

# Market structure in the Vietnamese banking system: a non-structural approach

Vietnamese  
banking  
system

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## Abstract

**Purpose** – This paper aims to examine the market structure of Vietnam's banking sector during 1999-2009, which is after the introduction of the two-tier banking system, using the non-structural (Panzar–Rosse) model.

**Design/methodology/approach** – The authors consider a more comprehensive range of specifications, in terms of a greater number of environmental covariates and different dependent variables, than in the previous applications of this model. Further, this is the first study that uses lagged input prices (to avoid endogeneity), excludes assets (to avoid specification bias) and includes a lagged dependent variable (to avoid dynamic panel bias) in such a study of the Vietnamese banking system.

**Findings** – The authors find that the Vietnamese banking system operates in monopoly.

**Originality/value** – The main contribution of this paper is to determine the market structure in the recent period after the Vietnamese banking system was transformed into a less centralised, two-tier system. This study is the first to uniquely identify the market structure of this developing economy's banking system (using data only for Vietnam and not observations from other countries) in a post-transition period.

**Keywords** Bank regulation, Central bank, Performance, Banking

**Paper type** Research paper

## 1. Introduction

In this paper, we provide a detailed analysis of the degree of market competition in the Vietnamese banking system using the [Panzar and Rosse \(1987\)](#) non-structural model. This model suggests that the market is a monopoly if the service offered by a particular bank is independent and originate. In contrast, the market is competitive if bank services are similar in the market. We apply the non-structural model to an extensive panel data set of 48 Vietnamese commercial banks, which includes state owned commercial banks and non-state owned commercial banks, from 1999 to 2009. Using this procedure, we consider whether the Vietnamese banking market is best characterised by monopoly, perfect competition or the intermediate case of monopolistic competition.

We estimate H-statistics of models that both include and exclude assets with current or lagged input prices. We also estimate E-statistics to test whether the long-run equilibrium conditions required for the H-statistics to be valid hold when using the fixed-effects estimator within the equilibrium approach. A comparison of models using current and



lagged input prices is used to assess whether input prices are endogenous. This is the first study that uses lagged input prices (to avoid endogeneity) and excludes assets (to avoid bias) in a study of the Vietnamese banking system. This study also extends the previous literature (Bikker *et al.*, 2006a, 2006b; Bikker and Spierdijk, 2009) by considering new additional variables such as total assets, capital/assets, loans/deposits and the number of branches in the model's specification. In addition, we compare inference using four alternative dependent variables being revenue/assets, interest income/assets, revenue and interest income. However, the main contribution of this paper is to determine the market structure in the recent period after the Vietnamese banking system was transformed into a less centralised, two-tier system. This study is the first to uniquely identify the market structure of this developing economy's banking system (using data only for Vietnam and not observations from other countries) in a post-transition period[1]. Another novelty of the paper is to assess the biases that arise from model misspecification, in particular, biases due to endogeneity, including assets and not accounting for a potential dynamic specification.

The rest of this paper is organised as follows: Section 2 deals with developments in the Vietnamese banking system in the period from 1986 to 2009; Section 3 provides a literature review of the non-structural model in banking; Section 4 discusses methodology and data; Section 5 presents our empirical results; and Section 6 concludes.

## 2. The Vietnamese banking system during 1986-2009

From 1986 to 2009, the Vietnamese banking system was transformed from a mono to two-tier banking system. The two-tier banking system has the State Bank of Vietnam (SBV) as the central bank (tier 1) and four specialised state owned banks (tier 2). Table I shows the number of Vietnamese commercial banks from 1990 to 2009. With extended networks in almost all provinces and larger cities, state owned commercial banks have a competitive edge in providing banking services. Although joint stock commercial banks increased their numbers immediately after their appearance in 1990 (in 2009, there were 37 joint stock commercial banks), the leading positions in the market still belong to state owned commercial banks. State owned commercial banks were originally sector departments under the State Bank of Vietnam, with specified lending programmes to state owned enterprises, which were based on government policies.

Non-state owned commercial banks consist of joint stock commercial banks, branches of foreign banks, joint venture commercial banks and foreign commercial banks[2]. Unlike state owned commercial banks, a number of joint stock commercial banks make profits because of good performance. Joint stock commercial banks have achieved average returns

Type of banks	1990	1995	2000	2005	2009
State owned commercial banks	4	4	5	5	5
Non-state owned commercial banks					
Joint stock commercial banks	0	36	39	37	37
Branches of foreign banks	0	18	26	31	48
Joint venture commercial banks	0	4	5	5	6
Foreign commercial banks	0	0	0	0	5
Total	4	62	75	78	101

**Table I.**  
The number of  
commercial banks  
from 1990 to 2009[15]

**Sources:** Dufhues (2003); SBV (2005, 2008, 2009); VCSC (2008)

on equity between 15 and 30 per cent. Being less than 15 years old, joint stock commercial banks are relatively young and they can be divided into three groups:

- (1) the top five large urban banks;
- (2) a smaller group of banks that are either growing rapidly or have established a niche; and
- (3) 12 small rural joint stock commercial banks.

The top five urban banks are Techcombank, Sacombank, VIBBank, Asia Commercial Bank and East Asia Commercial Bank. The smaller urban joint stock commercial banks include Viet A Bank and Saigon Bank. Small rural commercial banks were all transformed into city commercial banks at the end of 2010, such as An Binh Bank and Saigon-Hanoi Bank. These banks developed throughout the country, not just in rural areas, and with help from big business and foreign investors they also performed well in the 2000s. The number of branches of foreign banks increased from 18 banks in 1995 to 48 banks in 2009. However, each foreign bank normally has one branch in either Hanoi or Ho Chi Minh City. Hence, their assets, loans and deposits are very small compared to state owned commercial banks, joint stock commercial banks and joint venture commercial banks. Despite Foreign Direct Investment in US dollar terms growing by a factor of eight between 1990 and 2005, foreign companies are still hesitant as whether or not to choose domestic banks when they enter this new market. The number of joint venture commercial banks has increased slightly from four to six banks between 1995 and 2009. The first foreign commercial bank (being HSBC) had a license to set up a wholly foreign-owned bank from 2008 (Nguyen and Stewart, 2013).

Table II shows data on loans, assets, deposits, capital and non-performing loans of the Vietnamese banking system (state owned commercial banks and non-state owned commercial banks) from 1999 to 2009. On the whole, there was an increasing trend of loans, assets, deposits and capital over the period. Vietnamese banks were burdened by a high volume of non-performing loans, particularly during the 1990s; however, these generally decreased from 1999 to 2009. Non-performing loans of non-state owned commercial banks are typically lower than those of state owned commercial banks.

