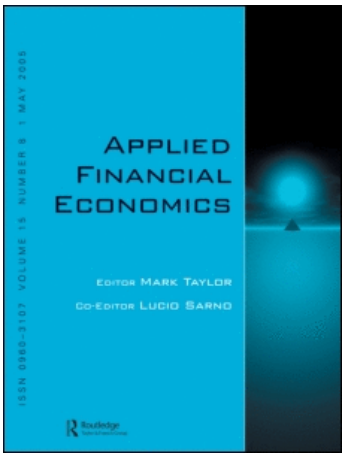

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Economies of scale and scope in China's banking sector

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Economies of scale and scope in China's banking sector

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Employing the stochastic frontier approach and expansion path measures, this article estimates economies of scale and scope in China's banking sector during the period 1985 to 2002. The objective is to assess whether different ownership types and banking reforms affect economies of scale and scope. The traditional nonfrontier approach and the standard measures are also applied for comparison and completeness. The results indicate the presence of constant returns to scale and significant economies of scope for most joint stock banks throughout the period, and for state-owned banks in the later part of period, following a second set of bank reforms. There is evidence that use of the traditional nonfrontier model biases the measures of scale and scope economies.

I. Introduction

China's banking sector is evolving following banking reforms which commenced in 1979. In line with the policy of general economic reform, the emphasis has been on introducing regulatory changes on a gradual basis. Before 1979, China's banking sector could be described as a state monopoly, with the People's Bank of China (PBC) active in both central and commercial banking operations. During the first phase of bank reforms (1979–1992) the well-known 'two-tier' model was adopted to improve the mobilization and allocation of financial resources. The highly regulated system was dominated by the state-owned specialized banks. In the absence of any effective competition, bank management had neither the means nor the incentives to be efficient. A second wave of reform commenced in 1993, aimed at developing an effective, competitive and stable banking sector. State-owned specialized banks were converted into state commercial banks, which coexist with policy banks, joint-stock commercial banks, city and rural commercial banks, urban and rural credit cooperatives, and foreign banks operating in their respective authorized business domains. In addition, an inter-bank market was established, commercial and investment banking business were separated, and interest rate controls (e.g. small business credit ceilings) were lifted, albeit in a highly limited way.[1]

These regulatory changes, growth oriented macro-economic policies, and technological changes put Chinese banks under more competitive pressure after 1993. The response of the state banks was to streamline their operations, while the joint stock banks expanded. For example, from 1996 onward, the state commercial banks adopted a strategy of shifting operations to medium-sized and large cities, so they could concentrate on servicing large and medium-sized enterprises and construction projects. Provincial and municipal branches were merged, and

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[1] For more detail on these reforms, see Fu (2004) and Wu (1998).

loss making county sub-branches/deposit taking outlets were closed. As a result, between 1998 and 2002, the number of branches and employees fell by 45.7% and 16.2%,[2] respectively.

The reforms also meant that after 1993, seven of the hitherto regional joint stocks began to operate nationwide. For example, Hua Xia Bank, established in 1992, was wholly owned by the Capital Iron and Steel Company. It injected capital into the bank to create equity worth RMB1 billion ($170 million). In March 1995, it became a joint-stock commercial bank, owned by 33 'legal persons' (shareholders) who injected more capital – RMB2.5 billion (or $300 million). Branches were set up in all the major developed cities in China. As a result of the introduction and rapid expansion of the 10 (now national) joint-stock banks, their total equity, in real terms, more than doubled from RMB48.49 bn ($5.84 bn) in 1996 to RMB104.23 bn ($12.59 bn) by the end of 2002.

The banks also diversified their product bundle. From the mid-nineties onward traditional banking activities (e.g. lending) declined in importance as banks expanded into new areas, such as 'investments' (treasury bills and other bonds), agent services[3] and letters of credit. This was in part due to the establishment of a centralized inter-bank market (for deposits, loans and bonds) in 1996, an important new channel by which commercial banks could diversify their assets. The average ratio of total investments to total loans increased from 12% in 1993 to 36% in 2002. Though both joint stocks and state banks have been active in investments, especially since 1997, the state banks led the way, probably because they were the main source of finance for government debt. The average ratio of noninterest income to total income increased by about 247% between 1993 and 2002. It was somewhat higher for the joint-stocks,[4] suggesting they opted to concentrate on diversifying into fee generating and commission based activities.[5]

In view of this fundamental restructuring of the banking sector in terms of organization and production, a central question is the degree to which these banks enjoy economies of scale and/or scope. The presence of scale economies mean large banks have a cost advantage over small ones, while evidence of economies of scope implies multi-product banks are more efficient than financial boutiques. As the literature review below illustrates, economies of scale and/or scope in the banking sector has been studied extensively in the USA and other developed countries, but relatively few papers have focused on banks in developing countries.

This article contributes to the literature by employing the stochastic frontier approach and expansion path measures to test for the presence of economies of scale and scope in China's banking sector, and to assess whether any of the findings can be explained by either the bank reforms and/or differences in ownership. Estimates based on the traditional nonfrontier approach and standard measures are also reported for comparison and completeness. This article is organized as follows: Section II reviews previous studies, and Section III discusses the methodologies and data set. The results are reviewed in Section IV. In Section V, the key conclusions and policy implications are discussed.

