMF WORLD ECONOMIC OUTLOOK Database, September 2004

Table E2. Average wage (per month in USD) in the financial intermediary institutions in the analysed CEE countries (1998-2003)

	1998	1999	2000	2001	2001	2003
Croatia	1023.15	916.56	942.71	948.26	1187.24	1420.09
the Czech Republic	704.94	647.25	680.73	806.53	1048.38	1289.87
Estonia	668.18	629.44	655.27	697.68	889.34	1169.69
Hungary	652.12	662.54	677.03	789.58	1072.88	1316.71
Latvia	512.07	530.58	579.25	629.67	768.36	862.72
Lithuania	474.06	494.75	518.00	573.64	742.47	911.66
Moldova	103.01	143.69	198.03	173.89	187.48	229.34
Poland	561.19	648.12	787.84	915.16	994.62	1050.08
Romania	368.61	320.88	316.55	364.57	462.48	596.89
Russia	94.64	146.45*	337.00*	394.57*	414.33	532.00
Slovakia	523.71	473.27	473.53	509.04	684.59	887.67
Slovenia	1433.95	1288.49	1229.82	1240.73	1523.53	1925.40
Ukraine	83.15	78.56	102.97	155.58	177.36	193.79

Note: All categories are reflect wages for International Labour Organization's tabulation category J 'Financial Intermediation' which includes codes 65 for 'Financial Intermediation, except Insurance and Pension Funding', 66 for 'Insurance and Pension Funding, except Compulsory Social Security', 67 for 'Activities auxiliary to Financial Intermediation'. Data for Belarus are average wage in the economy. Data for FYR Macedonia 1998 – 2000 are for Category 7 'Transport, Storage and Communication'. Data for Russia (1999-2001) are proxies and calculated by author (reflects the growth of wage in Belarus).

Source: International Labour Organization http://laborsta.ilo.org/, OANDA Corporation http://www.oanda.com, HM Revenue and Customs (HMRC), Statistics and Analysis of Trade Unit (SATU) http://www.uktradeinfo.com, own calculations

Table E3. GDP deflator in the analysed CEE countries (1998-2003) (base year 2004)

	1998	1999	2000	2001	2001	2003
Croatia	81.06	84.12	88.11	91.61	94.30	97.33
the Czech Republic	84.68	87.18	88.09	92.42	94.98	96.60
Estonia	77.45	80.79	85.11	90.02	94.06	96.36
Hungary	62.55	67.14	73.49	80.26	87.43	94.23
Latvia	80.96	84.84	88.04	89.91	93.00	96.15
Lithuania	98.92	98.32	99.34	99.23	99.21	98.28
Moldova	35.75	49.98	63.64	71.34	78.35	89.20
Poland	80.11	85.20	90.93	94.58	95.78	96.27
Romania	20.56	30.36	43.78	60.15	74.24	88.51
Russia	23.57	40.66	55.96	65.18	75.44	86.17
Slovakia	73.45	78.19	84.80	88.33	91.86	96.14
Slovenia	69.34	73.42	77.06	84.56	91.28	96.14
Ukraine	46.66	59.46	73.23	80.55	84.60	90.47

Source: IMF WORLD ECONOMIC OUTLOOK Database, September 2004

Table E4. Unemployment rate in the analysed CEE countries (1998-2003)

	1998	1999	2000	2001	2001	2003
Croatia	11.9	13.5	16.1	15.8	14.8	14.3
the Czech Republic	6.5	8.7	8.8	8.1	7.3	7.8
Estonia	9.8	12.2	13.6	12.6	10.3	10.0
Hungary	7.8	7.0	6.4	5.7	5.8	5.6
Latvia	14.1	14.3	14.4	13.1	12.0	10.6
Lithuania	13.2	14.6	16.4	17.4	13.8	12.4
Moldova	10.0	11.1	8.5	7.3	6.8	7.9
Poland	10.5	13.9	16.1	18.2	19.9	19.6
Romania	6.3	6.8	7.1	6.6	8.4	7.0
Russia	13.3	12.6	9.8	8.9	7.9	8.0
Slovakia	12.5	16.2	18.6	19.2	18.5	17.4
Slovenia	7.7	7.4	7.2	5.9	5.9	6.6
Ukraine	11.3	11.6	11.6	10.9	9.6	9.1

Sourse: International Labour Organisation, United Nations Economic Commission for Europe
Note: Unemployment rate for Moldova 1998 approximate and calculated by author using rate of regestred unemployment and difference between regerstered and total unemployment in 1999

Table E5. Gross domestic product based on purchasing-power-parity (PPP) per capita GDP in the analysed CEE countries (1998-2003)

	1998	1999	2000	2001	2001	2003
Croatia	8098.22	8510.85	8941.75	9500.87	10108.70	10491.67
the Czech Republic	12881.75	13139.29	13869.43	14711.42	15191.40	15668.76
Estonia	8462.61	8651.10	9598.75	10446.43	11310.40	12189.89
Hungary	10796.82	11457.19	12366.92	13213.01	13874.05	14574.49
Latvia	6495.76	6837.13	7527.22	8362.29	9044.12	9682.69
Lithuania	8070.70	8094.85	8654.40	9485.55	10273.25	11036.09

Moldova	1467.49	1437.56	1500.98	1634.21	1771.82	1905.91
Poland	8761.43	9252.43	9822.93	10151.18	10403.88	10853.89
Romania	5416.40	5440.82	5676.90	6158.07	6546.47	6974.03
Russia	5930.21	6440.56	7240.15	7829.80	8314.97	9000.60
Slovakia	10623.66	10898.39	11372.28	12015.26	12675.82	13362.88
Slovenia	15213.84	16159.52	17239.66	18123.02	18916.12	19618.25
Ukraine	3669.56	3736.34	4076.47	4601.88	4924.93	5312.40

Source: IMF WORLD ECONOMIC OUTLOOK Database, September 2004

Table E6. Annual percentage change of GDP in the analysed CEE countries (1998-2003)

	1998	1999	2000	2001	2001	2003
Croatia	2.5	-0.9	2.9	4.4	5.2	4.3
the Czech Republic	-1.0	0.5	3.3	2.6	1.5	3.1
Estonia	5.2	-0.1	7.8	6.4	7.2	5.1
Hungary	4.9	4.2	5.2	3.8	3.5	2.9
Latvia	4.7	3.3	6.9	8.0	6.4	7.5
Lithuania	7.3	-1.7	3.9	6.4	6.8	9.0
Moldova	-6.5	-3.4	2.1	6.1	7.8	6.3
Poland	4.8	4.1	4.0	1.0	1.4	3.8
Romania	-4.8	-1.2	2.1	5.7	5.0	4.9
Russia	-5.3	6.3	10.0	5.1	4.7	7.3
Slovakia	4.2	1.5	2.0	3.8	4.4	4.2
Slovenia	3.6	5.6	3.9	2.7	3.4	2.3
Ukraine	-1.9	-0.2	5.9	9.2	5.3	9.4

Source: IMF WORLD ECONOMIC OUTLOOK Database, September 2004

Table E7. Inflation rate in the analysed CEE countries (1998-2003)

	1998	1999	2000	2001	2001	2003
Croatia	113.28	117.98	125.33	131.52	134.54	136.56
the Czech Republic	130.59	133.37	138.58	145.27	147.89	148.05
Estonia	148.05	152.94	159.08	168.23	174.22	176.56
Hungary	166.97	183.67	201.67	220.23	231.90	242.80
Latvia	133.48	136.64	140.25	143.73	146.49	150.79
Lithuania	142.58	143.69	145.12	147.07	147.43	145.68
Moldova	148.67	207.03	271.83	298.37	314.13	350.83
Poland	154.02	165.27	181.96	191.96	195.61	197.18
Romania	562.62	820.32	1194.94	1606.81	1968.93	2269.67
Russia	216.48	402.10	485.64	589.87	682.97	776.30
Slovakia	119.72	132.48	148.42	159.30	164.59	178.67
Slovenia	128.44	136.35	148.45	160.97	173.05	182.74
Ukraine	230.95	283.34	363.25	406.69	409.78	431.12

Source: IMF WORLD ECONOMIC OUTLOOK Database, September 2004

Table E8. Inflation change in the analysed CEE countries (1998-2003)

	1998	1999	2000	2001	2001	2003
Croatia	5.7	4.1	6.2	4.9	2.3	1.5
the Czech Republic	10.6	2.1	3.9	4.8	1.8	0.1
Estonia	8.2	3.3	4	5.8	3.6	1.3
Hungary	14.3	10	9.8	9.2	5.3	4.7
Latvia	4.6	2.4	2.6	2.5	1.9	2.9
Lithuania	5.1	0.8	1	1.3	0.3	-1.2
Moldova	7.7	39.3	31.3	9.8	5.3	11.7
Poland	11.8	7.3	10.1	5.5	1.9	0.8
Romania	59.1	45.8	45.7	34.5	22.5	15.3
Russia	27.7	85.7	20.8	21.5	15.8	13.7
Slovakia	6.7	10.7	12	7.3	3.3	8.5
Slovenia	7.9	6.2	8.9	8.4	7.5	5.6
Ukraine	10.6	22.7	28.2	12	0.8	5.2

Source: IMF WORLD ECONOMIC OUTLOOK Database, September 2004

Table E9. Ratio of deposit money bank claims on domestic nonfinancial real sector to the sum of deposit money bank and Central Bank claims on domestic nonfinancial real sector in the analysed CEE countries (1998-2003)

	1998	1999	2000	2001	2001	2003
Croatia	1.000	0.996	0.996	0.998	0.999	0.999
the Czech Republic	0.963	0.951	0.964	0.958	0.960	0.966
Estonia	0.997	0.997	0.997	0.997	0.998	0.998
Hungary	0.554	0.624	0.714	0.799	0.869	0.918
Latvia	0.887	0.931	0.934	0.970	0.960	0.976
Lithuania	0.999	0.998	0.998	0.998	0.999	0.999
Moldova	0.535	0.519	0.600	0.660	0.696	0.755
Poland	0.915	0.925	0.938	0.938	0.978	0.999
Romania	0.890	0.795	0.861	0.945	0.987	1.000
Russia	0.584	0.668	0.760	0.816	0.834	0.887
Slovakia	0.984	0.997	1.000	1.000	1.000	0.972
Slovenia	0.989	0.990	0.991	0.996	0.996	0.991
Ukraine	0.418	0.413	0.506	0.605	0.698	0.796

Source: Financial Structure and Economic Development Database, World bank

Table E10. Market share of assets of three largest banks as a share of assets of all commercial banks in the banking system of the analysed CEE countries (1998-2003)

	1998	1999	2000	2001	2001	2003
Croatia	0.710	0.702	0.656	0.642	0.613	0.575
the Czech Republic	0.823	0.776	0.749	0.704	0.687	0.702
Estonia	0.989	0.989	0.979	0.985	0.982	0.982
Hungary	0.635	0.647	0.566	0.562	0.538	0.540
Latvia	0.569	0.491	0.550	0.561	0.551	0.529
Lithuania	0.955	0.943	0.877	0.829	0.799	0.794
Moldova	0.755	0.604	0.566	0.563	0.552	0.670

Poland	0.588	0.498	0.497	0.462	0.435	0.419
Romania	0.842	0.759	0.713	0.717	0.688	0.662
Russia	0.726	0.331	0.239	0.243	0.237	0.225
Slovakia	0.671	0.701	0.680	0.667	0.679	0.674
Slovenia	0.662	0.649	0.636	0.647	0.631	0.606
Ukraine	0.595	0.507	0.516	0.505	0.461	0.490

Source: Financial Structure and Economic Development Database, World bank

Table E11. Accounting value of bank's overhead costs as a share of its total assets in analysed CEE countries (1998-2003)

	1998	1999	2000	2001	2001	2003
Croatia	0.054	0.052	0.050	0.041	0.039	0.045
the Czech Republic	0.057	0.047	0.033	0.028	0.022	0.021
Estonia	0.066	0.065	0.049	0.042	0.046	0.043
Hungary	0.049	0.058	0.052	0.048	0.050	0.047
Latvia	0.094	0.065	0.047	0.053	0.038	0.032
Lithuania	0.069	0.071	0.063	0.060	0.049	0.040
Moldova	0.081	0.100	0.085	0.082	0.068	0.060
Poland	0.040	0.039	0.051	0.044	0.048	0.035
Romania	0.078	0.079	0.098	0.088	0.080	0.074
Russia	0.101	0.077	0.076	0.066	0.061	0.049
Slovakia	0.036	0.040	0.039	0.086	0.040	0.034
Slovenia	0.037	0.037	0.036	0.031	0.029	0.029
Ukraine	0.110	0.105	0.088	0.066	0.061	0.046

Source: Financial Structure and Economic Development Database, World bank

Table E12. Accounting value of bank's net interest revenue as a share of its interest-bearing (total earning) assets in analysed CEE countries (1998-2003)

	1998	1999	2000	2001	2001	2003
Croatia	0.062	0.062	0.057	0.046	0.043	0.050
the Czech Republic	0.051	0.040	0.030	0.029	0.020	0.020
Estonia	0.053	0.050	0.044	0.040	0.038	0.036
Hungary	0.039	0.045	0.052	0.056	0.060	0.056
Latvia	0.071	0.053	0.044	0.037	0.029	0.027
Lithuania	0.056	0.060	0.052	0.040	0.035	0.031
Moldova	0.167	0.138	0.108	0.099	0.076	0.078
Poland	0.058	0.049	0.051	0.043	0.044	0.040
Romania	0.104	0.104	0.088	0.073	0.067	0.063
Russia	0.059	0.074	0.078	0.070	0.065	0.057
Slovakia	0.038	0.027	0.029	0.029	0.035	0.034
Slovenia	0.043	0.038	0.043	0.034	0.031	0.032
Ukraine	0.144	0.119	0.097	0.079	0.062	0.053