In terms of regulation, the State Bank of Vietnam aims to create a banking supervision development (following Basel) from 2010 onwards. Meanwhile, the coverage, measures and procedures of banking supervision and monitoring are to be reformed in accordance with the development of internet technologies and banking technology. This will be done by applying key principles of international standards on banking supervision (Basel I and Basel II). The old capital adequacy ratio standards for banks in Basel I and Basel II are 8 per cent and 12 per cent, respectively. The capital adequacy ratio for the Vietnamese commercial banks is to be adjusted to 9 per cent (as Circular No. 13/TT-NHNN dated 20th May 2010 of the State Bank of Vietnam).

In parallel with the speed of the country's economic development, the loan growth rate rose dramatically. One of the reasons was that many banks had greatly increased their credit growth through real estate loans, because of the over-heating of the real estate market. The credit growth rate of the banking system increased to nearly 38 per cent in 2007 and peaked at an alarming 63 per cent in the first quarter of 2008 (WB, 2008, p. 3). This has been the highest growth rate within the past decade. When the inflation rate and trade balance deficit had become more serious, the government applied a traditional tightening of monetary policy to reduce money supply circulation, which affected the banking system. Compulsory measures were necessary for banks to reorganise and strengthen their organisations.

**Table II.**  
Data on loans, assets, deposits, capital and non-performing loans of the Vietnamese commercial banks (state owned commercial banks and non-state owned commercial banks) from 1999 to 2009  
(Unit: 1,000 Vietnamese Dong)

Year	Bank type	Loans	Assets	Deposits	Capital	Non-performing loans (%)
1999	SOCBs	72,142,247	134,890,858	87,326,439	5,468,772	10.78
	Non-SOCBs	35,899,360	58,871,839	30,293,986	9,284,887	N/A
2000	SOCBs	108,422,565	200,433,947	127,033,459	5,413,772	10.02
	Non-SOCBs	41,231,535	75,856,994	43,321,781	10,139,627	9.42
2001	SOCBs	135,647,621	247,151,769	160,738,302	5,421,134	8.83
	Non-SOCBs	45,466,715	88,614,974	51,759,565	10,953,034	7.81
2002	SOCBs	165,921,733	286,860,920	189,313,313	10,061,113	7.62
	Non-SOCBs	55,296,802	102,590,591	63,658,203	11,152,585	5.41
2003	SOCBs	214,481,096	367,813,825	237,485,761	14,516,916	5.13
	Non-SOCBs	74,068,790	130,337,981	79,255,399	12,398,334	3.57
2004	SOCBs	295,738,175	468,341,918	311,681,861	17,362,940	2.92
	Non-SOCBs	103,563,777	183,404,071	109,681,322	14,860,054	2.26
2005	SOCBs	380,850,503	603,540,889	406,957,181	18,429,980	3.81
	Non-SOCBs	143,449,737	261,307,537	144,499,838	20,009,805	1.42
2006	SOCBs	435,695,864	731,657,400	524,533,245	18,777,200	3.19
	Non-SOCBs	212,097,344	430,755,234	229,411,786	35,578,494	1.29
2007	SOCBs	564,677,195	904,004,852	652,913,108	30,091,997	1.87
	Non-SOCBs	420,184,441	903,961,807	456,920,152	66,066,418	0.94
2008	SOCBs	671,732,670	1,078,729,233	775,560,005	39,279,325	2.47
	Non-SOCBs	534,692,051	1,097,675,565	593,628,040	103,923,040	1.62
2009[16]	SOCBs	903,718,777	1,320,357,324	869,410,909	61,293,664	N/A
	Non-SOCBs	560,883,667	1,210,244,318	680,665,451	115,192,318	N/A

**Notes:** SOCBs: State owned commercial banks; non-SOCBs: Non-state owned commercial banks  
**Sources:** SBV (2009); financial statements of 48 Vietnamese commercial banks

### 3. Literature review

Empirical studies that use the non-structural model to establish the extent of contestability in banking markets are concerned with drawing inferences about market structure indirectly from observing conduct. This is because of contestability, which depends on the extent of potential competition, and is not observable directly (Goddard *et al.*, 2001). Panzar and Rosse (1987) formulated simple models for monopolistic, oligopolistic and perfectly competitive markets, and developed a test to discriminate between these market structures. Bikker and Bos (2008) explained this non-structural model as based on the properties of a reduced-form revenue equation at the firm or bank level and using the H-statistic, which, under certain assumptions, can serve as a measure of how competitive banks are. The test is from a general banking model, which determines equilibrium output and the equilibrium number of banks by maximising profits at both the bank and industry levels. This implies, firstly, that bank  $i$  maximises its profits, where marginal revenue equals marginal cost. The profit maximising condition is:

$$R'_i(Y_i, n, Z_i) - C'_i(Y_i, n, T_i) = 0 \quad (1)$$

$R_i$  refers to revenue,  $C_i$  to cost,  $Y_i$  to output,  $w_i$  to a vector of  $m$  factor input prices and  $Z_i$  and  $T_i$  to vectors of exogenous variables that shift the bank's revenue and cost functions, respectively. The sub index  $i$  refers to bank  $i$ ;  $n$  is the number of banks; and the prime symbol denotes a first derivative with respect to output. Secondly, at the market level, it means that in equilibrium, the zero supernormal profit constraint holds:

$$R_i^*(Y^*, n^*, Z_i) - C^*(Y^*, w_i, T_i) = 0 \quad (2)$$

Variables marked with an asterisk (\*) represent equilibrium values. Market power is measured by the extent to which a change in factor input prices ( $dw_{k,i}$ ) for  $k = 1, \dots, m$  is reflected in changes in equilibrium revenue ( $dR_i^*$ ), earned by bank  $i$  (where  $m$  denotes the number of input prices). [Panzar and Rosse \(1987\)](#) defined a measure of competition  $H$  as the sum of the elasticities of the reduced-form revenue function with respect to factor prices:

$$H = \sum_{k=1}^m \left( \frac{\partial R_i^*}{\partial w_{k,i}} \right) \left( \frac{w_{k,i}}{R_i^*} \right) \quad (3)$$

The first market model that Panzar and Rosse investigate is a monopoly. In their analysis, monopoly includes the case of price-taking competitive banks, as long as the prices they face are truly exogenous, that is, as long as their equilibrium values are unaffected by changes in the other exogenous variables in the model. The empirical refutation of monopoly constitutes a rejection of the assumption that the revenue of the banks in question is independent of the decisions made by their actual or potential rivals. The Panzar and Rosse model demonstrates that under monopoly, an increase in input prices will increase marginal costs, reduce equilibrium output and subsequently reduce revenue; hence,  $H$  will be zero or negative. In the case of monopolistic competition, the analysis is based on the comparative static properties of the Chamberlain equilibrium model. In the equilibrium condition, interdependence affects the structural revenue function, and the bank's profit finally becomes zero as the conditions of entry and withdrawal are unlimited; hence,  $H$  will be smaller than one. In the case of perfect competition, under certain conditions both marginal cost and average cost increase without changing the optimum amount of the individual bank's output. If this condition occurs and some banks withdraw from the market, the remaining banks would individually face increased demand. This increased demand leads to higher prices and revenue, which is equal to the increase of cost, and  $H$  will become one. In summary:

- $H \leq 0$ : indicates a monopoly;
- $0 < H < 1$ : indicates the intermediate case of monopolistic competition; and
- $H = 1$ : indicates a perfectly competitive industry.

