

國科會社會科學研究中心學術研習營

隨機邊界模型的應用

王泓仁

中央研究院經濟研究所

hjwang@econ.sinica.edu.tw

國立嘉義大學

June 2 - 3, 2007

Contents

- research directions using stochastic frontier (SF) models:
 - ◇ traditional efficiency study with *important* issues;
 - ◇ traditional efficiency study with new model;
 - ◇ creative use of the SF models in non-efficiency studies.
- Some Examples:
 - ◇ 資本投資模型;
 - ◇ 信用市場失衡模型;
 - ◇ 經濟成長模型;

application 2

- ◇ 勞動工資模型;
- ◇ 財務實證模型。

Search Theory and Wage Underpayment

Hofler and Murphy, 1992, Underpaid and Overworked: Measuring the Effect of Imperfect Information on Wages, Economic Inquiry.

- Because of imperfect information, job search is costly (positive discount rate; need time and efforts).
 - ◇ Workers are paid below the maximum wage that could be otherwise earned in a information-efficient market.
 - ◇ The degree of underpayment is related to demographic factors and social factors .

What They Do

- Investigate the degree of shortfall between the actual wages and the “maximum” wages (if information is perfect), and factors affecting the shortfall.
 - ◇ H1: Demographic groups exhibit differing degree of underpayment.
 - ◇ H2: Workers in areas paying relatively higher unemployment benefits exhibit less underpayment.
 - ◇ H3: More-educated workers exhibit less underpayment.
 - ◇ H4: Workers in urban areas exhibit less underpayment.
 - ◇ H5: Workers with greater wealth exhibit less underpayment.

How They Do It



$$w_i = X_i\beta + \gamma_i - u_i; \quad (1)$$

- ◇ X_i : individual-specific wage-determining factors;
- ◇ $\gamma_i \sim N(0, \sigma_\gamma^2)$: statistical error;
- ◇ $u_i \sim N^+(0, \sigma^2)$: represents the information effect on search.
- potential wage $X_i\beta + \gamma_i$ is greater than the actual wage $X_i\beta + \gamma_i - u_i$.
- Obtain $E(u_i | \gamma_i - u_i)$, and compare the mean values across groups implied by the hypothesis of H1 to H5.

What They Found

- Find supports for all the hypothesis.
- The efficiency cost of imperfect information to the economy as a whole, in GNP terms, is on the order of 10 percent. (?!)
- ◇ Show the importance to increase the information efficiency in the labor market.

Other Similar Studies

- Groot and Oosterbeek (1994, Labour Economics) makes u_i a function of information-related variables.
- Also, Hofler and Polachek (1985 Journal of Economics and Business), Hofler and Murphy (1994 Southern Economic Journal).
- Polachek and Yoon (1987 Review of Economics and Statistics, and 1996 Journal of Applied Econometrics) consider a two-tiered frontier model.
 - ◇ Workers do not know each firms' maximum wage offer, and firms do not know the reservation wage of workers.

application 8

- ◇ “two-tier” inefficiency: Firms pay too much, and workers do not get the maximum offer.
- ◇ $w_i = \mathbf{X}_i\boldsymbol{\beta} + v_i - u_i + w_i, u_i \geq 0, w_i \geq 0.$

Is it really the information problem?

**Polachek and Robst, 1998, Employee Labor Market Information:
Comparing Direct World of Work Measures of Workers' Knowledge to
Stochastic Frontier Estimates, Labour Economics**

- Criticism: the incomplete worker information is essentially measured as a residual. Does it really represent a measure of incomplete information?
- Polachek and Robst (1998) use “knowledge of the world of work test” of National Longitudinal Survey of Young Men (NLSYM) for measures of a worker’s knowledge of labor market opportunity.
- ◇ If the measures are consistent with the “residuals” of the

application 10

stochastic frontier model, then find support to the stochastic frontier analysis.