Source: Financial Structure and Economic Development Database, World bank

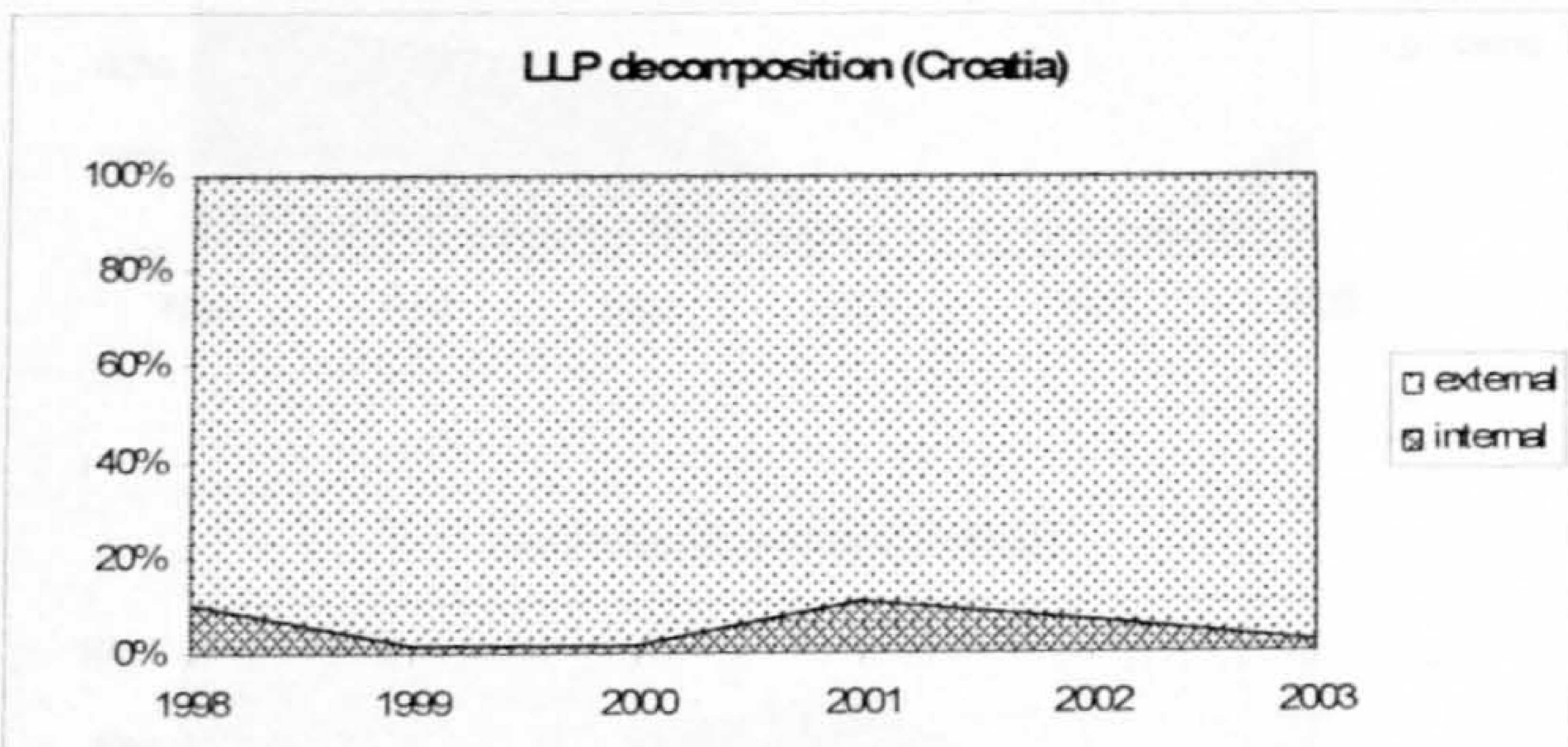
Table E13. Corruption Perception Index in analysed CEE countries (1998-2003)

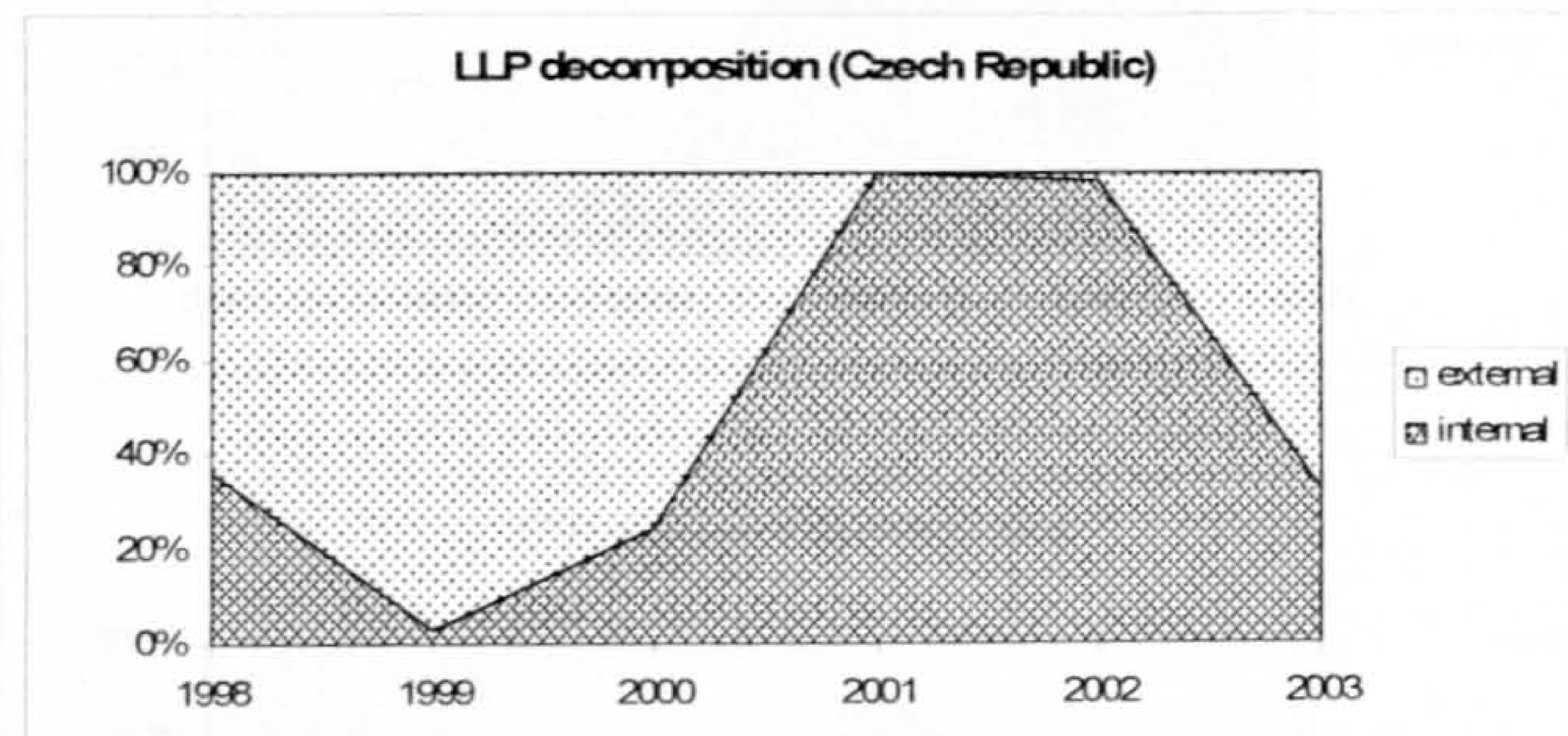
	1998	1999	2000	2001	2001	2003
Croatia	2.7*	2.7	3.7	3.9	3.8	3.7
the Czech Republic	4.8	4.6	4.3	3.9	3.7	3.9
Estonia	5.7	5.7	5.7	5.6	5.6	5.5
Hungary	5.0	5.2	5.2	5.3	4.9	4.8
Latvia	2.7	3.4	3.4	3.4	3.7	3.8
Lithuania	3.8*	3.8	4.1	4.8	4.8	4.7
Moldova	2.6*	2.6	2.6	3.1	2.1	2.4
Poland	4.6	4.2	4.1	4.1	4.0	3.6
Romania	3.0	3.3	2.9	2.8	2.6	2.8
Russia	2.4	2.4	2.1	2.3	2.7	2.7
Slovakia	3.9	3.7	3.5	3.7	3.7	3.7
Slovenia	6.0*	6.0	5.5	5.2	6.0	5.9
Ukraine	2.8	2.6	1.5	2.1	2.4	2.3

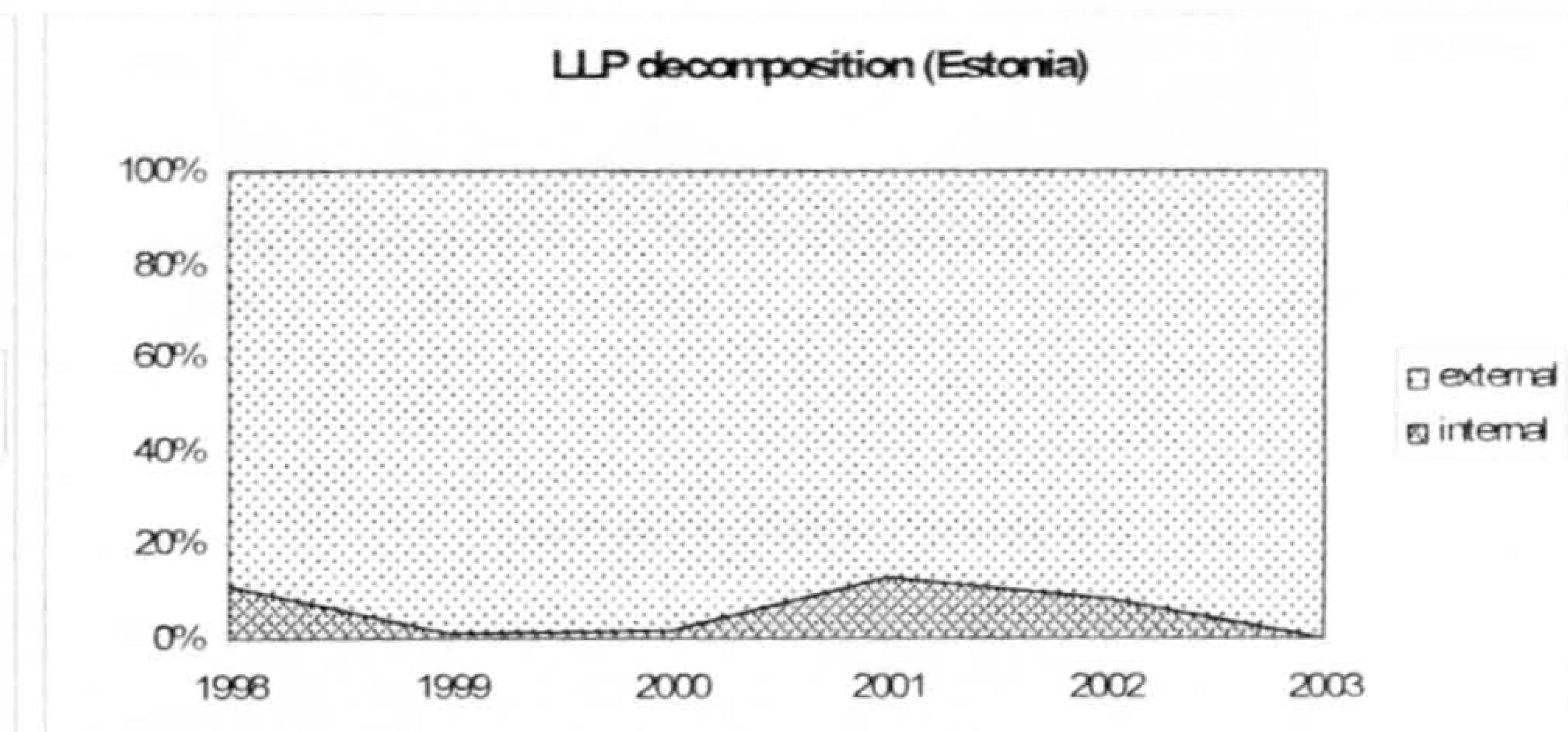
Source: Transparency International, Internet Centre for Corruption Research