[Shaffer \(1982\)](#) obtained  $0 < H < 1$  for a sample of unit banks in the New York banking sector, suggesting monopolistic competition. [Nathan and Neave \(1989\)](#) confirmed this result for New York banks even when the effect of loan losses is considered. [Nathan and Neave \(1989\)](#) tested for contestability for a group of Canadian banks, trust companies and mortgage companies with data for the period from 1982 to 1984. The result indicated  $0 < H < 1$ . [DeBandt and Davis \(2000\)](#) provided a significant improvement on the specification of variables used in the model and its functional form. They emphasised that the banking industry is not a general industry, such as manufacturing; rather, it is an industry with individual characteristics, which is in line with the argument of [Panzar and Rosse \(1987\)](#). They obtained  $0 < H < 1$  for France, Germany, Italy and the USA. Competition appears to be most intense in the US markets, while small banks are found to enjoy some monopoly power in the German and French markets.

The model used for calculating the  $H$ -statistic has taken a variety of specific forms in the general banking literature. [Molyneux et al. \(1994\)](#) and [Bikker and Groeneveld \(2000\)](#) used the ratio of interest revenue to the total balance sheet as an endogenous variable.

Molyneux *et al.* (1994) investigated key European banking markets between 1986 and 1989, and they suggested that banks in Germany, France, Spain and the UK were in monopolistic competition during this period, whereas banks in Italy behave as if in monopoly. Bikker and Groeneveld (2000) used data on 892 banks from 15 EU countries over the sample period 1989-1996. Their results show that European banking sectors operate under conditions of monopolistic competition. On the other hand, Nathan and Neave (1989) used the logarithm of interest revenue as the dependent variable. According to DeBandt and Davis (2000), this is the most appropriate measure as the ratio of interest revenue to total assets might be interpreted as yielding a price equation rather than a revenue function. However, homogeneity might be induced even in the logarithmic specification. DeBandt and Davis (2000) insisted that in empirical studies on banking competition, although cross-sectional results are generally used, the implicit assumption is that all banks have access to the same factor market and only the scale of operations differs. They argued that the dimension of the time-series is crucial, and that irregular results might arise from estimating a cross-sectional regression of the equation with ordinary least squares for every year ( $t = 1, [ \dots ] T$ ). As a result, they asserted that it is desirable to focus on the pooled sample regression.

In Vietnam, three previous studies have applied the Panzar-Rosse model to the Vietnamese banking system. Bikker *et al.* (2006a, 2006b) and Bikker and Spierdijk (2009) analysed bank structure in the world (with 101 countries including Vietnam) from 1986 to 2004. Owing to data constraints, they only investigated banking structure in Vietnam from 1991 to 2004 for 24 banks[3]. They calculated the H-statistic for the Vietnamese banking system as 0.74. However, they applied only one model for all 101 countries, including Vietnam, and this model did not reflect the actual business in Vietnam where state owned commercial banks still dominate the whole banking system. Further, they could not observe the three input prices directly. Therefore, they used the ratio of annual personal expenses to total assets as an approximation for the price of personal expenses, and the ratio of other non-interest expenses to fixed assets as a proxy for the price of capital expenditure. Moreover, Bikker *et al.* (2006a, 2006b) and Bikker and Spierdijk (2009) preferred interest income as the dependent variable, while other researchers, such as Nathan and Neave (1989), favoured using revenue in the Panzar-Rosse model. Hence, for comparison purposes, we will use both interest income and revenue as dependent variables in this paper.

Our data set includes 48 Vietnamese commercial banks over the period 1999 to 2009. This is the first time that such an extensive panel data set has been used to uniquely identify the Vietnamese banking system's market structure using the non-structural model (our maximum sample period is 376 observations). No previous study has used lagged input prices (to avoid endogeneity) and excluded assets (to avoid bias) in a study of the Vietnamese banking system. Environmental factors such as total assets, capital/assets, loans/deposits and number of branches are incorporated in our models and have not all been used in previous studies of Vietnam. In addition, for comparative purposes, we use the following four different dependent variables: revenue divided by total assets (REV/TA); interest income divided by total assets (INT/TA); revenue (REV); and interest income (INT). We use the non-structural model to determine whether the Vietnamese banking system is best characterised by monopoly, monopolistic competition or perfect competition.

#### 4. Methodology and data

##### 4.1 Calculating H-statistics

We use non-structural models based on the Panzar-Ross equation (below):

$$\begin{aligned}
LN(ROA_{i,t}) = & \delta_0 + \delta_1 LN\left(\frac{PE_{i,t}}{TE_{i,t}}\right) + \delta_2 LN\left(\frac{IE_{i,t}}{FF_{i,t}}\right) + \delta_3 LN\left(\frac{CE_{i,t}}{FA_{i,t}}\right) + \delta_4 \frac{TC_{i,t}}{TA_{i,t}} \\
& + \delta_5 \frac{CL_{i,t}}{CD_{i,t}} + \delta_6 LN(TA_{i,t}) + \delta_7 LN(BR_{i,t})
\end{aligned}
\tag{4}$$

where  $LN(ROA_{i,t})$  is bank  $i$ 's revenue, which is initially measured in two ways: the natural logarithm of revenue divided by total assets  $LN(REV_{i,t}/TA_{i,t})$  and the natural logarithm of interest income divided by total assets  $LN(INT_{i,t}/TA_{i,t})$ . Also included is  $LN(PE_{i,t}/TE_{i,t})$ , the natural logarithm of the unit price of labour, *PersonalExpenses/TotalEmployees*;  $LN(IE_{i,t}/FF_{i,t})$ , the natural logarithm of the unit cost of funds, *InterestExpenses/FundableFunds*;  $LN(CE_{i,t}/FA_{i,t})$ , the natural logarithm of the unit cost of fixed assets; and *CapitalExpenses/FixedAssets* (Claessens and Laeven, 2004; Gelos and Roldos, 2004, p. 50 and Nathan and Neave, 1989, p. 580).  $TC_{i,t}/TA_{i,t}$  is the capital to assets ratio;  $CL_{i,t}/CD_{i,t}$  is the loans to deposits ratio; and  $LN(TA_{i,t})$  is the natural logarithm of total assets and  $LN(BR_{i,t})$  is the natural logarithm of the number of branches.