How They Do It and What They Find



$$W_i = \mathbf{X}_i\boldsymbol{\beta} + v_i - u_i, \quad (2)$$

$$u_i \sim N^+(\mathbf{Z}_i\boldsymbol{\delta}, \sigma^2). \quad (3)$$

where \mathbf{Z} are measures of information in the NLSYM:

- ◇ \mathbf{Z} : job title descriptions, required education, highest pay job from among two choices
- Essentially, the model of Battese and Coelli (1995).
- If $\boldsymbol{\delta} < 0$, provides supports to the stochastic frontier analysis. Fond supports.

Finance: Hunt-McCool, Koh, and Francis, 2005, “Testing for Deliberate Underpricing in the IPO Premarket

- **Underpricing of IPO:** Initial offer price of IPO is below the closing day bid price.
- deliberate: (1) initiating a cascade of buying activity (Shiller 1990 and Welch 1992), (2) “leave a good taste” with investors (Faulhaber 1989, Grinblatt and Hwang 1989, Welch 1989), (3) avoid potential lawsuits (Tinic 1988)
- not deliberate: the initial prices are set to fundamentals; and the excess returns in the after market are due to after-market problems, such as fads and speculative bubbles (Aggarwal and Rivoli 1990, Shiller 1990).

How to Distinguish the Two Hypotheses?

- Use pre-market data to estimate a stochastic frontier model.

$$p_i = f(X_i; \beta) + v_i - u_i, \quad (4)$$

$$u_i \sim N^+(0, \sigma^2), \quad (5)$$

where p_i is initial offer price.

- ◇ If no deliberate underpricing, no different from OLS.
- Obtain the “pre-market” underpricing measure: $E(u_i | v_i - u_i) / p_i^*$, which is the percent of underpricing.
- ◇ Regress
after market excess return = $a + b \cdot E(u_i | v_i - u_i) / p_i^* + \epsilon$.

application 14

- ◇ If b is significant, it means the *after-market* excess return is affected by *pre-market* under-pricing \implies evidence of deliberate under-pricing.

The Growth Model

Kumbhakar and Wang, 2005, Estimation of Growth Convergence

Using a Stochastic Production Frontier Approach, Economics Letters

- Given its resources, a country might fall short of producing the maximum possible (frontier) output.
 - ◇ inadequate financial institutions and inapposite regulatory intervention, etc.
- Economic convergence is observed if countries operating below the frontier move toward the world production frontier: technological catch-up.

The Model

\underline{t} : initial time period.

Features

- the technical inefficiency is interpreted in the context of growth convergence;
 - ◇ the initial distance from the frontier is a function of country-specific initial capital to labor ratio;
 - ★ when $t = \underline{t}$, $u_{it} = u_i \sim N^+(\delta_0 + \delta_i(k_{i\underline{t}} - l_{i\underline{t}}), \sigma^2)$
- the parameterization of inefficiency allows easy computation and test of the rate of convergence;
 - ◇ the inefficiency evolves over time according to $\exp[\gamma(t - \underline{t})]$;
 - ◇ If $\gamma < 0$, then when $t \rightarrow \infty$, $u_{it} \rightarrow 0$. Therefore, the convergence hypothesis is tested by $H_0 : \gamma \leq 0$ against

application 18

$$H_1 : \gamma > 0.$$

- includes country-specific fixed effects in the world frontier to recognize country heterogeneity.

The Disequilibrium Model

**Chen and Wang, 2005, Financial Crisis and the Effects on Bank
Credits – The Evidence from Taiwan, manuscript**

Motivation

- After the Asian financial crisis, the annual growth rate of domestic bank credits dropped from 19.65% in January 1998 to 5.92% in September 2000.
- The slowdown in the bank credit is considered an important contributing factors of the ensuing recession which is one of the worst in the recent history.

Credit Slowdown: Demand or Supply?

- the weak-demand story:
firms might cut back investment due to pessimistic perspectives of the economy, and thus reduced their demand for bank loans
- the weak-supply story:
capital-impaired banks were not in a position to extend credits;
banks might be more selective in extending credits

Questions to Answer

- How did the demand and the supply of bank credits change after the financial crisis? What are the attributing factors?
- How did the changes explain the dramatic credit slowdown? Was the slowdown demand-driven or supply-driven?
- Was it a general credit contraction, or did the credit cutback affects only certain types of firms ? What types of firms were affected the most in the credit slowdown?

