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Abstract

Vietnam has experienced a dramatic growth in its fisheries sector over the last two decades. One key factor underlying the impressive achievements of this sector is the rapid growth of the processing firms, which include both state-owned and privately-owned firms. In order to measure their technical and allocative efficiency, we estimate a shadow cost system using a Bayesian Markov Chain Monte Carlo procedure. We find that firms have not fully exploited economies of scale. They are likely to over-utilize labor relative to capital, but those located in the Mekong delta generally perform better than those located in other regions. Small firms tend to have higher allocative efficiency than larger ones. Interestingly, based on this measure, while in other regions state-owned enterprises do worse than private enterprises, the pattern seems to be reversed in the Mekong delta. In addition, large fluctuations in efficiency change and productivity change across several firms may indicate the vulnerability of weaker firms to competition from international trade.

JEL codes: C1, C3, L0, O3

Keywords: Allocative Inefficiency, Gibbs Sampling, Productivity Change, Technical Change, Technical Inefficiency

1 Introduction

Since the early 1990s, the fisheries[1] sector has been one of the most dynamic and fastest growing sectors in Vietnam. In 1990-2007, total production increased 4.6 times from 941 thousand tons to over 4.3 million tons. Although the sector contributes roughly 4 percent of GDP, its value added in fish processing, distribution, and marketing is significant. The sector has quickly surpassed other traditional Vietnamese agricultural products such as rice and rubber in terms of export values. Its foreign exchange earnings are now the third largest, after the crude oil and garment industries. According to Vietnam's Ministry of Fisheries (MOFI, 2005), the sector supplies about 40 percent of animal protein in the national human diet and has generated approximately four million jobs.

The rapid expansion of the fisheries sector over the past few decades, however, has led to a high risk of environmental pollution and overfishing, causing hardship for many coastal and downriver communities. In addition, stringent requirements of export markets have raised growing concerns about traceability and quality control of inputs, processing, and relevant services. These issues, among others, will probably hinder the sector's long-term sustainable development.

Despite the important role of the fisheries sector in the Vietnamese economy, there are few studies on this sector. Pomeroy et al. (2008) critically review changes in government policy towards small-scaled fisheries in Vietnam, of which the subsidized-interest scheme to expand the off-shore fleet, according to Nguyen and Symington (2008), is claimed to have contributed to greater fishing of in-shore waters and a greater reduction of in-shore resources. Lem et al. (2004) evaluate measures to improve domestic marketing arrangements to satisfy the increasing local consumption of fish stimulated by strong economic growth. Following the anti-dumping case brought against the Vietnamese catfish industry by the Catfish Farmers of America (CFA), Nguyen (2003) examines intensively the low production cost of catfish in the Mekong delta. But there are no studies so far on the production efficiency of fisheries

[1]In this paper, fisheries include capture/fishing and aquaculture.

processing firms in Vietnam.

This paper investigates whether these firms have attained allocative and technical efficiency. To that end, a shadow cost system is estimated with the data from the 2003 and 2005 Enterprise Censuses surveyed by Vietnam's General Statistics Office (GSO). Since the data are limited, we employ a Bayesian Markov Chain Monte Carlo (MCMC) parametric approach developed by Atkinson and Dorfman (2005). We find that firms have not fully exploited economies of scale. Nearly all of the firms over-utilize labor relative to capital, but those located in the Mekong delta generally perform better than those located in other regions. Small firms, having less than 300 employees, tend to have higher allocative efficiency than larger ones. Interestingly, while in other regions state-owned enterprises (SOEs) do worse than private enterprises in this measure, the pattern seems to be reversed in the Mekong delta. In addition, large fluctuations in efficiency change and productivity change across several firms may indicate the vulnerability of weaker firms to competition from international trade.

The paper is structured as follows. In section 2, we give a brief overview of Vietnam's fisheries sector's performance in recent years. Section 3 reviews the shadow cost system. In section 4, we present the econometric model. Section 5 discusses the empirical results. Conclusions follow in section 6.

2 Vietnam's Fisheries Sector

Fishing and aquaculture are ancient traditions in Vietnam. But it was not until the late 1980s, when the comprehensive economic reform was introduced, that the fisheries sector started growing remarkably. Vietnam has outperformed other neighboring countries in terms of production. Its annual growth rate from 1990 to 2007 is on average 9.37 percent, higher than that of Bangladesh, Thailand, and Myanmar. (The exception is Cambodia, which had a rather low base). Figure 1 shows that, while in 1990 Vietnam, Bangladesh, and Myanmar had approximately the same output levels, in 2007 Vietnam left Bangladesh and Myanmar far behind and even overtook Thailand, whose aquatic production was three times greater than that of Vietnam in 1990.

Export earnings from shrimp, fish and other seafood products increased by 7.26 times between 1995 and 2008, reaching $4.5 billion and making this sector the third most prominent after the crude oil and garment industries. In the same period, the export volume of rice, which once symbolized Vietnam's success in its early stages of reform, rose by only 2.4 times. Aquatic products are now exported to over 100 countries and territories. The major markets are the U.S., Japan, China, Korea, Taiwan, and the EU.

The outstanding performance of the fisheries sector is attributed to the abundance of aquatic resources. Vietnam has a coastline of about 3,600 km, with many bays and estuaries, mangrove forests[2] of more than 1,500 km^2, and an exclusive economic zone[3] of over one million km^2 (MOFI, 2005). In addition, the inland area is netted with a dense river network, including 2,360 rivers of more than 10 km in length. It is estimated that the total water surface potentially available for freshwater capture or aquaculture is 17,000 km^2. The great diversity of resources generates considerable opportunities for the development of not only the fisheries sector, but other industries such as tourism and transportation.

Since the majority of fishing vessels are equipped with engines of less than 90 horsepower (hp), capture activities are mostly small-scaled and concentrated in coastal waters. The increase in human population has resulted in heavy pressure on in-shore resources. According to MOFI (2005), catch per unit of effort decreased from 0.7 tons/hp/year in 1993 to 0.4 tons/hp/year in 2003, implying a rapid decline in productivity. In response, the government has strongly promoted off-shore capture since 1997 through a subsidized-interest scheme that has financed construction of 1,300 off-shore vessels[4]. However, due to the lack of off-

[2] Mangroves are crucial to the sustainability of Vietnam's fisheries since they provide habitat for coastal and marine fish and crustacea.

[3] An exclusive economic zone is the sea zone within which a coastal state has sovereign rights for exploration and exploitation of marine resources. This area extends seaward 200 nautical miles from the coast.

[4] Vessels are classified as off-shore if their engines are over 90 hp.

shore technology, the inexperience by skippers and crew, meager supporting services, and inappropriate specifications of vessels, the subsidized vessels have suffered a high failure rate. In 2003, roughly 90% of them could not meet their repayment schedules, although the interest rate was reduced from 7% to 5.4% (MOFI and World Bank, 2005). Moreover, some of these large vessels fish in-shore, causing faster depletion of coastal resources. As a result, the capture-production in Vietnam increased by only 2.7 times in 1990-2007 (see Figure 2).