The H-statistic, which is used to determine the degree of competition, is calculated from equation (4) using the following equation:

$$H = \delta_1 + \delta_2 + \delta_3 \tag{5}$$

From equation (5), if  $H \leq 0$  the market is a monopoly, if  $0 < H < 1$  the market is in monopolistic competition and if  $H = 1$  the market is in perfect competition.

#### 4.2 Models with and without assets

Many previous empirical studies include among the controls the log of assets,  $LN(TA_{i,t})$ , to measure size or some other similarly defined measure of bank size; and many studies also scale the dependent variables with total assets; that is:  $LN(REV_{i,t}/TA_{i,t})$  and  $LN(INT_{i,t}/TA_{i,t})$ . However, Bikker *et al.* (2006a) pointed out that it is incorrect to estimate a revenue elasticity using a specification that includes a quantity-type variable among the controls, or by using a specification, which, through rescaling, converts a revenue variable into a price-type variable. In fact, if  $LN(TA_{i,t})$  appears among the controls, then it is immaterial whether the dependent variable is unscaled (not divided by total assets) or scaled (divided by total assets). In either case, the coefficients on the factor input prices ( $\delta_1, \delta_2, \delta_3$ ) should be interpreted as output price elasticities and not as revenue elasticities. The model is misspecified if assets are included and inference regarding market structure is invalid. Hence, on the left-hand side of the models, the dependent variables should be  $LN(REV_{i,t})$  and  $LN(INT_{i,t})$  instead of  $LN(REV_{i,t}/TA_{i,t})$  and  $LN(INT_{i,t}/TA_{i,t})$ , respectively. Further,  $LN(TA_{i,t})$  should be removed from the right-hand side of the models (Goddard and Wilson, 2009)[4]. The valid unscaled model (that we also estimate) is obtained from (4) with  $\delta_6 = 0$  and by using the unscaled dependent variables,  $LN(REV_{i,t})$  and  $LN(INT_{i,t})$ .

#### 4.3 Calculating E-statistics (testing equilibrium)

For the H-statistic to be a valid test it must be calculated on observations that are in long-run equilibrium. This suggests that competitive capital markets will equalise risk-adjusted rates of return across banks such that, in equilibrium, rates of returns should not be significantly

correlated with input prices (Claessens and Laeven, 2004; Lloyd-Williams *et al.*, 1994; Matthews *et al.*, 2007; Molyneux and Forbes, 1995; Shaffer, 1982). Thus, in the context of the theory of competitiveness and contestability set out in equation (4), we specify a model for the determination of whether equilibrium holds. This is obtained by replacing the dependent variable in equation (4) with profit before tax on assets  $(1 + \text{PBT}/\text{TA})$  thus[5]:

$$\begin{aligned} \text{LN}\left(1 + \frac{\text{PBT}_{i,t}}{\text{TA}_{i,t}}\right) = & \gamma_0 + \gamma_1 \text{LN}\left(\frac{\text{PE}_{i,t}}{\text{TE}_{i,t}}\right) + \gamma_2 \text{LN}\left(\frac{\text{IE}_{i,t}}{\text{FF}_{i,t}}\right) + \gamma_3 \text{LN}\left(\frac{\text{CE}_{i,t}}{\text{FA}_{i,t}}\right) + \gamma_4 \frac{\text{TC}_{i,t}}{\text{TA}_{i,t}} \\ & + \gamma_5 \frac{\text{CL}_{i,t}}{\text{CD}_{i,t}} + \gamma_6 \text{LN}(\text{TA}_{i,t}) + \gamma_7 \text{LN}(\text{BR}_{i,t}) \end{aligned} \quad (6)$$

A version of equation (6) without  $\text{LN}(\text{TA}_{i,t})$  is also estimated by setting  $\gamma_6 = 0$ .

The E-statistic that is used for testing whether the market is in equilibrium is defined as follows:

$$E = \gamma_1 + \gamma_2 + \gamma_3 \quad (7)$$

We test whether  $E = 0$  using an F-test. If rejected, the market is not in equilibrium (Claessens and Laeven, 2004), whereas if  $E = 0$ , the market is in equilibrium, and the H-statistic calculated using equations (4) and (5) is valid.

#### 4.4 Models with current and lagged input prices

Simultaneity is a dual direction of causality in a system of equations which violates the assumption that the explanatory variables and equation's error term are uncorrelated. Variables in a regression can violate this assumption for several reasons, including omitted variable bias, measurement error and simultaneity/reverse causation. In our regression, the models including the current values of input prices might suffer from simultaneity (endogeneity) bias between input prices and the dependent variables (revenue and interest income). We assess whether one or more of the input prices ( $\text{LN}(\text{IE}/\text{FF})$ ,  $\text{LN}(\text{PE}/\text{TE})$  and  $\text{LN}(\text{CE}/\text{FA})$ ) suffers from endogeneity, by comparing regressions that include current input prices and regressions that include lagged input prices – see Shaffer (2004) and Goddard and Wilson (2009). To obtain models using lagged input prices, the current price variables are replaced by their values lagged one period in equations (4) and (6). Large differences in the estimated coefficients (and, therefore, H- and E-statistics) using models with current input prices and using models with lagged input prices is taken as an indication of the endogeneity. If endogeneity appears evident inference from models that incorporate lagged input prices is preferred.

#### 4.5 Model estimation

Econometric problems may arise from estimating equation (4) using panel data including the process being dynamic, with current realisations of the dependent variable being influenced by its past values, and that the idiosyncratic disturbances may have individual-specific patterns of heteroscedasticity and serial correlation. To address these issues, a generalised method of moments (GMM) estimator, such as that introduced by Arellano and Bond (1991) and those discussed by Roodman (2009), may be used when lagged dependent



variables are added. The difference and system GMM estimators can be applied using either the one-step or two-step method.

After experimentation to find a valid specification, we report the results from the one-step system GMM estimator with heteroscedasticity and autocorrelation robust coefficient standard errors (results from the other estimators are available upon request).

The pooled OLS and fixed-effects estimators applied to a model that includes a lagged dependent variable and that should allow for cross-sectional fixed-effects have the following properties. The (pooled) OLS estimator that excludes fixed-effects will be inconsistent when  $T$  is small (even when  $N$  is large) and the lagged dependent variable's coefficient will be upwards biased[6]. The fixed-effects estimator will also be inconsistent when  $T$  is small, and there is a downward bias in the lagged dependent variable's coefficient. As the bias on the lagged dependent variable for the pooled OLS and fixed-effects estimators are in the opposite direction, we expect the true coefficient on the lagged dependent variable to fall in between these two estimators' values[7].