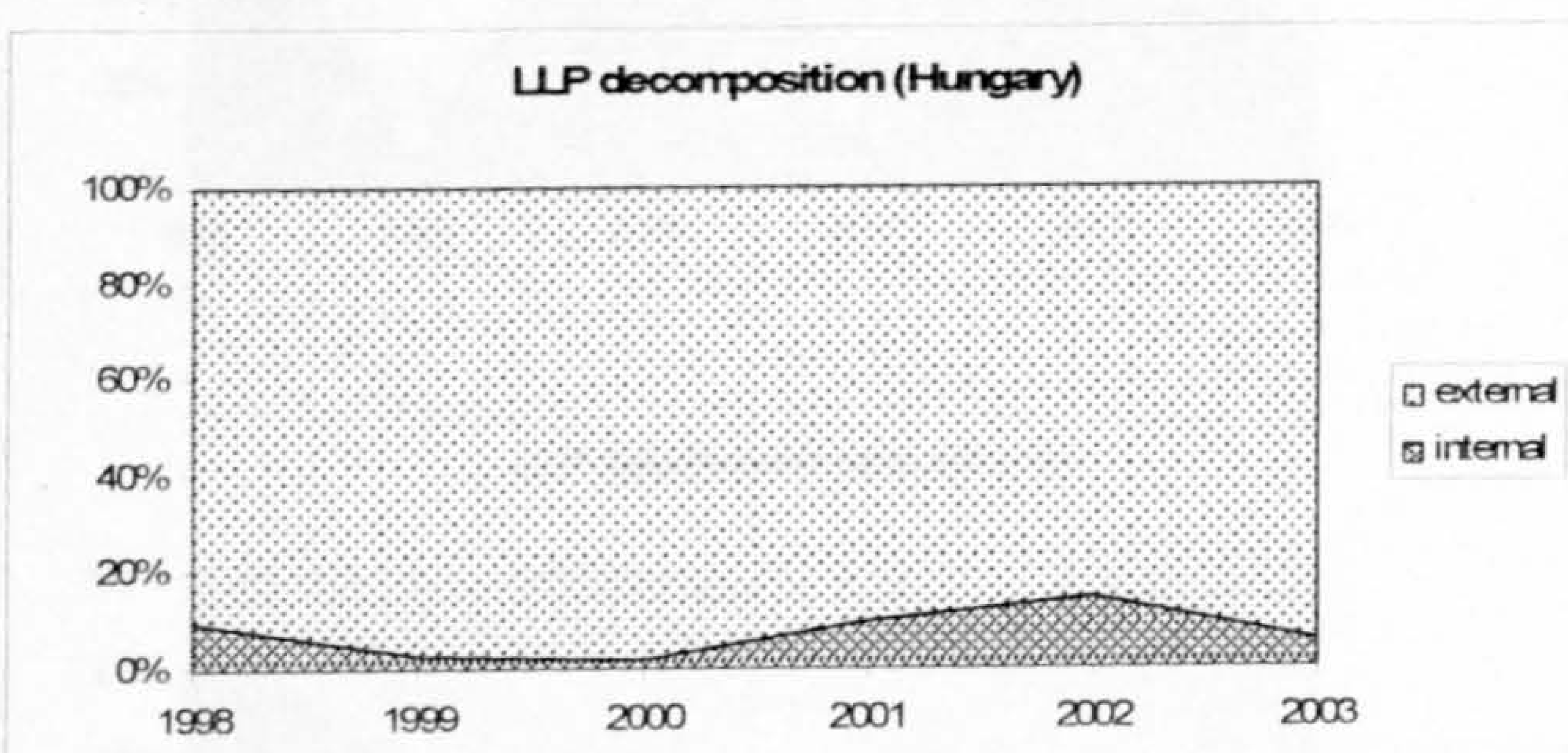
Note: Indexes for Croatia, Lithuania, Moldova and Slovenia in 1998 are taken as for 1999