The driving force underlying the impressive achievements of the fisheries sector is aquaculture. Its output has grown on average at 16.6% annually since 1990, from 162,076 tons to 2,194,500 tons, contributing more than 50% by weight to total fishery production (FAO). Dramatic expansion over the last two decades is the result of a sharp increase in aquaculture exports. Aquaculture farmers have adapted shrimp and catfish species suitable for export. Cultural practices have been diversified, including mono- and poly-aquaculture in fresh, brackish, and marine waters as well as integrated aquaculture with paddy rice production.

The total aquaculture area has enlarged significantly to 1,019 thousand hectares (ha)[5] by 2007, averaging 7% annual growth since 1995. Figures 3 and 4 indicate that aquaculture is expanding in all regions, but the Mekong delta dominates in terms of both area and production, representing 71% and 72%, respectively, of Vietnamese totals. With capture taken into account, the Mekong delta is the largest contributor, with two-thirds of Vietnam's fisheries production (GSO, 2009).

Another key factor that has helped boost the fisheries sector is the development of processing firms. This sub-sector has expanded rapidly, particularly with the construction of large modern facilities. In 2003, Vietnam had about 400 registered processing plants with approximately 0.8 million tons of input capacity (Ruckes and Nguyen, 2004). Around half of them were located in the Mekong delta. Seventy four percent of processors had Hazard Analysis at Critical Control Points (HACCP) certification and 100 enterprises were certified for the EU market. By 2006, the number of plants having EU certification increased to

[5] A hectare is equal to 10,000 m^2, and equivalent to 2.471 acres.

209. In addition, 300 plants were eligible to export their products to the U.S. (Ta, 2006). According to the MOFI and World Bank (2005), processors employ an average of nearly 300 people, of whom 80-85% are female. These jobs are valuable to poor communities (e.g., the Khmer community in Soc Trang province). Often workers are exposed to several potential long-term health risks, although improvements are being made.

Apart from these companies, there are many thousands of small enterprises processing fish products for domestic markets, with a total input capacity of roughly 330,000 tons/year (MOFI, 2004). Their outputs include dried products, fishmeal, fish sauce, as well as frozen and chilled products. Dried products such as dried fish, shrimp, squid, and seaweed are popular with small businesses since the production method is simple and does not require complicated facilities and technology.

Capture and aquaculture generally provide a wide diversity of livelihood activities and have helped to reduce poverty among rural households. However, there are many concerns over sustainable development. Although Vietnam has upgraded its internal sanitary legislation in line with international standards, food safety is still a big challenge. In major export markets such as the U.S., the EU, and Japan, there is an increasing trend towards traceability and application of HACCP at the farm level in order to lower risks of contamination. This demands knowledge, skills, and investment in infrastructure that poorer households are likely to find very difficult to meet, since they usually do not have business connections or property that can be used as collateral to allow them easier access to formal credit. In addition, there are insufficient fishery supporting services, such as high quality seed, feed and fingerlings supply, disease control, environmental management, wide-spread extension of better fishing and farming practices, quality control systems, and market information.

3 Shadow Cost System

In this paper, we use a shadow cost system based on duality theory in which systems of input demand equations can be derived by simple differentiation and estimated with flexible functional forms. Firms are assumed to choose input quantities to minimize the total shadow costs of the chosen levels of output.

The theory below follows Atkinson and Primont (2002). Let $\mathbf{x} = (x_1, ..., x_N)' \in R_+^N$ denote an $(N \times 1)$ vector of N nonnegative inputs and let $\mathbf{y} = (y_1, ..., y_M)' \in R_+^M$ denote an $(M \times 1)$ vector of M nonnegative outputs. The input requirement set is given by

$$L(\mathbf{y}) = \{\mathbf{x} : \mathbf{x} \, \text{can produce} \, \mathbf{y}\}. \tag{1}$$

Under the assumption of shadow cost minimization, the shadow cost function is

$$C(\mathbf{y}, \mathbf{p}^*) = \min_{\mathbf{x}}\{\mathbf{p}^*\mathbf{x} : \mathbf{x} \in L(\mathbf{y})\}, \tag{2}$$

where $\mathbf{p}^* = (p_1^*, ..., p_N^*) = (k_1 p_1, ..., k_N p_N) \in R_+^N$ is a $(1 \times N)$ vector of N shadow input prices. $\mathbf{p}^*$ is the price that makes the optimal input vector, $\mathbf{h}(\mathbf{y}, \mathbf{p}^*)$, equal to the actual input vector, $\mathbf{x}$. The k_n parameters, $n = 1, ..., N$, measure the divergence of actual prices from shadow prices.

Applying Shephard's lemma, we obtain

$$\frac{\partial C(\mathbf{y}, \mathbf{p}^*)}{\partial p_n} = h_n(\mathbf{y}, \mathbf{p}^*), \qquad n = 1, ..., N, \tag{3}$$

where $\frac{\partial C(\mathbf{y}, \mathbf{p}^*)}{\partial p_n}$ is the partial derivative of $C(\mathbf{y}, \mathbf{p})$ with respect to p_n, evaluated at $\mathbf{p}^*$.

Let S_n denote the shadow cost share of input n

$$S_n \equiv \frac{p_n^* x_n}{C(\mathbf{y}, \mathbf{p}^*)}, \qquad n = 1, ..., N. \tag{4}$$

Rearranging (4), we have

$$x_n = S_n C(\mathbf{y}, \mathbf{p}^*)(p_n^*)^{-1}, \qquad n = 1, ..., N. \tag{5}$$

The firm's total actual cost is

$$C^A = \sum_{n=1}^{N} p_n x_n. \tag{6}$$

Substituting (5) into (6), the total actual cost function becomes

$$C^A = C(\mathbf{y}, \mathbf{p}^*) \sum_{n=1}^{N} (k_n)^{-1} S_n. \tag{7}$$

Taking logarithms, we get

$$\ln C^A = \ln C(\mathbf{y}, \mathbf{p}^*) + \ln \left[\sum_{n=1}^{N} (k_n)^{-1} S_n \right]. \tag{8}$$

Given a flexible functional form approximation to the unobserved shadow cost function $C(\mathbf{y}, \mathbf{p}^*)$, we can estimate allocative and technical inefficiency by joint estimation of equation (8) and the N - 1 actual cost share equations (which are derived later) with error terms appended to each equation. Let us now move to econometric estimation of this stochastic shadow cost system.

4 Econometric Estimation

a. A Stochastic Translog Shadow Cost System

Again, following Atkinson and Primont (2002), we use the translog cost function to approximate the unobserved shadow cost function. Let f denote an individual firm, $f =$

$1, ..., F$, and t a time trend, $t = 1, ..., T$. The stochastic translog shadow cost function is

$$
\begin{aligned}
\ln\left[C(\mathbf{y}_{ft}, \mathbf{p^*}_{ft}, t)h(\epsilon_{ft})\right] &= \ln C(\mathbf{y}_{ft}, \mathbf{p^*}_{ft}, t) + \ln h(\epsilon_{ft}) \\
&= \gamma_{0f} d_f + \sum_m \gamma_m \ln y_{mft} + \frac{1}{2}\sum_m\sum_w \gamma_{mw} \ln y_{mft} \ln y_{wft} \\
&\quad + \sum_m\sum_n \gamma_{mn} \ln y_{mft} \ln p^*_{nft} + \sum_n \gamma_n \ln p^*_{nft} \\
&\quad + \frac{1}{2}\sum_n\sum_l \gamma_{nl} \ln p^*_{nft} \ln p^*_{lft} + \sum_m \gamma_{mt} \ln y_{mft} t \\
&\quad + \gamma_{t1} t + \ln h(\epsilon_{ft}), \qquad (9)
\end{aligned}
$$

where d_f is a dummy variable for firm f and

$$h(\epsilon_{ft}) = \exp(v_{ft} + u_{ft}). \qquad (10)$$

The composite error $\ln h(\epsilon_{ft})$ is an additive error with a one-sided component, $u_{ft} \geq 0$, and a statistical noise, v_{ft}, assumed to be iid with zero mean.