When using GMM, Hansen's J-statistic is applied to assess whether the instruments are exogenous whilst allowing for heteroscedastic and autocorrelated disturbances[8]. As this test is biased towards accepting that the instruments are exogenous as the number of instruments increases, we follow Roodman's (2009) recommendation and ensure that the number of instruments is less than the number of cross-sections in the panel to help guard against this potential problem.

#### 4.6 Data

In this paper, annual individual balance sheets and income statements of 48 Vietnamese commercial banks from 1999 to 2009 have been collected from the State Bank of Vietnam, National Library of Vietnam and individual banks. Although the number of banks for which there is data is only half of the total in the Vietnamese banking system, they account for more than 90 per cent of total customer loans, total customer deposits and total assets[9].

### 5. Empirical results

Table III reports the non-structural model estimated for the full sample using the fixed-effects estimator. The results include estimated revenue equations (in the column headed "H-statistics") and profit equations (in the column headed "E-statistics") using all measures of the dependent variable with current or lagged input prices both with and without assets.  $H_0^1$  refers to the F-test of the null hypothesis that cross-sectional fixed-effects are redundant.  $H_0^2$  refers to the F-test of the null hypothesis that both cross-sectional and period fixed-effects are redundant. All of the F-tests reject the exclusion of cross-sectional and period fixed-effects; therefore, the "2-way-FE" model is favoured and reported in the table[10]. We also report  $R^2$ , the adjusted  $R^2$  (Adj  $R^2$ ), the statistic for testing the null hypothesis that  $R^2 = 0$  ( $F$ -statistic) and the number of observations.

In the table, the H-statistic is reported in the row labelled H-sta. The H-statistics are 0.59 [with LN(REV/TA) as the dependent variable] and 0.62 [with LN(INT/TA)] in the models with assets and with current input prices. The rows below the H-statistics show the result of t-tests for the null hypotheses that  $H = 0$  and  $H = 1$ . The H-statistics are significantly different from both zero and one in these models. When the H-statistic is between zero and one (as in this case), it indicates monopolistic competition. In the models without assets and with current input prices, the H-statistics are 0.96 for the equation where LN(REV) is the dependent variable and 0.98 for the specification with LN(INT) as the regressand. They are both significantly different from zero and insignificantly different from one. As  $H \cong 1$ , this

**Table III.**  
Fixed-effects  
estimations for the  
full sample  
(observations = 376)

Variables	With assets and with current input prices		Without assets and with current input prices		E-statistics	
	LN(REV/TA)	LN(INT/TA)	LN(REV)	LN(INT)	LN(1+PBT/TA)	LN(1+PBT/TA)
Intercept	0.733 (1.538)	1.051** (2.207)	10.556*** (21.510)	10.904*** (22.090)	-0.005 (-0.240)	-0.005 (-0.240)
LN(PE/TE)	0.130** (2.253)	0.071 (1.219)	0.413*** (4.102)	0.355*** (3.5035)	0.004 (0.953)	0.004 (0.953)
LN(IE/FF)	0.395*** (11.759)	0.500*** (14.731)	0.480*** (8.117)	0.586*** (9.849)	0.001 (0.261)	0.001 (0.261)
LN(CE/FA)	0.064*** (2.537)	0.045* (1.771392)	0.001 (0.728682)	0.062 (1.398)	0.001 (0.731)	0.001 (0.731)
TC/TA	0.432*** (5.065)	0.432*** (5.005)	0.041*** (6.688)	-0.662*** (-5.054)	0.0459*** (8.533)	0.0459*** (8.533)
CL/CD	-0.01342 (-1.429)	-0.009 (-0.936)	-0.001 (-0.737)	-0.021 (-1.259)	-0.000 (-0.691)	-0.000 (-0.691)
LN(TA)	-0.193*** (-6.275)	-0.193*** (-6.125)	-0.003 (-1.471)	0.749*** (13.286)	0.001 (0.315)	0.001 (0.315)
LN(BR)	0.145*** (3.721)	0.152*** (3.856)	0.003 (1.124)	0.749*** (13.286)	0.001 (0.315)	0.001 (0.315)
R <sup>2</sup>	0.725	0.758	0.497	0.961	0.494	0.494
Adj. R <sup>2</sup>	0.669	0.708	0.394	0.953	0.392	0.392
H <sub>0</sub> <sup>1</sup>	3.961*** Reject	3.430*** Reject	1.680*** Reject	19.286*** Reject	1.629*** Reject	1.629*** Reject
H <sub>0</sub> <sup>2</sup>	3.854*** Reject	3.166*** Reject	1.861*** Reject	17.022*** Reject	1.819*** Reject	1.819*** Reject
H-sta. [E-sta.]	0.589	0.617	[0.007]	0.956	[0.006]	[0.006]
H <sub>c</sub> : H = 0	77.593*** Reject	83.076*** Reject	2.345 Accept	68.154*** Reject	1.552 Accept	1.552 Accept
H <sub>c</sub> : H = 1	37.645*** Reject	31.909*** Reject	4.812***	0.146 Accept	4.836***	4.836***
F-statistic	12.827***	15.238***		122.817***		
<b>With assets and with lagged input prices</b>						
Intercept	0.681 (1.034)	0.683 (0.945)	11.223*** (20.302)	11.485*** (19.670)	-0.034 (-1.504)	-0.034 (-1.504)
LN(PE/TE) <sub>(t-1)</sub>	0.066 (0.913)	-0.004 (-0.047)	0.009 (2.057)	0.218* (1.281)	0.008* (1.862)	0.008* (1.862)
LN(IE/FF) <sub>(t-1)</sub>	0.082* (1.932)	0.136*** (2.934)	-0.003 (-1.183)	0.245*** (3.847)	-0.004 (-1.579)	-0.004 (-1.579)
LN(CE/FA) <sub>(t-1)</sub>	0.012 (0.376)	-0.002 (-0.065)	-0.001 (-0.569)	-0.009 (-0.192)	-0.001 (-0.503)	-0.001 (-0.503)
TC/TA	0.240** (2.242)	0.210* (1.787)	0.033*** (4.882)	-0.893*** (-6.489)	0.0409*** (7.042)	0.0409*** (7.042)
CL/CD	-0.072** (-2.333)	-0.041 (-1.203)	-0.002 (-1.179)	-0.120** (-2.538)	-0.002 (-1.028)	-0.002 (-1.028)
LN(TA)	-0.217*** (-5.304)	-0.198*** (-4.422)	-0.005* (-1.832)	0.624*** (9.922)	0.000 (0.006)	0.000 (0.006)
LN(BR)	0.079 (1.593)	0.065 (1.183)	0.003 (1.053)	0.624*** (9.922)	0.000 (0.006)	0.000 (0.006)
R <sup>2</sup>	0.650	0.635	0.547	0.957	0.541	0.541
Adj. R <sup>2</sup>	0.569	0.550	0.442	0.948	0.437	0.437
H <sub>0</sub> <sup>1</sup>	3.363*** Reject	1.904 Accept	1.736*** Reject	16.318*** Reject	1.684*** Reject	1.684*** Reject
H <sub>0</sub> <sup>2</sup>	4.299*** Reject	85.161*** Reject	2.044*** Reject	14.486*** Reject	1.986*** Reject	1.986*** Reject
H-sta. [E-sta.]	0.160	0.130	[0.007]	0.453	[0.003]	[0.003]
H <sub>c</sub> : H = 0	3.477* Accept	1.904 Accept	0.909 Accept	12.136*** Reject	0.401 Accept	0.401 Accept
H <sub>c</sub> : H = 1	95.566*** Reject	85.161*** Reject	7.545***	17.633*** Reject	100.225***	100.225***
F-statistic	8.055***	7.545***	5.237***	109.849***	5.222***	5.222***

