Efficiency vs. Heterogeneous Technologies in the Turkish Banking: 1990-2000

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Abstract

We model unobserved heterogeneity in banking technologies as a mixture model and investigate the efficiencies of 53 Turkish banks using likelihood-based stochastic frontier analysis for the 1990-2000 period. The measure of "inefficiency" may be corrupted due to unobserved heterogeneity in banking technology. Therefore we estimate a mixture model using the EC (Estimation-Classification) estimator, and its companion EC-algorithm, which were first introduced in El-Gamal and Grether (1995), to obtain data-driven classification and estimation of banking technologies.

In contrast to previous efficiency studies which tend to draw conclusions on the pooled estimates or estimates based on a priori classifications, the data-driven EC estimates point mainly to distinctions between small and foreign banks vs. large and domestic ones, respectively. We then investigate the inefficiency scores with respect to the two different cost frontiers recovered by EC. Surprisingly, we do not find evidence of heterogeneity between state and private banks. Moreover, contrary to common wisdom, we find that state banks are not significantly less efficient than private banks, and "special finance houses" seem indistinguishable from conventional banks.

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1. Introduction

While financial innovations have caused traditional banking to decline in developed countries, banks continue to play a dominant financial intermediation role in all countries. For instance, the share of U.S. commercial banks' lending as a percentage of total domestic non-financial sector credit has declined from 35% in 1974 to 25% in 1998. Moreover, U.S. commercial banks' share of total financial intermediary assets declined from 40% in 1980 to below 25% in 1998 (Mishkin and Eakins 2000 p. 481). On the other hand, commercial banks are still the primary financial intermediaries in the financial sector and U.S. banks' relative share in GDP is increasing (Allen and Santamero, 2001).

Since the main function of banks is moving funds from lenders to borrowers, loans to assets ratio is a good indicator of this basic function. In this regard, while U.S. banks lent 60% of their total assets, Turkey's commercial banks averaged a loans-to-assets ratio below 40% for the period 1990-2000. Taking into account that the majority of financial flows go through the banking sector, and that the banking sector accounts for 75% of the assets of the total financial sector in Turkey (BRSA Report 2001 p1), it is fair to say that Turkish banking sector is not fulfilling its potential in generating loans.

Turkish banks have not fared better on the deposits-generation side of financial intermediation. In this regards, it is estimated that Turkish households are hording roughly 15 billion dollars[1] in the form of cash and gold, the latter serving as an inflation hedge in a highly inflationary environment[2]. Indeed, this pattern is explained by the fact that real returns for foreign exchange transactions and gold have been positive, while real return on deposits has been negative. For instance, the real return from USD exchange transaction in 2001 was 27.6%, and the real return from DM exchange transaction was 20.5%, while gold-holdings offered a 30.6% real rate of return. In contrast, the real return on bank deposits was *negative* 5% (Milliyet 2002).

Mismanagement of a country's banking sector can cause significant damages beyond the low growth caused by financial disintermediation. For instance, banking crises in Mexico, South Korea, Russia and Indonesia cost 21% to 50% of the GDP of the respected countries in the past decade. Similarly, the Banking Regulation Supervision Agency (BRSA) declared at the end of 2001 that the recent Turkish banking crises have cost the country more than 20 billion USD.

Turkish banking began in 1856 with the establishment of Ottoman Bank. Established by foreign capital, Ottoman Bank was granted the authority of printing money, and mainly served the function of internal and external borrowing. Ottoman

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[1] 205 tons of gold (6% of total international gold imports) were imported by in Turkey in 2000 ranking 7th in the world.

[2] Average annual inflation rate is 77 % during 1990-2000.

period banking was dominated by foreign banks until the declaration of Turkish Republic in 1923, (B.A.T's 40th Year Book, p8).

Akguc (1989) examines the evolution of Turkish banking system after 1923 in five phases; the period of national banks (1923-1932), the period of state-owned banks (1933-1944), the period of developing private banks (1945-1959), the planned period (1960-1980), and the period of liberalization and open economy (After 1980). A detailed review of those five periods is provided in B.A.T's 40th Year Book.

In its early periods of development, the Turkish banking sector's main goal was to regain national control of domestic capital. During the import-substitution era prior 1980, the national plan called for negative real interest rates to finance the development of domestic industries. This period was also characterized by limited competition and state control of the banking sector. For instance, only 7 new banking licenses were issued between 1960 and 1980, 2 out of which for foreign banks. Therefore, the issue of efficiency of the banking system only came to the fore during the period of liberalization and open economy starting in 1980.

The 1980 structural change and reform program called for free market and export-oriented policies, including liberalization of the repressed financial system. The new policies included the abolition of directed credit, liberalization of deposit and credit interest rates, liberal exchange rate policies, and the adoption of international best standard banking regulations, c.f. BRSA (2001, p1).

The liberalization program allowed a number of domestic and foreign banks to enter the market, with a marked increase in competition. On the other hand, banks also had access to "easy profits"-making strategies during this period. With increased freedom of capital movement and foreign currency transactions, banks borrowed funds from abroad, and invested them in deficit-financing government bonds which offered high interest rates. Those high interest rates were in turn financed through more public borrowing, and inflationary monetary expansions, leading to very high inflation in the early 1990s.

There has been a considerable amount of research done on the efficiency of Turkish banking sector starting in late 1980's, especially to investigate the effects of the liberalization program. The main contribution of this work is that to highlight the existence of heterogeneity in Turkish banking industry. In the presence of such heterogeneity in banking technology, measures of "inefficiency" may be corrupted. In particular, we find significant differences in banking technology between small and large banks, and between foreign (mostly small) and domestic banks. We employ the data-driven EC-estimator of El-Gamal and Grether (1995) to obtain data-driven classification and estimation of banking technologies among the 53 Turkish banks in our sample, and to investigate the differences in technology between the different types of banks. The banking technologies will be estimated using Stochastic Frontier cost functions. Following Mester (1996), our estimated cost functions include controls for the quality of loans, as well as the risk exposure of the banks in our dataset.

Apart from methodology, our study also has the benefit of using a superior panel data set to those used in previous studies. First, the dataset consists of all banks present throughout the entire period. The 49 conventional banks compromise more than 93% of the total assets of conventional banking system. Second, our dataset includes special finance houses (SFHs, hereafter) which basically function as "Islamic banks" in Turkey. The four special finance houses in our dataset manage 90% of the total assets of Islamic banking system in Turkey. While Islamic banking in Turkey started in 1985, there have been virtually no empirical studies on the interaction between the SFHs and the Turkish banking sector. As a matter of fact, there has been very little empirical study of "Islamic banking" in general, despite the significant growth of this sector in a number of countries over the past two decades. The most recent and distinguishable one is Aggarwal and Yousef, (2000). Aggarwal and Yousef (2000) study financial instruments used by Islamic banks, and find that most are not based on profit-and-loss sharing (equity) but instead, are very debtlike in nature. Al-Deehani, Abdelkarim, and Murinde (1999) propose a model in which, under certain assumptions, an increase in investment accounts financing enables the Islamic bank to increase both its market value and its shareholders' rates of return at no extra financial risk to the bank. They estimate and test their model on annual accounts drawn from a sample of 12 Islamic banks which support their theoretical predictions i.e. increase in the Islamic bank's market value without a change in its cost of capital. There are also some limited case studies which focus on specific countries. Iqbal (2001) evaluates the performance of Islamic banks along with the conventional banks from the same countries using both trend and ratio analyses. His sample of twelve Islamic banks with a "control group" of twelve conventional banks come from ten different countries and covers the 1990-98 period. Samad (1999) determines the relative efficiency position of Islamic bank of Malaysia in Malaysian conventional banking system with financial ratios for 1992-1996. His dataset includes one Islamic bank and seven conventional banks. Bashir (1999) investigates the risk and profitability measures of two Sudanese banks. As clear from the previous Islamic banking literature, efficiency analysis of Islamic banking is limited with financial ratios while constrained by the time span and the number of Islamic banks. In this manner, our paper will be a first step in the rigorous efficiency analysis of Islamic banking literature.

We provide a literature review of the most commonly used methods of efficiency analysis, as well as previous efficiency studies of Turkish banking. In section 3, we describe our dataset and provide basic ratio analyses. Efficiency analysis for the pooled dataset, and allowing for heterogeneity, is presented in Section 4. Finally, we provide some concluding remarks in Section 5.

2. Literature Review

2.1 Efficiency Studies

Efficiency studies can be grouped under three main methodologies; parametric, nonparametric and semi-parametric techniques. Parametric techniques impose strong functional and distributional assumptions while nonparametric techniques require neither the explicit specification of functional form nor the theoretical notion of the error. Parametric efficiency date go back to Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977), who independently proposed a stochastic frontier approach (SFA). The model originally specified for cross-sectional data had an error term which had two components: one to account for random effects (normally distributed), and another to account for technical inefficiency (half-normally distributed). A parametric maximum likelihood based efficiency estimation (which we use and augment in our study) was developed by Battese and Coelli (1992) for panels, allowing for missing data. The stochastic frontier approach was applied to panel data by Schmidt and Sickles (1984) (also known as Distribution Free Approach), imposing no distributional assumptions on error terms. Cornwell, Schmidt and Sickles (1990) improved the distribution free approach by allowing time heterogeneity in slopes and intercepts. Adams, Berger, and Sickles (1997) made further improvements on the semi-parametric approach by imposing only minimal assumptions on the functional form. Berger and Humphrey, (1997) is an excellent survey of 130 studies that apply frontier efficiency analysis to financial institutions in 21 countries.

Nonparametric techniques, such as Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH) require neither the explicit specification of functional form nor the assumption of cost minimization or profit maximization. However, DEA is a mathematical approach which does not allow for any error in the data and confounds random errors with inefficiency. Thus, the SFA approach dominates the DEA approach by allowing for measurement error.

In this paper, we chose ML estimation of a parametric SFE in order to utilize the likelihood-based EC-estimator of El-Gamal and Grether (1995), which has been shown to have many theoretical and numerical advantages, for modeling heterogeneity. The issue of separating heterogeneity effects from efficiency has been a concern in many studies of U.S. and European banking. For instance, Brown and Glennon (2000) performed tests of homogeneity in U.S. banking and rejected the null hypothesis. They performed their test by grouping the banks using cluster analysis and then estimating the efficiencies for six different clusters. Similarly, Altunbas and et al. (2001) estimated cost and alternative profit frontiers for three different ownership types and then compared the results with those derived from a pooled cost frontier for German banking industry. They found little

evidence to suggest that private banks are more efficient than their mutual and public sector counterparts in Germany. Lastly, Elysiani and Rezvanian (2002) compared the production technologies and the cost characteristics of foreign vs. domestic owned banks in U.S. within a cost minimization context. They also rejected the hypothesis of identical cost structures between the two groups.