The fixed effects approach is used here to relax strong distributional assumptions on both v_{ft} and u_{ft}, and the unlikely assumption of no correlation between u_{ft} and the explanatory variables that are required in the random effects approach. The γ_{0f}'s, $f = 1, ..., F$, represent time-invariant, firm-specific differences in technology. In addition, we include continuous time interacted with the logs of output quantities and a first-order term in time to account for the effect of time.

Logarithmic differentiation of the equation (9) yields parametric expressions for the shadow cost shares (4),

$$
\begin{aligned}
\frac{\partial \ln C(\mathbf{y}_{ft}, \mathbf{p^*}_{ft}, t)}{\partial \ln p^*_{nft}} &= \frac{\partial C(\mathbf{y}_{ft}, \mathbf{p^*}_{ft}, t)}{\partial p^*_{nft}} \frac{p^*_{nft}}{C(\mathbf{y}_{ft}, \mathbf{p^*}_{ft}, t)} = \frac{x_{nft} p^*_{nft}}{C(\mathbf{y}_{ft}, \mathbf{p^*}_{ft}, t)} = S_{nft} \\
&= \gamma_n + \sum_l \gamma_{nl} \ln p^*_{lft} + \sum_m \gamma_{mn} \ln y_{mft}. \qquad (11)
\end{aligned}
$$

Substituting the stochastic translog shadow cost function and the shadow cost shares into

(8), we obtain the stochastic actual cost function

$$
\begin{aligned}
\ln C^A_{ft} \;=\;& \gamma_{0f} d_f + \sum_m \gamma_m \ln y_{mft} + \frac{1}{2}\sum_m\sum_w \gamma_{mw} \ln y_{mft} \ln y_{wft} \\
& + \sum_m\sum_n \gamma_{mn} \ln y_{mft} \ln p^*_{nft} + \sum_n \gamma_n \ln p^*_{nft} \\
& + \frac{1}{2}\sum_n\sum_l \gamma_{nl} \ln p^*_{nft} \ln p^*_{lft} + \sum_m \gamma_{mt} \ln y_{mft} t + \gamma_{t1} t \\
& + \ln\left[\sum_{n=1}^{N} (k_{nft})^{-1}\left(\gamma_n + \sum_l \gamma_{nl} \ln p^*_{lft} + \sum_m \gamma_{mn} \ln y_{mft}\right)\right] \\
& + v_{ft} + u_{ft}. \qquad (12)
\end{aligned}
$$

The actual cost share of input n is

$$S^A_{nft} = \frac{p_{nft} x_{nft}}{C^A_{ft}}. \qquad (13)$$

Substituting (5) and (7) into (13) yields

$$S^A_{nft} = \frac{(k_{nft})^{-1} S_{nft}}{\sum_{n=1}^{N} (k_{nft})^{-1} S_{nft}}. \qquad (14)$$

Substituting for S_{nft} from equation (11), we obtain

$$S^A_{nft} = \frac{(k_{nft})^{-1}(\gamma_n + \sum_l \gamma_{nl} \ln p^*_{lft} + \sum_m \gamma_{mn} \ln y_{mft})}{\sum_{n=1}^{N} (k_{nft})^{-1}(\gamma_n + \sum_l \gamma_{nl} \ln p^*_{lft} + \sum_m \gamma_{mn} \ln y_{mft})}. \qquad (15)$$

We need to impose some restrictions before estimating the model. Symmetry requires that

$$
\begin{aligned}
\gamma_{mw} &= \gamma_{wm}, \quad \forall m, w, m \neq w, \\
\gamma_{nl} &= \gamma_{ln}, \quad \forall n, l, n \neq l. \qquad (16)
\end{aligned}
$$

Since $C(\mathbf{y}, \mathbf{p}^*, t)$ is homogeneous of degree one in $\mathbf{p}^*$, the parameters in (9) have the following relationships:

$$\begin{aligned}\sum_n \gamma_n &= 1,\\ \sum_n \gamma_{nl} &= \sum_l \gamma_{nl} = \sum_n \sum_l \gamma_{nl} = 0,\\ \sum_n \gamma_{mn} &= 0, \quad \forall m.\end{aligned} \tag{17}$$

The set of equations to be estimated is the actual cost function (12) and the N - 1 actual cost share equations (15), since one share equation must be dropped due to the linear dependence of the error terms. We cannot estimate the absolute values of the k_{nft}'s because the actual cost equation and the actual cost share equations are homogenous of degree zero in the k_{nft}'s. Therefore, for one input n, we must restrict a k_{nft} to some constant $\forall t$. Here, we restrict k_{nft} for input N[6]. For the remaining inputs, we specify

$$k_{nft} = \exp(\kappa_{nf} + \kappa_n t), \quad n = 1, ..., N-1, \tag{18}$$

which allows for firm-specific, time-invariant parameters κ_{nf} and industry-wide time-varying parameters κ_n that are shared across firms.

Due to limited data (which will be discussed in the next section), we are not able to include the second-order terms in time in (18) and (12). Moreover, we employ the Bayesian Markov Chain Monte Carlo approach developed by Atkinson and Dorfman (2009) to obtain posterior densities for estimates of allocative inefficiency. We treat the covariance of the errors and the unknown parameters of the shadow cost system as random variables. The parameters are assumed to have a multivariate normal distribution.

In each draw, we first obtain the covariance matrix of the model's stochastic errors (Ω) in the form of the standard inverted Wishart conditional on parameter starting values. Then, we get posterior estimates of three groups of parameters (the firm dummies, the k_{nft}'s, and the

[6]The choice of the numeraire input does not affect the results.

other parameters) separately. In each step, we (i) estimate the shadow cost system, holding previously estimated parameters constant, (ii) combine estimated parameters with priors (zero mean, covariance matrix H_0[7]) to obtain posterior means and variances using Bayes' theorem, (iii) draw from a multivariate normal distribution with these posterior means and variances, (iv) impose monotonicity for at least 85% of all observations[8], and (v) proceed to next step conditional on all previous draws. After three steps are done to gain posterior estimates of the three groups of parameters, we regress the shadow cost system, holding Ω constant, to get new estimates of the error terms for the next draw. A total of 28,000 Gibbs draws are generated from two separate models. Each model contains 14,000 draws of which the first 4,000 are discarded to remove dependence on initial starting values.

