The Impact of Health Information Technology Outsourcing on Hospital Productivity

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Health Information Technology

- “Innovations in electronic health records will help transform healthcare in America”, President Bush
- “We will update and computerize our health care system to cut red tape, prevent medical mistakes, and help reduce health care costs by billions of dollars each year”, President Obama

Background

- Health IT is widely regarded as a solution to health quality and cost problems
  - Bush Administration: establish the Office of the National Coordinator for health IT in 2004
  - Obama Administration: sign Health Information Technology for Economic and Clinical Health in 2009

What does IT do?

- Different types of IT
  - Clinical ITs: EHRs, CPOE, etc
  - Administrative ITs: Cost Accounting, Patient Billing, etc
- These and other systems serve a wide range of purposes, including:
  - Discharge planning and Capacity utilization
  - Decrease transaction costs
  - Improve billing and charge capture
  - Avert decision errors and Prevent communication errors

IT Outsourcing Expansion

- A rapid expansion of outsourcing in manufacturing and services over the two decades.
  - A notable area is the information technology (IT) services.
  - The global IT outsourcing market grew over $250 billion for last two decades
- Healthcare IT outsourcing has grown significantly among healthcare organizations
  - global healthcare IT outsourcing market forecast to grow at a significant annual growth rate of 7.6 percent
  - north America accounts for the largest share, 72 percent, of the global healthcare IT outsourcing market

Theoretical Background of Health IT outsourcing

- Reduction of direct operating costs
  - stressed by transaction cost economics
  - focuse on reduction of wage and managerial administrative overhead
- Specialization in core competences
  - asset specificity is involved if specific investments are required to support transactions and realize least cost performance
- Substitution of non-core competences with inputs from a specialist provider
  - substitution effect arises when an organization replace its non-core operations with inputs from a specialist provider with greater knowledge depth.

Theoretical Background of Health IT outsourcing

- IT is a durable good
- The theoretical effect of ownership on IT capital productivity is unclear
  - Owned IT asset will have consequences for long-term productivity
  - Outsourced IT will be more productive if vendors have specialized technical skills that complement the technology

IT Outsourcing Literatures

- The relationship between IT outsourcing and performance is mixed
  - Cost savings (Lacity et al, 1996; Saunders et al., 1997)
  - Higher financial performance (Loh and Venkatraman, 1995; Han et al., 2011;Knittel and Stango, 2007; Chang and Gurbaxani, 2013)
  - No effects on performance (Bhalla et al., 2008; Florin et al., 2005)
  - Worsened Financial performance (Wang et al, 2008; Oh et al, 2006)

Research Questions

- Does Information Technology outsourcing increase hospital productivity?
  - Value added production function
- Other ancillary Questions;
  1. Does hospital ownership affects the productivity of health IT?
  2. Does hospital size affect the productivity of health IT?
  3. Does hosptial use appropriate amount of IT outsourcing?
  4. Are there vintage or learning effects in the productivity of health IT?

Hospital Production Function

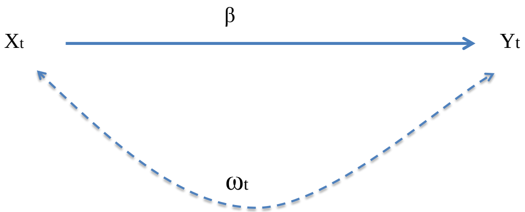
- $Y = f(L, K, L_c, K_c^I, K_c^O, \epsilon) = \epsilon^{\beta_\epsilon} L^{\beta_l} K^{\beta_k} {L_c}^{\beta_{l_c}} {K_c^I}^{\beta_{k_c^I}} {K_c^O}^{\beta_{k_c^O}}$
  - Use the Cobb-Douglas specification, widely used to represent the relationship of an output to inputs.
  - $\beta_l, \beta_k, \beta_{l_c}, \beta_{k_c^I}$ and $\beta_{k_c^O}$: output elasticities
  - Value added production function:
    Operating revenues less intermediate inputs

Hospital Production Function - Cobb Douglas

- $y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_{l^c} l^c_{it} + \beta_{k^I_c} k^I_{c\,it} + \beta_{k^O_c} k^O_{c\ it} + \epsilon_{it}$
- $\epsilon_{it} = \alpha_i + \gamma_t + \omega_{it} + \eta_{it}$

y_{it} : log of value added
l_{it} : log conventional labor
k_{it} : log conventioanl capital
l^c_{it} : log IT labor
$k^I_{c\,it}$: log owned IT capital
$k^O_{c\ it}$: log outsourced IT capital
α_i : hospital fixed effect
γ_t : time varying productivity shock
ω_{it} : unobserved productivity shock
η_{it} : observed productivity shock.