In contrast to the above mentioned *a priori* tests of homogeneity across pre-specified divisions (which we also perform in our paper), EC-estimation has the advantage of parsimoniously selecting the classifications based on bank-contributions to the likelihood function. For instance, as we shall see in later sections, our null of homogeneity of cost functions is rejected (using a LR test) for small vs. large banks, as well as for foreign vs. domestic banks. However, since most foreign banks are also small, the two effects are confounded. As discussed in El-Gamal and Grether (1995), the data-driven penalized likelihood estimator has the advantage of parsimoniously choosing the smallest number of classifications necessary to account for heterogeneity in the sample.

2.2 Efficiency studies on Turkish banking

Research on the efficiency of Turkish banking sector began in late 1980's, focusing mainly on investigating the effect of liberalization policies. Recent studies by Ozkan-Gunay (1996, 1998), Mahmud and Zaim (1998), Yildirim (1999), and Mercan and Yolalan (2000) concluded that liberalization increased the efficiency of banking sector. Most of the Turkish banking studies either pooled all the commercial banks and drew conclusions from the estimated efficiencies, or focused on a particular group of banks according to ownership structure or size. For instance, Mahmud and Zaim (1998) focused on private commercial banks, while Cingi and Tarim (2000) studied the efficiencies of 21 commercial banks (some state-owned and some private) with a deposit share of more than 1% in the banking sector.

Studies that allowed for a priori heterogeneity sometimes reached different conclusions. For instance, Zaim (1995), Yolalan (1996), Ozkan-Gunay (1997), Emir (1999), Mercan and Yolalan (2000), Cingi and Tarim (2000) found that state owned banks were more inefficient than private and foreign banks, whereas Zaim (1995) and Denizer, Dinc, and Tarimcilar (2000) claimed that state owned banks were no less efficient than their counterparts. Those divergent conclusions may be attributed to differences in methodology, as well as differences in the data sets used in the different studies.

In a recent study, Isik and Hassan (2002) investigated input and output efficiency in Turkish banking, focusing on the impact of size, international variables, ownership-structures and other variables. Their results suggest that heterogeneity in bank-characteristics have significant effects on their measured efficiencies. Isik and Hassan (2002) performed their analysis by estimating three separate annual efficiency frontiers, specifically for the years 1988, 1992 and 1996. They summarized their results for both separate and pooled frontiers for national and foreign banks, after failing to reject the null of homogeneity across the domestic/foreign distinction.

To our best knowledge, there is only one empirical study of Special Finance Houses in Turkey, which is currently out-of-date. Agaoglu (1994) compared C.A.M.E.L. based financial ratios for the period for conventional banks and SFHs in the period 1986-1991. We therefore believe that this study is the first to perform a rigorous empirical efficiency analysis of SFHs together with conventional Turkish banks.

3. Data and Ratio Analysis

The data[3] for 49 conventional banks was downloaded from The Banks Association of Turkey's (B.A.T) website which includes the balance sheets and income and expense statements of the banks from 1990 to 2000. Of those 49 banks, 13 banks are foreign banks or branches of foreign banks, 23 are domestically owned, 4 are state owned, and 9 are failed private banks that were transferred to Savings Deposits Insurance Fund (SDIF) during 1997-2000.[4] By December 2000, the shares of state, private, foreign and SDIF banks' total assets[5] in the sector were: 34.2%, 47.4%, 5.4% and 8.5%, respectively, c.f. BRSA Banking Restructuring Report (p2).

The data for 4 special finance houses were obtained directly from the individual institutions. The data were gleaned from the quarterly financial statements that SFHs are required to report to Central Bank of Turkey.

We shall now provide some summary financial ratios for the banks in our sample. Financial ratios are the most commonly used tools that "outsiders" use to analyze the performance of banks. We report graphically selected C.A.M.E.L. (Capital adequacy, Asset quality, Management, Earnings, Liquidity) based financial ratio trends for different banks, by ownership structure.

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[3] Data originally expressed in nominal Turkish Liras, are deflated according to the values of Consumer Price Index (CPI) of Turkey. Then all of the variables are converted to USD using real exchange rate based on year 1995 which is the base year of both Turkish and U.S. CPI.

[4] In year 2001, 9 more private banks failed and were transferred to the SDIF, summing the total failed bank number to 18. However, since our study covers until the end of year 2000, we consider only 9 of them as SDIF banks. SDIF was run by the Turkish Central Bank during 1983-2000, and was transferred to the Banking Regulation Supervision Agency (BRSA) on August 31, 2000.

[5] By the end of 2000, the total assets of Turkish banking sector was 155.2 billion USD which makes up 76.9% of GDP. (Source TBA)

3.1 Capital Adequacy

The 1988 Basle Capital Accord[6] defines Capital Adequacy ratio as the ratio of total capital to the sum of credit risk and market risk. Credit and market risk are calculated based on risk weights (0%, 10%, 20%, 50%, or 100%) attached to the balance sheet assets; where 0% weighting indicating zero risk (e.g. cash held in the bank) and 100% indicating the most risky assets (e.g. claims non-OECD foreign banks). Basle Committee sets a minimum a capital adequacy ratio as 8%, of which at least half must be in Tier 1 capital, where tier 1 capital is equity and disclosed reserves. Because of the difficulty in distinguishing the risk categories of the balance sheet assets and for the sake of parsimony, we used the leverage ratio (which doesn't weight the assets for default risk) as an indicator for the capital adequacy for different types of banks. Leverage ratio is calculated by dividing equity capital to total assets. Fig. 1 shows the trends of leverage ratios for different owner type banks. Interestingly, SDIF banks have the highest ratios both at the beginning and at the end of the decade. The reason for the increase in the equity capital of these banks in the last years can be explained by the fact that they were restructured, and received significant capital injections, after being taken over by the state. On average, foreign banks are the best capitalized for the period. State owned banks and SFHs seem to be the least capitalized, even though SFHs increased their equity capital after they were made subject to the banking law.
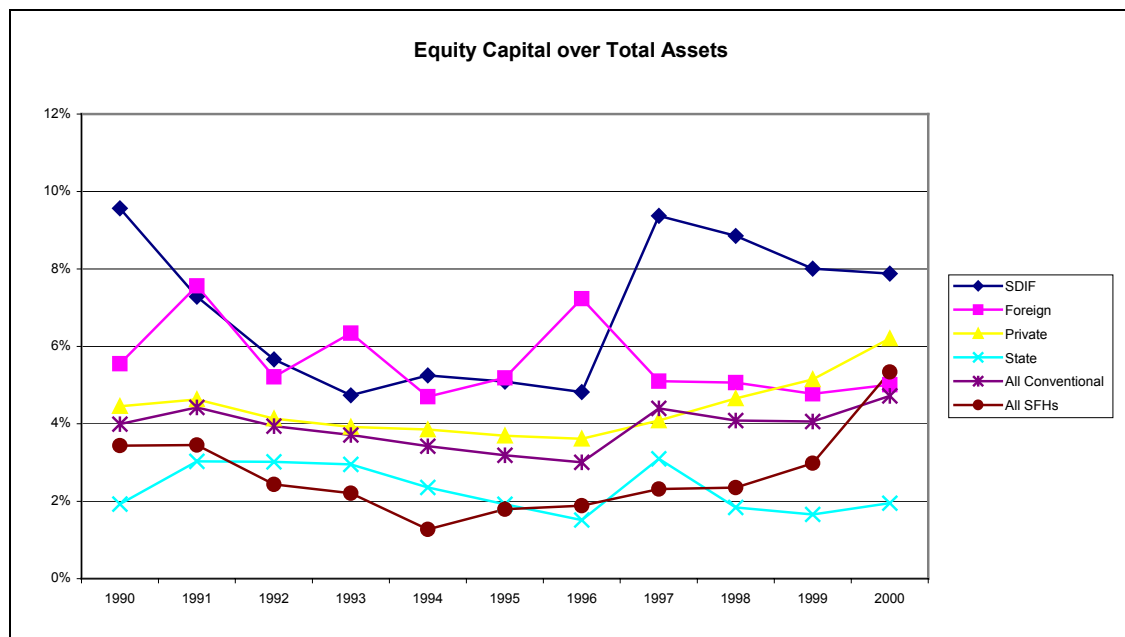

Figure 1

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[6] Basel Committee introduced the new Accord in 2001 to be implemented in 2004. The new Accord focuses on improvements in the measurement of risks, i.e., the calculation of the denominator of the capital ratio. The new framework adds operational risk to credit and market risk.

3.2 Asset Quality

The loans-to-assets ratio is significantly different for SFHs (70% on average) and conventional banks (39% on average). The loans-to-assets ratio for foreign banks dropped to 31% on average. This reluctance of foreign banks to make loans is explained by the above mentioned profitability of borrowing abroad and investing the funds in high-interest-paying government bonds. This trend will become even more apparent when we analyze liquidity ratios.