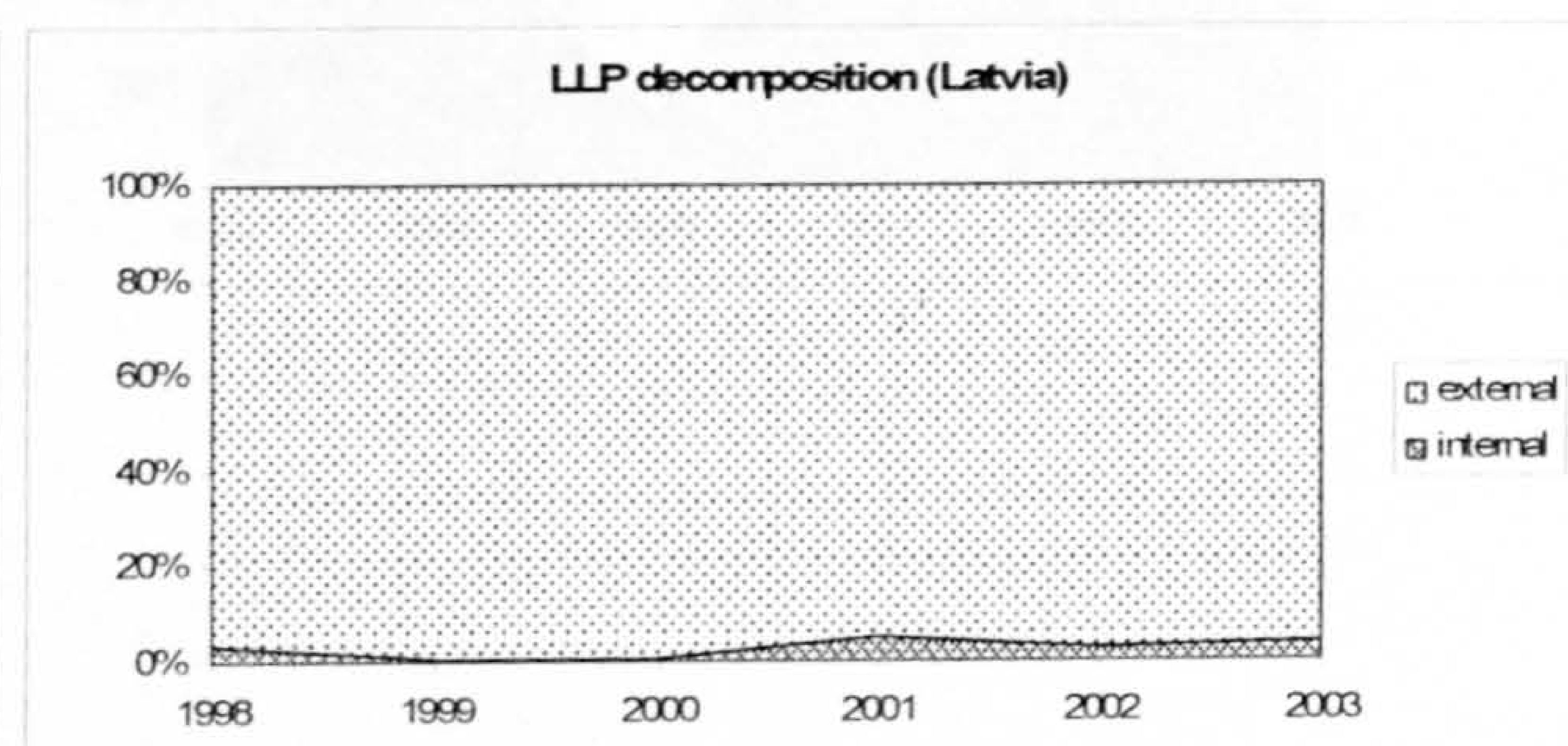
APPENDIX F. BANKING RISK DECOMPOSITION BY ANALYZED COUNTRIES

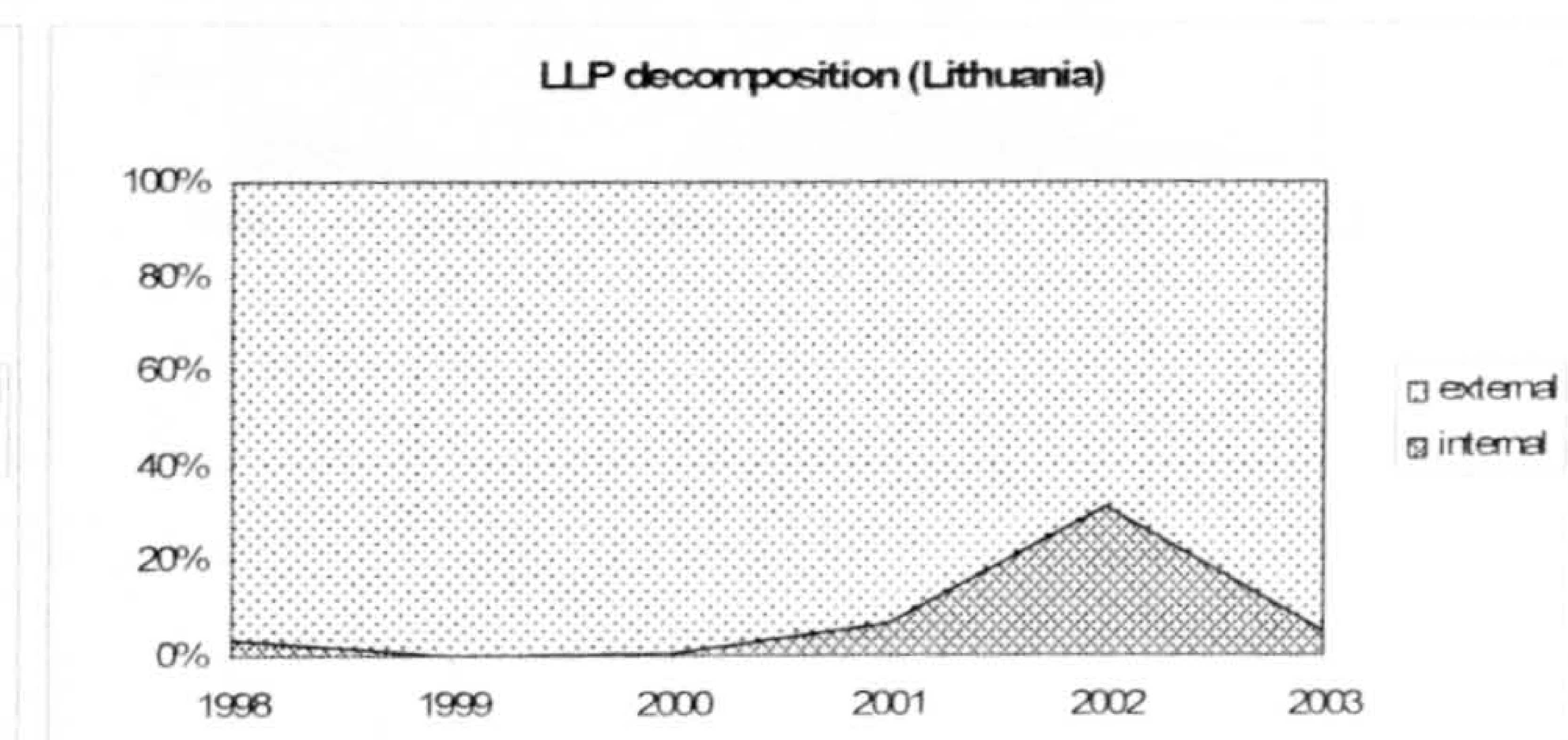


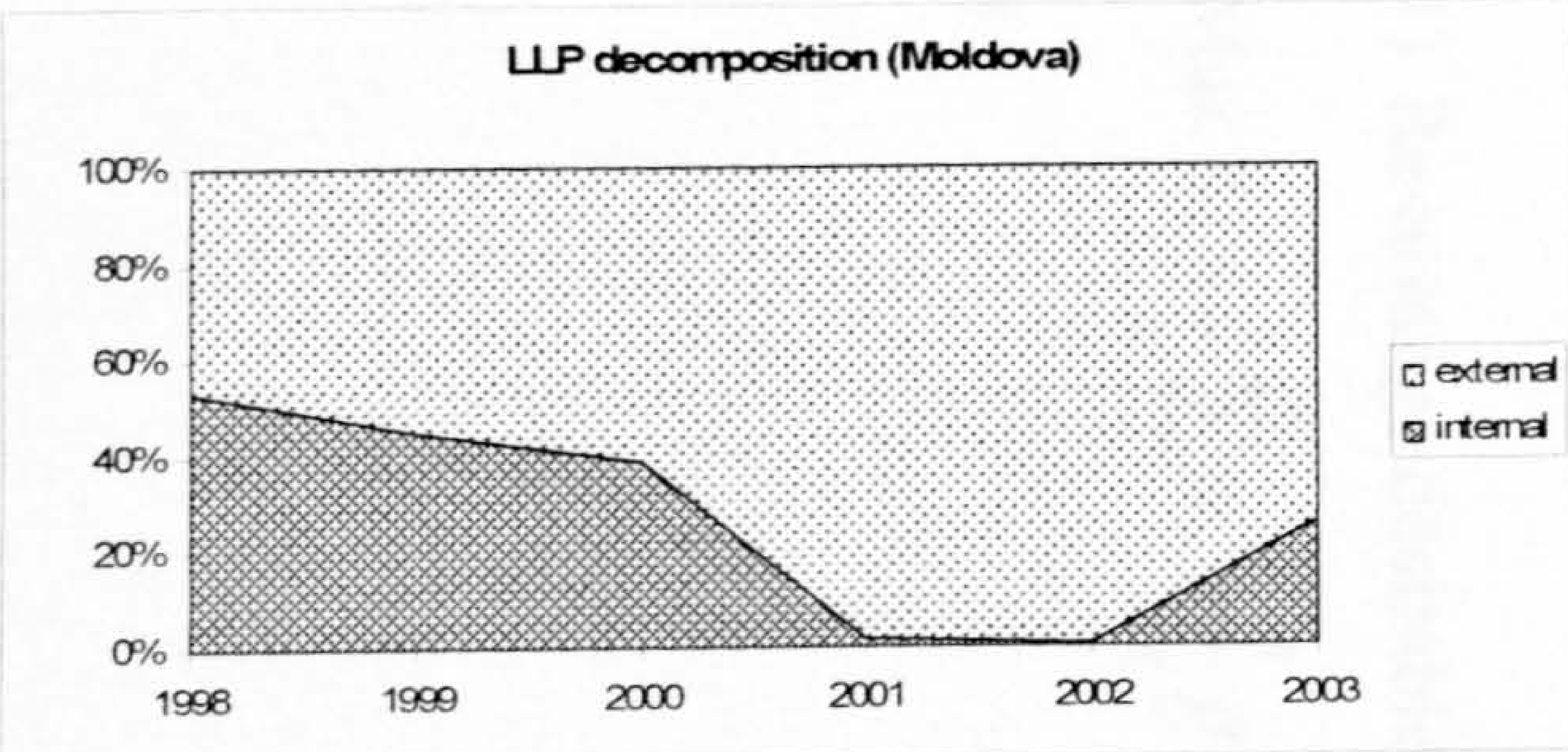











LLP decomposition (Moldova)
100%
80%
60%
40%
20%
0%
1998
1999
2000
2001
2002
2003
external
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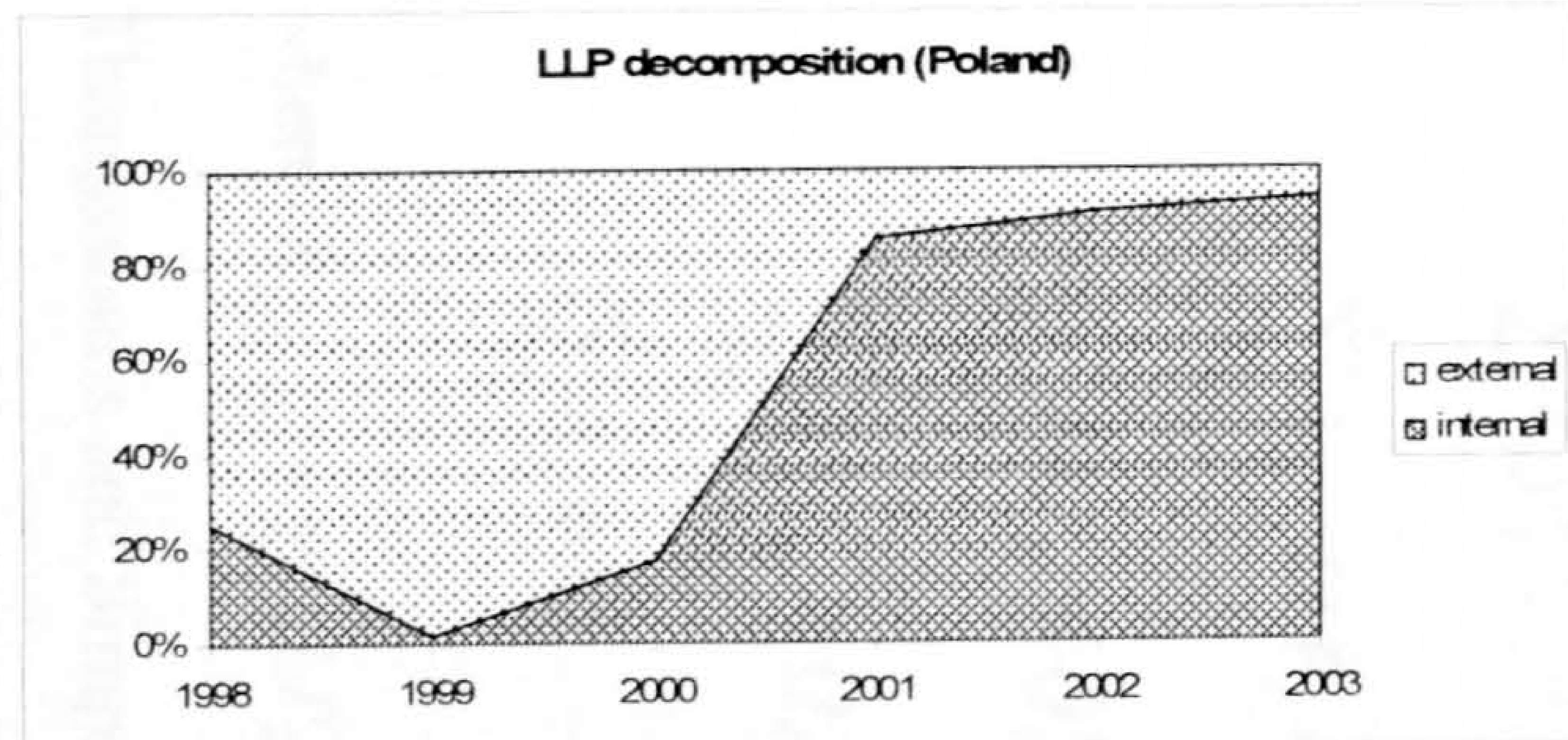
LLP decomposition (Poland)
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80%
60%
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1998
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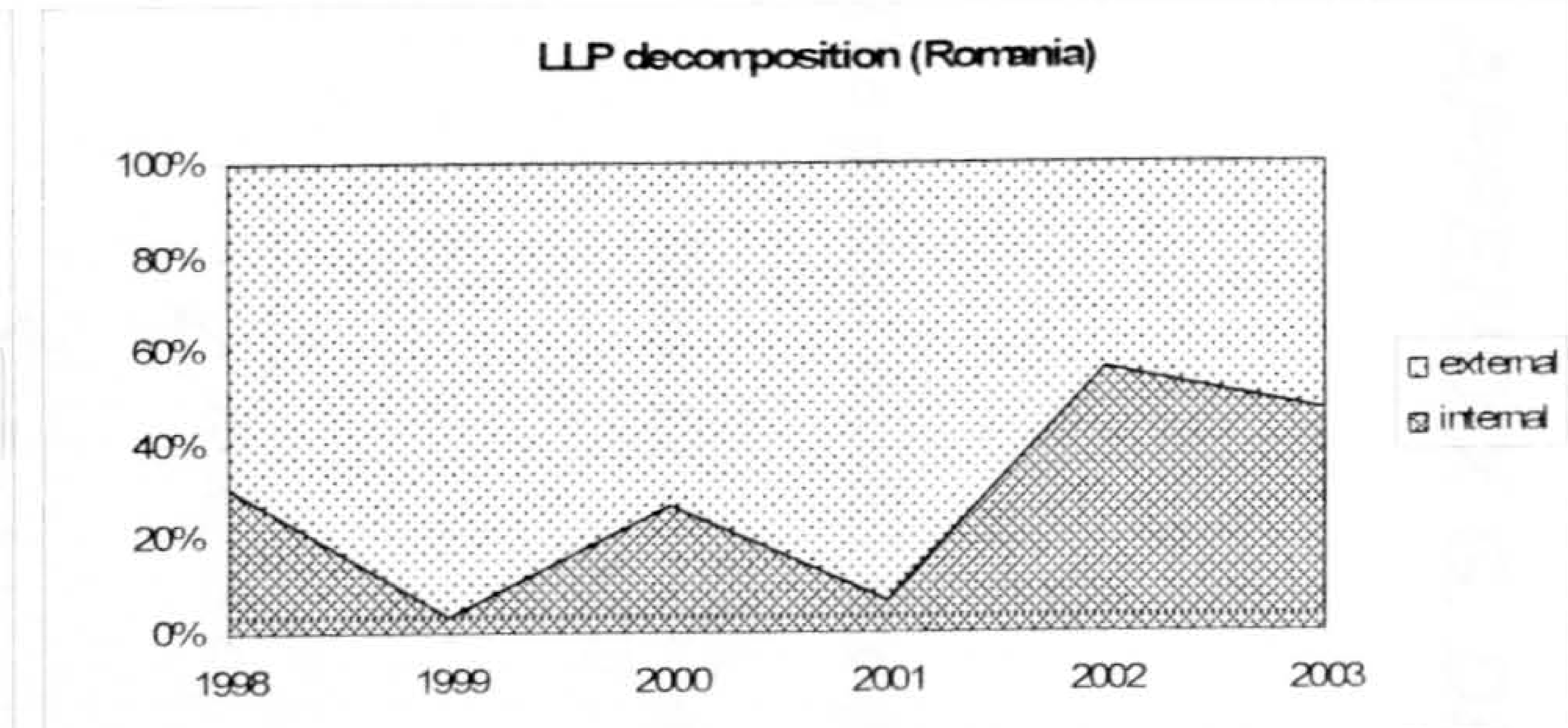
LLP decomposition (Romania)
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80%
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1998
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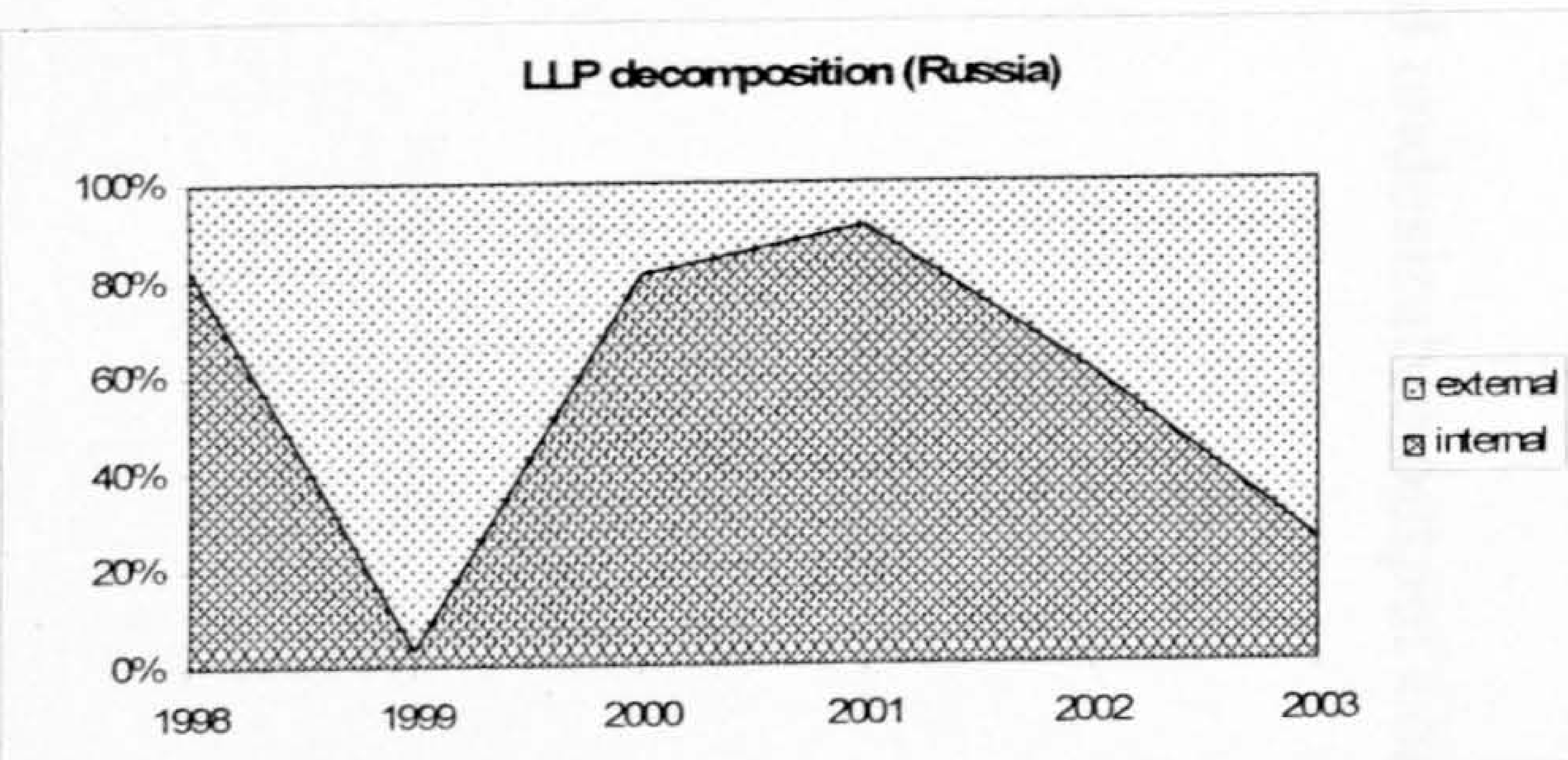
LLP decomposition (Russia)
100%
80%
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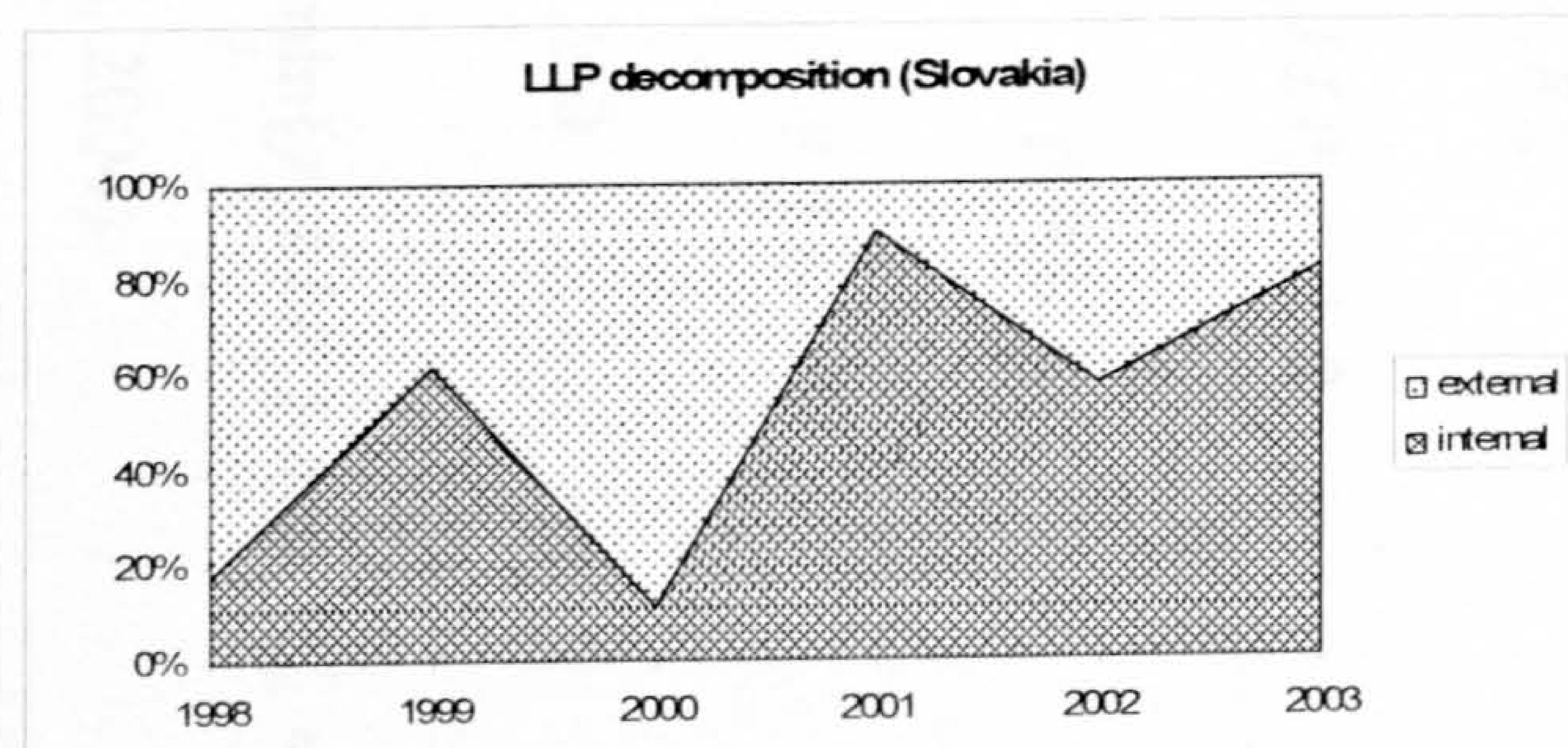
LLP decomposition (Slovakia)
100%
80%
60%
40%
20%
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1998
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2003
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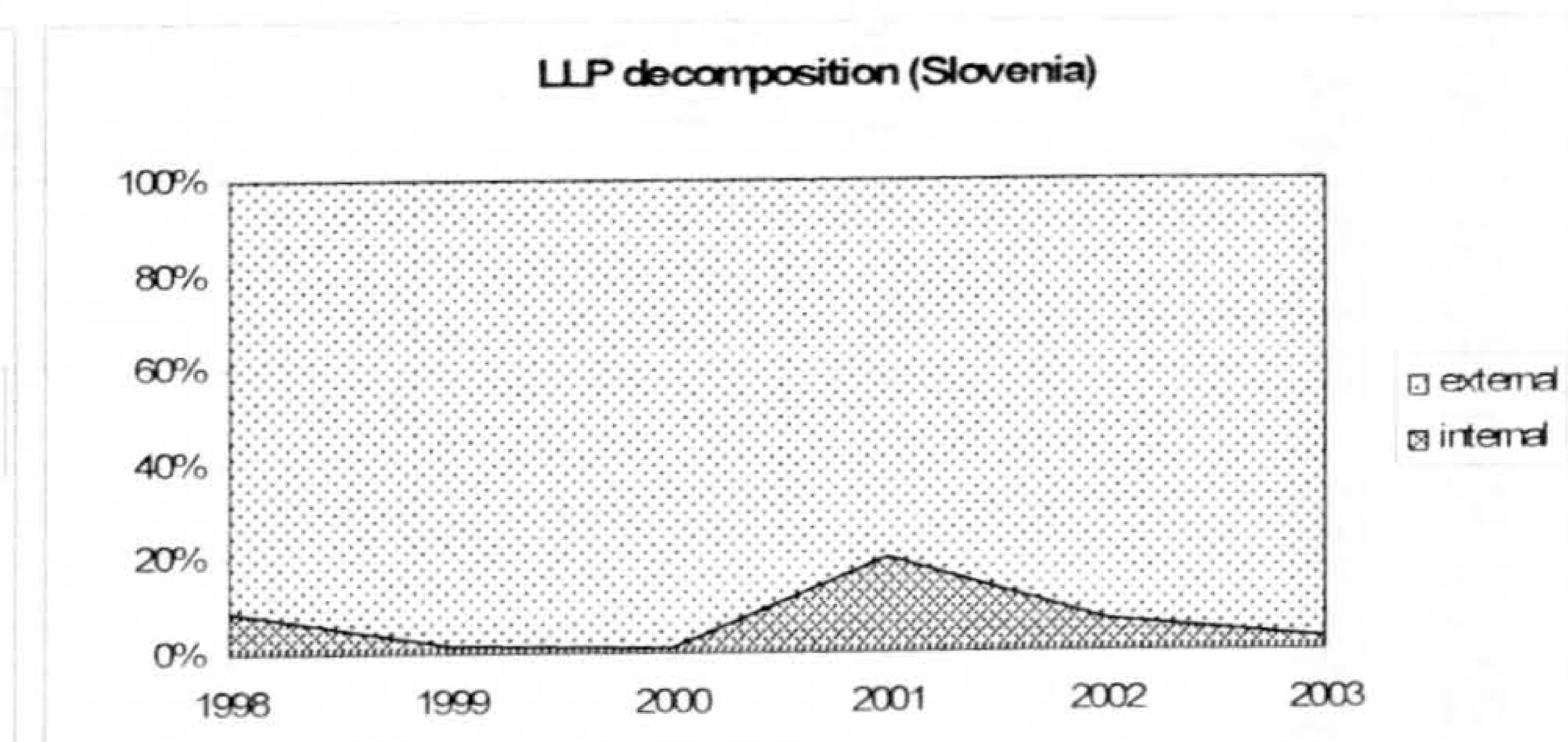
LLP decomposition (Slovenia)
100%
80%
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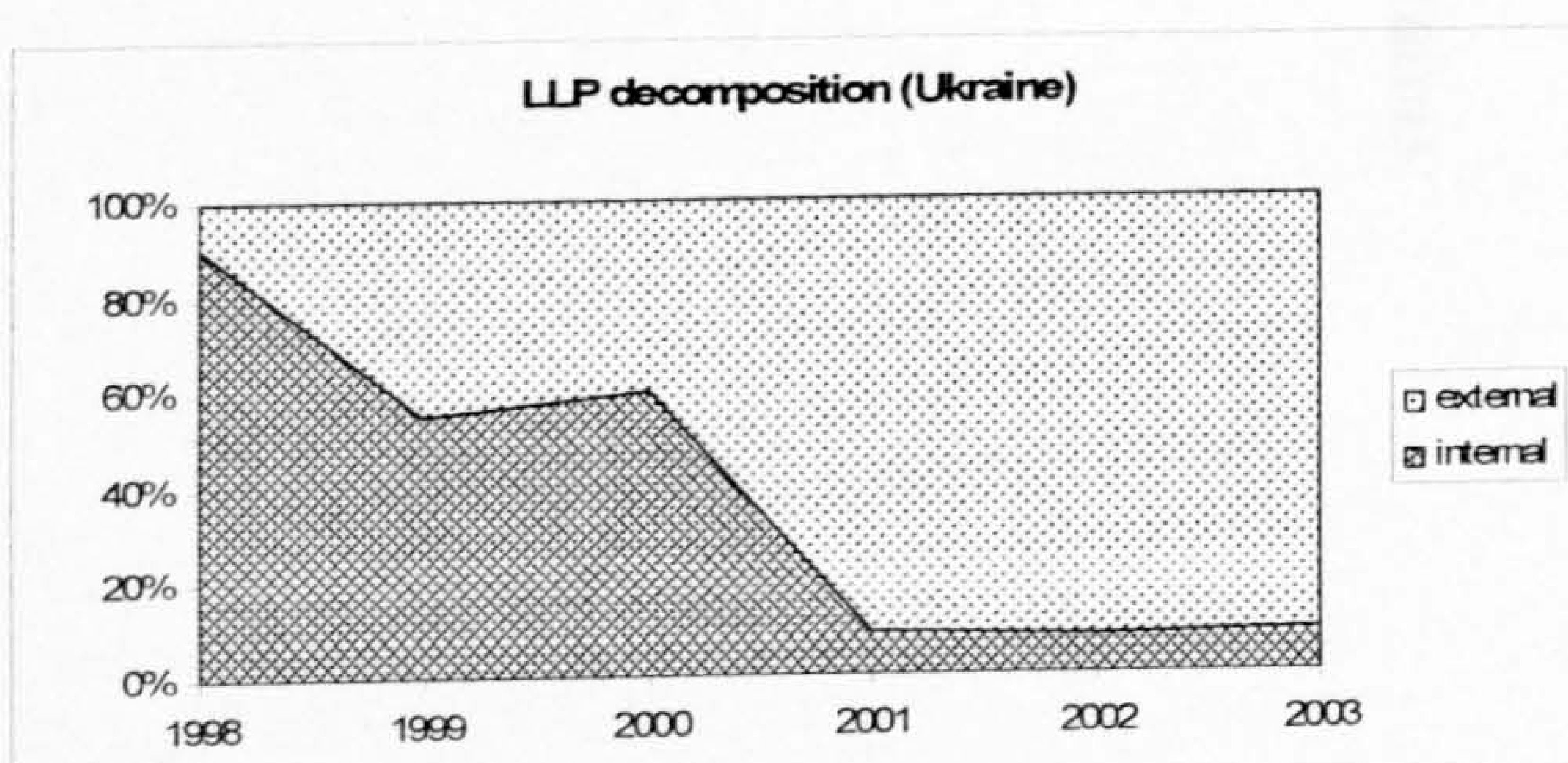
LLP decomposition (Ukraine)
100%
80%
60%
40%
20%
0%
1998
1999
2000
2001
2002
2003
external
internal