Econometrics

- The model incorporates the short-side rule of market transactions (i.e., $Q_t = \min(D_t, S_t)$) to accommodate excess demand and excess supply in the market.
- Use the calculated *probability* of excess demand (Π_t) to infer the *relative* changes of the demand and the supply conditions.

- For instance, excess demand ($\Pi_t > 0.5$) is consistent with a shift-in of supply.

- Similarly, excess supply ($\Pi_t < 0.5$) is consistent with a shift-in of demand.

A Novel Model of Disaggregate Data

- Derive a model that accommodates the short-side rule of market transactions, but it requires only the borrowers' (demand) *or* the lenders' (supply) data.
- Advantage: Do not need to have *matched* demand and supply data at each t (recall: $Q_t = \min(D_t, S_t)$), so that unmatched micro data of the borrowers or the lenders can be used.
 - ◇ can apply the model to borrowers' data *or* to lenders' data
 - ◇ the larger number of the available data \longrightarrow more precise estimates of model parameters
 - ◇ can study heterogeneities among the micro establishments

Demand-Based Model: An Illustration

$$Q_t = D_t - E_t^d, \quad E_t^d \geq 0;$$

$$\Rightarrow q_{it} = d_{it} - e_{it}^d + v_{d,it}, \quad e_{it}^d \geq 0.$$

Supply-Based Model: An Illustration

$$Q_t = S_t - E_t^s, \quad E_t^s \geq 0;$$

$$\Rightarrow q_{it} = s_{it} - e_{it}^s + v_{s,it}, \quad e_{it}^s \geq 0.$$

Identification

- The model is:

$$q_{it} = d_{it} - e_{it}^d + v_{d,it}, \quad e_{it}^d \geq 0;$$

or,

$$q_{it} = s_{it} - e_{it}^s + v_{s,it}, \quad e_{it}^s \geq 0.$$

- Impose distributional assumptions on e_{it}^d and $v_{d,it}$ (e_{it}^s and $v_{s,it}$) to identify the models.

Demand-Based Model

$$q_{it} = d_{it} - e_{it}^d + v_{d,it}, \quad e_{it}^d \geq 0.$$

- impose a distributional assumption on e_{it}^d (Wang and Schmidt 2002):

$$e_{it}^d \sim \exp(\mathbf{z}_{it}'\boldsymbol{\delta}) \cdot N^+(\tau, \sigma_d^2),$$

- ◇ $\mathbf{z}_{it} = \{\ln asset_{it}, \ln cpb_{it}, \ln nstock_{it}\}$: a vector of variables explaining excess demand.

application 31

- ◇ A simpler version: $\mathbf{z} = \{\}$, $\tau = 0$, so that $e_{it}^d \sim N^+(0, \sigma_d^2)$. Note that $E(e_{it}^d) = f(\sigma_d^2)$, and that we parameterize $\sigma_d^2 = \exp(c_0)$.

$$Z_{it} = \{\ln asset_{it}, \quad \ln cpb_{it}, \quad \ln nstock_{it}\}$$

	definition	hypotheses
$\ln asset$	(log of) asset sizes	larger firms are less likely to have unsatisfied demand
$\ln cpb$	volume of commercial papers and bonds (alternative debt financing)	alternative financing should reduce excess demand for bank loans
$\ln nstock$	proceeds from issuing new equity (equity financing)	should also help release demand of bank loan; δ_r