The ratio of nonperforming loans to total loans (NPL/TL) is a good indicator of loan-quality. We can see in Figure 3 that the average ratio of NPL/TL increased steeply for all banks towards the end of our period. This increase is particularly marked for SDIF banks, for which the ratio of non-performing loans reached a staggering 77% by 1999. However, this sharp increase may be attributed in part to the adoption of best accounting practices after those banks were taken over by the state, thus recognizing many previously hidden non-performing loans.
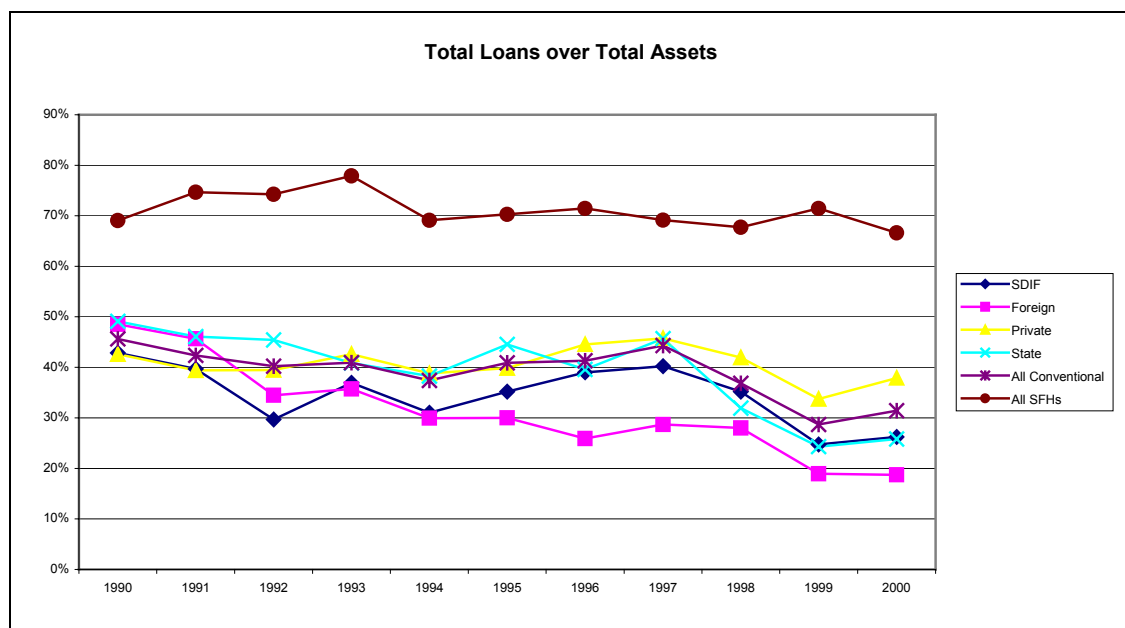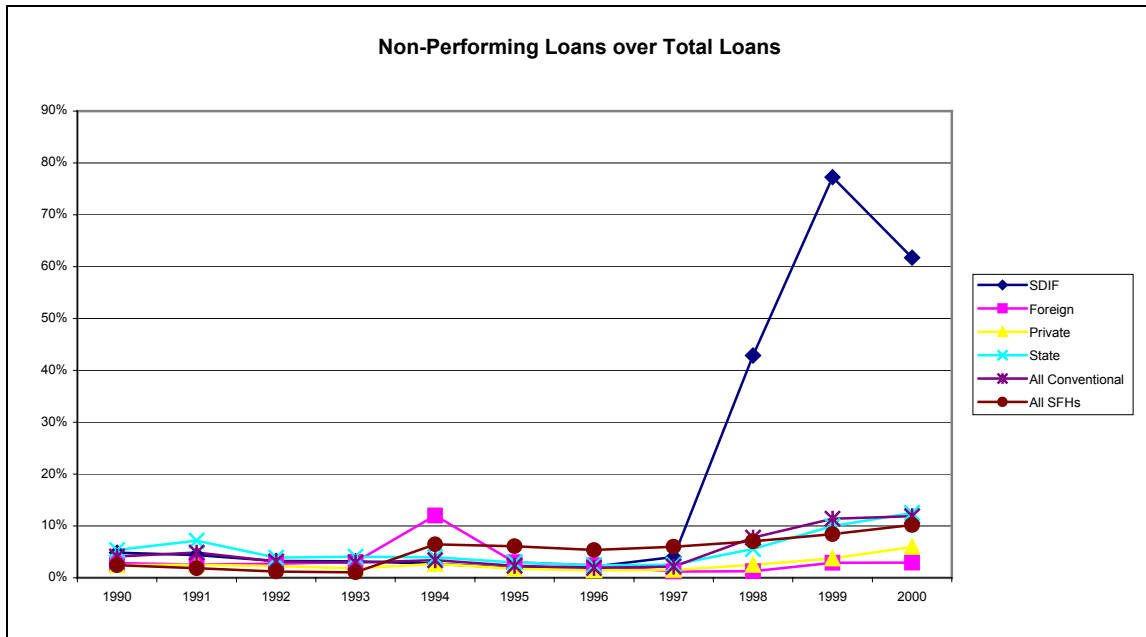

Figure 2

Non-Performing Loans over Total Loans

Figure 3

3.3 Management

To study management-efficiency, we consider the ratio of employee expenses to total assets. This ratio seems to have declined for the conventional private banks, and to have slightly increased for SFHs, reaching convergence between the two groups around 2000. The secular decline for conventional private banks reflects the overall decline in bank-employment over the studied period. On the other hand, the increase in SFH employment expenses reflects the increase in branching from the mid-1990s. The earliest SFHs (Al-Baraka Turk, Faisal Finance and Kuveyt Finace House) were originally capitalized by Gulf-country owners who initially resisted opening many branches. However, as the domestically-owned Ihlas Finance House and Asya Finance House entered the Islamic finance market, and pursued aggressive branching strategies in 1995 and 1996 respectively, the old SFHs had to responded accordingly.
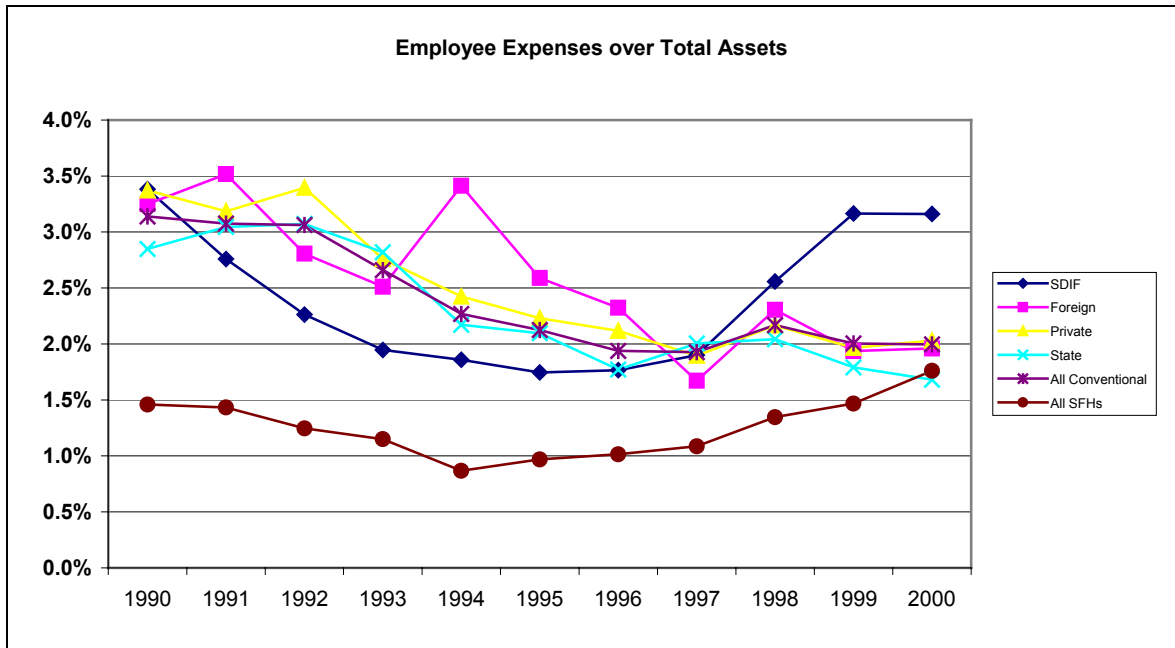
Employee Expenses over Total Assets

Figure 4

3.4 Earnings

Turkish banks' bad loans and maturity mismatch losses show up clearly in their earnings performance. Both the ROE (return on Equity) and the ROA (Return on Assets) profitability ratios are very low. SDIF banks consistently made losses while foreign banks appeared to be the most profitable in our sample. Foreign banks' short positions in foreign exchange proved profitable when the return on government bonds was greater than the cost of foreign exchange liability plus the devaluation rate.
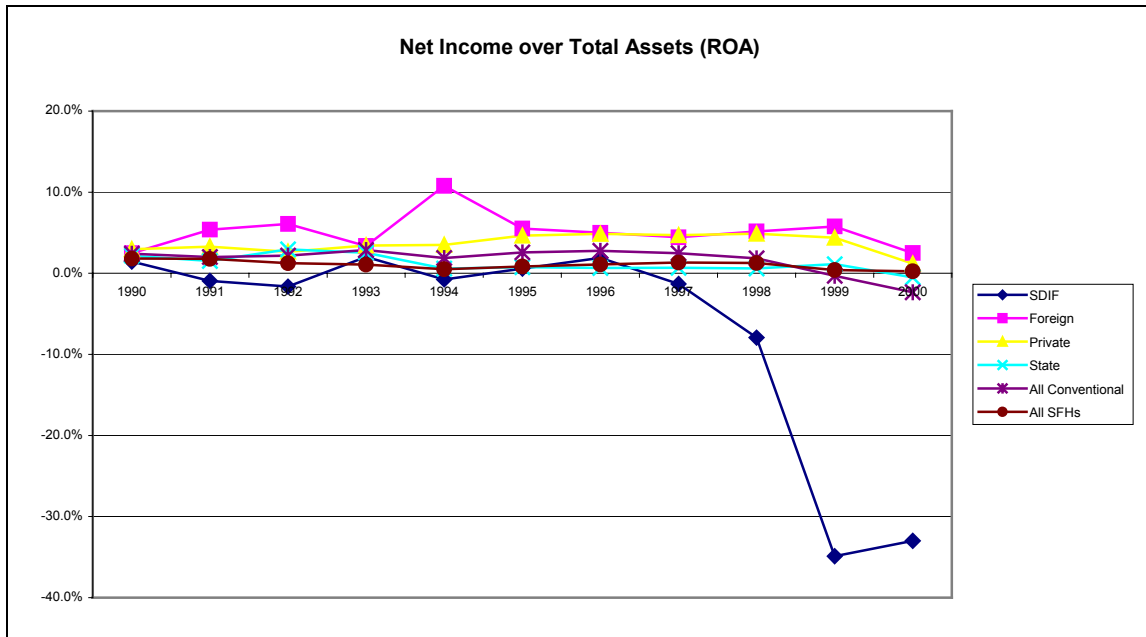
Figure 5

3.5 Liquidity

Liquid assets are defined as vault-cash, cash at Central Bank and other banks, securities and reserve requirement. SFHs had the most illiquid assets in our sample, followed by state banks. At the other extreme, foreign banks had the most liquid assets. This is explained by the fact that foreign banks' loan portfolios were the lowest as we have seen. Instead of making loans, foreign banks used the funds which they transferred from abroad to buy government papers. At the other extreme, SFHs' liquidity was the lowest since SFHs were not allowed to invest in government papers because of their very nature. Most of the liquid assets held by the SFHs in our sample consist of the obligatory 10% cash holdings stipulated in their banking law.