APPENDIX G. DERIVATION OF THE DUAL FOR THE LINEAR PROGRAMMING 4.8.

The primal model is equation 4.8:

$$\text{Max } \Omega = \frac{1}{s}\sum_{r=1}^{R}\alpha_r + \frac{1}{s}\beta$$

s.t.

$$\sum_{j=1}^{n}\lambda_j x_{ij} \le x_{i0}$$

$$\sum_{j=1}^{n}\lambda_j y_{rj}^{g} \ge y_{r0}^{g} + \alpha_r R_{r0}^{g}$$

$$\sum_{j=1}^{n}\lambda_j \gamma_j LLP_j = \gamma_0 LLP_0 - \beta_0 R_{\gamma_0 LLP_0}$$

$$\sum_{j=1}^{n}\lambda_j Q_{pj}^{+} \le Q_{p0}^{+}, \qquad p = 1,\dots,P$$

$$\sum_{j=1}^{n}\lambda_j Q_{qj}^{-} \ge Q_{q0}^{-}, \qquad q = 1,\dots,Q$$

$$\sum_{j=1}^{n}\lambda_j = 1, \qquad \lambda_j \ge 0$$

where $R_{\gamma_j LLP_0} = \gamma_0 LLP_0 - \min_j\{\gamma_j LLP_j\}$ and $R_{r0}^{g} = \max_j\{y_{rj}^{g}\} - y_{r0}^{g}$ (Silva Portela, Thanassoulis and Simpson, 2004)

1) Re-arrange desirable and undesirable output constraints:

$$\text{Max } \Omega = \frac{1}{s}\sum_{r=1}^{R}\alpha_r + \frac{1}{s}\beta$$

s.t.

$$\sum_{j=1}^{n}\lambda_j x_{ij} \qquad\qquad \le x_{i0}$$

$$\sum_{j=1}^{n}\lambda_j y_{rj}^{g} \quad -\alpha_r R_{r0}^{g} \quad \ge y_{r0}^{g}$$

$$\sum_{j=1}^{n}\lambda_j \gamma_j LLP_j + \beta_0 R_{\gamma_0 LLP_0} = \gamma_0 LLP_0$$

$$\sum_{j=1}^{n}\lambda_j Q_{pj}^{+} \qquad \le Q_{p0}^{+}, \qquad p = 1,\dots,P$$

$$\sum_{j=1}^{n}\lambda_j Q_{qj}^{-} \qquad \ge Q_{q0}^{-}, \qquad q = 1,\dots,Q$$

$$\sum_{j=1}^{n}\lambda_j = 1, \qquad \lambda_j \ge 0$$

2) Assign dual variables (for simplicity in writing-up the dual) and multiply desirable output and environmental variables with negative impact on efficiency constraints by (-1) to get consistency in inequality signs of constraints:

$$\text{Max } \Omega = \frac{1}{s}\sum_{r=1}^{R}\alpha_r + \frac{1}{s}\beta$$

s.t.