II. Literature Review

As indicated by Baumol *et al.* (1982), there are two types of production economies that may be achieved by any firm in any industry – economies of scale and scope. Economies of scale are associated with firm size, and exist if average production costs decline as output rises. Conversely, a firm exhibits diseconomies of scale if average production costs increase with output. Economies of scope are present if a firm can jointly produce two or more products/services at a lower cost than if produced separately. If there are diseconomies of scope, the cost of joint production is higher.

Two issues arise in the assessment of whether a bank enjoys economies of scale and scope. The first relates to measurement; the second is concerned with estimation. There are two types of measures: standard and expansion path. The assumptions associated with the standard measures are very restrictive: banks must have identical product mixes and/or specialize completely, and increase one output while holding the others constant. However, banks rarely, if ever, satisfy these criteria. Berger *et al.* (1987) addressed these problems by using expansion path measures, which capture the impact of changing scale and

[2] All data are collected from the *Almanac of China's Finance and Banking*, 1986 to 2003, unless otherwise stated.
[3] Agent services mainly refer to activities such as collecting and paying household bills on a customer's behalf, and acting as an agent for securities and insurance firms. For example, banks formed affiliations with securities firms and introduced a telephone bank-broking business, whereby clients can buy or sell stock using their deposits accounts. Any earnings from shares are returned to the account (Shi, 2001).
[4] The ratio was 22.5% for the joint-stocks, and 18.6% for the state banks in 2002.
[5] All the figures, except the number of employees and branches, are deflated by the CPI, with 1985 as the base year.

product mix simultaneously. Given their obvious superiority, expansion path measures are employed in this study; they are discussed at greater length in Section III. To estimate scale and scope economies, the stochastic translog frontier approach is used. It overcomes problems arising from using the traditional nonfrontier models, which implicitly assume the absence of *X*-inefficiency.

The literature contains studies that use either one or both of the two measures/estimation approaches. The majority employ traditional nonfrontier translog cost models using standard measures. Typically, the results show economies of scale for small banks and economies of scope for all banks (e.g. Mertens and Urga, 2001; Rezvanian and Mehdian, 2002). Other studies have combined standard measures and the stochastic frontier approach, with mixed findings. For example, using data for 194 banks in 15 countries from 1988 to 1992, Allen and Rai (1996) found that small banks in all the countries exhibited significant economies of scale, and there was no evidence of either economies or diseconomies of scope. Employing data from 1991 to 1992, Mester (1996) reported slight economies of scale and scope neutrality for 214 US banks from the Third Federal Reserve District.

A few studies applied both the stochastic frontier approach and the traditional nonfrontier approached on the same data to determine whether the implicit assumption of no *X*-inefficiencies in the traditional nonfrontier approach significantly biases the measure of scale and scope economies. The results are mixed. Berger and Humphrey (1991) employed 1984 data for all US banks. Each approach produced evidence of scale economies for small banks and slight scale diseconomies for the largest banks. However, scope diseconomies were found with the frontier approach while the traditional approach revealed scope economies, especially for the largest banks. Drawing on a sample of 1015 US savings and loans for 1991, Mester (1993) reported that the two approaches yield similar results – near constant returns to scale and economies of scope.

Other papers compare the standard and expansion path measures, with the traditional nonfrontier approach. Employing the standard measures on 1983 US bank data, Berger *et al.* (1987) found evidence of constant returns to scale for all banks; modest scope economies for the smallest banks, and pronounced scope diseconomies for the largest. When the expansion path measures were used, they still found evidence of CRS but small banks exhibited diseconomies of scope, and scope neutrality was found for the others. In Mitchell and Onvural (1996; US bank data from 1986 to 1990), the standard measures showed small banks enjoyed increasing returns to scale but large banks faced constant returns to scale. There was no evidence of either economies or diseconomies of scope. Employing the expansion path measures produced CRS and scope economies for the majority of banks in the sample.

III. Methodology and Data

Empirical models

In this study, banks are assumed to be multi-product firms employing a vector of inputs to produce a vector of outputs. Under duality theory, the multi-product cost function dual to the production function can be defined as:

$$C = f(Y, W) \tag{1}$$

where

C: total cost,
Y: a vector of outputs,
W: a vector of input prices.

The limited number of observations in this study creates degrees of freedom problems. For this reason, a parametric approach with a translog specification is used instead of the Fourier-flexible (FF) specification,[6] and a pooled ordinary least squares (OLS) regression model is used instead of a panel data approach. In common with the published work in this area, time and bank subscripts are dropped for ease of exposition. The traditional nonfrontier translog cost function takes the following form:

$$\ln C = \alpha_0 + \sum_p \beta_p \ln y_p + \sum_m \delta_m \ln w_m + \frac{1}{2}\sum_p \sum_q \beta_{pq} \ln y_p \ln y_q + \frac{1}{2}\sum_m \sum_n \delta_{mn} \ln w_m \ln w_n + \sum_p \sum_m \gamma_{pm} \ln y_p \ln w_m + \varepsilon \tag{2}$$

where

C: total cost,
y_p: pth output,
w_m: mth input price,
ε: a normally distributed random error term.

[6] The FF functional form provides a global approximation of any cost function over the entire range of the banking data. It has a linear combination of the sine and cosine function, which are mutually orthogonal over the [0, 2π] interval and function space-spanning.

Both standard symmetry ($\beta_{pq}=\beta_{qp}$, $\delta_{mn}=\delta_{nm}$) and linear homogeneity restrictions ($\sum_m \delta_m = 1$, $\sum_m \delta_{mn} = 0$, $\sum_m \gamma_{pm} = 0$) are imposed during estimation.