b. Measuring Economies of Scale

According to Hanoch (1975), scale economies should be measured by the relationship between total cost and output along the expansion path. Scale economies (SE) equal one minus the elasticity of total cost with respect to output

$$\begin{aligned} SE_{ft} &= 1 - \frac{\partial \ln C^A_{ft}}{\partial \ln y_{mft}} \\ &= 1 - \gamma_m - \sum_w \gamma_{mw} \ln y_{wft} - \sum_n \gamma_{mn} \ln p^*_{nft} - \gamma_{mt} t \\ &\quad - \frac{\sum_{n=1}^N (k_{nft})^{-1} \gamma_{mn}}{\sum_{n=1}^N (k_{nft})^{-1} \left(\gamma_n + \sum_l \gamma_{nl} \ln p^*_{lft} + \sum_m \gamma_{mn} \ln y_{mft} \right)}. \end{aligned} \tag{19}$$

Positive scale economies receive positive numbers and scale diseconomies negative numbers.

c. Measuring Allocative Inefficiency

The N - 1 relative values of k_{nft} estimated above indicate relative price inefficiencies. Relative price efficiency is achieved at time t if marginal rates of technical substitution equal the corresponding ratios of market input prices or $k_{nft} = 1$, $n = 1, ..., N-1$. We then compute ratios of fitted demands using the estimated values of k_{nft} to efficient demands

[7] H_0 is a diagonal matrix with diagonal elements set to 100 for the firm dummies, 0.01 for the allocative parameters, and 100 for the other parameters.

[8] The costs are monotonically increasing in input prices and outputs.

with k_{nft} set equal to 1, $n = 1, ..., N-1$. These ratios imply relative inefficiencies for input usage.

d. Measuring Technical Inefficiency and Productivity Change

To compute technical efficiency (TE), efficiency change (EC), technical change (TC), and productivity change (PC), we follow Atkinson, Cornwell, and Honerkamp (2003). For a given level of outputs, the technically efficient firm is the one that employs the fewest inputs. We measure EC as the rate of catching up to the frontier from period to period and TC as the movement outward of the frontier over time. Then PC is the sum of EC and TC.

We first calculate the residuals from (12) as $\hat{v}_{ft} + \hat{u}_{ft}$. Since u_{ft} needs to be non-negative, we transform $\hat{u}_{ft}$ by subtracting $\hat{u}_t = min_f(\hat{u}_{ft})$, which is the estimated frontier intercept and obtain $\hat{u}^F_{ft} = \hat{u}_{ft} - \hat{u}_t \geq 0$. Adding and subtracting $\hat{u}_t$ from the estimated (9) yields

$$\begin{aligned}\ln[\hat{C}(\mathbf{y}_{ft}, \mathbf{p^*}_{ft}, t)h(\hat{\epsilon}_{ft})] &= \ln\hat{C}(\mathbf{y}_{ft}, \mathbf{p^*}_{ft}, t) + \hat{v}_{ft} + \hat{u}_{ft} + \hat{u}_t - \hat{u}_t \\ &= \ln\hat{C}(\mathbf{y}_{ft}, \mathbf{p^*}_{ft}, t) + \hat{u}_t + \hat{v}_{ft} + \hat{u}^F_{ft} \\ &= \ln\hat{C}^F(\mathbf{y}_{ft}, \mathbf{p^*}_{ft}, t) + \hat{v}_{ft} + \hat{u}^F_{ft}, \end{aligned} \tag{20}$$

where $\ln\hat{C}^F(\mathbf{y}_{ft}, \mathbf{p^*}_{ft}, t) = \ln\hat{C}(\mathbf{y}_{ft}, \mathbf{p^*}_{ft}, t) + \hat{u}_t$ is the fitted frontier shadow cost function. Firm f's level of TE in period t is defined as

$$TE_{ft} = \exp(-\hat{u}^F_{ft}). \tag{21}$$

TE should lie between 0 and 1 due to the normalization of $\hat{u}^F_{ft}$. EC_{ft} is the change in TE_{ft} from t to $t+1$

$$EC_{ft} = TE_{f,t+1} - TE_{f,t}. \tag{22}$$

TC_{ft} is estimated as the difference between $\ln\hat{C}^F(\mathbf{y}, \mathbf{p}^*, t+1)$ and $\ln\hat{C}^F(\mathbf{y}, \mathbf{p}^*, t)$, holding input and output quantities constant,

$$
\begin{aligned}
TC_{ft} &= \ln \hat{C}(\mathbf{y}, \mathbf{p}^*, t+1) + \hat{u}_{t+1} - \ln \hat{C}(\mathbf{y}, \mathbf{p}^*, t) - \hat{u}_t \\
&= \sum_m \hat{\gamma}_{mt} \ln y_{mft} + \hat{\gamma}_{t1} + \hat{u}_{t+1} - \hat{u}_t.
\end{aligned} \tag{23}
$$

Given EC_{ft} and TC_{ft}, we obtain PC_{ft}:

$$PC_{ft} = TC_{ft} + EC_{ft}. \tag{24}$$

5 Data and Empirical Results

The data used in this paper are from the Enterprise Censuses surveyed by Vietnam's General Statistics Office. These surveys have been conducted annually since 2000. They are designed to collect systematically information on quantities of factors of production and the performance of firms that came into operation by January 1^{st} of that year and were still in business. The survey data can be used to evaluate competitiveness in all industries and sectors of the Vietnamese economy.

Those enterprises under survey are either state-owned, 'equitized'[9], domestically private, joint ventures, or 100% foreign-owned and are doing business in farming, aquaculture, mining, processing, electricity, gas and water, construction, trading, manufacturing, hospitality, transportation, finance, health, education, among others. The questionnaires cover revenue, taxes, number of employees and their income, assets, liabilities and equity, investments, on-the-job training, and input costs including fuel, raw materials, services and utilities, etc. The GSO follows a stratified random cluster sampling procedure so that the sample's results are statistically representative of industries and sectors at the national and regional levels.

A cost section is included in questionnaires only in odd-numbered years. Data with costs

[9]SOEs in Vietnam have undergone a reform in which their equity shares continue to be kept by the State or are sold fully or partly to the private sector. 'Equitized' firms are those owned partly by the State and partly by the private sector.

information included are available for 2001, 2003, and 2005[10]. But a very large percentage of firms did not fully report their costs, especially for 2001 and 2003. Those firms whose data are missing are more likely to be smaller and private. Therefore, inferences should be made with caution. The data situation is better for 2005, though far from perfect. For this year, there are 685 enterprises in the fisheries processing sector, but only 223 firms report revenue and cost data. We have to drop 41 firms, among which 1 firm has negative revenue, 13 have negative equities, 1 has negative liabilities, 2 have zero total costs, 8 have non-positive capital, 10 have negative values added, 3 have extraordinarily high wages, 2 have negative corporate tax rates, and 1 has an interest rate greater than 100%. That leaves 182 firms. Merging them with the 102 firms from 2003 produces a balanced panel with only 47 firms. We employ this panel that has 94 observations.