It is noteworthy that there was a systemic liquidity risk in Turkish banking system in our sample, which cannot be seen in Figure 6. The major source of liquidity risk in the system stemmed from maturity mismatches. The average maturity of assets in the system was one year, while the average maturity of the liabilities was approximately one month.
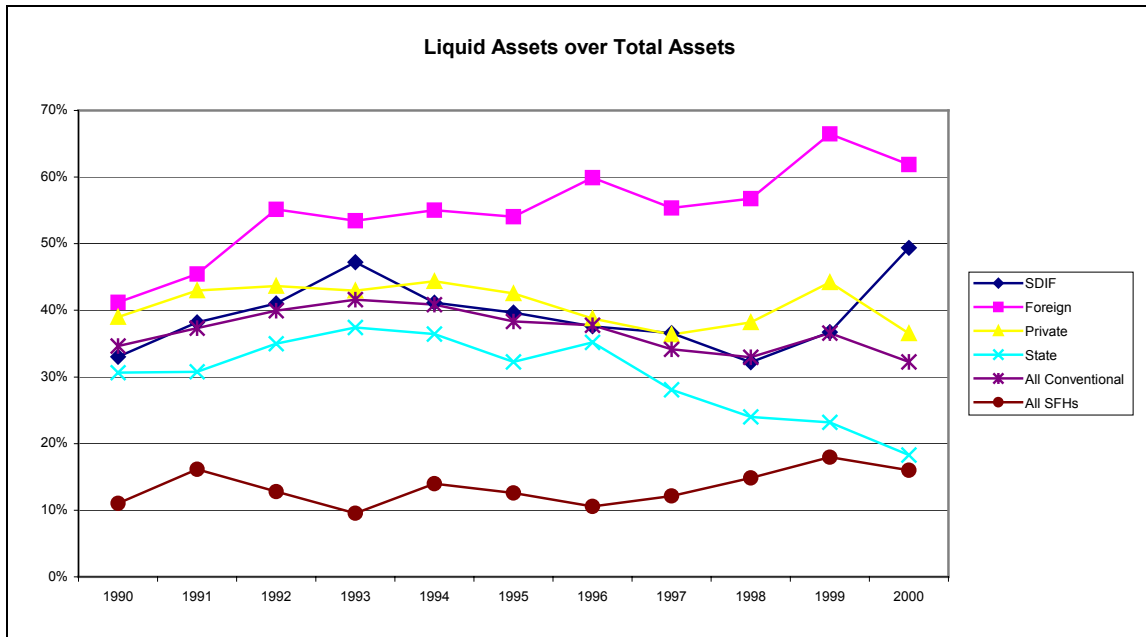
Liquid Assets over Total Assets

Figure 6

4. Efficiency Analysis

4.1. Stochastic Frontier Analysis

A stochastic frontier analysis (SFA) comprises the estimation of a best-practice frontier from the firms in the sample, and comparison of the individual firms with that frontier. In this study, we will use a stochastic cost frontier and assume that each bank attempts to maximize output (= loans) from the given inputs. Given cost-minimizing behavior by the firm, the production technology of banks can be represented by a dual cost function. A cost function gives the minimum expenditure needed to produce a given output. Bank inefficiency is then measured by the difference between the bank's realized costs production and the estimated theoretical minimum (frontier).

Although conventional banks are multi-product firms, in this study we will be concerned with a single output: loans. We focus on this one output since the SFHs' in our sample issue virtually no securities during our sample. Moreover, SFHs did not distinguish between short and long term loans, and thus we considered aggregated loans as the single output of the banks in our sample.

The cost frontier is obtained by estimating a cost function with a composite error term:

$$\ln C_{it} = \ln C(y_{it}, p_{it}, q_{it}, r_{it}; \text{B}) + u_{it} + v_{it.}$$

where C_{it} is the observed cost of bank i in period t

y_{it} is its output

p_{it} is a vector of input prices

q_{it} is a quality index

r_{it} is a risk index

B is a vector of parameters

v_{it} is a two-sided random error term (i.i.d.)

u_{it} is a one-sided error term (deviation from the cost frontier=inefficiency)

We measured total cost as the sum of weighted interest expense and employee and fixed assets expenses. As Mester (1996) indicates, interest expense should be weighted by loans/total earning assets to reflect the interest expense if the only output is loans. The prices of inputs are approximated by dividing the related input expenses by the inputs. In other words, the price of labor is calculated by total employee expenses/total number of employees; the price of physical capital is calculated by fixed asset expenses (depreciation and amortization)/total fixed assets and the price of borrowed capital is calculated by weighted interest expense/total borrowed funds.

We chose the classical translog[7] functional form which relates cost to output and input prices as follows:

$$\ln C = \alpha_0 + \alpha_1 \ln y + \alpha_2 \ln y \ln y + \sum_i \beta_i \ln P_i + \frac{1}{2} \sum_i \sum_j \delta_{ij} \ln P_i \ln P_j$$

$$+ \sum_i \gamma_i \ln y \ln P_i + \lambda_r \ln r + \lambda_{rr} \frac{1}{2} \ln r \ln r + \lambda_{ry} \ln r \ln y$$

$$+ \sum_i \lambda_{ri} \ln r \ln P_i + \lambda_{rq} \ln r \ln q + \lambda_q \ln q + \lambda_{qq} \frac{1}{2} \ln q \ln q$$

$$+ \lambda_{qy} \ln q \ln y + \sum_i \lambda_{qi} \ln q \ln P$$

Thus, the share of the ith input in the total cost can be derived as:

$$S_i = \frac{\partial \ln C}{\partial \ln P_i} = \beta_i + \sum_j \delta_{ij} \ln P_j + \gamma_i \ln y + \lambda_{ri} \ln r + \lambda_{qi}$$

Molyneux and et al (1996, p.164) listed the following five properties that cost functions must satisfy:

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[7] Berger and Mester (1997) use the distribution-free approach as well as the stochastic frontier approach for both the translog and the Fourier specification of the cost and profit function. They conclude that the empirical findings in terms of either average industry efficiency or ranking of individual banks are similar across methods.

1. Homogeneity of degree one in the input prices,
2. Cost exhaustion (the sum of cost shares is equal to unity),
3. Symmetry (the second order outputs and inputs parameters must be symmetric),
4. Positivity (the cost shares and the cost elasticities must be non-negative), and
5. Monotonicity (cost function is increasing in the input prices and in the level of output).

The conditions of linear homogeneity in input prices and symmetry imply:

$$\sum_i \beta_i = 1, \quad \sum_i \delta_{ij} = \sum_i \gamma_i = \sum_i \lambda_{ki} = \sum_i \lambda_{qi} = 0, \text{ and } \delta_{ij} = \delta_{ji}$$

The linear homogeneity restriction is imposed in estimation by normalizing total cost and prices (dividing them by the price of physical capital). Symmetry is easily imposed in the estimation. Finally, positivity and monotonicity will be tested after the estimation.

4.2. Pooled Empirical Results

The parameter estimates for the estimated cost frontier for the pooled sample of 53 banks over 11 years are reported in Table 1, and the efficiency rankings of the banks is reported in Table 2. Six foreign banks are ranked at the top, followed by a state-owned bank. Etibank and Sumerbank, both SDIF banks, rank the 52nd and 53rd respectively, while other SDIF banks are also ranked close to bottom, designating their cost inefficiency.

However, these rankings may reflect the fact that different technologies of the different banks, rather than inefficiency in using the same technology. For instance, consider a case in Figure 7, where firms A and B use the technology represented by cost function I (dashed curve). Notice in the picture the Firm B seems more efficient than Firm A (closer vertically to the dashed curve). However, if the frontier cost function for the two firms are estimated along with a number of other firms using the technology represented by cost function II (solid curve), resulting in the hybrid cost function represented by the dot-dashed line, the efficiency scores for the two firms may be reversed. Numerous other erroneous efficiency results can be illustrated in similar cases, where potential heterogeneity of cost functions is ignored.
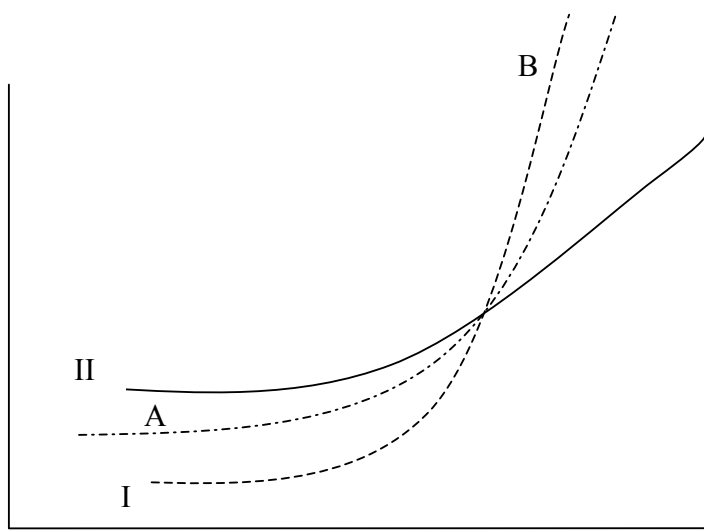
Figure 7

Table 1. Maximum Likelihood Estimation of the Cost Frontier with Pooled Data

	Coefficient	t-ratio
Constant	15.594	3.027
$\ln P_1^*$	0.175	0.261
$\ln P_2^*$	1.078	2.257
Lny	-0.778	-4.007
(lny)(lny)	0.104	13.884
$(\ln P_1^*)(\ln P_1^*)$	0.058	1.332
$(\ln P_2^*)(\ln P_2^*)$	0.122	3.953
$(\ln P_1^*)(\ln P_2^*)$	-0.181	-2.914
$\ln y \ln P_1^*$	-0.029	-2.647
$\ln y \ln P_2^*$	0.032	3.014
Lnq	-0.210	-1.650
Lnr	0.657	1.756
(lnq)(lnq)	0.016	4.158
(lnr)(lnr)	-0.029	-1.164
(lnq)(lnr)	0.017	2.345
(lnq)(lnl)	0.022	4.548
(lnr)(lnl)	-0.031	-2.448
(lnq)(lnw)	0.002	0.263
(lnq)(lnb)	-0.004	-0.506
(lnr)(lnw)	-0.018	-0.702
(lnr)(lnb)	-0.004	-0.186
Sigma-square	0.904	3.784
Gamma	0.872	23.997