The functional form for the translog cost function under the stochastic cost frontier approach is:

$$\ln C = \alpha_0 + \sum_p \beta_p \ln y_p + \sum_m \delta_m \ln w_m + \frac{1}{2}\sum_p \sum_q \beta_{pq} \ln y_p \ln y_q + \frac{1}{2}\sum_m \sum_n \delta_{mn} \ln w_m \ln w_n + \sum_p \sum_m \gamma_{pm} \ln y_p \ln w_m + u + v \quad (3)$$

where

u: an X-inefficiency factor,
v: the random error.

The aforementioned standard symmetry restrictions continue to apply. To impose linear homogeneity restrictions on the function, all of the cost and input price terms are normalized by the last input price, w_3. Shephard's lemma is not applied for either approach, because it would impose the undesirable assumption that there were no allocative inefficiencies (Berger, 1993).

Measures of economies of scale and scope

The expansion path measures are used to calculate economies of scale and scope and include:

- EPSCE: expansion path scale economies and
- EPSUB: expansion path subadditivity.

The standard measures are also calculated for comparison and include:

- SCALE: overall scale economies. These are sometimes also known as ray scale economies (Baumol *et al*., 1982).
- WSCOPE: within-sample overall scope economies.
- WPSSE: within-sample product-specific scale economies.
- WPSCO within-sample product-specific scope economies.

Overall scale economies (SCALE) is the elasticity of cost with respect to output, assuming the output mix is constant. It is defined as follows:

$$\text{SCALE}(Y) = \sum_p \frac{\partial \ln C(Y)}{\partial \ln y_p} \quad (4)$$

where

$C(Y)$: a multiple-output cost function,
Y: a vector of outputs, $=[y_1 \ldots y_p]'$,
p: indexes of different products.

Thus, SCALE gives the percentage change in cost for a 1% change in all outputs. SCALE <1 implies economies of scale since the rise in costs is proportionally less than the increase in outputs. There are diseconomies of scale if SCALE >1. The obvious limitation is that the measure is only meaningful if banks grow by changing their scales but not their output mix. Baumol *et al*. (1982) suggested an additional measure to illustrate how costs change when the output of one product changes with the quantities of all other products held constant. Product-specific scale economies (PSSE) are present if an increase in production of a specific product results in a decline in the average cost, holding the other outputs constant. However, Berger *et al*. (1987) argued that PSSE could give rise to substantial extrapolation error because the cost function is evaluated when the value of one output is near zero, which was generally well outside the sample over which cost functions are estimated. To remedy this problem, Mester (1992) defined a new measure of product-specific economies of scale, known as within-sample product-specific scale economies (WPSSE). A product's within-sample degree of economies of scale can be obtained by examining the relation between its incremental average cost and marginal cost:

$$\text{WPSSE}(y_k) = \frac{IC(\tilde{y}_k)/C}{\partial \ln C(Y)/\partial \ln y_k} \quad (5)$$

where

$$IC(\tilde{y}_k) = [C(y_1,\ldots,y_p) - C(y_1,\ldots,y_{k-1},y_k^m,y_{k+1},\ldots,y_p)]$$

y_k^m = the sample minimum of y_k.

Thus, WPSSE(y_k) is just PSSE(y_k) with the sample minimum of y_k replacing zero[7], WPSSE(y_k) >1 WPSSE(y_k) <1) implies economies (diseconomies) of scale in production of the kth output.

Ideally, a product's WPSSE should be measured independently from the other products in the output mix (Clark, 1988). In practice, however joint production means it is usually impossible to change the output of one product while holding these other products constant. Berger *et al*. (1987) proposed an alternative measure: expansion path scale economies (EPSCE), which is the elasticity of incremental cost

[7] For some bank groups, the minimum levels of bank investments and noninterest income are zero. Following Mester (1992), in this chapter, the minimum values of these outputs are the same as the conventional measures (0.001).

with respect to incremental output along the observed expansion path from the small bank A to the large bank B (Banks A and B are arbitrarily chosen with Bank A smaller than B). It is defined as follows:

$$\mathrm{EPSCE}(Y^A, Y^B) = \frac{\sum_p \left[(y_p^B - y_p^A)/y_p^B\right]\left[\partial \ln C(Y^B)/\partial \ln y_p\right]}{[C(Y^B) - C(Y^A)]/C(Y^B)} \quad (6)$$

where

y_p^A: the quantities of the pth output at bank A,
y_p^B: the quantities of the pth output at bank and B,
$C(Y^A)$: total costs at bank A,
$C(Y^B)$: total costs at bank B.

The numerator is the percentage change in cost when each output changes in the same proportion as it does between bundles A and B. The denominator is the percentage difference in costs between banks A and B, computed from the cost function. Thus, EPSCE measures the proportional changes in costs as banks move along the observed expansion path from a small to a large bank. There are economies of scale if $\mathrm{EPSCE} < 1$ because costs increase proportionally less than outputs; $\mathrm{EPSCE} > 1$ implies diseconomies of scale.

Baumol *et al*. (1982) also developed overall scope economies (SCOPE), which measures the cost saving from joint vs. specialized production; and product-specific scope economies (PSCO), which measures the cost saving from jointly producing one particular output vs. producing it separately. But the translog cost function is undefined at the zero output level required by SCOPE and PSCO. Mester (1992) addresses this issue by introducing two new measures, within-sample scope economies (WSCOPE) and within-sample product-specific economies of scope (WPSCO).