$$(u) \qquad \sum_{j=1}^{n}\lambda_j x_{ij} \qquad \le x_{i0}, \quad i = 1,\dots,M$$

$$(w^{g}) \qquad \sum_{j=1}^{n}\lambda_j (-y_{rj}^{g}) \quad +\alpha_r R_{r0}^{g} \quad \le -y_{r0}^{g}, \quad r = 1,\dots,R$$

$$(w^{b}) \qquad \sum_{j=1}^{n}\lambda_j \gamma_j LLP_j + \beta_0 R_{\gamma_0 LLP_0} \quad = \gamma_0 LLP_0$$

$$(v^{+}) \qquad \sum_{j=1}^{n}\lambda_j Q_{pj}^{+} \qquad \le Q_{p0}^{+}, \qquad p = 1,\dots,P$$

$$(v^{-}) \qquad \sum_{j=1}^{n}\lambda_j (-Q_{qj}^{-}) \qquad \le -Q_{q0}^{-}, \qquad q = 1,\dots,Q$$

$$(u_0) \qquad \sum_{j=1}^{n}\lambda_j = 1,$$

$$\lambda_j \ge 0$$

3) Write-up the **dual:**

$$\text{Min } \xi_0 = \sum_{i=1}^{M} u_i x_{i0} - \sum_{r=1}^{R} w_r^g y_{r0}^g + w^b \gamma_0 LLP_0 + \sum_{p=1}^{P} v_p^+ Q_{p0}^+ - \sum_{q=1}^{Q} v_q^- Q_{q0}^- + u_0$$

s.t.

$$\sum_{i=1}^{M} u_i x_{ij} - \sum_{r=1}^{R} w_r^g y_{rj}^g + w^b \gamma_j LLP_j + \sum_{p=1}^{P} v_p^+ Q_{pj}^+ - \sum_{q=1}^{Q} v_q^- Q_{qj}^- + u_0 \geq 0, \qquad j = 1,\dots,n$$

$$w_r^g \geq \frac{1}{sR_{r0}^g}, \qquad r = 1,\dots,R$$

$$w^b = \frac{1}{sR_{\gamma_0 LLP_0}}$$

$$u_i, w^g \geq 0$$

4) ***Shadow price of bad output*** = w^b (not normalised)

5) To examine bank's return (follow Banker and Thrall,1992, and Seiford and Zhu,1999)

$$\text{Min } \hat{u}_0$$

s.t.

$$\sum_{i=1}^{M} u_i x_{i0} - \sum_{r=1}^{R} w_r^g y_{r0}^g + w^b \gamma_0 LLP_0 + \sum_{p=1}^{P} v_p^+ Q_{p0}^+ - \sum_{q=1}^{Q} v_q^- Q_{q0}^- + u_0 = \Omega_0^*$$

$$\sum_{i=1}^{M} u_i x_{ij} - \sum_{r=1}^{R} w_r^g y_{rj}^g + w^b \gamma_j LLP_j + \sum_{p=1}^{P} v_p^+ Q_{pj}^+ - \sum_{q=1}^{Q} v_q^- Q_{qj}^- + u_0 \geq 0, \qquad j = 1,\dots,n$$

$$w_r^g \geq \frac{1}{sR_{r0}^g}, \qquad r = 1,\dots,R$$

$$w^b = \frac{1}{sR_{\gamma_0 LLP_0}}$$

$$u_i, w^g \geq 0$$

APPENDIX H. SOME ISSUES ON LUENBERGER PRODUCTIVITY INDEX AND ITS DECOMPOSITION

Proof of (38): Suppose that the distance is of the form of (6.8), then (6.6) becomes $\lfloor A(t)\hat{D}_j(x_j^t, y_j^t, b_j^t) - A(t)\hat{D}_j(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\rfloor$ and (6.7) becomes $\lfloor A(t)\hat{D}_j(x_j^t, y_j^t, b_j^t) - A(t)\hat{D}_j(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\rfloor$. As can be seen the two definitions coincide.

Decomposition of the Bias Index of the technical change component of the arithmetic mean version of the Luenberger productivity index:

The bias index $BTCH(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1})$:

$$BTCH(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) =$$

$$\frac{1}{2}\left[\left(D_j^{t+1}(x_j^t, y_j^t, b_j^t) - D_j^t(x_j^t, y_j^t, b_j^t)\right) + \left(D_j^t(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - D_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right)\right]$$

can be decomposed into an input bias and an output bias index. Since I assume the production technology which takes into account the undesirable by-products, there may be four possible decompositions.

The decomposition of bias index where I hold the input vector constant at x^{t+1} and compare the magnitude of technical change along a ray through y^t and b^t with the magnitude of technical change along a ray through y^{t+1} and b^{t+1}:

$$BTCH(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = OBTCH(y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) + IBTCH(x_j^t, y_j^t, b_j^t, x_j^{t+1})$$

$$= \frac{1}{2}\left[\left(D_j^{t+1}(x_j^{t+1}, y_j^t, b_j^t) - D_j^t(x_j^{t+1}, y_j^t, b_j^t)\right) + \left(D_j^t(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - D_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right)\right]$$

$$+ \frac{1}{2}\left[\left(D_j^{t+1}(x_j^t, y_j^t, b_j^t) - D_j^t(x_j^t, y_j^t, b_j^t)\right) + \left(D_j^t(x_j^{t+1}, y_j^t, b_j^t) - D_j^{t+1}(x_j^{t+1}, y_j^t, b_j^t)\right)\right]$$

The arithmetic mean of the differences in the first square brackets can be referred as a period $t+1$ output bias index, whereas the arithmetic mean of the differences in the second square brackets - a period $t+1$ input bias index.

Alternatively, I may hold an output constant at the level of $t+1$ period. However, since I have both desirable and undesirable outputs, I may hold only desirable output constant at y^{t+1}:

$$BTCH(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = OBTCH(x_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) + IBTCH(x_j^t, y_j^t, b_j^t, y_j^{t+1})$$
$$= \frac{1}{2}\left[\left(D_j^{t+1}(x_j^t, y_j^{t+1}, b_j^t) - D_j^t(x_j^t, y_j^{t+1}, b_j^t)\right) + \left(D_j^t(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - D_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right)\right]$$
$$+ \frac{1}{2}\left[\left(D_j^{t+1}(x_j^t, y_j^t, b_j^t) - D_j^t(x_j^t, y_j^t, b_j^t)\right) + \left(D_j^t(x_j^t, y_j^{t+1}, b_j^t) - D_j^{t+1}(x_j^t, y_j^{t+1}, b_j^t)\right)\right]$$

or hold the undesirable output constant at b^{t+1} :

$$BTCH(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = OBTCH(x_j^t, y_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) + IBTCH(x_j^t, y_j^t, b_j^t, b_j^{t+1})$$
$$= \frac{1}{2}\left[\left(D_j^{t+1}(x_j^t, y_j^t, b_j^{t+1}) - D_j^t(x_j^t, y_j^t, b_j^{t+1})\right) + \left(D_j^t(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - D_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right)\right]$$
$$+ \frac{1}{2}\left[\left(D_j^{t+1}(x_j^t, y_j^t, b_j^t) - D_j^t(x_j^t, y_j^t, b_j^t)\right) + \left(D_j^t(x_j^t, y_j^t, b_j^t) - D_j^{t+1}(x_j^t, y_j^t, b_j^{t+1})\right)\right]$$

or both undesirable and desirable outputs constant at y^{t+1} and b^{t+1} :

$$BTCH(x_j^t, y_j^t, b_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) = OBTCH(x_j^t, x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) + IBTCH(x_j^t, y_j^t, b_j^t, y_j^{t+1}, b_j^{t+1})$$
$$= \frac{1}{2}\left[\left(D_j^{t+1}(x_j^t, y_j^{t+1}, b_j^{t+1}) - D_j^t(x_j^t, y_j^{t+1}, b_j^{t+1})\right) + \left(D_j^t(x_j^{t+1}, y_j^{t+1}, b_j^{t+1}) - D_j^{t+1}(x_j^{t+1}, y_j^{t+1}, b_j^{t+1})\right)\right]$$
$$+ \frac{1}{2}\left[\left(D_j^{t+1}(x_j^t, y_j^t, b_j^t) - D_j^t(x_j^t, y_j^t, b_j^t)\right) + \left(D_j^t(x_j^t, y_j^{t+1}, b_j^{t+1}) - D_j^{t+1}(x_j^t, y_j^{t+1}, b_j^{t+1})\right)\right]$$

The input bias indexes in all four decompositions are expressed in terms of output distance functions, however, since the technology I assume requires the variable returns to scale assumptions, it is unfeasible to express the input bias indexes more naturally, i.e. in terms of input distance functions as Färe et al (1999) have done for decomposition of the technical change component of the Malmquist productivity index.

REFERENCE

Altunbas, Y., Liu, M., Molyneux, P. and Seth, R. (2000), "Efficiency and risk in Japanese banking" *Journal of Banking and Finance*, 24, 2000, 1605-1628.

Altunbas, Y., Evans, L., and Molyneux, P. (2001), "Bank ownership and efficiency" *Journal of Money, Credit and Banking*, 33(4), Nov. 2001, 926-954.

Anderson, Robert. "A Shotgun Wedding in the Czech Republic." Financial Times, October 29, 2001.

Balaguer-Coll M.T., Prior D. and Tortosa-Ausina E. (2006), "On the determinants of local government performance: A two-stage nonparametric approach" *European Economic Review,* forthcoming.

Bangert-Drowns, R. L., & Rudner, L. M. (1991). Meta-analysis in Educational Research. ERIC Digest. Retrieved February 17, 2002, from the Educational Resources Information Center Web Site: http://www.ed.gov/databases/ERIC_Digests/ed339748.html.

Banker R.D. and Natarajan R. (2004) 'Statistical tests based on DEA efficiency scores' in '*Handbook on DEA*' edited by Cooper, Seiford and Zhu (2004), Chapter 11, pp. 299 – 321.

Banker R.D., Cooper W.W., Seiford L.M., Thrall R.M., and Zhue J. (2004), "Returns to scale in different DEA models", *European Journal of Operational Research*, 154, pp. 345 – 362 .

Banker, R.D. (1996) "Hypothesis Tests Using Data Envelopment Analysis," *Journal of Productivity Analysis*, (July 1996), pp. 139-160.

Banker, R.D. and Morey, R. (1986), "Efficiency analysis for exogenously fixed inputs and outputs", *Operations Research*, 34, 513–521.

Banker, R.D., and Thrall, R.M., (1992), "Estimation of returns to scale using Data Envelopment Analysis", *European Journal of Operational Research*, 62, 74–84.

Banker, R.D., Charnes, A., and Cooper, W.W., (1984), "Some models for the estimation of technical and scale inefficiencies in Data Envelopment Analysis". *Management Science*, 30, 1078–1092.

Barisitz S. (2000), 'The Development of the Banking Sectors in Russia, Ukraine, Belarus and Kazakhstan since Independence', Oesterreichische Nationalbank, Focus on Transition, 1/2000.

Barisitz S. (2001), 'The Development of the Romanian and Bulgarian Banking Sectors since 1990', Oesterreichische Nationalbank, Focus on Transition, 1/2001.

Barisitz S. (2002), 'Banking in the Baltics — The Development of the Banking Systems of Estonia, Latvia and Lithuania since Independence The Emergence of Market-Oriented Banking Systems in Estonia, Latvia and Lithuania (1988—1997)', Oesterreichische Nationalbank, Focus on Transition, 2/2002.

Basle Committee on Banking Supervision (1999), "Credit risk modeling: Current practices and applications", Basle, Apr 1999, available at http://www.bis.org/publ/bcbs49.pdf

Basle Committee on Banking Supervision (2000), "Best Practices for Credit Risk Disclosure", Sept 2000, available at http://www.bis.org/publ/bcbs53.htm

Basle Committee on Banking Supervision (2000), "Principles for the Management of Credit Risk" Sept 2000, available at http://www.bis.org/publ/bcbs54.htm

Basle Committee on Banking Supervision (2006), "Sound credit risk assessment and valuation for loans", Jun 2006, available at http://www.bis.org/publ/bcbs126.htm

BBC (2000), "Panic at Romania's biggest bank", available at http://news.bbc.co.uk/1/hi/world/europe/770309.stm.

Beccalli E., Casu B. and Girardone C., "Efficiency and Stock Performance in European Banking" http://papers.ssrn.com/sol3/papers.cfm?abstract_id=391668.

Bell F.M. and Murphy N.B., 1968, "Economies of scale and division of labour in commercial banking" National Banking Review, 5, pp. 131 – 139.

Benston G.J. (1968) "Economies of scale and marginal costs in banking operations", National Banking Review, 2, pp. 507 – 549.

Benston G.J., (1965), "Branch banking and economies of scale", Journal of Finance, 20, pp.312 – 331.

Berg S.A., Forsund F.R. and Jansen E.S., (1991), "Bank output measurement and construction of best practice frontiers", Journal of Productivity Analysis, 2, pp.127-142.

Bergendahl, G., (1998), "DEA and Benchmarks - An Application to Nordic Banks", *Annals of Operations Research*, 82, 233-249.

Berger A. N. and Humphrey D. B. (1991), "The dominance of inefficiencies over scale and product mix economies in banking", Journal of Monetary Economics. 28. 117-148.

Berger A. N., and R. DeYoung, (1997), "Problem loans and cost efficiencies in commercial banks", *Journal of Banking and Finance*, 21, 849-870.

Berger A.N. and Humphrey D.B., (1992), "Measurement and efficiency issues in commercial banking", in Grilliches Z., eds. Output measurement in the service sectors, University of Chicago Press: 245-279, Chicago.

Berger A.N. and Humphrey D.B., (1997), "Efficiency of financial institutions: International survey and directions for future research", European Journal of Operational research, 98: pp. 175-212.

Berger, A.N., Hancock, D., and Humphrey, D.B. (1993), "Bank efficiency derived from the profit function", *Journal of Banking and Finance*, 17, pp. 317-348.

Bhattacharya K. (2003), "How good is the BankScope database? A cross-validation exercise with correction factors for market concentration measures", BIS Working Papers No 133, Monetary and Economic Department, September 2003.

Bonin, J. P., Hasan, I. and Wachtel, P. (2003), "Bank Performance, Efficiency and Ownership in Transition Countries," Paper presented at the Ninth Dubrovnik Economic Conference, June 26-28, 2003.