Loglikelihood: -274.5

P_1^*=Price of Labor/Price of Physical Capital

P_2^*=Price of Borrowed Funds/Price of Physical Capital

Table 2: Inefficiency Estimates for Pooled Data

Banks	Type	Size (Total Assets)		Ineff. Measure	Rank
Societe Generale	Foreign	210,276,732	Small	1.033	1
Credit Lyonnais	Foreign	23,877,552	Small	1.060	2
Habib Bank	Foreign	26,953,184	Small	1.121	3
Banca Di Roma	Foreign	97,433,715	Small	1.126	4
West Deutsche	Foreign	403,052,223	Small	1.139	5
Abn Amro	Foreign	224,069,662	Small	1.268	6
Emlakbank	State	5,214,489,281	Large	1.296	7
HSBC	Foreign	1,030,277,431	Small	1.535	8
Oyakbank	Private	254,663,218	Small	1.569	9
Chase Manhattan	Foreign	300,623,612	Small	1.589	10
Vakifbank	State	6,921,179,394	Large	1.616	11
Kuveyt Turk	SFH	472,856,200	Small	1.692	12
Bank Mellat	Foreign	43,424,024	Small	1.721	13
Iktisatbank	Private	969,996,167	Small	1.886	14
Bnp-Ak	Foreign	511,483,483	Small	1.899	15
Sitebank	Private	114,051,755	Small	1.943	16
Alternatifbank	Private	912,193,243	Small	1.972	17
Ziraat Bankasi	State	23,202,875,652	Large	1.977	18
Halkbank	State	15,198,125,321	Large	1.987	19
Al Baraka	SFH	790,351,206	Small	1.990	20
Arap Turk	Foreign	344,919,514	Small	2.093	21
Bayindirbank	Private	366,430,541	Small	2.122	22
Faisal	SFH	181,852,962	Small	2.138	23
Kocbank	Private	3,014,108,496	Large	2.231	24
Pamukbank	Private	6,613,960,086	Large	2.278	25
Demirbank	SDIF	3,542,582,265	Large	2.382	26
Isbank	Private	11,033,130,158	Large	2.398	27
Yapi ve Kredi	Private	10,627,671,780	Large	2.399	28
Esbank	SDIF	1,342,115,142	Small	2.404	29
Interbank	SDIF	1,573,141,423	Small	2.479	30
Bank Ekspres	SDIF	440,593,905	Small	2.479	31
Garanti Bankasi	Private	9,355,274,277	Large	2.505	32
Tarisbank	Private	206,163,622	Small	2.544	33
Tekstilbank	Private	810,599,709	Small	2.548	34
Citibank	Foreign	898,950,897	Small	2.559	35
Finansbank	Private	2,839,314,061	Large	2.577	36
Kentbank	Private	1,272,373,442	Small	2.579	37
Korfezbank	Private	1,624,630,313	Small	2.586	38
Egebank	SDIF	1,124,659,575	Small	2.694	39
Disbank	Private	1,606,778,057	Small	2.818	40
Osmanli	Foreign	3,038,068,140	Large	2.863	41
Sekerbank	Private	1,193,976,660	Small	3.040	42
Anadolu	SFH	242,328,134	Small	3.063	43
Toprakbank	Private	1,539,466,574	Small	3.266	44
Adabank	Private	173,704,588	Small	3.303	45
Turkishbank	Private	133,022,166	Small	3.328	46
Yasarbank	SDIF	1,164,906,059	Small	3.381	47
Akbank	Private	10,414,374,616	Large	3.406	48
Imarbank	Private	1,101,321,285	Small	3.548	49
Turk Ticaret	SDIF	958,489,084	Small	3.569	50
TEB	Private	1,457,760,621	Small	3.746	51
Etibank	SDIF	1,169,489,077	Small	4.569	52
Sumerbank	SDIF	632,322,011	Small	5.559	53

4.2. Homogeneity Tests

Efficiency rankings of firms can only be obtained under the assumption of homogeneity of the production technologies of ranked firms. We have seen that ignoring potential heterogeneity and pooling firms with different technologies may produce erroneous efficiency rankings in the pooled sample. In our sample of 53 banks, there are four obvious types of heterogeneity that may exist based on banks' size, ownership structure, or mode of operation. Therefore, before proceeding to perform our data-driven Estimation-Classification of bank technologies (cost functions), we consider tests of homogeneity across the most obvious potential sources of heterogeneity: (1) small vs. large banks, (2) private vs. state banks, (3) foreign vs. domestic banks, and (4) conventional banks vs. SFHs.

We use the most powerful likelihood ratio statistic to test the null hypothesis of homogeneity of banking production technology across those four dimensions. The likelihood ratio (LR) test statistic is computed as $-2\ln\lambda$ where λ is the likelihood ratio, computed as the ratio of the constrained maximum of the likelihood function (i.e. under the null hypothesis of homogeneity) to the unconstrained maximum of the likelihood (computed by performing ML estimation for each sub-sample separately).

Hence the likelihood ratio test statistic is:

$$LR = -2\ln\lambda = -2(ln L_R - ln L_{max})$$

If the homogeneity restriction is valid, then $ln L_R$ should not be significantly smaller than $ln L_{max}$, the unrestricted maximum value of $ln L$. Table 3. presents the homogeneity test results. LR tests reject homogeneity along the small/large and foreign/domestic dimension. Since foreign banks are all small, the two effects are confounded. Most interestingly, we fail to reject the null hypothesis of homogeneity for private vs. state banks and for conventional banks vs. SFHs. We shall return to those results shortly.

Mahmud and Zaim (1998) included only private commercial banks in their sample indicating that large state-owned banks may provide a different set of services to their customers than private commercial banks, hence state-owned and private banks, may have different cost structures. Indeed state banks are required to extend concessionary loans to the agricultural sector, to small and medium sized enterprises and to the housing sector under the title of "Specialized Loans"[8]. In this manner, state banks which extended these specialized loans generously in the last decade, differ from private banks. The ratio of specialized loans to total loans is on average 59% for state banks while specialized loans not required for private banks, is less than one percent (0.6 %) ratio during 1990-2000. In addition to specialized loans, Ertugrul and Selcuk (2001) draws attention to another aspect of state banks which affects them in the efficiency

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[8] The focus of the state banks on specialized loans differs among them which can be easily understood from the Turkish names of the state banks; Ziraat Bank on agricultural loans; Halkbank on small and medium enterprise loans; and Emlakbank on housing.

context, i.e., quasi-fiscal duties of state banks which is the implicit resource allocation decisions of the government. Ertugrul and Selcuk (2001) notes that the total burden of specialized loan policy and quasi-fiscal duties on the state banks reached up to 20 billion USD, (also known as "duty losses") at the end of year 2000. As a consequence of social and political roles of state banks, some authors are convinced to use different production technologies (i.e. frontiers). However, this heterogeneity among state and private banks is not reflected in our study. The first reason for this is that our translog cost function does not include the "duty losses" as cost. Second, we have single output i.e. aggregated loans in our model which does not distinguish specialized loans from others.

While our study is first in combining SFHs with conventional banks in a stochastic frontier analysis, it has been assumed that SFHs, which basically function as Islamic banks, use a different production technology than conventional banks. As mentioned in the introduction, Aggarwal and Yousef (2000) find that financial instruments used by Islamic banks are not based on profit-and-loss sharing (equity) but instead, are very debtlike in nature. However, our efficiency analysis does not focus on the financial instruments used by SFHs but instead, tries to relate the cost with output (loans) and input prices. Hence, a possible heterogeneity characteristic which may separate SFHs from conventional banks, is not observed.

To sum up, we fail to reject homogeneity along private vs. state banks and conventional banks vs. SFHs in our sample.

Table 3.Tests of Homogeneity[1]

	Test Statistics χ^2_{21}	Critical value[2]	Decision
Small vs. Large	39.4	33.41	*Reject H_0*
Private vs. State-owned	15.26	33.41	*Fail to reject H_0*
Foreign vs. Domestic	196.8	33.41	*Reject H_0*
Conventional vs. SFHs	5.07	33.41	*Fail to reject H_0*

1. Log-likelihood value under null hypothesis (poolability) is -274.5

2. Critical value of the test statistics at the 1% level of significance

The confounding effects of foreign bank sizes provide us with an incentive to seek a data-driven classification approach that would distinguish between differences in production technology caused by country of origin, and those caused by bank size. More generally, it is more parsimonious and epistemologically appealing to derive a classification from the likelihood function itself, instead of relying on *a priori* apparent causes of heterogeneity. Towards that end, we model unobserved heterogeneity in banking technologies as a mixture model, and estimate it using the EC (Estimation-Classification) estimator introduced in (El-Gamal and Grether, 1995), to which we now turn.

4.3. Allowing for Heterogeneity

The general framework of the EC estimator is a panel model with heterogeneity of types, whereby we observe data ($y_{it}, \vec{x}_{it}$) for n banks i over T_i time periods each. Let Θ be the parameter space indexing the banks' likelihood function. Then, if we have two types of banks in our sample, parameterized by ($\bar{\theta}_1, \bar{\theta}_2$) $\in \Theta^2$, we need simultaneously to estimate the two parameter vectors $\bar{\theta}_1$ and $\bar{\theta}_2$, as well as the classifications of our 53 banks to one of the two groups. Thus, bank i's data is assumed to be generated by

$$(y_{it}, x_{it})_{t=1}^{Ti} \sim \prod_{j=1}^{2} \left(f(\{y_{it}, x_{it}\}_{t=1}^{Ti}; \theta_j) \right)^{\delta_{ij}}$$

where $\delta_{ij} \in \{0,1\}$ and $\sum_{j=1}^{2} \delta_{ij} = 1$, for some likelihood function $f(.; \theta)$ parameterized by θ $\in \mathbb{R}^d$. The δ_{ij}'s are unknown parameters, which may be treated as missing data and integrated out using the EM algorithm (Dempster et al. (1977), Redner and Walker (1984), Little and Rubin (1987)). Alternatively, the EC estimator (also known as the "maximum likelihood approach to classification", El-Gamal and Grether (1995)) can treat the δ_{ij}'s as parameters of interest, and maximize the likelihood function simultaneously over the δ_{ij}'s as well as ($\bar{\theta}_1, \bar{\theta}_2$).

The EC algorithm is a computationally efficient means of obtaining EC-estimates, which are in turn asymptotically equivalent (as T goes to infinity) to EM estimates:
- For any given ($\bar{\theta}_1, \bar{\theta}_2$)
- For each bank i:
  – Calculate $lf_i(h; \theta_h) = \log f(\{y_{it}, x_{it}\}_{t=1}^{T} | \theta_h)$ for $h \in \{1, 2\}$
  – Choose $h \in \{1, 2\}$ to maximize $lf_i(h; .)$ over $h \in \{1, 2\}$

– Call the maximal value $lf_i(\theta)$ (This corresponds to maximizing over the $\delta_{ij}s$ for bank i, conditional on the 2 different parameter vectors.)[9]
– Sum the obtained log likelihoods $lf_i(\theta)$ over banks $i \in \{1,...,53\}$
– Call the outcome $lf(\theta)$

The classification approach (assigning each bank to the parameter group that maximizes its contribution to the likelihood function) induces a classification bias. EM estimation avoids such a bias by distributing each bank's likelihood contribution to the two groups based on the posterior probability for each firm i belonging to group j. The results of El-Gamal and Grether (1995), and Monte Carlo analyses of El-Gamal and Grether (1998) suggest that sample sizes of $T>5$ tend to produce very small sample biases, to the extent that the large T approximation may be sufficiently precise to make a subsequent EM step for bias correction unnecessary.