In this study, the fisheries processing firms' output or value added is a function of two inputs: capital (K) and labor (L). The price of labor, p_l, is the wage rate, defined as the sum of salaries, wages and other benefits, divided by the average number of employees. The price of capital, p_k, is calculated by the Christensen-Jorgenson (1969) rental price index defined as

$$p_k = (r + \delta)\frac{1 - bds}{1 - bs}, \tag{25}$$

where

$r =$ interest rate,

$\delta =$ rate of depreciation,

$b =$ corporate income tax rate,

$d =$ present value of depreciation allowances, and

$s =$ ratio of equity to total capitalization.

Straight-line depreciation is assumed. Because enterprises are likely to depreciate their as-

[10]The survey questionnaire in 2007 does not include a cost section as expected.

sets as fast as possible to reduce their tax burden, Vietnam's Ministry of Finance issued decree No. 206, which states that the minimum number of years for assets in the food processing industries to be completely depreciated is 7 years. The present value of depreciation allowances is

$$d = \frac{1}{7r}\left[1 - \left(\frac{1}{1+r}\right)^7\right].$$

Since the number of time periods T is just two (i.e., years 2003 and 2005), it is not possible to include the second-order terms in time in (12) and (18) and to estimate separate values of k_{nft} for individual firms. One possibility for identifying the k_{nft}'s is to divide the sample into groups of firms. The 47 firms are grouped in two ways: (a) 4 groups based on location (in vs. out of the Mekong delta) and firm size (small vs. large), and (b) 6 groups based on location and firm ownership (state-owned, equitized vs. private). The shadow cost system is thus run twice accordingly.

The shadow cost system is comprised of the total actual cost function (12) and one actual cost share equation (15) and estimated with the restrictions (16) and (17) imposed. Because we cannot estimate two absolute values k_{lft} and k_{kft}, we normalize $k_{kft} = 1$, for $t = 1, 2$, and $f = 1, ..., 47$. The condition for relative price efficiency then becomes $k_{lft} = 1$. Table 1 presents posterior medians for estimates of 4 groups' k_{lft}'s in 2003 and 2005. All of them are less than 1, meaning that the ratio of the shadow price of labor to that of capital is lower than the corresponding ratio of actual prices. This implies widespread over-utilization of labor relative to capital, which is supported by the fact that ratios of fitted to efficient demands for labor are all greater than 1 (see Table 2).

Moreover, firms located in the Mekong delta have higher values of k_{lft} than those located in other regions in both years. This is probably attributable to more intense competition in the nation's biggest marine food producing basin. Small enterprises also have bigger k_{lft}'s than larger ones. Due to the availability of a large pool of low cost labor in Vietnam that firms seem to have easier access to than to capital, they are likely to use much more labor as their production expands. This fact is strengthened when we compare years 2003 and 2005. Generally, four groups of firms grew in size from 2003 to 2005, and their k_{lft}'s all decline over time.

Relative over-utilization of labor is revealed clearly in Table 2. All groups employ labor more than they should. The patterns displayed here correspond to those indicated in Table 1. Allocative inefficiencies are worse for out-of-Mekong enterprises in the two time periods. Small firms have more efficient input combinations than larger ones in other regions of the country, but this does not hold for firms in the Mekong delta. Large firms' weighted-average ratios of fitted to efficient demands for labor (where the weights are firms' shares of their group's total output) are smaller, suggesting that several bigger companies in this group may actually use labor more properly than the small-firm group.

Tables 3 and 4 give posterior medians for estimates of k_{lft}'s and relative inefficiencies for 6 groups, which are categorized based on location and ownership. The range of their values is similar to that in Tables 1 and 2. Firms in the Mekong delta are more allocatively efficient than those located elsewhere, except for private firms. While private firms in other regions have the highest values of k_{lft} for both years, their counterparts in the Mekong delta have the lowest.

This may be caused by two reasons. First, the composition of the private firm group may not be well representative for the Mekong delta where small private firms tend to be less transparent financially and, hence, are dropped from the sample. For the 17 private firms in the sample that are based in the Delta, more than half (9) are classified as large. It is more acceptable for 13 private firms located elsewhere when 5 of them are large. Second, the State has actively chosen to keep large and well-performing SOEs and gradually sold the unsound ones. Although the retained SOEs may or may not sustain their competitiveness in the long term, they are likely to perform better than private firms, at least in the short term.

We also estimate the k_{lft}'s with a cross-section sample that pools 102 firms in 2003 and 182 firms in 2005. Tables 5 and 6 show posterior medians for estimates of the 4 and 6 groups' k_{lft}'s, respectively. An interesting point is that, while out-of-Mekong enterprises tend to over-utilize capital in 2003 and then under-utilize this input in 2005, those enterprises in the Mekong delta do the opposite. The abrupt changes in the k_{lft}'s over time are probably due to the unobserved heterogeneity that is not dealt with in the cross-section sample.

With the estimated parameters in the shadow cost system for the panel data, we are able to compute scale economies for each firm. Median estimates of scale economies for the firm with the median output in each group are presented in Tables 7 and 8. In each year, large firms have higher SEs than smaller ones. As all 4 median firms' sizes increase over time, the estimates of SEs in 2005 are bigger than in 2003. Moreover, despite being classified in the same categories as small or large, the median enterprises in the Mekong delta have larger outputs than their counterparts in other regions. Furthermore, the SE estimates in the right column are higher than those in the left column. The positive correlation between size and scale economies implies that all these firms' production levels are below the efficient scale, so that returns to scale are increasing. In Table 8, among the 6 median firms in each year, the state-owned firm in the Mekong delta has the largest size and the biggest SE (even larger than 1 in 2005). Another reason is that SOEs still enjoy privileges in terms of lower input prices.

Tables 9 and 10 provide posterior medians for TE_{ft}, EC_{ft}, TC_{ft}, and PC_{ft} corresponding to two ways of grouping. Median technical efficiency scores reveal an enormous range of efficiencies. Both tables show that firm 41 achieves the highest EC_{ft}. It is a small SOE located in the North Central Coast. Between 2003 and 2005, it laid off 70% of its staff and increased its wages by 146%. Although its capital stock remained the same, its output almost doubled. The firm also has the second-highest and highest PC_{ft} according to Tables 9 and 10, respectively.

However, the two tables indicate two different enterprises that have the lowest EC_{ft} and

PC_{ft}. In Table 9, the firm coded 39 is large, privately-owned, and located in the Mekong delta. It underwent a restructuring in which its capital decreased by 24% while its number of employees rose by 32%. Although wages were cut 8.2%, they were still much higher than the wages of the North Central Coast firm[11]. The restructuring seems to have been unsuccessful, as the firm's value added declined by 5%. In Table 10, the most technically efficient firm in 2003 experienced a very disappointing result two years later. This private, small firm located in the Mekong delta had unchanged capital and staff. In spite of its remarkable wage rise, its output fell by more than 80%.

The wide range of the median estimates of TE_{ft}, EC_{ft}, TC_{ft}, and PC_{ft} as well as the large fluctuations in performance of the firms examined above may be attributed to the huge difficulties that the fisheries sector in Vietnam faced in this period. The anti-dumping case brought against the Vietnamese catfish industry by the CFA reversed the commodity export boom into the U.S, which is the Vietnam's biggest marine food market. Many firms were badly hit and had to struggle to survive.