Bonin, J., and Ábel, I. (2000), "Retail banking in Hungary: A foreign affair?", William Davidson Institute Working Paper No., 356, available at http://ideas.repec.org/p/wdi/papers/2000-356.html.

Bos J.W.B. and Schmiedel H. (2003) "Comparing Efficiency in European Banking: A Meta Frontier Approach", Research Series Supervision no. 57, De Nederlandsche Bank.

Bou-Said M.-J. and Saucier P., (2003), "Liquidity, solvency, and efficiency? An empirical analysis of the Japanese banks' distress", Université d'Orléans, University of Birmingham 20 th Symposium on Banking and Monetary Economics, Birmingham, June 5-6 2003.

Boussemart, J-P., Briec W., Kerstens K., and Poutineau J.-C., (2003) "Luenberger and Malmquist productivity indices: Theoretical comparisons and empirical illustration", *Bulletin of Economic Research*, Vol. 55, pp. 391-405.

Briec, W., Dervaux, B. and Leleu, H. (2003), "Aggregation of directional distance functions and industrial efficiency", *Journal of Economics*, 79, 237–261.

Brown K. (2003) "Islamic Banking Comparative Analysis" The Arab Bank Review, Vol. 5, No. 2, October 2003.

Caprio G. and Klingebiel D., (2003) 'Episodes of systemic and borderline financial crises', World bank, Jan 2003.

Casu B. and Girardone C. (2002a) "Efficiency of Large Banks in the Single European Market", Middlesex University Discussion Paper, No. 102, November.

Casu B. and Girardone C. (2002b), "A Comparative Study of the Cost Efficiency of Italian Bank Conglomerates" Managerial Finance, Vol.28, No.9.

Casu B. and Girardone C., "An analysis of the relevance of OBS items in explaining productivity change in European banking" http://papers.ssrn.com/sol3/papers.cfm?abstract_id=492863.

Casu B. and Molyneux P. (2000), "A comparative study of efficiency in European banking" Wharton School Research Paper N. 00/17, Wharton School, Philadelphia, USA.

Casu, B., Girardone, C. and Molyneux P. (2004), "Productivity change in European banking: A comparison of parametric and non-parametric approaches", *Journal of Banking and Finance,* V. 28, (10), 2521-2540

Cavallo L. and Rossi S.P.S. (2002), "Do environmental variables affect the performance and technical efficiency of the European banking systems? A parametric analysis using the stochastic frontier approach" The European Journal of Finance, Volume 8, 2002, pp. 123-146 .

Caves, D., L. Christensen and W.E. Diewert, (1982). "The economic theory of index numbers and the measurement of input, output and productivity", *Econometrica*, 50:6, 1393-1414.

Central Banking in Czech Republic (1999), 'Speech of Mr. Jan Vit Vice-governor of the Czech National Bank at the international conference "The Art of Central Banking in Eastern Europe in the 1990s"', 26 January 1999,Sofia.

Chakravarty S. P. and Williams J.M. (2002) "How Significant is the Alleged Unfair Advantage Enjoyed by State-Owned Banks in Germany?" http://sbard.bangor.ac.uk/site_english/pdf/papers/SPC_JW_Elett02.pdf .

Chambers, R.G. (2002), "Exact nonradial input, output and productivity measurement", Economic Theory, 20, 751 – 765 .

Chambers, R.G., R. Färe and S. Grosskopf, (1996). "Productivity Growth in APEC Countries", *Pacific Economic Review*, 1:3, 181-190.

Chen Y., (2003), "A non-radial Malmquist productivity index with an illustrative application to Chinese major industries", *International Journal of Production Economics*, 83, 27 -35.

Chung, Y. R. Färe, and S. Grosskopf. (1997) "Productivity and Undesirable Outputs: A Directional Function Approach" *Journal of Environmental Management.* 51: 229-240.

Dalić M., 2003, 'Comparative Analysis of the Financial System in Croatia and the Financial Systems in Advanced Transition Economies', Croatian Economic survey, 2003.

De Guevara J.F., Maudos J. and Pérez F., (2002) "Market power in European banking sectors" WP-EC 2002-05, Instituto Valenciano de Investigaciones Económicas (Ivie).

De Melo M., Denizer C., Gelb A. and Tenev S. (1997), 'Circumstance and choice: The role of initial conditions and policies in transition economies', World Bank Policy Research Working Paper No 1688, Washington DC: The World Bank.

Dietsch, M. and Lozano Vivas, A. (2000), "How the environment determines banking efficiency: A comparison between French and Spanish industries", *Journal of Banking and Finance*, 24, 985-1004.

Drake, L., and Hall, M.J.B. (2003), "Efficiency in Japanese Banking: An Empirical Analysis", *Journal of Banking & Finance*, 27, 891 -917.

Drake, L., Hall, M.J.B. and Simper, R. (2005), "Bank modeling methodologies: A comparative non-parametric analysis of efficiency in the Japanese banking sector", Economics Research Paper, Nov 2005, Loughborough University.

Drake, L., Hall, M.J.B. and Simper, R. (2006), "The impact of macroeconomic and regulatory factors on bank efficiency: A non-parametric analysis of Hong Kong's banking system", *Journal of Banking & Finance*, 30(5), 1443-1466.

EBRD (2003), Transition report, European Bank of Reconstruction and Development, London, EBRD.

EBRD (2004), Transition report, European Bank of Reconstruction and Development, London, EBRD.

Färe R and Grosskopf, S. (1996), "Intertemporal production frontiers: with dynamic DEA", Kluwer Academic Publishers, Boston.

Färe R., Grifell-Tatjé E., Grosskopf, S. and C.A.K. Lovell (1999), "Biased technical change and the Malmquist productivity index" *Scandinavian Journal of Economics*. 99 (1): 119-127.

Färe R., Grosskopf, S., and Russell R.R. (Eds.) (1998), "Index Numbers: Essays in Honour of Sten Malmquist", Kluwer Academic Publishers, Boston, 1998

Färe R., S. Grosskopf, C.A.K. Lovell and S.Yaisawarng (1993), "Derivation of shadow prices for undesirable outputs: A distance function approach", *Review of Economics and Statistics* 75: 375-80.

Färe, R. and Primont, D. (2003), Luenberger productivity indicator: aggregation across firms, Journal of Productivity Analysis, 20, 425–435.

Färe, R., and Grosskopf, S. (2004), "New directions: Efficiency and Productivity", Kluwer Academic Publishers, Boston/Dordrecht/London.

Färe, R., and Grosskopf, S., (1985) "A nonparametric cost approach to scale efficiency", *Scandinavian Journal of Economics* 87, 594–604.

Färe, R., Grosskopf, S., Lindgren, B., Roos, P., (1992), "Productivity changes in Swedish pharmacies 1980 -1989: A nonparametric approach". *Journal of Productivity Analysis* 3, 85-101.

Färe, R., Grosskopf, S., Lovell, C.A.K., and Pasurka, C. (1989), "Multilateral Productivity Comparisons when Some Outputs are Undesirable: a nonparametric approach", *Review of Economics and Statistics*, 71, 90-98.

Farrell, M.J., (1957) "The measurement of productive efficiency", *Journal of the Royal Statistical Society* A 120, 253-281.

Favero C. A. & Papi L., (1995), "Technical efficiency and scale efficiency in the Italian banking sector: a non-parametric approach", Applied Economics, 27, pp. 385-395.

Fixler D. and Zieschang K. (1999) "The productivity of the banking sector: integrating financial and production approaches to measuring financial service output" Canadian Journal of economics, Vol.32, No.2, 547-569.

FRBSF Economic Letter, (1999), "Rising Bank Risk?", 99-32; October 22, 1999, available at http://www.frbsf.org/econrsrch/wklyltr/wklyltr99/el99-32.html

Freixas, X. and J.-C. Rochet (1997), "Microeconomics of Banking", MIT Press, Cambridge and London.

Fries S. and Taci A. (2004), "Cost efficiency of banks in transition: Evidence from 289 banks in 15 post-communist countries", European Bank for Reconstruction and Development, Working paper No. 86 .

Fries, S., Neven, D. and Seabright, P., (2002), "Bank performance in Transition Economies", EBRD, June 2002.

Gilbert R. A. and Wilson P.W. (1998) "Effects of Deregulation on the Productivity of Korean Banks", *Journal of Economics and Business*, V. 50, (2), 133-155

Glass, G. V (1976), "Primary, secondary, and meta-analysis of research", Educational Researcher, 5, 3-8.

Global Finance (2001), "Hungary's OTP bank grows with efficiency", Copyright Global Finance Media Inc. Feb 2001, Provided by ProQuest Information and Learning Company. Available at http://www.findarticles.com/p/articles/mi_qa3715/is_200102/ai_n8935398

Gorton, G. and Winton, A., 1998, "Banking in Transition Economies: Does Efficiency Require Instability?" *Journal of Money, Credit and Banking*, 30 (3) (August 1998, Part 2), 621- 650.

Green C.J., Murinde V. and Nikolov I. (2004) "Are foreign banks in Central and Eastern Europe more efficient than domestic banks?", *Journal of Emerging Market Finance*, Vol. 3, No. 2, 175-205.

Grifell-Tatjé E. and Lovell C. A. K. (1996), "Deregulation and productivity decline: the case of Spanish savings banks" *European Economic Review, V. 40 (6),1281-1303*

Grifell-Tatjé E. and Lovell C. A. K. (1997), "The sources of productivity change in Spanish banking", *European Journal of Operational Research, V.*98 *(2), 364-380*

Grigorian, D.A. and Manole, V., (2006), "Determinants of Commercial Bank Performance in Transition: An Application of Data Envelopment Analysis", *Comparative Economic Studies*, 48 (3), pp.497-522 (26).

Grilli, V., D. Masciandaro and G. Tabellini (1991), 'Political and Monetary Institutions and Public Financial Policies in the Industrial Countries', Economic Policy 13, pp. 342–82.

Grosskopf, S.,(1993) Efficiency and productivity. In: Fried, H.O., Lovell, C.A.K., Schmidt, S.S. (Eds.), The Measurement of Productive Efficiency: Techniques and Applications. Oxford University Press,UK.

Grosskopf, S.,(1993) Efficiency and productivity. In: Fried, H.O., Lovell, C.A.K., Schmidt, S.S. (Eds.), The Measurement of Productive Efficiency: Techniques and Applications. Oxford University Press,UK.

Grosskopf, S.,(2003) "Some Remarks on the Malmquist Productivity Index and Its Decomposition," *Journal of Productivity Analysis*, 20, 2003, 459-474.

Grosskopf, S.,(2003) "Some Remarks on the Malmquist Productivity Index and Its Decomposition," *Journal of Productivity Analysis*, 20, 2003, 459-474.

Hancock, D. (1991), "A theory of production for the financial firm", Norwell, Mass. and Dordrecht: Kluwer Academic, 1991.

Hasan I., Lozano-Vivas A. and Pastor J.T. (2000), "Cross-Border Performance in European Banking", Bank of Finland, Discussion papers, 24/2000.

Hasan, I. and Marton, K, (2003),"Banking in Transition Economy: Hungarian Evidence," *Journal of Banking and Finance*, 27: 2249-2271.

Havrylchyk O. (2004) "Consolidation of the Polish banking sector: consequences for the banking institutions and the public", *Economic Systems*, V. 28 (2) 125-140

Heshmati A. (1997), "Labour demand, labour use efficiency and risk in Swedish banks", Working paper No 243, Department of Economics, Gothenburg University.

Hollander M. and Wolfe D. (1999) 'Nonparametric Statistical Methods', 2nd Edition, John Wiley and Sons, New York, N.Y. 787p.

Hua, Z., Bian, Y. and Liang, L.(2007) "Eco-efficiency analysis of paper mills along the Huai river: An extended DEA approach", *Omega, The International Journal of Management Science*, 35, pp. 578-587.

Hughes J. P. & Mester L. J. (1993), "A quality and risk-adjusted cost function for banks: evidence on the "Too-big-to-fail" doctrine", The Journal of Productivity Analysis, 4, pp. 293-315.

Hughes, J. P. and Mester, L. (1993), A quality and risk-adjusted cost function for banks: evidence on the `too-big.to-fail' doctrine, *The Journal of Productivity Analysis*, 4 (3), 293–315.

Huizinga H.P., Nelissen J.H.M. and Vennet R.V. (2001), "Efficiency Effects of Bank Mergers and Acquisitions in Europe", Ghent University, Working paper, June 2001, 2001/106.

Humphrey D. B., (1991), "Productivity in banking and effects from deregulation", Economic Review (Federal Reserve Bank of Richmond), 16-28.

IMF, Remes, D.T. and Ghizari, E.I. (2000), Supplementary Letter of Intent of the government of Romania, which describes the policies that Romania intends to implement in the context of its request for financial support from the IMF, 6 June 2000, available at http://www.imf.org/external/np/loi/2000/rom/02/index.htm.

IMF Country Report No. 05/64, (2005), "Republic of Moldova: Financial System Stability Assessment, including Reports on the Observance of Standards and Codes on the following topics: Monetary and Financial Policy Transparency, Banking Supervision", February 2005.

IMF Country Report No. 04/357, (2004), "Republic of Estonia: Selected Issues", November, 2004.

IMF Country Report No. 04/316, (2004), "Russian Federation: Selected Issues", September 2004.

IMF Country Report No. 05/213, (2005), "Hungary: 2005 Article IV Consultation - Staff Report; Staff Statement; and Public Information Notice on the Executive Board Discussion", June, 2005.