Table 4: demand-based model

	coeff.	std. err.			co
R_{t-1}^d	-0.012	(0.020)	h function		
$\ln i_{it}^d$	-0.022	(0.015)		$\ln asset_{it}$	-0.05
$\ln inv_{it}$	0.141***	(0.012)		$\ln cpb_{it}$	-0.03
$\Delta \ln s_{it}$	0.091	(0.061)		$\ln nstock_{it}$	-0.03
$\Delta \ln E_t$	0.243*	(0.128)		$\ln asset_{it} \times d98$	-0.0
$\Delta \ln H_t$	0.300	(0.511)		$\ln cpb_{it} \times d98$	0.0
$\ln P_t$	-2.591***	(0.404)		$\ln nstock_{it} \times d98$	0.02
$\ln asset_{it}$	0.864***	(0.023)		$d98$	0.38
$R_{t-1}^d \times d98$	-0.069*	(0.040)	τ		-8.35
$\ln i_{it}^d \times d98$	-0.043**	(0.021)	σ_d^2	$c1$	3.29
$\ln inv_{it} \times d98$	0.055***	(0.020)	$\sigma_{d,v}^2$	$c2$	-0.90
$\Delta \ln s_{it} \times d98$	-0.124	(0.095)			
$\Delta \ln E_t \times d98$	-0.075	(0.223)			
$\Delta \ln H_t \times d98$	-3.241**	(1.487)			
$\ln P_t \times d98$	-4.028***	(1.245)			
$\ln asset_{it} \times d98$	0.022	(0.044)			
$d98$	18.851***	(5.815)			
constant	11.595***	(1.843)			

log-likelihood value = -298

application 35

Table 4: demand-based model, part 2

		coeff.	std. err.
<i>h</i> function			
	$\ln asset_{it}$	-0.051***	(0.009)
	$\ln cpb_{it}$	-0.037***	(0.008)
	$\ln nstock_{it}$	-0.038***	(0.005)
	$\ln asset_{it} \times d98$	-0.035**	(0.016)
	$\ln cpb_{it} \times d98$	0.019 [†]	(0.012)
	$\ln nstock_{it} \times d98$	0.023***	(0.009)
	$d98$	0.381***	(0.074)
	τ	-8.350***	(1.098)
σ_d^2	$c1$	3.299***	(0.116)
$\sigma_{d,v}^2$	$c2$	-0.904***	(0.043)

application 37

- Smaller firms had difficulty to borrow before 1998, and the situation worsened after 1998. \implies Smaller firms must have borne disproportionately the impacts of the credit cut-back.
- The substitution between bank loans and other types of financing was compromised after 1998. \implies Another possible factor contributing to the excess demand of bank credit.

Table 5: supply-based model see model

	coeff.	std. err.		coeff.	std. err.
r_{it-1}^s	-0.078***	(0.010)	σ_s^2	c1	-20.754*** (0.166)
$\left(\frac{k}{a}\right)_{it}$	0.810***	(0.123)			
$\ln dep_{it}$	0.936***	(0.025)	$\sigma_{s,v}^2$	c2	-3.837*** (0.123)
$\ln over_{it}$	-0.023	(0.134)			
$\Delta \ln E_t$	0.006	(0.053)			
$\Delta \ln H_t$	0.149	(0.274)			
$\ln P_t$	-0.645***	(0.225)			
$\ln asset_{it}^b$	0.047***	(0.015)			
$r_{it-1}^s \times d98$	-0.023	(0.017)			
$\left(\frac{k}{a}\right)_{it} \times d98$	-0.828**	(0.354)			
$\ln dep_{it} \times d98$	0.052	(0.039)			
$\ln over_{it} \times d98$	-0.565***	(0.206)			
$\Delta \ln E_t \times d98$	-0.032	(0.085)			
$\Delta \ln H_t \times d98$	0.561	(0.624)			
$\ln P_t \times d98$	0.724	(0.468)			
$\ln asset_{it}^b \times d98$	0.019	(0.027)			
$d98$	-2.608	(2.220)			
constant	3.539***	(0.985)			
			$\sigma_s^2 = \exp(-20.754) \approx 0$		
			log-likelihood value = 445.967		

application 40

The Capital Investment Model

**Wang, 2003, A Stochastic Frontier Analysis of Financing Constraints
on Investment: The Case of Financial Liberalization in Taiwan,
Journal of Business and Economic Statistics**

- Slides are given in the first lecture.