**Notes:** R<sup>2</sup> denotes the coefficient of determination, Adj. R<sup>2</sup> the adjusted coefficient of determination, H<sub>0</sub><sup>1</sup> is an F-test for the significance of cross-sectional fixed-effects, H<sub>0</sub><sup>2</sup> is an F-test for the joint significance of cross-sectional and period fixed-effects and F-sta. tests the null that R<sup>2</sup> is equal to zero. The variables' coefficients and t-statistics (in brackets) are reported in the table; \*\*\*indicates significance at the 1% level, \*\*significance at the 5% level, \*significance at the 10% level

**Source:** For the data is the financial statements of 48 Vietnamese commercial banks

indicates that the Vietnamese banking system is a competitive industry[11]. Comparing the models with and without assets, we notice that excluding total assets from the revenue equations has transformed our inference of the Vietnamese banking market from monopolistic competition to perfect competition. This is consistent with the prediction of [Bikker et al. \(2006a\)](#) and [Goddard and Wilson \(2009\)](#) because the downward bias in  $H$  is removed when assets are excluded.

In the models with assets and with lagged input prices, the  $H$ -statistic is 0.16 when  $\text{LN}(\text{REV}/\text{TA})$  is the dependent variable and 0.13 when  $\text{LN}(\text{INT}/\text{TA})$  is the regressand. The null hypotheses that the  $H$ -statistic is zero or one are both rejected. This indicates that the industry is in monopolistic competition, if close to monopoly. Lastly, the  $H$ -statistics based upon revenue equations excluding assets that include lagged input prices as regressors are 0.45-0.43 (both are significantly different from zero and one, indicating monopolistic competition). Once again the models including assets have notably lower  $H$ -statistics than those excluding assets; this likely reflects the specification bias arising from the inclusion of assets. Further, these  $H$ -statistics are notably smaller than the corresponding equations that use current input prices, being 0.96-0.98. This difference is most likely owing to simultaneity bias[12]. Hence, we favour the results using lagged input prices and without assets for inference and conclude that the Vietnamese banking system is in monopolistic competition.

[Table III](#) also shows the results of the profit equations and their  $E$ -statistics for the full sample (in the column headed “ $E$ -statistics”). The  $E$ -statistic is used to determine whether the long-term equilibrium condition of the market is met. If the  $E$ -statistic is equal to zero the market is in long-term equilibrium, whereas when the  $E$ -statistic is not equal to zero the market is not in long-term equilibrium. If the market is not in equilibrium the value of the  $H$ -statistic (obtained from the corresponding revenue equation) is temporal and the degree of competitiveness is changing through time. In this case, the estimated models are not valid for inference, and it is appropriate to use a dynamic model to determine the equilibrium value of the market. We use the “2-way-FE” specification for inference because both cross-section and period fixed-effects are jointly significant according to the  $H_0^1$  and  $H_0^2$   $F$ -tests. The  $E$ -statistic in the “2-way-FE” models is 0.007 (with assets and with current input prices), 0.006 (without assets and with current input prices), 0.007 (with assets and with lagged input prices) and 0.003 (without assets and with lagged input prices). In all cases, the null hypothesis that the Vietnamese banking system is in equilibrium is not rejected. Hence, all the corresponding  $H$ -statistics are valid. Owing to simultaneity bias in the models using current input prices and the misspecification of the models that include assets ([Bikker et al., 2006a](#); [Goddard and Wilson, 2009](#)), we favour the model without assets and with lagged input prices. Hence, the Vietnamese banking system is in long-run equilibrium ( $E \cong 0.003$ ) and characterised by monopolistic competition ( $H \cong 0.43 - 0.45$ ) during the period 1999 to 2009.

We also note the following findings from the favoured models estimated over the full sample. The unit cost of funds ( $\text{LN}(\text{IE}/\text{FF})$ ) is positive and significant at the one per cent level for both dependent variables. The unit price of labour ( $\text{LN}(\text{PE}/\text{TE})$ ) is positive and significant at the 10 per cent level in the model where revenue is the dependent variable and insignificant when interest income is the regressand. The unit cost of fixed assets ( $\text{LN}(\text{CE}/\text{FA})$ ) is insignificant in the models with both dependent variables. These results suggest that the unit cost of funds has the most significant impact on revenue and interest income of the three input prices. These favoured specifications also indicate that customer loans over customer deposits ( $\text{CL}/\text{CD}$ ), and total capital over total assets ( $\text{TC}/\text{TA}$ ) are negative and significant, while the number of branches ( $\text{LN}(\text{BR})$ ) is positive and significant.

Table IV reports the revenue equations estimated using the one-step system GMM estimator (for models excluding assets and including lagged input prices) over the full sample period. Period fixed effects are included in both models (because  $F$ -tests reject their exclusion for both models) however the statistics relating to these variables are not reported to save space. To investigate misspecifying restrictions, we use the Hansen (Sargan) test, which indicates the null hypothesis that the population moment conditions are correct is not rejected as  $p = 0.110 > 0.05$  [where LN(REV) is dependent variable] and  $p = 0.107 > 0.05$  [where LN(INT) is dependent variable]. The test for first-order serial correlation (probability values are reported in the row labelled AR(1) in Table IV) does not indicate whether the model is misspecified because first-order negative autocorrelation is expected when using panel GMM. Hence, our finding of evident first-order autocorrelation is expected and does not cause us to view either of the models given in Table IV as invalid. We, therefore, follow conventional practice and focus on the test for second-order serial correlation to determine whether the model is valid (Roodman, 2009)[13]. The probability value for the test for second-order serial correlation [AR(2)] is 0.715 in the model where revenue is the dependent variable, and 0.757 in the model where interest income is dependent variable indicating no evident autocorrelation. Hence, both models are considered valid for inference. Further, for both equations, the lagged dependent variable is significant, which indicates that these models estimated by GMM should be preferred to those using the fixed-effects estimators, as reported in Table III.