6 Conclusions

Vietnam has gone through a dramatic development of its fisheries sector over the last two decades, with an average annual growth rate of 9.37% from 1990 to 2007. Vietnam quickly left Bangladesh and Myanmar far behind in fisheries output and even surpassed Thailand, whose production was three times greater than that of Vietnam in 1990. However, sustainable development has been called into question because of concerns about the risk of environmental pollution, overfishing, quality control, supporting services, the performance of firms in this sector, etc.

Using a shadow cost system and an MCMC parametric approach, we find that firms have not fully exploited economies of scale and there are a lot of opportunities for future expansion. Nearly all of the firms over-utilize labor relative to capital. Firms located in the

[11]The North Central Coast is the poorest region in Vietnam.

Mekong delta tend to have higher degrees of allocative efficiency than those located in other regions. Small firms generally perform better than larger ones. However, while in other regions SOEs combine inputs less efficiently than private enterprises, the pattern seems to reverse itself in the Mekong delta. In addition, we have looked at firms that are the best or worst in terms of TE_{ft}, EC_{ft}, TC_{ft}, and PC_{ft}. The performance of private enterprises relative to SOEs is mixed. This may be due to the privileges that SOEs still enjoy. Large fluctuations over time on these rankings may indicate the vulnerability of the weaker firms to competition from international trade.

However, since the data are limited, we are not able to estimate separate values of k_{lft} for individual firms. Grouping them is likely to lead to aggregation bias, as seen in Table 2. In addition, two time periods do not allow the specification of the time effect to be more flexible, and prevent us from obtaining firm-specific and time-varying estimates of allocative efficiency. Therefore, richer data are needed to extend this study.

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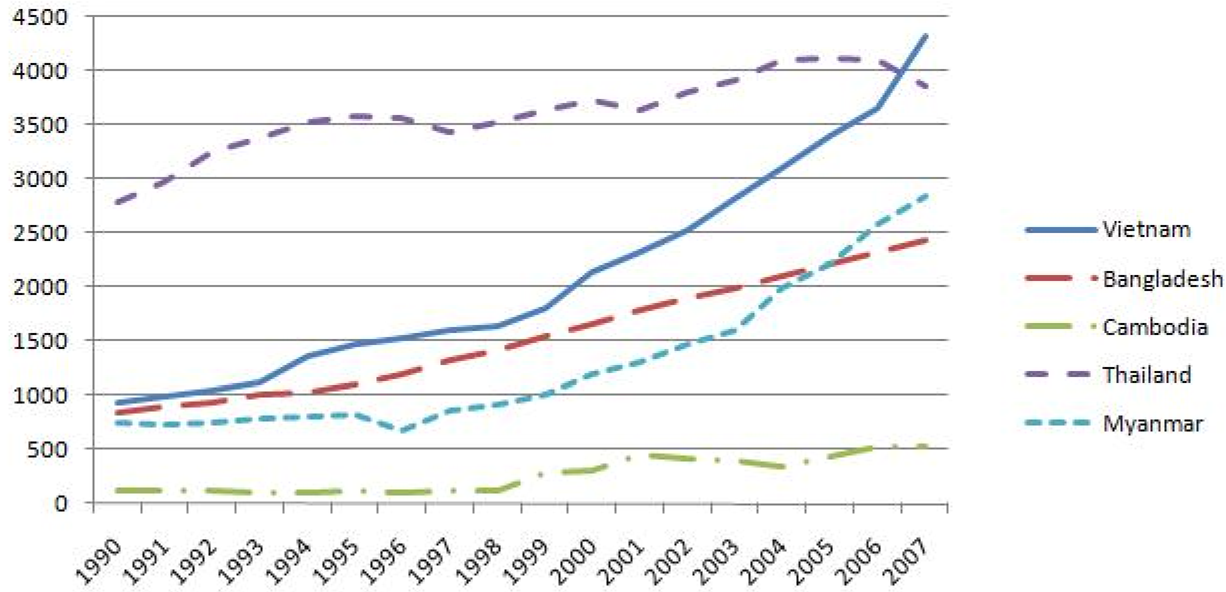
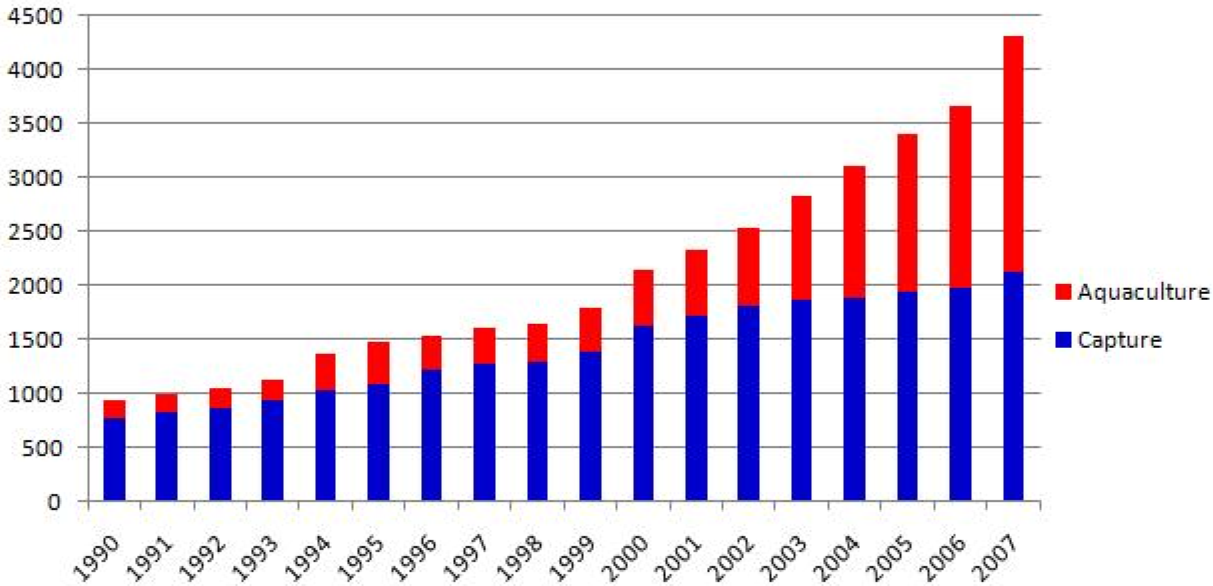
Figure 1: Aquatic Production (thousand tons) of Vietnam, Bangladesh, Cambodia, Thailand and Myanmar in 1990-2007