The size of our classification bias is directly related to the distance between the posterior probabilities over classifications on the one hand, and the (0 or 1) δ_{ij}'s on the other. For any given classification of firms, posterior odds ratio may be calculated as follows (assuming uniform priors):

Posterior Odds Ratio = $P_{i,n}$ = $\dfrac{l_i(\theta_1)}{\sum\limits_{j=1}^{2} l_i(\theta_j)}$ where $i=\{1,...53\}$ and $n=\{1,2\}$,

P_{i1}=Prob$\{\delta_{i1}=1\}$=Prob$\{$Bank$_i$ belongs to Group 1$\}$
P_{i2}=Prob$\{\delta_{i2}=2\}$=Prob$\{$Bank$_i$ belongs to Group 2$\}$

If these probabilities are close to zeros and ones, then the data are strongly in agreement with the assignment of banks to types, and the classification-induced bias is minimal. We use the diagnostic statistic introduced in the above mentioned references, named ANE (Average Normalized Entropy) to judge the crispness of the classifications, i.e. the closeness of P_{ij}'s to zeros and ones:

$$\text{ANE(k)}=\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{k} p_{ij} \log_k (p_{ij})$$

ANE always lies between zero and one, with small numbers reflecting crisp classifications and negligible small-sample biases, and large ANEs reflecting weak classifications and significant potential biases. ANE is zero when the P_{ij}'s are equal to the δ_{ij}'s, indicating very good behavior for the EC procedure. Thus, the EM algorithm and EC procedure results would coincide when ANE is equal to zero. If ANE is not

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[9] Number of such configurations is 2^53/2! = 4,500,000,000,000,000, hence brute-force searches over all possible δ_{ij} configurations is prohibitively difficult.

sufficiently small, we have to use the EC estimates as initial conditions for the EM algorithm.

4.3. Likelihood-based EC Results

Table 4. Data-driven Classification of Banks and Posterior Odds

Bank Name	GROUP	Odds(Group1)	Odds(Group2)	Asset Size	Type
Bank Ekspres	1	0.976	0.024	Small	SDIF
Demirbank	1	1	0	Large	SDIF
Egebank	1	1	0	Small	SDIF
Esbank	1	1	0	Small	SDIF
Etibank	1	1	0	Small	SDIF
Interbank	1	1	0	Small	SDIF
Sumerbank	1	1	0	Small	SDIF
Turk Ticaret	1	1	0	Small	SDIF
Yasarbank	1	1	0	Small	SDIF
Abn Amro	2	0	1	Small	Foreign
Arap Turk	2	0.285	0.715	Small	Foreign
Banca Di Roma	2	0	1	Small	Foreign
Bank Mellat	2	0	1	Small	Foreign
Bnp-Ak	2	0.188	0.812	Small	Foreign
Chase	2	0	1	Small	Foreign
Citibank	2	0.008	0.992	Small	Foreign
Credit Lyonnais	2	0	1	Small	Foreign
Habib Bank	2	0	1	Small	Foreign
HSBC	1	0.997	0.003	Small	Foreign
Osmanli	1	1	0	Large	Foreign
Societe Generale	2	0	1	Small	Foreign
West Deutsche	2	0	1	Small	Foreign
Adabank	1	1	0	Small	Private
Akbank	1	1	0	Large	Private
Alternatifbank	1	0.987	0.013	Small	Private
Bayindirbank	2	0	1	Small	Private
Disbank	1	0.998	0.002	Small	Private
Finansbank	1	1	0	Large	Private
Garanti	1	1	0	Large	Private
Iktisat	1	1	0	Small	Private
Imar	1	1	0	Small	Private
Isbank	1	1	0	Large	Private
Kentbank	1	1	0	Small	Private
Kocbank	1	1	0	Large	Private
Korfezbank	1	0.992	0.008	Small	Private
Oyakbank	2	0.003	0.997	Small	Private
Pamukbank	1	1	0	Large	Private
Sekerbank	1	1	0	Small	Private
Sitebank	1	1	0	Small	Private
Tarisbank	1	1	0	Small	Private
TEB	1	0.917	0.083	Small	Private
Tekstilbank	1	1	0	Small	Private
Toprakbank	1	1	0	Small	Private
Turkishbank	1	0.825	0.175	Small	Private
Yapi ve Kredi	1	1	0	Large	Private
Emlakbank	1	1	0	Large	State
Halkbank	1	1	0	Large	State
Vakifbank	1	1	0	Large	State
Ziraat Bankasi	1	1	0	Large	State
Al- Baraka	1	1	0	Small	SFH
Anadolu	1	1	0	Small	SFH
Faisal	1	0.985	0.015	Small	SFH
Kuveyt-Turk	1	0.861	0.139	Small	SFH

Our EC estimates are shown in Table 4. Of the 53 banks in our sample, 40 banks are classified into Group 1, while 13 banks are classified into Group 2. Group 2 banks are all small, and all but two of them are foreign, the two exceptions being the small domestic banks Bayindirbank and Oyakbank[10]. The posterior odds are very crisp, i.e. close to zeros and ones. The collective diagnostic measure ANE is calculated as 0.072 which is sufficiently close to zero. Hence the small-sample classification errors and classification-induced parameter estimate biases are too small to warrant an EM correction.

Table 5 displays the cost function parameter estimates for the two groups. We test the positivity and monotonicity for both of the frontiers. To do so, we substituted every observation in the translog cost function to check that the cost function is non-decreasing and concave in input prices and cost elasticities have a positive sign. Group 1's marginal cost values with respect to P_1^* (Price of Labor normalized by price of physical capital) and P_2^* (Price of Borrowed Funds normalized by physical capital) are positive at 91% and 99% of the observations, while Group 2's marginal cost values with respect to P_1^* and P_2^* are positive at 95% and 98% of the observations, respectively. The substituted values of the marginal cost for observations are plotted in figures 8 and 9 for comparison of the two different technologies' response to prices. Group 1 is more responsive to P_2^* while Group 2 is more responsive to P_1^*. In other words, Group 1 banks' cost increases more when price of borrowed funds increases whereas Group 2 banks' increases more when price of labor increases. This makes sense if we note that majority of Group 2 banks are foreign banks which have high employee cost disadvantage and Group 1 banks are mostly domestic banks which have expensive borrowed funds disadvantage where the economy was dependent on the short-term capital flows. It is clear that foreign banks enjoyed short-term borrowing from abroad and investing them in deficit-financing government bond as a result of high interest margins. These two marginal cost differences between domestic banks and foreign banks are revealed by EC classification.

Moreover, there are also differences between the groups when we take into account the quality and risk indexes. Group 1 is more responsive to quality index while Group 2 is more responsive to risk index. Quality index is measured by dividing non-performing loans to total loans indicating higher values lower quality. Risk index is calculated by dividing equity capital to total assets indicating higher values less risky (See figures 10 and 11).

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[10] Oyakbank started to operate as an Istanbul branch of Bank of Boston in 1984. In 1990, its status was changed to domestically owned bank shared by four partners including OYAK (Armed Forces Pension Fund). OYAK bought all of the shares in 1993 and changed the bank's name to Oyakbank in 1996. While Bayindirbank's status was always a domestically owned bank, shareholders of the banks changed twice during the last decade, in 1992 and 1998, respectively. We believe these changes in the management of the two banks in the last decade caused a misclassification for them.

Table 6. and Table 7. show the new rankings for Group 1 and 2 , respectively. When the top 6 foreign banks are taken out by EC algorithm from the pooled data, SFHs climb up in the Group 1 ranking. SFHs low non-performing loans portfolio clearly helped them to increase their cost efficiency. In contrast to SFHs, Etibank and Sumerbank, both SDIF banks, still share the bottom in Group 1 ranking with high non-performing loan ratio. State banks are widely spread in the Group 1 rankings. Ziraat Bank which focuses on agricultural loans is ranked 4th being the most efficient state bank while Halkbank, being least efficient state bank, is ranked 33rd. Consequently, state banks are not significantly less efficient than private banks.

Top 6 foreign banks in the pooled data preserved their rankings with minor changes in the Group 2 ranking. Bayindirbank which is not a foreign bank, is the least efficient and Oyakbank, another domestic bank is close to bottom, in the Group 2 ranking, indicating these two indeed do not belong to Group 2.

Table 5. Maximum Likelihood Estimation of Group 1 and Group 2

	Group 1			Group 2		
	Coefficient	Std Error	t-ratio	Coefficient	Std Error	t-ratio
Constant	24.264	1.949	12.451	22.890	1.312	17.445
lnP_1^*	-0.609	0.453	-1.343	-1.336	0.341	-3.914
lnP_2^*	1.763	0.519	3.399	2.622	0.559	4.689
Lny	-0.888	0.242	-3.671	-1.731	0.284	-6.088
(lny)(lny)	0.090	0.007	12.784	0.092	0.016	5.643
$(lnP_1^*)(lnP_1^*)$	0.075	0.062	1.199	0.138	0.032	4.366
$(lnP_2^*)(lnP_2^*)$	0.147	0.034	4.290	0.058	0.057	1.020
$(lnP_1^*)(lnP_2^*)$	-0.252	0.078	-3.222	-0.223	0.076	-2.924
$lnylnP_1^*$	-0.010	0.021	-0.476	0.081	0.011	7.073
$lnylnP_2^*$	0.029	0.016	1.836	-0.109	0.019	-5.719
Lnq	0.088	0.144	0.613	-0.720	0.199	-3.623
Lnr	0.867	0.431	2.013	-4.948	0.967	-5.119
(lnq)(lnq)	0.022	0.004	5.181	0.021	0.009	2.354
(lnr)(lnr)	-0.066	0.028	-2.374	-0.173	0.064	-2.696
(lnq)(lnr)	0.011	0.008	1.286	0.070	0.014	5.045
(lnq)(lnl)	0.014	0.005	2.589	0.033	0.013	2.539
(lnr)(lnl)	-0.053	0.016	-3.264	0.081	0.027	2.945
(lnq)(lnw)	-0.011	0.010	-1.025	0.043	0.013	3.364
(lnq)(lnb)	-0.003	0.009	-0.349	-0.053	0.013	-4.027
(lnr)(lnw)	-0.008	0.033	-0.236	0.267	0.052	5.126
(lnr)(lnb)	0.013	0.026	0.491	-0.209	0.049	-4.262
The common parameters						
Sigma-square	0.424	0.027	15.954			
Gamma	0.769	0.017	44.840			