Consider the case where there are four outputs. The WSCOPE is defined as follows:

$$\mathrm{WSCOPE}(Y^B) = \frac{\begin{array}{l} C(y_1^B - 3y_1^m, y_2^m, y_3^m, y_4^m) \\ \quad + C(y_1^m, y_2^B - 3y_2^m, y_3^m, y_4^m) \\ \quad + C(y_1^m, y_2^m, y_3^B - 3y_3^m, y_4^m) \\ \quad + C(y_1^m, y_2^m, y_3^m, y_4^B - 3y_4^m) \\ \quad - C(y_1^B, y_2^B, y_3^B, y_4^B) \end{array}}{C(y_1^B, y_2^B, y_3^B, y_4^B)} \quad (7)$$

where

y_p^m: the minimum value of y_p in the sample.[8]

WSCOPE measures the percentage increase in cost arising from dividing the outputs into relative specialized banks, though none are more specialized than the most specialized bank in the sample. $\mathrm{WSCOPE} > 0$, $\mathrm{WSCOPE} < 0$ and $\mathrm{WSCOPE} = 0$ suggest the presence of within-sample scope economies, scope diseconomies, and scope neutrality, respectively.

In addition, the WPSCO is defined as:

$$\mathrm{WPSCO}(y_k) = \frac{\begin{array}{l} C(y_1, \ldots, y_{k-1}, y_k^m, y_{k+1}, \ldots, y_p) \\ \quad + C(y_1^m, \ldots, y_{k-1}^m, y_k - y_k^m, y_{k+1}^m, \ldots, y_p^m) \\ \quad - C(y_1, \ldots, y_p) \end{array}}{C(y_1, \ldots, y_p)} \quad (8)$$

where

y_k^m: the minimum level of output k within the sample.

WPSCO is said to exist in the production of y_k if $\mathrm{WPSSE}(y_k) > 0$, whereas $\mathrm{WPSSE}(y_k) < 0$ indicates within-sample product-specific diseconomies of scope.

WSCOPE and WPSCO are useful if extreme product specialization is a viable business strategy. However, banks rarely engage in extreme product specialization. In fact, banks in different size categories usually have different output mixes. Accordingly, Berger *et al*. (1987) developed another measure called expansion path subadditivity (EPSUB), which gives the proportional cost increase from two-bank instead of one-bank production of Y^B, using the smaller bank on the expansion path:

$$\mathrm{EPSUB}(Y^B) = \frac{C(Y^A) + C(Y^D) - C(Y^B)}{C(Y^B)} \quad (9)$$

EPSUB measures the predicted cost differences if an observed bank were arbitrarily divided into two smaller banks that produced the same total output. Following Berger *et al*. (1987) and Mitchell and Onvural (1996), EPSUB is estimated along the expansion path from the mean output level of one size class to the mean of the next size class. $\mathrm{EPSUB} > 0$, or 'subadditive' costs means a larger bank can engage in the joint production of two or more good/services at a lower cost than if they are

[8] In this article, $(y_p^B - 3y_p^m)$ in Equation 7 is substituted by $(y_p^B - y_p^m)$, because for the output vector y_1 (deposits) and y_2 (loans), the value calculated by the former equation is negative, and hence cannot be used in the translog function to obtain costs. This may overestimate the costs of producing separately, or underestimate the costs of joint production. Hence, the results of WSCOPE should be interpreted with regards to this possible biasedness.

Table 1. List of sample commercial banks in china

Type	No.	Name of bank
State-owned commercial banks	1	Industrial and Commercial Bank of China (ICBC)
	2	Agricultural Bank of China (ABC)
	3	Bank of China (BOC)
	4	China Construction Bank (CCB)
Joint-stock commercial banks	1	Bank of Communication (BOCOM)
	2	CITIC Industrial Bank (CITICIB)
	3	China Merchants Bank (CMB)
	4	Shenzhen Development Bank (SDB)
	5	Guangdong Development Bank (GDB)
	6	Industrial Bank (IB, known as Fujian Industrial Bank before March 2003)
	7	China Everbright Bank (CEB)
	8	Hua Xia Bank (HXB)
	9	Shanghai Pudong Development Bank (SPDB)
	10	China Minsheng Banking Corporation (CMBC)

Source: Almanac of China's Finance and Banking (2003).

separately produced by two (or more) smaller banks. Hence, smaller banks have an incentive to expand and engage in the joint production of two or more services. Conversely, EPSUB < 0 implies 'superadditive' costs: the two (or more) smaller banks can produce each service separately at a lower total cost.

Data

At the end of 2002, there were four types of commercial banks operating in China: state-owned commercial banks, joint-stock commercial banks, city commercial banks, and foreign banks.[9] This article focuses on the state-owned and joint-stock commercial banks (Table 1). At the end of 2002, their market share was 93% measured by total assets. The latter two types of banks are basically regional banks, which are confined to operate within a specific region. The sample periods are from 1985 to 2002 with 187 observations in total. All of the data (except mentioned specifically) used in this study are obtained from various editions of the *Almanac of China's Finance and Banking*.

Table 2 provides the summary statistics for all variables used in both Equations 2 and 3. Following Humphrey (1992), the intermediation approach is adopted to measure the flow of bank services in this study, with some modification to capture the dual role played by deposits, i.e. they are treated as both inputs (to fund loans) and outputs – providing services to depositors such as security, liquidity, and in some cases, paying interest.