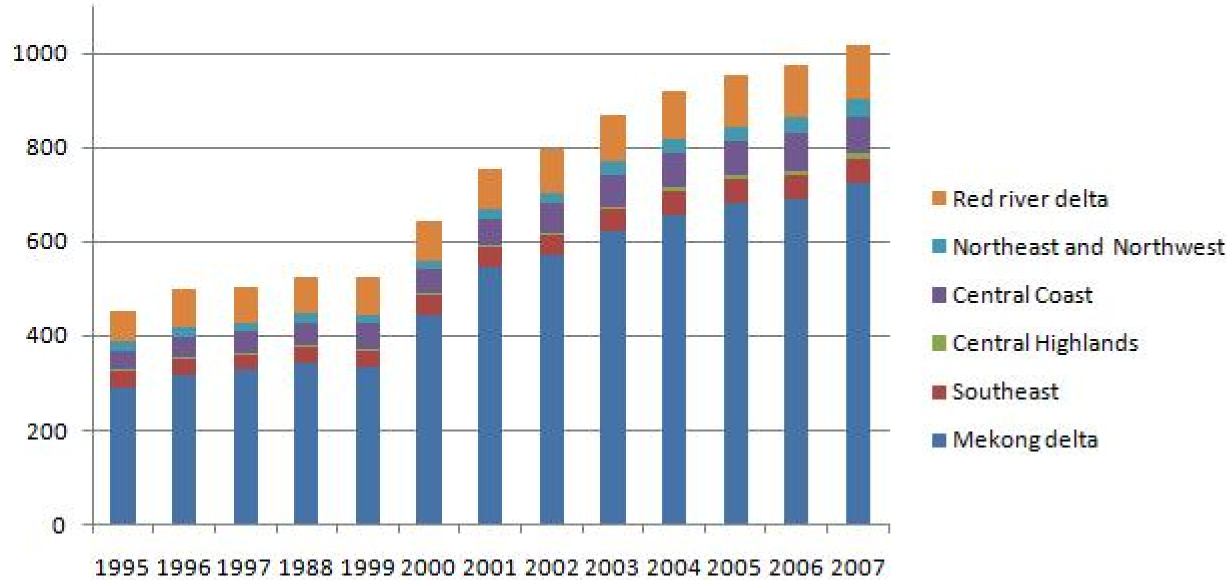
Source: FAO's Fisheries and Aquaculture Department

Figure 2: Vietnam's Capture and Aquaculture Production (thousand tons) in 1990-2007



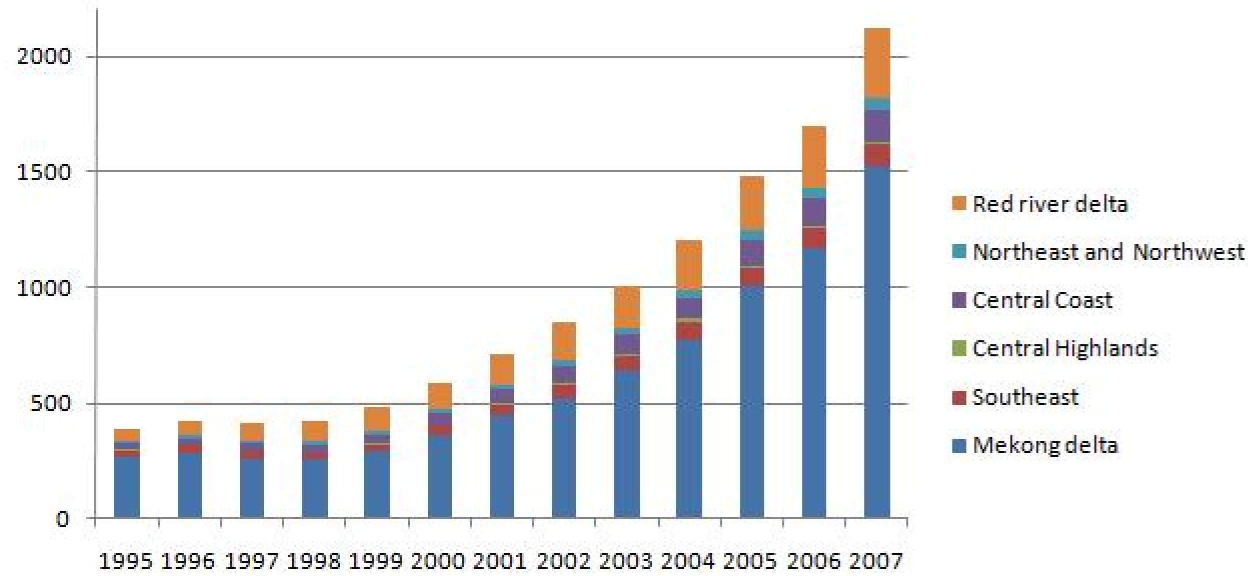
Source: FAO's Fisheries and Aquaculture Department

Figure 3: Aquaculture Area (thousand hectares) by Region in 1995-2007



Source: GSO (2009)

Figure 4: Aquaculture Production (thousand tons) by Region in 1995-2007



Source: GSO (2009)

Table 1: Posterior Medians for k_{lft} (4 groups)

	Out of Mekong	In Mekong
	year 2003	
Small firms	0.897	0.915
	(0.195)	(0.194)
Large firms	0.830	0.882
	(0.185)	(0.200)
	year 2005	
Small firms	0.790	0.804
	(0.345)	(0.345)
Large firms	0.731	0.777
	(0.325)	(0.349)

Note: Standard errors in parentheses.

Table 2: Posterior Medians for Relative Inefficiencies for Labor (4 groups)

	Out of Mekong	In Mekong
	year 2003	
Small firms	1.028	1.025
	(0.061)	(0.063)
Large firms	1.046	1.024
	(0.062)	(0.051)
	year 2005	
Small firms	1.057	1.053
	(0.107)	(0.105)
Large firms	1.067	1.043
	(0.097)	(0.081)

Note: Standard errors in parentheses.

Table 3: Posterior Medians for k_{lft} (6 groups)

	Out of Mekong	In Mekong
	year 2003	
State-owned firms	0.840	0.874
	(0.198)	(0.204)
Equitized firms	0.819	0.876
	(0.184)	(0.198)
Private firms	0.897	0.852
	(0.214)	(0.195)
	year 2005	
State-owned firms	0.720	0.749
	(0.357)	(0.366)
Equitized firms	0.701	0.753
	(0.343)	(0.359)
Private firms	0.770	0.729
	(0.388)	(0.356)

Note: Standard errors in parentheses.

Table 4: Posterior Medians for Relative Inefficiencies for Labor (6 groups)

	Out of Mekong	In Mekong
	year 2003	
State-owned firms	1.039	1.024
	(0.059)	(0.049)
Equitized firms	1.043	1.031
	(0.056)	(0.057)
Private firms	1.027	1.027
	(0.062)	(0.047)
	year 2005	
State-owned firms	1.061	1.043
	(0.092)	(0.077)
Equitized firms	1.076	1.051
	(0.099)	(0.084)
Private firms	1.049	1.051
	(0.090)	(0.080)

Note: Standard errors in parentheses.

Table 5: Posterior Medians for k_{lft} (4 groups) in a Cross-section Sample

	Out of Mekong	In Mekong
	year 2003	
Small firms	1.026	0.964
	(0.094)	(0.089)
Large firms	1.020	0.969
	(0.119)	(0.092)
	year 2005	
Small firms	0.939	1.125
	(0.084)	(0.098)
Large firms	0.939	1.050
	(0.087)	(0.099)

Note: Standard errors in parentheses.