Aggregate log-likelihood:-159.3

Table 6: Inefficiency Estimates for Group 1

Banks	Type	Ineff. Measure	Rank
Faisal	SFH	1.1036	1
Al- Baraka	SFH	1.1068	2
HSBC	Foreign	1.1072	3
Ziraat Bankasi	State	1.1280	4
Adabank	Private	1.1309	5
Kuveyt-Turk	SFH	1.1442	6
Sitebank	Private	1.1453	7
Anadolu	SFH	1.1454	8
Alternatifbank	Private	1.2362	9
Tarisbank	Private	1.2692	10
Iktisat	Private	1.2952	11
Pamukbank	Private	1.3879	12
Kocbank	Private	1.4279	13
Korfezbank	Private	1.4495	14
Tekstilbank	Private	1.4540	15
Bank Ekspres	SDIF	1.4758	16
Kentbank	Private	1.4761	17
Vakifbank	State	1.4824	18
Turkishbank	Private	1.4930	19
Esbank	SDIF	1.5025	20
Egebank	SDIF	1.5095	21
Demirbank	SDIF	1.5231	22
Interbank	SDIF	1.5475	23
Emlakbank	State	1.5914	24
Finansbank	Private	1.6138	25
Yapi ve Kredi	Private	1.6744	26
Imar	Private	1.6875	27
Disbank	Private	1.7064	28
Garanti	Private	1.7629	29
Isbank	Private	1.7725	30
Yasarbank	SDIF	1.8267	31
Sekerbank	Private	1.8461	32
Halkbank	State	1.8495	33
Osmanli	Foreign	1.8618	34
Toprakbank	Private	1.8729	35
Akbank	Private	2.1147	36
TEB	Private	2.1365	37
Turk Ticaret	SDIF	2.1534	38
Etibank	SDIF	2.3187	39
Sumerbank	SDIF	2.5576	40

Table 7: Inefficiency Estimates for Group 2

Banks	Type	Ineff. Measure	Rank
Societe Generale	Foreign	1.0842	1
Habib Bank	Foreign	1.0858	2
Credit Lyonnais	Foreign	1.1536	3
Bank Mellat	Foreign	1.2017	4
Chase	Foreign	1.2051	5
Banca Di Roma	Foreign	1.2787	6
West Deutsche	Foreign	1.3941	7
Abn Amro	Foreign	1.4659	8
Arap Turk	Foreign	1.7349	9
Oyakbank	Private	1.9175	10
Bnp-Ak	Foreign	2.2914	11
Citibank	Foreign	3.2921	12
Bayindirbank	Private	4.1516	13
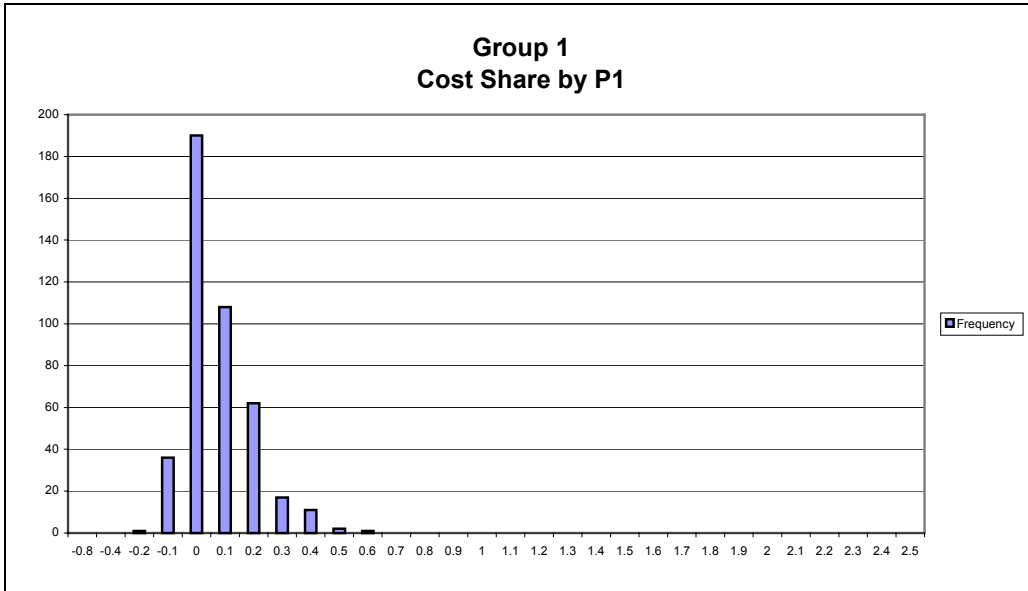
Figure 8a
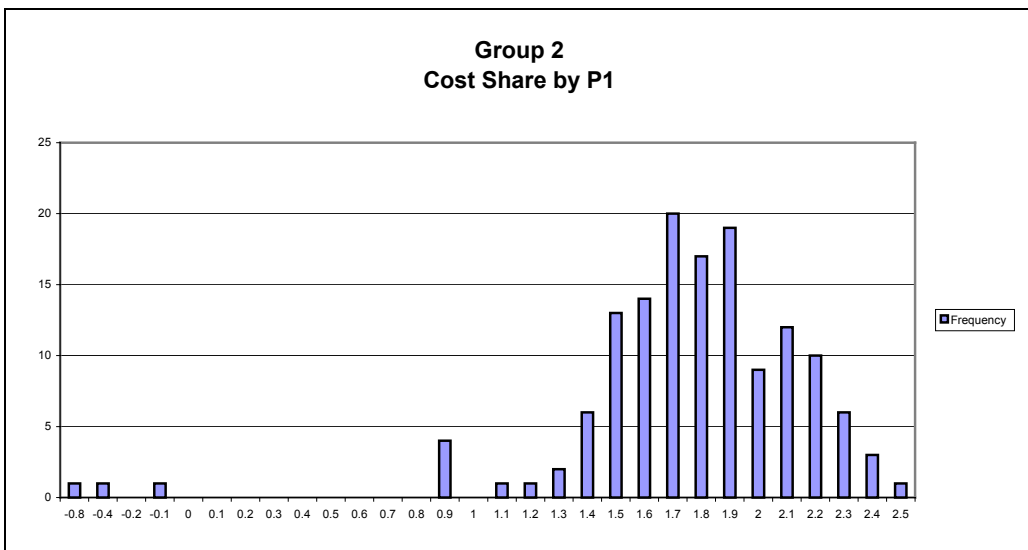
Figure 8b
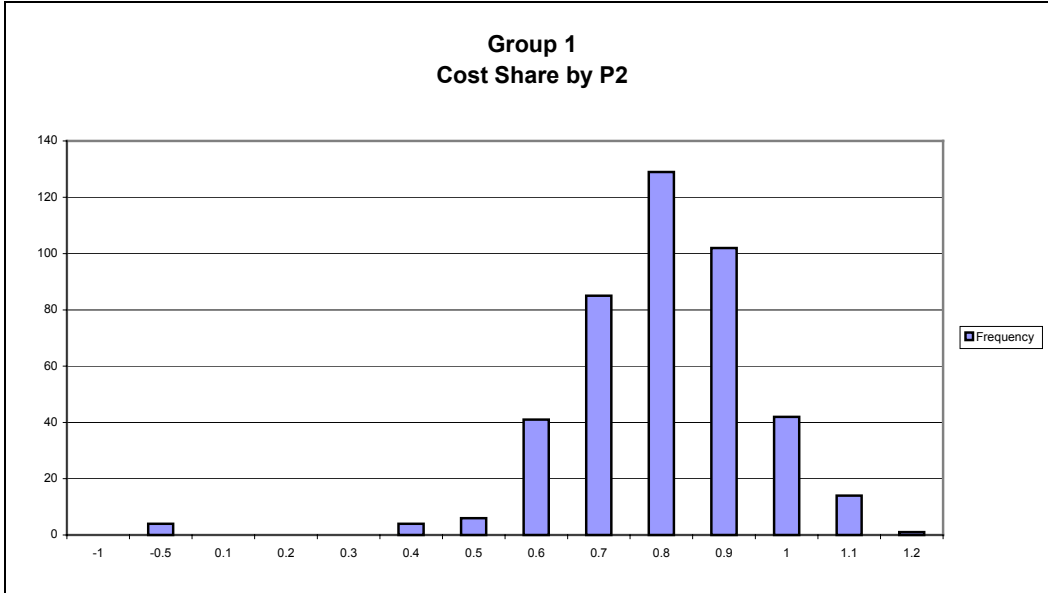
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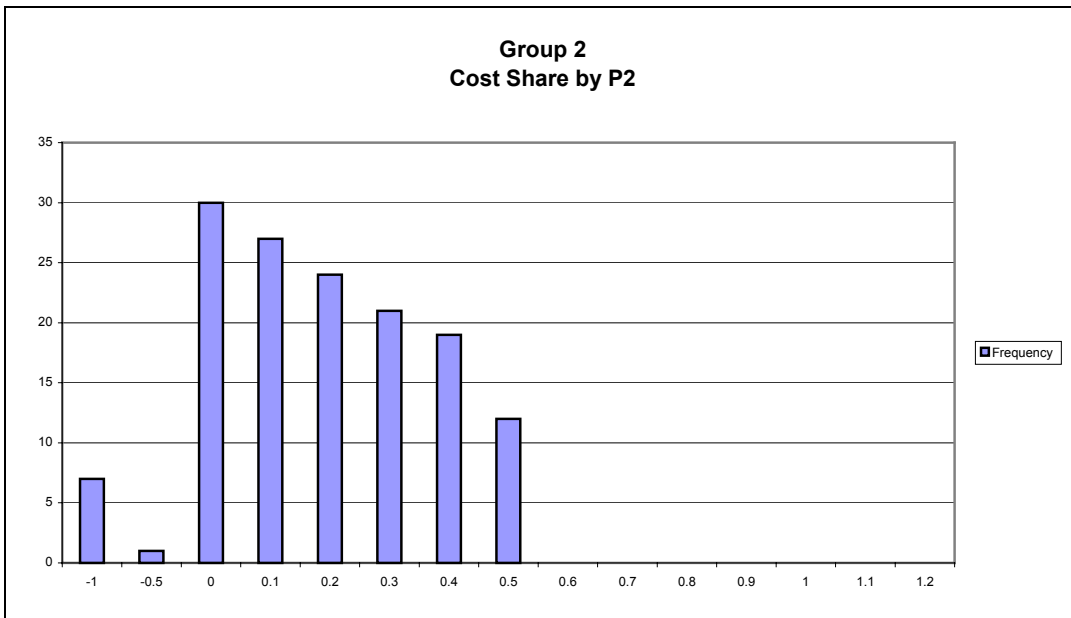
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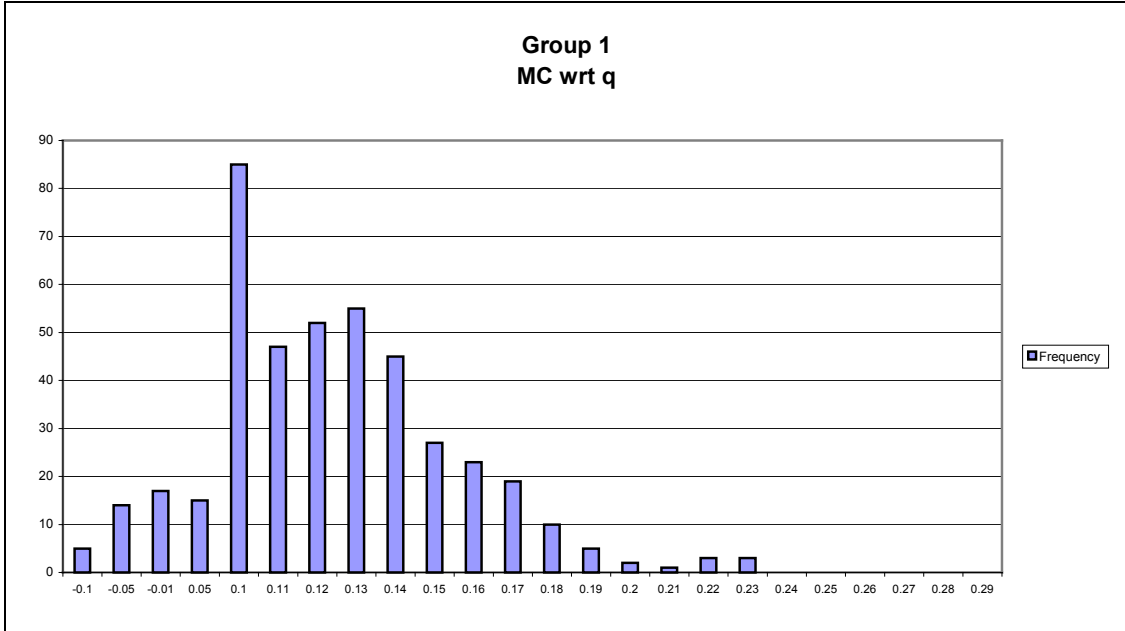
Figure 10a