Some authors (e.g. Jagtiani *et al*., 1995; Stiroh, 2000; Altunbas *et al*., 2001; Vander Vennet, 2002) argue that bank output may be understated if measured solely by the banks' balance-sheets, especially with the growth of derivatives and asset backed securitization. For this reason, they added noninterest income as a proxy for off-balance sheet (OBS) activity. For completeness, this study also includes noninterest income as one of the outputs, even though Chinese banks are far less active in the newer types of OBS business. Table 3 reports some descriptive statistics for the different categories of bank assets, together with the expansion paths for each type of bank.

IV. Empirical Results

Table A1 reports the coefficients and *p*-values from estimating the traditional nonfrontier function, Equation 2 and the stochastic frontier function, Equation 3. Use of these estimated coefficients together with the original data set yields different measures of economies of scale and scope, which appear in Tables 4(a) and (b). In the discussion that follows, 'significance' refers to a level of confidence in the 1–10% range, unless stated otherwise.

As mentioned in Section II, the stochastic frontier approach and the expansion path measures are the preferred methods of estimation. The estimated

[9] There were other two types of banking institutions: policy banks and credit cooperatives. Policy banks have different fund resources and lending according to state policies. Credit cooperatives focus on a certain group of members. Therefore, both are not discussed in this article.

Table 2. Summary statistics for sample banks (1985–2002)

Bank groups	Periods	No. of obs.	C (Total costs)		$y1$ (Total deposits)		$y2$ (Total loans)		$y3$ (Total investments)		$y4$ (Noninterest income)		$w1$ (Prices of funds)		$w2$ (Prices of fixed assets)		$w3$ (Prices of employees)	
All banks	1985–2002	187	6317	(11 948)	159 057	(231 466)	143 498	(192 872)	246 378	(530 00)	1324	(2668)	0.021	(0.020)	0.287	(0.214)	0.004	(0.002)
All state-owned banks	1985–2002	72	15 647	(15 166)	373 043	(252 155)	341 378	(178 784)	55 633	(753 99)	2799	(3793)	0.031	(0.027)	0.206	(0.180)	0.003	(0.001)
All joint-stock banks	1987–2002	115	476	(528)	25 083	(28 081)	19 608	(23 934)	5232	(7476)	401	(649)	0.015	(0.010)	0.337	(0.218)	0.005	(0.002)
State-owned banks (1)	1985–1992	32	12 809	(7751)	187 514	(100 859)	226 949	(124126)	10 018	(15 625)	1892	(4970)	0.042	(0.028)	0.211	(0.100)	0.001	(0.000)
State-owned banks (2)	1993–2002	40	17 918	(18 949)	521 466	(238 378)	432 922	(163 109)	92 125	(84 158)	3526	(2311)	0.022	(0.023)	0.202	(0.226)	0.003	(0.001)
Joint-stock banks (1)	1987–1992	22	233	(335)	5596	(10 597)	5202	(7938)	561	(713)	39	(85)	0.027	(0.011)	0.358	(0.366)	0.004	(0.001)
Joint-stock banks (2)	1993–2002	93	533	(550)	29 693	(28 969)	23 016	(25 181)	6337	(7917)	486	(694)	0.012	(0.007)	0.332	(0.169)	0.006	(0.002)

Sources: Almanac of China's Finance and Banking (1986–2003); China Statistical Yearbook (2003).
Notes: (1) All the figures are based on the mean value of the relative year. SD are in parentheses.
(2) All financial variables measured in million's of constant 1985 RMB.
(3) Total costs (C): operating costs plus interest costs, including costs of funds, fixed assets, and labour.
(4) Total deposits (y_1): short-term deposits, short-term savings deposits, fiscal deposits, long-term deposits, and long-term savings deposits.
(5) Total loans (y_2); short-term loans, trade bills, bills discounted, medium and long-term loans, and impaired loans; excludes loan loss reserves.
(6) Total investments (y_3): short-term investment, trading securities, securities held under Repo agreement, and long-term investment, while excluding investment loss reserves.
(7) Noninterest income (y_4): operating income less interest income.
(8) The cost of funds (w_1): the ratio of total interest expenses on borrowed funds to total borrowed funds. Total interest expenses on borrowed funds include interest paid on total deposits plus interest paid on interbank borrowing. Total borrowed funds include total deposits, borrowing from central bank, deposits from banks, borrowing from banks, borrowing from nonbank financial institutions, deposits against other credit facilities, bonds issued, and long-term borrowing.
(9) The cost of employees (w_3): The ratio of total expenses on employees to the number of employees. Total expenses on employees are unavailable, so two categories of average wage are applied here: the annual average wages paid by state-owned and other types of financial institutions, respectively. Though the number of employees at the four state banks, and some joint stock banks is known, the data are incomplete for six of the joint stock banks. Following Altunbas *et al.* (2001), Rezvanian and Mehdian (2002) and Vander Vennet (2002), it is assumed that the growth rate of employee numbers is the same as that of the total assets for a given bank.
(10) The cost of fixed assets (w_2): the ratio of total expenses on the fixed assets to total fixed assets. Total fixed assets = gross fixed assets less depreciation. Total expenses on the fixed assets = operating expenses minus expenses on employees.
Unit: million RMB.