Variables	LN(REV)	LN(INT)
L1 LN(REV)	0.7498*** (9.705)	
L1 LN(INT)		0.8274*** (8.215)
L1 LN(PE/TE)	-0.0755 (-0.5435)	-0.1709 (-1.201)
L1 LN(IE/FF)	-0.2404*** (-3.077)	-0.3327*** (-3.651)
L1 LN(CE/FA)	-0.005 (-0.146)	-0.0114 (-0.3096)
TC/TA	-0.1286 (-0.6753)	-0.03 (-0.1454)
CL/CD	-0.0338 (-0.7207)	-0.0061 (-0.1262)
LN(TA)		
LN(BR)	0.2069*** (2.89)	0.1441 (1.62)
Constant	2.659*** (3.964)	1.925** (2.182)
Instruments	34	34
Groups	46	46
AR(1)	0.005***	0.009***
AR(2)	0.715*** Valid	0.757*** Valid
Hansen	0.110*** Valid	0.107*** Valid
H <sub>0</sub> period FE	130.87*** [0.0000] Reject	169.11*** [0.0000] Reject
L1 OLS	0.8256	0.8420
L1 period FE	0.7168	0.7642
<i>H</i> -statistic	-1.2825	-2.9842
H = 0	-1.1217 Accept	-1.0133 Accept
H = 1	-2.000*** Reject	-1.3529 Accept
Wald test	12389.79	13839.51
Obs.	327	327

**Table IV.**  
GMM one-step  
system estimator  
(excluding assets and  
including lagged  
input prices) for the  
full sample

**Notes:** Coefficients,  $t$ -statistics (round brackets) and probabilities (square brackets) are reported in the table; \*\*\*significant at the 1% level; \*\*significant at the 5% level

**Sources:** Financial statements of 48 Vietnamese commercial banks from 1999 to 2009. Time dummy variable are included in the estimated models; however, we do not report the coefficients of the variables to save space

Goddard and Wilson (2009, pp. 2285-2286) provided simulation evidence that the difference GMM estimator of Arellano and Bond (1991), in a model with a lagged dependent variable, is better at identifying the H-statistic as compared to the fixed-effects estimator (in a model without a lagged dependent variable) when the true coefficient on the lagged dependent variable is greater than zero, which is the case in our study.

Our estimated H-statistics based on the model estimated by fixed-effects (without assets and including lagged input prices) that imposes  $\delta_7 = 0$  are reported in Table III as 0.453 and 0.430. The H-statistics based on the Blundell and Bond (1998) system GMM estimator that allows  $\delta_7 > 0$  are reported in Table IV as  $-1.283$  and  $-2.984$ . We find that the fixed-effects estimates of the H-statistic are smaller in magnitude than the system GMM estimates, which is consistent with the bias predicted when  $\delta_7 > 0$ . As our system GMM estimates of  $\delta_7$  reported in Table IV are 0.75 and 0.83 and are significantly different from zero and positive, this suggests that we would expect such a bias [this assumes that Goddard and Wilson's (2009) results based on the difference GMM estimator are also valid for the system GMM estimator that we use]. That is, our results are consistent with the predictions of Goddard and Wilson (2009) in this respect.

Goddard and Wilson (2009, p. 2285) also showed, via simulation, that as the true value of  $\delta_7$  approaches unity its difference GMM estimate becomes downward biased causing the H-statistic to be downward biased in absolute value. This, in turn, causes the test for the null hypothesis that the H-statistic is equal to one to be incorrectly sized [14]. Our estimates of  $\delta_7$  by system GMM reported in Table IV are 0.75 and 0.83. If these estimates are regarded as sufficiently close to unity to cause bias, it means that our H-statistics are smaller in absolute value than they should be. Given that our H-statistics are negative, this suggests that they are not as negative as they should be. This can only reinforce our conclusion of a negative H-statistic. It also means that the test statistic for the null hypothesis that the H-statistic is equal to one may not be as negative as it should be, and it may be that our failure to reject this hypothesis for the equation where LN(INT) is the dependent variable is owing to this bias. Hence, to the extent that our results are subject to such bias, they serve to reinforce our inference that the Vietnamese banking system is monopolistic.

The model with the dependent variable LN(REV) is reported in Column 2 of Table IV. The H-statistic is negative ( $-1.28$ ) and is not significantly different from zero; however, it is significantly different from one. This equation suggests that the Vietnamese banking system is monopolistic over the period 1999 and 2009. Regarding the input price coefficients, the logarithm of interest expense per total funds is negative and significant, while personal expense per person and capital expense per fixed asset are insignificant. LN(BR) is positive and significant. All other variables (except the intercept and lagged dependent variable) are insignificant.

The model where the dependent variable is LN(INT) is reported in Column 3 of Table IV. The H-statistic is negative ( $-2.98$ ), which, as is the case when LN(REV) is the dependent variable, also indicates that Vietnamese banking system is monopolistic. However, because the H-statistic is not significantly different from either one or zero, this statistic is not well determined and suggests caution with this interpretation. Nevertheless, as the point estimate of the H-statistic is negative and because the model with LN(REV) is well determined and clearly negative, we believe that the overall conclusion of a monopolistic Vietnamese banking system over the period 1999 to 2009 is convincing.

We recall that the favoured models from Table III (that exclude assets and include lagged input prices) suggest that the Vietnamese banking system is in monopolistic competition. However, these models exclude a statistically significant lagged dependent variable and are, therefore, not valid. When the statistically significant lagged dependent variable is included,

as is done in [Table IV](#), the results suggest that the Vietnamese banking system is monopolistic. Hence, we have demonstrated that not accounting for this significant lagged dependent variable will bias the results and lead to inferring monopolistic competition when the banking system is monopolistic.