Isik, I., and Hassan, M. K., (2003a), "Financial deregulation and total factor productivity change: An empirical study of Turkish commercial banks", *Journal of Banking & Finance,* V. 27 (8), 1455-1485

Isik, I., and Hassan, M. K., (2003b) "Financial disruption and bank productivity: The 1994 experience of Turkish banks", *The Quarterly Review of Economics and Finance, V.43 (2), 291-320*

Jemric, I. and Vujcic, B. (2002), "Efficiency of Banks in Croatia: A DEA approach", Croatian National Bank, W-7, February 2002.

Kraft, E. and Tirtiroglu, D. (1998), "Bank efficiency in Croatia: A Stochastic – Frontier Analysis", *Journal of Comparative Economics*, Vol. 26, 282 – 300.

Kuosmanen T. and Post T. (1999) "Measuring economic efficiency with incomplete price information With an Application to European Commercial Banks".

Laeven L., (1999), "Risk and Efficiency in East Asian Banks", Papers 2255, World Bank - Country Economics Department .

Leightner J.E. and Lovell C. A. K. (1998), "The Impact of Financial Liberalization on the Performance of Thai Banks", *Journal of Economics and Business*, V. 50 (2), 115-131

Li, Q., (1996) "Nonparametric Testing of Closeness between Two Unknown Distributions", *Econometric Reviews*, 15, 261-274.

Llewellyn, D. T. (1995), "What is a Bank and Who is a Bank: from Money Collectors to Financial Advisers", *Luxemburg.*

Llewellyn, D. T. (1998), "A Strategic Perspective on the Global Banking Industry", *Revue de la Banque/ Bank – en Financiewezen,* No 6/1995.

Llewellyn, D. T. (1999) "The New Economics of Banking" , *SUERF, Amsterdam* .

Lozano – Vivas A., and Pastor J.T. (2006), "Banking and economic activity performance: An empirical study at the country level", *The Manchester School, V. 74 No. 4 Special Issue 1463–6786, 469–482*

Lozano-Vivas A., Pastor J.T., Pastor J.M. (2002) "An efficiency comparison of European banking systems operating under different environmental conditions", Journal of Productivity Analysis, 18, 59-77, 2002.

Lozano-Vivas A., Psator J.T and Hasan I.H. (2001), "European Bank Performance Beyond Country Borders: What Really Matters?", European Finance Review 5: 141–165, 2001.

Lozano-Vivas, A., and Humphrey D.B. (2002), "Bias in Malmquist index and cost function productivity measurement in banking", *International Journal of Production Economics,* V. 76 (2), 177-188

Luenberger, D.G., (1992a). "Benefit functions and duality", Journal of Mathematical Economics 21, 461-481.

Luenberger, D.G., (1992b), "New optimality principles for economic efficiency and equilibrium", *Journal of optimization theory and applications*, 75, No 2, 221 -264.

Maggi B. and Rossi S.P.S. (2003) "An efficiency analysis of banking systems: a comparison of European and United States large commercial banks using different functional forms", Department of Economics, University of Vienna, Working paper No.0306.

Maliszewski W.S., 2000, 'Central bank independence in transition economies', Economics of Transition, Vol. 8 (3), 749-789.

Maniadakis, N. and Thanassoulis, E. (2004) "A cost Malmquist productivity index", European Journal of Operational Research, 154, 396 -409.

Matousek R. (2004), "Efficiency and scale economies in banking: Empirical evidence from eight accession countries", XIV. Conference A.I.S.S.E.C.

Maudos J., Pastor J.M., Pe'rez F. and Quesada J. (2002), "Cost and profit efficiency in European banks" Journal of International Financial Markets, Institutions and Money 12 (2002) 33–58.

McAllister P.H. and McManus, D.A., (1993), "Resolving the scale efficiency puzzle in banking", Journal of Banking & Finance, 17, pp. 389-405.

Mester L.J., (1996) "A study of bank efficiency taking into account risk-preferences", Journal of Banking and Finance, 20, pp. 1025-1045.

Mlima A.P. and Hjalmarsson L. (2002), "Measurement of inputs and outputs in the banking industry", Tanzanet Journal, 2002, Vol. 3(1), pp.12-22.

Montinola G. and Morena R. (2001) "The political economy of foreign bank entry and its impact: Theory and a case study", Center for Pacific Basin Monetary and Economic Studies, Working Paper No. PB01-11.

Opiela, T. (2000), 'Assessing the evaluation of Polish commercial banks', Paper No 18, Warsaw, National Bank of Poland.

Pastor J.M. and Serrano L., (2005), "Efficiency, endogenous and exogenous credit risk in the banking systems of the Euro area," Applied Financial Economics, vol. 15(9), pp. 631-649.

Pastor, J. M. (1999a), "Efficiency and risk management in Spanish banking: a method to decompose risk", *Applied Financial Economics*, 1999, 9, 371-384 .

Pastor, J. M., Pérez, F., and Quesada, J. (1997), "Efficiency analysis in banking firms: An international comparison" *European Journal of Operational Research,* V. 98 (2), 395-407

Pastor, J.M. (1999b), "Credit risk and efficiency in the European banking systems: A three stage analysis", Working paper WP-EC 99-18, Departamento de

Estadõ Â stica e InvestigacioÂ n Operativa, Universidad de Alicante, Alicante, Spain.

Pastor, J.M. (2002), "Credit risk and efficiency in the European banking system: A three-stage analysis", *Applied Financial Economics*, 2002, 12, 895 – 911.

Peristiani, S. and Wizman, T.A. (1997), Mutual – to – stock conversions in the thrift industry in the 1990s, *Journal of Economics and Business*, 49, 95 – 166.

Rajan R. and Zingales L., (2003), *Saving Capitalism from Capitalists: Unleashing the Power of Financial Markets to Create Wealth and Spread Opportunity*, Random House, New York 2003

Reininger T. and Walko Z. (2005), 'The Croatian Banking System', Oesterreichische Nationalbank, Financial Stability Report 9 (6/2005).

Reininger T., Schardax F. and Summer M. (2001), 'The financial system in the Czech Republic, Hungary and Poland after a decade of transition', Discussion paper 16/01, Economic Research Centre of the Deutsche Bundesbank, Dec 2001.

Rejesus R.M. and Lovell A.C. (2003) 'Economics and Marketing. Are added land and new producer provisions in crop insurance vulnerable to abuse? The case of insured Texas cotton producers', *The Journal of Cotton Science*, 7, pp.75-85, 2003.

Rezitis A.N. (2006), "Productivity growth in the Greek banking industry: A non-parametric approach", Journal of Applied Economics, V. IX, (1, 119 - 138)

Rudner, Glass, Evartt, and Emery (2002) "A user's guide to the meta-analysis of research studies", College Park, MD: ERIC Clearinghouse on Assessment and Evaluation.

RZB Research Group (2004), 'CEE banking sector repot. Trends in CEE banking. Coutry Overviews. Market Players. Company Updates.', RZB Research Group, Oct 2004.

Scheel, H. (1998), "Undesirable Outputs in Efficiency Valuations", *European Journal of Operational Research*, 132, 400-410.

Schure P. and Wagenvoort R. (1999) "Economies of scale and efficiency in European banking: New evidence", European Investment Bank, Economic and Financial Report, 1999/01.

Scott, D. W. (1992). *Multivariate Density Estimation: Theory, Practice, and Visualization.* New York: Wiley.

Sealey C.W. and Lindley J.T. (1977), "Inputs, outputs, and a theory of production and cost at depository financial institutions", Journal of Finance, 32, pp.1251-1266.

Seiford L.M., and Zhu J. (1999) "An investigation of returns to scale in data envelopment analysis", Omega; 27, pp. 1–11.

Sheather, S. J. and M. C. Jones, (1991), "A Reliable Data-Based Bandwidth Selection Method for Kernel Density Estimation." *Journal of the Royal Statistical Society, Ser. B* 53(3), 683–690.

Siegel S. and Castellan N.J. Jr., (1988) 'Nonparametric Statistics for Behavioral Sciences' McGraw-Hill, London.

Silva Portela, M.C.A, Thanassoulis, E. and Simpson, G. (2004), "Negative Data in DEA: A directional distance approach applied to bank branches", *Journal of the Operational Research Society*, 55, 1111-1121.

Silva Portela, M.C.A, and Thanassoulis, E., (2007), "Comparative efficiency analysis of Portuguese bank branches", *European Journal of Operational Research*, 177(2), pp. 1275-1288.

Silverman, B. W. (1986). Density Estimation for Statistics and Data Analysis. London: Chapman and Hall.

Simar L., and Wilson P.W., (2002), "Non-parametric tests of returns to scale", *European Journal of Operational Research*, 139, pp. 115-132.

Simar, L. and P.W.Wilson. (1998). "Sensitivity Analysis of Efficiency Scores: How to Bootstrap in Nonparametric Frontier Models." *Management Science* 44(1), 49–61.

Simar, L., and Zelenyuk, V., (2006) "On testing equality of two distribution functions of efficiency scores estimated from DEA", *Econometric Reviews*, forthcoming.

Speagle, R.E., and Kohn, E. (1958), "Employment and Output in Banking, 1919 - 1955", The Review of Economics and Statistics, V.40, No. 1 (Feb., 1958), pp. 22-35.

Sturm J. and Williams B. (2004), "Foreign bank entry, deregulation and bank efficiency: Lessons from the Australian experience", *Journal of Banking and Finance,* V. 28 (7), 1775-1799

Sylla R. (2006) "Schumpeter Redux: A Review of Raghuram G. Rajan and Luigi Zingales's Saving Capitalism from the Capitalists", *The Journal of Economic Literature* Vol. 44, No. 2, June 2006.

Taci, A. and Zampieri, E. (1998), 'Efficiency in the Czech banking sector', CERGE-EI Discussion Paper No 4/98, Charles University, Prague.

Thorne A., 1993, 'Eastern Europe's experience with banking reform: Is there a role for banks in the transition?', Journal of Banking and Finance, 17, (1993), pp 959 – 1000.

Tone K. (2001), "A slack – based measure of efficiency in Data Envelopment Analysis", European Journal of Operational Research, 130, pp. 498 – 509

Tortosa-Ausina E. (2002a) "Bank cost efficiency and output specification" *Journal of Productivity Analysis*, 18, 199-222, 2002.

Tortosa-Ausina E. (2002b), "Exploring efficiency differences over time in the Spanish banking industry ", *European Journal of Operational Research*, 139 (3), 643-664.

Tortosa-Ausina E. (2003) "Nontraditional activities and bank efficiency revisited: a distributional analysis for Spanish financial institutions", *Journal of Economics and Business,* 55(4) 371-395.

Tortosa-Ausina E. (2004) "An alternative conditioning scheme to explain efficiency differentials in banking ", *Economics Letters*, 82 (2),147-155.

Tsionas E.G., Lolos S. E. G. and Christopoulos D. K. (2003) "The performance of the Greek banking system in view of the EMU: results from a non-parametric approach" *Economic Modelling,* V. 20 (3), 571-592

Vennet R.V. (2002), "Cross-border mergers in European banking and bank efficiency", Ghent University, Working paper, September 2002, 2002/152.

VUB Annual report (2000), Vseobecna Uverova Banka, Annual Report, available at http://www.vub.sk/EN/show.asp?category=26.

Wand, M. P. and M. C. Jones, (1994), "Multivariate Plug-in Bandwidth Selection." *Computational Statistics* 9, 97–116.

Weelock D.C. and Wilson P.W., (1995), "Evaluating the efficiency of commercial banks: Does our view of what banks do matter?", Review, July/August 1995, Federal Reserve Bank of St.Louis.

Weill L. (2002) "Does restructuring improve banking efficiency in a transition economy?" Applied Economics Letters, 2002, 9, 279-281.

Weill L. (2003) "Banking efficiency in transition economies. The role of foreign ownership", Economics of Transition Volume 11 (3) 2003, 569–592.

Weill L. (2004) "Measuring cost efficiency in European banking: A comparison of frontier techniques", Journal of Productivity Analysis, 21, 133-152, 2004.

Weill L., "Is There a Lasting Gap in Bank Efficiency between Eastern and Western European Countries ?" http://www.univ-orleans.fr/DEG/GDRecomofi/Activ/weill_birmingham.pdf.

Williams J. and Gardener E.P.M. (2003), "The Efficiency of European Regional Banking", Regional Studies, Vol. 37.4, pp. 321–330, 2003.

Williams J., "Are European savings banks too small? A comparison of scale economies and scale efficiency" http://sbard.bangor.ac.uk/site_english/pdf/papers/scale.pdf.

World Bank (2002), "Report on the Observance of Standards and Codes (ROSC). Corporate Governance Country Assessment, Czech Republic", July 2002, available at http://www.worldbank.org/ifa/Czechrosc_cg0702.pdf.

Yildirim H.S. and Philippatos G.C., 2003, 'Competition and contestability in Central and Eastern European banking markets', available on http://ideas.repec.org/p/wpa/wuwpfi/0310004.html.

Yildirim, H.S., Philippatos, G.C. (2002) "Efficiency of banks: Recent evidence from the transition economies of Europe – 1993-2000", April 2002, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=314894 .

Young I.T. (1977) 'Proof without prejudice; Use of the Kolmogorov-Smirnov test for the analysis of histograms from flow systems and other sources', *The Journal of Histochemistry and Cytochemistry*, Vol.25, No.7, pp.935-941.

Zhou P., Poh K.L. and Ang B.W. (2006), "A non-radial DEA approach to measuring environmental performance", *European Journal of Operational Research*, forthcoming.