Table 3. Total assets of sample banks (1985–2002)

Categories	Periods	Mean	Median	Min.	Max.	Asset range in expansion path[3]
All sample banks	1985–2002	254 431	66 317	386	1 432 002	(386–66 317)–(66 317–1 432 002)
All state-owned banks	1985–2002	600 243	554 222	168 843	1 432 002	(168 843–554 222)–(554 222–1 432 002)
All Joint-stock banks	1987–2002	37 923	20 561	386	231 964	(386–20 561)–(20 561–231 964)
State-owned banks (1)	1985–1992	390 217	389 397	168 843	789 022	(168 843–389 397)–(389 397–7 890 22)
State-owned banks (2)	1993–2002	768 264	749 361	406 523	1 432 002	(406 523–749 361)–(749 361–1 432 002)
Joint-stock banks (1)	1987–2002	9755	4336	386	85 976	(386–4336)–(4336–85 976)
Joint-stock banks (2)	1993–2002	44 586	28 233	2621	231 964	(2621–28 233)–(28 233–231 964)

Sources: Almanac of China's Finance and Banking (1986–2003).
Notes: (1) Total assets are adjusted for inflation using the CPI, with 1985 as the base year.
(2) To calculate the EPSCE and EPSUB, sample banks are divided into large banks and small banks by the median value of total assets in the relevant categories.
(3) The expansion path is from group of small banks to group of large banks.
Unit: million RMB.

expansion path scale economies (EPSCE – Table 4a) indicate that the values are not significantly different from one for the joint stocks during both stages of reform. This means they show constant returns to scale, taking account of changes in output composition as the scale of these banks increase along their expansion path. Thus there is no evidence that the joint stocks could cut costs by increasing production. The state banks exhibited decreasing returns to scale during the first phase of reform and CRS by the second stage. Here, change may be due to stage II reforms that prompted the state banks to streamlining their operations, as discussed in of this article.

Most values for the estimated expansion path subadditivity (EPSUB) are significantly positive, meaning costs are subadditive. Thus, as banks get larger, costs fall with joint production. By expanding their product bundle, banks could meet customers' joint demands and/or reduce risks. That is, in addition to the basic core intermediary functions, they offered new products, including agent services (e.g. selling insurance on behalf of insurance firms), letters of credit, and also invested in government bonds. Thus, the reforms appear to have encouraged them to expand into new off-balance sheet activities. However, it is possible the restoration of universal banking[10] would further improve the potential for scope (and scale) economies.

The results based on the standard measures (i.e. SCALE and WSCOPE – see Table 4b) tell a different story. When both the state and joint stock banks are estimated as a single sample [column (1)], increasing economies of scale and diseconomies of scope are found to be statistically significant. Thus, either banks that increase outputs or specialized banks will lower costs. When estimated separately, columns (2) and (3) show the state-banks exhibit significant economies of scope. The joint-stocks show significant economies of scale[11] and diseconomies of scope. It follows that the state banks would gain from more joint production, whereas joint-stocks should increase their scale of operations but specialize.

If the results of the expansion path and standard measures are compared, the findings are similar to those of previous studies (e.g. Berger *et al*. 1987; Mitchell and Onvural, 1996; Rime and Stiroh, 2003). That is, different approaches used to estimate economies of scale and scope often lead to inconsistent results. A plausible explanation for the difference is that the expansion path measures capture the impact of changing scale and product mix simultaneously but the standard measures do not. For these reasons, little is to be gained from discussing or interpreting the results from the standard measures.

Turning to the within sample tests on all banks, the results of the WPSSE show significant diseconomies of scale for deposits, loans, and OBS activities. In contrast, the sign for y_3, bank investments, is significantly positive. These results hold for the other bank groups, with some exceptions. Product-specific economies of scope are significantly negative for deposits, loans and investments for the full sample of banks, but the coefficient on OBS activities is significantly positive. The joint-stock banks tell a similar story, but the results of the groups of state-owned banks suggest that, in addition to joint production of the OBS

[10] In 1993, the PBC introduced a rule that put an end to universal banking, i.e. firms could opt to be investment or commercial banks but not both. Nor could banks offer insurance. It was formalized in the 1995 Commercial Bank Law.
[11] The finding of scale economies is consistent with much of the literature which report evidence of economies of scale for smaller banks.