Table 6: Posterior Medians for k_{lft} (6 groups) in a Cross-section Sample

	Out of Mekong	In Mekong
	year 2003	
State-owned firms	1.063	0.986
	(0.109)	(0.098)
Equitized firms	1.001	1.009
	(0.098)	(0.103)
Private firms	1.006	0.925
	(0.089)	(0.084)
	year 2005	
State-owned firms	0.964	1.048
	(0.093)	(0.143)
Equitized firms	0.894	1.047
	(0.080)	(0.096)
Private firms	1.038	1.139
	(0.092)	(0.099)

Note: Standard errors in parentheses.

Table 7: Posterior Medians for Scale Economies of the 4 Groups' Median Firms

	Out of Mekong	In Mekong
	year 2003	
Small firms	0.260	0.276
	(0.075)**	(0.086)**
Large firms	0.346	0.503
	(0.128)**	(0.216)*
	year 2005	
Small firms	0.535	0.573
	(0.104)**	(0.078)**
Large firms	0.676	0.838
	(0.063)**	(0.146)**

Notes: Standard errors in parentheses.

* significant at the 0.05 level, ** significant at the 0.01 level.

Table 8: Posterior Medians for Scale Economies of the 6 Groups' Median Firms

	Out of Mekong	In Mekong
	year 2003	
State-owned firms	0.565	0.877
	(0.065)**	(0.122)**
Equitized firms	0.657	0.875
	(0.079)**	(0.115)**
Private firms	0.543	0.560
	(0.064)**	(0.067)**
	year 2005	
State-owned firms	0.716	1.114
	(0.043)**	(0.106)**
Equitized firms	0.614	0.894
	(0.044)**	(0.063)**
Private firms	0.619	0.664
	(0.044)**	(0.041)**

Notes: Standard errors in parentheses.

** significant at the 0.01 level.

Table 9: Posterior Medians for TE, EC, TC, and PC (4 groups)

Firm	TE		EC	TC	PC
	year 2003	year 2005			
1	0.41	0.28	-0.13	-0.09	-0.22
2	0.31	0.47	0.15	0.15	0.31
3	0.40	0.39	-0.02	-0.32	-0.34
4	0.42	0.41	-0.01	-0.16	-0.19
5	0.28	0.35	0.06	0.04	0.10
6	0.34	0.58	0.22	-0.35	-0.12
7	0.35	0.66	0.30	0.91	1.23
8	0.27	0.31	0.04	0.20	0.25
9	0.32	0.40	0.08	-0.22	-0.14
10	0.23	0.39	0.16	0.08	0.24
11	0.58	0.31	-0.26	0.60	0.31
12	0.32	0.49	0.16	-0.11	0.06
13	0.71	0.25	-0.45	-0.37	-0.84
14	0.64	0.56	-0.07	0.38	0.31
15	0.38	0.56	0.17	0.47	0.65
16	0.45	0.49	0.04	-0.43	-0.38
17	0.72	0.26	-0.45	-0.76	-1.23
18	0.45	0.30	-0.14	-0.39	-0.54
19	0.57	0.28	-0.28	-0.92	-1.22
20	0.56	0.29	-0.27	-0.84	-1.13
21	0.53	0.28	-0.25	-0.63	-0.90
22	0.65	0.23	-0.41	-0.64	-1.08
23	0.28	0.32	0.04	-0.10	-0.06
24	0.53	0.77	0.20	0.38	0.59
25	0.43	0.39	-0.04	-0.05	-0.10
26	0.27	0.48	0.21	0.39	0.61
27	0.42	0.46	0.03	-0.21	-0.18
28	0.36	0.52	0.15	0.07	0.23
29	0.45	0.31	-0.13	-0.28	-0.42
30	0.19	0.73	0.53	0.18	0.73
31	0.46	0.59	0.13	0.27	0.41
32	0.22	0.39	0.16	0.11	0.28
33	0.34	0.45	0.10	0.10	0.21
34	0.57	0.29	-0.27	-0.68	-0.98
35	0.46	0.36	-0.09	0.03	-0.07
36	0.51	0.27	-0.24	-0.60	-0.86
37	0.62	0.31	-0.30	-0.59	-0.92
38	0.39	0.38	-0.01	-0.14	-0.15
39	0.83	0.25	-0.56	-1.05	-1.63
40	0.24	0.65	0.40	0.46	0.88
41	0.20	0.86	0.64	0.30	0.92
42	0.34	0.44	0.10	-0.02	0.08
43	0.30	0.49	0.18	0.28	0.47
44	0.37	0.33	-0.04	-0.34	-0.39
45	0.27	0.52	0.24	0.04	0.29
46	0.54	0.32	-0.21	-0.66	-0.89
47	0.29	0.45	0.16	0.11	0.28

Table 10: Posterior Medians for TE, EC, TC, and PC (6 groups)

Firm	TE		EC	TC	PC
	year 2003	year 2005			
1	0.39	0.32	-0.06	0.12	0.06
2	0.35	0.51	0.15	0.15	0.30
3	0.37	0.52	0.14	0.10	0.25
4	0.43	0.50	0.07	0.12	0.18
5	0.29	0.38	0.09	0.14	0.23
6	0.31	0.85	0.53	0.10	0.63
7	0.57	0.53	-0.04	0.23	0.19
8	0.29	0.32	0.03	0.15	0.18
9	0.32	0.50	0.18	0.11	0.30
10	0.23	0.42	0.18	0.14	0.33
11	1	0.25	-0.69	0.19	-0.48
12	0.37	0.52	0.15	0.12	0.28
13	0.62	0.37	-0.25	0.10	-0.16
14	0.90	0.64	-0.22	0.17	-0.05
15	0.51	0.58	0.06	0.18	0.24
16	0.50	0.59	0.09	0.09	0.19
17	0.57	0.42	-0.15	0.06	-0.09
18	0.49	0.34	-0.15	0.10	-0.06
19	0.41	0.47	0.05	0.05	0.10
20	0.41	0.50	0.08	0.06	0.14
21	0.42	0.44	0.02	0.07	0.09
22	0.51	0.37	-0.14	0.07	-0.07
23	0.26	0.37	0.11	0.12	0.23
24	0.73	0.82	0.07	0.17	0.24
25	0.44	0.46	0.02	0.13	0.15
26	0.32	0.48	0.16	0.17	0.33
27	0.41	0.61	0.20	0.11	0.32
28	0.40	0.63	0.22	0.14	0.37
29	0.41	0.42	0.01	0.11	0.12
30	0.21	0.78	0.57	0.15	0.72
31	0.59	0.70	0.10	0.16	0.26
32	0.24	0.38	0.13	0.14	0.28
33	0.37	0.52	0.14	0.14	0.29
34	0.46	0.46	0	0.07	0.07
35	0.50	0.44	-0.06	0.14	0.07
36	0.41	0.40	-0.01	0.08	0.07
37	0.55	0.45	-0.10	0.08	-0.03
38	0.39	0.46	0.07	0.12	0.20
39	0.54	0.50	-0.04	0.04	0
40	0.30	0.65	0.35	0.18	0.53
41	0.24	0.91	0.65	0.16	0.80
42	0.36	0.50	0.14	0.13	0.28
43	0.36	0.52	0.15	0.16	0.31
44	0.32	0.45	0.12	0.10	0.23
45	0.29	0.60	0.31	0.14	0.45
46	0.46	0.49	0.02	0.07	0.09
47	0.31	0.50	0.18	0.15	0.33

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