## 6. Conclusion

In this paper, the Panzar–Rosse model has been applied to investigate the degree of competition faced by cooperative financial institutions in Vietnam. Our paper makes the following contributions to the literature. Firstly, our results are based upon the largest sample both in terms of the number of banks and total sample size compared to any previous study of non-structural models in the Vietnamese banking system and ours is the first to clearly isolate the market structure for Vietnam from other countries. Secondly, this study also extends the previous literature by considering new additional variables. Environmental factors such as total assets, capital/assets, loans/deposits and the number of branches that are incorporated in our models have not been used in previous studies of Vietnam. Further, we use four different dependent variables to provide comparative inference. Thirdly, this is also the first study that considers the exclusion of assets (to avoid specification bias) and the inclusion of lagged input prices (to avoid endogeneity) in a study of the Vietnamese banking system. Fourthly, we also compare the OLS/fixed-effects estimators with the GMM estimator (where the model includes a lagged dependent variable) for the Vietnamese banking system, and find that choosing the most appropriate (GMM in our case) is important because it substantively changes the conclusions drawn. This represents a further novelty of our paper. The favoured OLS/fixed effect estimators suggest that the Vietnamese banking system is in monopolistic competition. However, incorrectly including assets and/or current input prices can affect the results and, in some cases, lead to the erroneous conclusion that the Vietnamese banking system is perfectly competitive. Furthermore, we found that accounting for a significant lagged dependent variable, as is achieved when using the GMM estimator, indicates that the Vietnamese banking system is monopolistic. Hence, not accounting for significant dynamics also biases inference. Our results illustrate the importance of correctly specifying the model to achieve the most reliable inference because all three market structures (perfect competition, monopolistic competition and monopoly) can be inferred depending upon which model is used. The significant coefficient of the lagged dependent variable confirms the dynamic character of the model specifications for Vietnamese banks. Using the correctly specified model that uses lagged input prices, excludes assets and includes a lagged dependent variable suggests that the whole Vietnamese banking system is characterised by monopoly from 1999 to 2009.

Our results for Vietnam are different from those for the EU countries found in previous works. Our results show that the Vietnamese banking system is monopolistic while other studies found that European banking sectors operate under conditions of monopolistic competition ([Molyneux et al., 1994](#); [Bikker and Groeneveld, 2000](#); [Bikker et al., 2006a, 2006b](#); [Bikker and Spierdijk, 2009](#)). In Vietnam, three out of five state owned commercial banks accounted for 45 per cent of customer deposits, 41 per cent of total assets and 51 per cent of customer loans of the banking system in 2009 ([Nguyen and Stewart, 2013](#)). From 1999 to 2009, five state owned commercial banks still dominated the whole banking system although non-state owned commercial banks exhibited greater overall technical efficiency than state owned commercial banks ([Stewart et al., 2016](#)).

A number of policy implications arise out of this paper. We argue that the monetary policy tightening that began in 2008 had a large impact on the banking system in terms of compulsory reserves, loans and deposits. Generally, the banking system encounters many

difficulties, resulting from the loss of balance in the source and use of funds, and the rapid increase in credit growth (Nguyen and Stewart, 2013). Hence, macroeconomic policies from the State Bank of Vietnam should be used to simultaneously meet the high demand of loans from the public and to control rising inflation brought about by a rapid increase in credit growth. We also find that banks that open more branches increase their revenue. Thus, the State Bank of Vietnam should consider introducing policies to enhance the development of commercial banks to raise competition and revenue in the banking system.

## Notes

1. The few previous studies that have sought to determine Vietnam's market structure have done so in an earlier period when less of the transition had taken place, and have assumed homogeneity of the Vietnamese banking system's market structure with the other countries analysed.
2. Foreign commercial banks normally transformed out of branches of foreign banks. Data on assets, loans and deposits of branches of foreign banks are very small compared to other banks. Therefore, in our application, non-state owned commercial banks consist of joint stock commercial banks, joint venture commercial banks and one foreign commercial bank.
3. The total number of observations for Vietnam, which they use, is only 135, whereas our maximum sample size is 376 observations.
4. In this study, we estimate models that both include and exclude assets for comparison purposes.
5. Because profit before tax can take on small (negative) values, we compute the dependent variable as  $(1 + \text{PBT}/\text{TA})$ .
6. The GMM estimators assume small  $T$  and large  $N$  in the panel. Hence, the GMM estimators are consistent as  $N$  tends to infinity and not as  $T$  tends to infinity. When  $T$  is large, dynamic models using the pooled OLS or fixed-effects estimators are consistent meaning that there is little benefit from using GMM (which can become unreliable when  $T$  is large due to the overfitting of endogenous variables).
7. In our application,  $T$  is small and we expect both the OLS and fixed-effects estimators to be biased.
8. In the application of GMM, the Sargan test has a null hypothesis of "the instruments as a group are exogenous". Therefore, the higher the  $p$ -value of the Sargan statistic, the better is the result. In robust estimation, Stata reports the Hansen statistic instead of the Sargan test, and both tests have the same null hypothesis. The Arellano–Bond test for autocorrelation has a null hypothesis of no autocorrelation and is applied to the differenced residuals. The test for AR(2) in first differences is important because it will detect autocorrelation in levels. These models are valid when these tests'  $p$ -values are higher than 0.05 (Roodman, 2009).
9. Of the 48 banks, 5 are state-owned commercial banks, 5 are joint stock commercial banks, 1 is a foreign commercial bank and the remaining 37 are joint stock commercial banks. Several banks established in 2008 and 2009 are included in the data. The number of records ranged from a low of 17 banks in 1999 to a high of 46 in 2009. Banks also have differing frequencies of years in the data – see Table I. There are 16 banks with data for all years; 12 banks with 4-8 years of data; 14 banks with 5-7 years of data and five banks with 2-4 years of data (of which 3 banks were established in 2008 and 1 was founded in 2006). Only one bank (which was transformed from a branch of a foreign bank to a foreign commercial bank in 2008) has one year of data.
10. "2-way-FE" incorporates both cross-sectional and period fixed-effects.
11. An increase in costs causes some banks to exit, prices to increase and the revenue of the survivors to rise at the same rate as the increase in costs.

12. Unreported results (that are available from the authors upon request) using the Wu–Hausman test broadly confirm that current input prices are unlikely to be weakly exogenous.
13. “To test for autocorrelation aside from the fixed effects, the Arellano–Bond test is applied to the residuals in differences. Because  $\Delta vit$  [the difference of the current period error term] is mathematically related to  $\Delta vi, t-1$  via the shared  $vi, t-1$  term, negative first-order serial correlation is expected in differences and evidence of it is uninformative. Thus, to check for first-order serial correlation in levels, we look for second-order correlation in differences, on the idea that this will detect correlation between the  $vi, t-1$  in  $\Delta vit$  and the  $vi, t-2$  in  $\Delta vi, t-2$ . In general, we check for serial correlation of order  $l$  in levels by looking for correlation of order  $l + 1$  in differences” (Roodman, 2009, p. 119); our comments are given in squared parentheses.
14. Goddard and Wilson (2009, p. 2285) suggested that the test for the null of the H-statistic being equal to unity will be oversized (suggesting that the null hypothesis will be rejected too often) when the true value of  $\delta_7$  is close to one. This is because they only consider the situation when the sum of the input price coefficients,  $\delta_1 + \delta_2 + \delta_3$ , is positive. However, when this sum is negative, as is the case in our estimates, the test will not reject the null as often as it should (because the H-statistic will not be as negative as it should be).
15. Besides these commercial banks, there are the Social Policy Bank and Vietnam Development Bank, which operate as non-profit institutions.
16. We could not collect data of the North Asia Commercial Bank and Vinasiam Bank in 2009.

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