Figure 10b

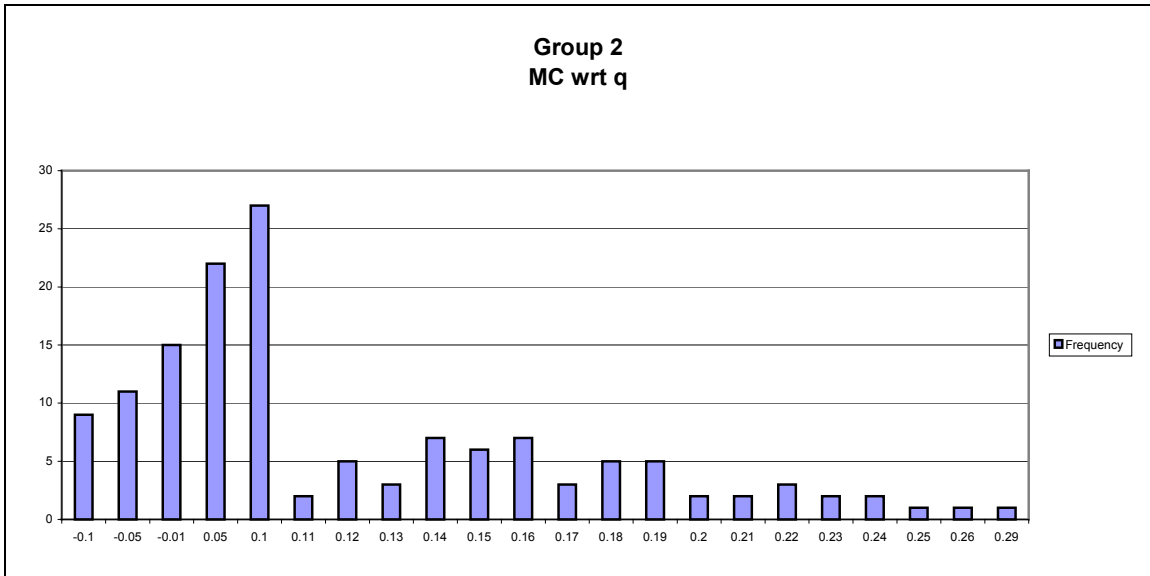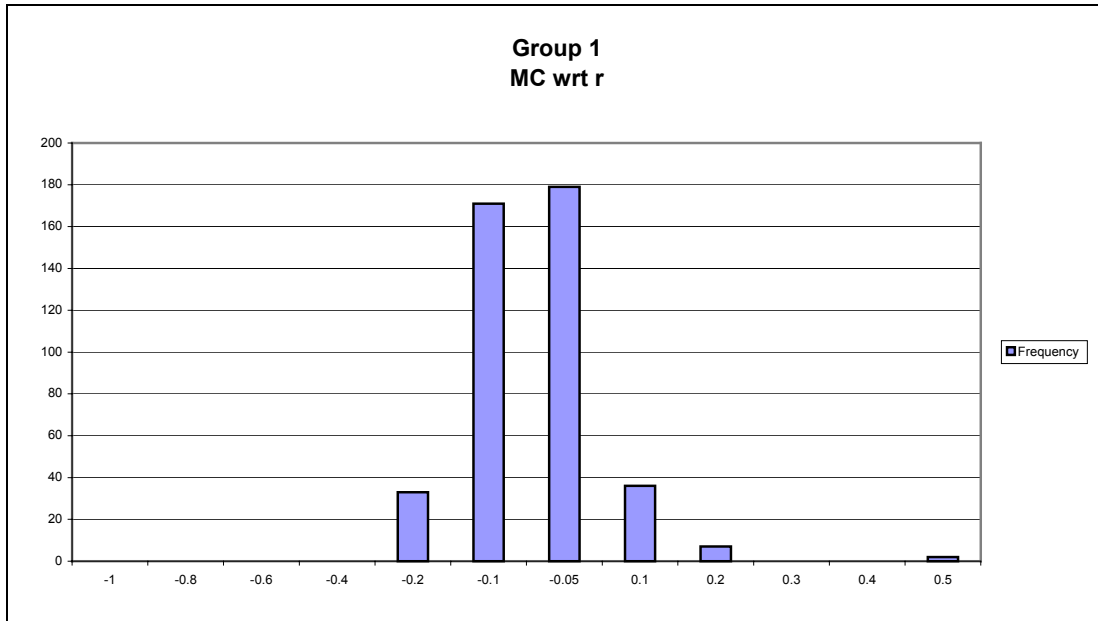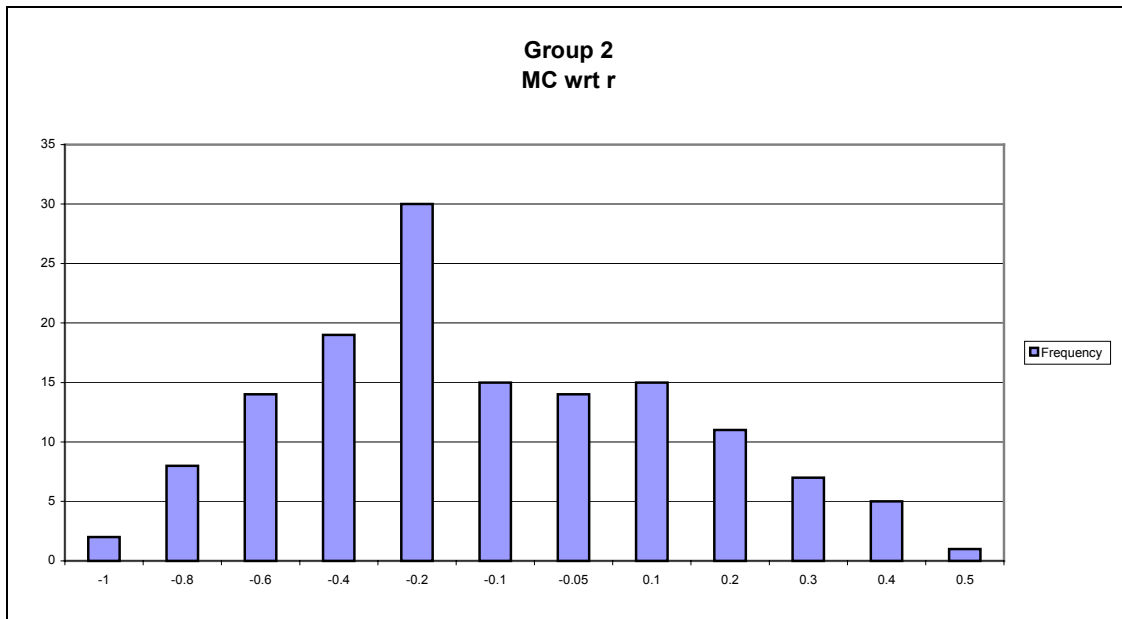**Figure 11a**

Figure 11b

5. Conclusions

In this paper we model unobserved heterogeneity in banking technologies as a mixture model and investigate the efficiencies of 53 Turkish banks using likelihood-based stochastic frontier analysis for the 1990-2000 period. In contrast to previous efficiency studies which tend to draw conclusions on the pooled estimates or estimates based on a priori classifications, the data-driven EC estimates point mainly to distinctions between small and foreign banks vs. large and domestic ones, respectively. We then investigate the inefficiency scores with respect to the two different cost frontiers recovered by EC. Surprisingly, we do not find evidence of heterogeneity between state and private banks. Moreover, contrary to common wisdom, we find that state banks are not significantly less efficient than private banks, and "special finance houses" seem indistinguishable from conventional banks.

Our findings suggest that during the last decade foreign banks in Turkey took the advantage of short-term borrowing abroad and investing them in risk free government issued papers. While private banks pursued the same goal, they were in a disadvantageous position in finding the less expensive funds from abroad.

While state-owned banks had suffered from huge "duty losses" during this period, they are not less efficient then private banks. Without taking the social goals that state banks pursued into account, it will not be fair to say that the state banks is a burden on the economy. Unless and until social aims are not intervened with political aims, state banks will not have duty losses. Hence there will be no need for privatization.

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