Table 4. Economies of scale and scope

	Types of scale and scope economies	Descriptions	(1) All banks 1985–2002	(2) All state owned 1985–2002	(3) All joint stock 1987–2002	(4) State-owned-1 1985–1992	(5) State-owned-2 1993–2002	(6) Joint-stock-1 1987–1992	(7) Joint-stock-2 1993–2002
(a) Stochastic frontier approach									
1	SCALE	Overall scale economies	**0.973*****	1.030***	**0.937*****	1.085***	**0.986***	1.013	**0.919*****
2	EPSCE	Expansion path scale economies	1.003	1.893	1.024	2.205*	0.829	0.945	1.001
3	WSCOPE	Within-sample scope economies	−0.81***	**1.064*****	−0.70***	**1.274*****	**0.690*****	−0.216	−0.45***
4	EPSUB	Expansion path subadditivity	**0.192*****	**0.204*****	**0.189*****	0.252	**0.177****	**0.270****	**0.181*****
5	WPSSE(y_1)	Within-sample scale economies specific to y_1 (total deposits)	0.679***	0.354***	0.796***	0.024**	0.426***	0.797***	0.715***
6	WPSSE(y_2)	Within-sample scale economies specific to y_2 (total loans)	−2.79***	−1.32***	−2.53***	−1.16***	−0.75***	−2.60***	−2.13***
7	WPSSE(y_3)	Within-sample scale economies specific to y_3 (total investments)	**2.709*****	1.410	**3.522*****	0.458	**1.854*****	**2.997****	**2.251*****
8	WPSSE(y_4)	Within-sample scale economies specific to y_4 (OBS)	−2.56***	−3.52***	−1.34***	−1.02**	0.723	0.851	0.784
9	WPSCO(y_1)	Within-sample scope economies specific to y_1 (total deposits)	−0.87***	−0.26***	−0.84***	−0.04	0.011	−0.49***	−0.63***
10	WPSCO(y_2)	Within-sample scope economies specific to y_2 (total loans)	−0.68***	**0.738*****	−0.59***	**0.818*****	**0.078****	−0.36***	−0.49***
11	WPSCO(y_3)	Within-sample scope economies specific to y_3 (total investments)	−0.19***	**0.065***	−0.23***	**0.158****	**0.107*****	−0.05	−0.25***
12	WPSCO(y_4)	Within-sample scope economies specific to y_4 (OBS)	**0.132*****	**0.558*****	−0.01	**0.507*****	**0.217*****	−0.04	−0.01
(b) Traditional nonfrontier approach									
1	SCALE	Overall scale economies	**0.933*****	1.009	**0.885*****	1.081***	**0.951*****	0.989	**0.860*****
2	EPSCE	Expansion path scale economies	**0.952*****	2.028	**0.928***	1.182**	1.361**	**0.892*****	**0.950*****
3	WSCOPE	Within-sample scope economies	−0.68***	**3.288*****	−0.52***	**1.308*****	**3.088*****	−0.99***	−0.99***
4	EPSUB	Expansion path subadditivity	**0.238****	**1.644*****	**0.758*****	**0.467***	**1.613*****	−0.15	**0.595*****
5	WPSSE(y_1)	Within-sample scale economies specific to y_1 (total deposits)	0.434***	0.299***	0.474***	0.218***	0.227***	0.454***	0.435***
6	WPSSE(y_2)	Within-sample scale economies specific to y_2 (total loans)	−0.89***	−0.23***	−0.89***	0.017	0.503**	−1.18***	−1.12***
7	WPSSE(y_3)	Within-sample scale economies specific to y_3 (total investments)	**2.118****	1.553	**2.454****	**1.128*****	0.758*	**1.942***	**1.359*****
8	WPSSE(y_4)	Within-sample scale economies specific to y_4 (OBS)	−0.441**	−2.856**	0.979*	−1.430*	−1.065	**1.273***	**1.896****
9	WPSCO(y_1)	Within-sample scope economies specific to y_1 (total deposits)	−0.93***	−0.42***	−0.90***	−0.53***	**1.938*****	−0.99***	−0.99***
10	WPSCO(y_2)	Within-sample scope economies specific to y_2 (total loans)	−0.63***	**3.116*****	−0.44***	**1.203*****	**1.770*****	−0.99***	−0.99***
11	WPSCO(y_3)	Within-sample scope economies specific to y_3 (total investments)	−0.31***	−0.03	−0.35***	−0.27***	**1.878*****	−0.99***	−0.98***
12	WPSCO(y_4)	Within-sample scope economies specific to y_4 (OBS)	**0.178*****	**0.701*****	−0.04	**0.205**	**2.272*****	−0.99***	−0.96***

Notes: (1) Values with ***, ** and * are (1) Statistically different from one for the measures of economies of scale (e.g. SCALE, EPSCE and WPSSE). (2) Statistically significant from zero for the measures of economies of scope (e.g. WSCOPE, EPSUB and WPSCO) at the 1%, 5% and 10% levels of significance, respectively.
(2) Bold typeface for values indicates significant economies of scale and scope at the 10% level.

activities, there is cost advantage from the joint production of loans and investments. Note, however, that all the test results on WPSSE and WPSCO should be interpreted with caution because of the limiting assumption that banks change the output of one specific product while holding the output of the other products constant. Here, 3 of the 4 'outputs' are on the balance sheet: bank loans (y_2) and investments (y_3) are from the assets side, while bank deposits (y_1) are from the liabilities side. From an accounting standpoint, assets and liabilities must balance, making the variation of one output (loans) without a change in another (e.g. deposits) all but impossible.

The estimates from the stochastic frontier and traditional nonfrontier approaches are similar. However, comparing the first four rows of Table 4(a) and (b), the degree of economies of scale/scope is generally larger under the traditional nonfrontier approach. For example, for all banks the degree of overall scale economies (SCALE) under the stochastic frontier approach is 2.7%, but 6.7% under the traditional approach.[12] Thus, the traditional nonfrontier approach appears to overstate overall bank scale economies by 4%.

In contrast, the degree of scope diseconomies appears to be underestimated if the traditional nonfrontier approach is used. For example, WSCOPE for all banks is 81% if the stochastic frontier approach is used, and 68% under the traditional nonfrontier approach.[13] Thus, use of the traditional nonfrontier model biases the estimate of scale/scope economies upward/downward, a finding consistent with Berger and Humphrey (1991).

V. Conclusions and Policy Implications

This article contributes to the literature by being the first study to use Chinese data to estimate economies of scale and scope during the period 1985 to 2002. The methodology is exhaustive, employing both the stochastic frontier approach and expansion path measures, together with the traditional nonfrontier approach and the standard measures of scale and scope economies. In addition, economies of scale and scope for both state and joint stock banks were estimated and compared in the different reform stages. The findings in the previous section show the superiority of the stochastic frontier approach with expansion path measures, and for this reason, the conclusions focus on these results.

Three major conclusions emerge from this study. First, the results indicate that the majority of joint stock banks exhibited constant returns to scale during both phases of reform. For this group, the reforms do not appear to have affected their optimal scale – proportionate changes in output will not reduce costs. Thus, the do not enjoy scale economies, despite reforms that allowed them to expand from regional to nation-wide banking.

Second, the state banks faced decreasing returns to scale during the first set of reforms, but constant returns to scale in the second phase. It is well known that the second set of reforms encouraged these banks to engage in organizational restructuring. These appear to have paid off through improvements in their cost structure.

Finally, both the joint stocks and state banks were found to exhibit significant economies of scope. Economies of scope exhibited during the first phase were likely related to the banks being allowed to engage in both commercial and investment banking, and during the second stage, linked to expanding the commercial banking product bundle offered to customers. The restoration of universal banking could create new opportunities for banks, and possibly, lead to greater economies of scale and/or scope.

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[12] $|0.973 - 1| = 2.7\%$; $|0.933 - 1| = 6.7\%$.
[13] $|-0.81 - 0| = 81\%$; $|-0.68 - 0| = 68\%$.

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Appendix

Table A1. Parameter estimates of the translog cost functions

		Stochastic frontier approach			Traditional nonfrontier approach		
Variable	Description	Coefficients	*p*-values (SE)		Coefficients	*p*-values (SE)	
Constant		0.966	0.432	(1.231)	**1.546**	0.068	(0.842)
LNY1	Total deposits	0.891	0.377	(1.008)	**1.006**	0.054	(0.519)
LNY2	Total loans	−0.111	0.898	(0.836)	−0.323	0.511	(0.490)
LNY3	Total investments	0.053	0.590	(0.099)	0.069	0.135	(0.046)
LNY4	Noninterest income	−0.012	0.945	(0.171)	0.011	0.894	(0.080)
LNY1LNY1/2	Total deposits * Total deposits/2	−0.092	0.842	(0.463)	−0.217	0.406	(0.260)
LNY1LNY2	Total deposits * Total loans	0.078	0.841	(0.387)	0.170	0.489	(0.245)
LNY1LNY3	Total deposits * Total investments	−0.052	0.506	(0.078)	−0.012	0.803	(0.049)
LNY1LNY4	Total deposits * Noninterest income	0.080	0.251	(0.070)	**0.073**	0.031	(0.034)
LNY2LNY2/2	Total loans * Total loans/2	−0.021	0.950	(0.339)	−0.067	0.780	(0.240)
LNY2LNY3	Total loans * Total investments	0.041	0.598	(0.078)	0.001	0.988	(0.048)
LNY2LNY4	Total loans * Noninterest income	−0.095	0.148	(0.066)	**−0.091**	0.011	(0.035)
LNY3LNY3/2	Total investments * Total investments/2	0.013	0.013	(0.005)	**0.010**	0.004	(0.003)
LNY3LNY4	Total investments * Noninterest income	0.003	0.667	(0.007)	0.005	0.114	(0.003)
LNY4LNY4/2	Noninterest income * Noninterest income/2	0.001	0.899	(0.009)	0.001	0.855	(0.004)
LNW1	Price of funds	0.247	0.382	(0.282)	0.284	0.291	(0.268)
LNW2	Price of fixed assets	0.491	0.212	(0.393)	0.462	0.124	(0.230)
LNW3	Price of employees	NA	NA	NA	0.253	0.146	(0.173)
LNW1LNW1/2	Price of funds * Price of funds/2	0.029	0.433	(0.037)	0.053	0.175	(0.039)
LNW1LNW2	Price of funds * Price of fixed assets	0.076	0.170	(0.055)	0.048	0.331	(0.049)
LNW1LNW3	Price of funds * Price of employees	NA	NA	NA	**−0.101**	0.001	(0.025)
LNW2LNW2/2	Price of fixed assets * Price of fixed assets/2	−0.088	0.302	(0.085)	−0.058	0.376	(0.065)
LNW2LNW3	Price of fixed assets * price of employees	NA	NA	NA	0.010	0.773	(0.035)
LNW3LNW3/2	Price of employees * Price of employees/2	NA	NA	NA	**0.091**	0.001	(0.035)
LNY1LNW1	Total deposits * Price of funds	−0.012	0.909	(0.104)	**0.041**	0.614	(0.080)
LNY1LNW2	Total deposits * Price of fixed assets	-0.050	0.746	(0.155)	−0.086	0.424	(0.107)
LNY1LNW3	Total deposits * Price of employees	NA	NA	NA	0.045	0.567	(0.079)
LNY2LNW1	Total loans * Price of funds	0.036	0.719	(0.100)	−0.013	0.865	(0.078)
LNY2LNW2	Total loans * Price of fixed assets	0.006	0.965	(0.136)	0.035	0.730	(0.102)
LNY2LNW3	Total loans * Price of employees	NA	NA	NA	−0.022	0.773	(0.076)
LNY3LNW1	Total investments * Price of funds	−0.011	0.600	(0.022)	−0.009	0.401	(0.102)
LNY3LNW2	Total investments * Price of fixed assets	0.017	0.475	(0.023)	0.015	0.204	(0.120)
LNY3LNW3	Total investments * Price of employees	NA	NA	NA	−0.007	0.406	(0.008)
LNY4LNW1	Noninterest income * Price of funds	0.018	0.426	(0.023)	0.015	0.262	(0.013)
LNY4LNW2	Noninterest income * Price of fixed assets	0.024	0.456	(0.033)	**0.027**	0.092	(0.016)
LNY4LNW3	Noninterest income * Price of employees	NA	A	NA	**−0.042**	0.037	(0.020)
R^2		0.99			0.99		

Note: Bold typeface for values indicates significantly different from zero at the 10% level.