Problem with Estimating Production Functions



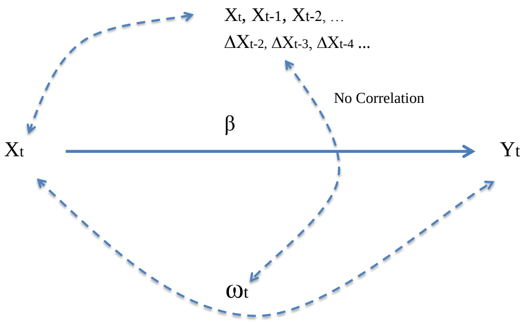
Estimating Production Functions

- Marshak & Andrews (1944)
  - $y_{it} = \beta x_{it} + \eta_i + v_{it}$
  - Endogeneity Problem in Production Function
- Anderson & Hsiao (1981, 1982)
  - Basic First Differenced Two Stage Least Squares (2SLS)
  - $\Delta y_{it} = \beta \Delta x_{it} + \Delta v_{it}$
  - Use x_{it-2} as instrument variables because $E(x_{it-2}\Delta v_{it}) = 0$
  - Not asymptotically efficient

Estimating Production Functions Cont.

- Allerano & Bond (1991) and Holtz-Eakin *et al.*(1998)
  - First Differenced Generalized Method of Moments (GMM)
  - Asymptotically efficient
  - Weak instrument problem when data are highly persistent
- Blundell & Bond (1998, 2000)
  - Dynamic Panel Data (PDP)
  - Use lagged difference and lagged levels as instruments
    - $E[x_{it-s}\Delta v_{it}] = 0$ & $E[y_{it-s}\Delta v_{it}] = 0$, for $s \geq 2$ and $t \geq 3$
    - $E[\Delta x_{it-s} v_{it}] = 0$ & $E[\Delta y_{it-s} v_{it}] = 0$, for $s \geq 1$ and $t \geq 3$
  - Show a lower finite sample bias and a substantial increase in precision

Dynamic Panel Data (DPD) approach



Data

- California Hospital Data (Office of Statewide Health Planning and Development): 1997-2007
    - Hospital level
    - Provide the hospital income statement, balance sheet, and statement of cash flows.
    - **Dollar measure of IT capital and IT labor**

Sample

Average number of Acute Care Hospitals by Ownership

Total	*For Profit*	*Not For Profit*	*Gov.*
333.7	78.6	194.4	61.5
100%	23.6%	58.3%	18.4%

Average Bed Size by Ownership

Total	*For Profit*	*Not For Profit*	*Gov.*
226.2	159.6	257.7	210.4

Descriptive Statistics

Average share for entire sample (Unit: thousand)

Variable	Total	Share	FP Share	NFP Share	Gov. Share
Value added	133,895	100.0%	100.0%	100.0%	100.0%
	(181,806)				
Labor, L	117,851	88.0%	89.7%	88.0%	86.4%
	(151,530)				
Capital, K	173,090	129.3%	108.4%	133.6%	121.3%
	(267,923)				
IT Labor, L^c	1,576	1.2%	0.7%	1.2%	1.4%
	(3,146)				
IT Capital, K_c^I	3,636	2.7%	0.8%	3.1%	2.6%
	(8,579)				
IT Capital, K_c^O	1,901	1.4%	1.0%	1.6%	1.1%
	(4,040)				

*Share: input relative to value added

Estimation results

Variable	OLS Level	Fixed Effect	DPD
Labor, l_t	0.779**	0.602**	0.776**
	(0.099)	(0.070)	(0.046)
Capital, k_t	0.099**	0.089**	0.147**
	(0.014)	(0.015)	(0.026)
IT Labor, l_t^c	0.012**	0.011**	0.019**
	(0.003)	(0.003)	(0.007)
IT Capital, Owned, $k_{t_c}^I$	0.014**	0.012**	0.018**
	(0.002)	(0.003)	(0.005)
IT Capital, Outsourced, $k_{t_c}^O$	0.006**	0.006**	0.014**
	(0.002)	(0.003)	(0.007)

$** : p < 0.01$

Identification of DPD

- Estimates in OLS & FE model are almost all lower than the estimates in DPD
    - Indicate input choices are endogenous

- Common factor restrictions are not rejected
- Over-identification restrictions are not rejected
- Do not reject a constant returns to scale technology.

Marginal productivity in IT inputs

- Short-run gross marginal product
  - Owned IT: 66.7%
  - Outsourced IT: 100%
- Long-run gross marginal product
  - Owned IT is stock variable
  - Marginal product of owned IT ranges from 152% to 177%.
- The value of owned IT capital would be substantially higher if it remained fully productive until the end of its useful life

DPD estimates by Ownership

Variable	For Profit	Not For Profit	Government
Labor, l_t	0.927**	0.561**	0.471**
	(0.041)	(0.065)	(0.073)
Capital, k_t	0.062**	0.087*	0.109**
	(0.026)	(0.033)	(0.031)
IT Labor, l_t^c	0.030**	0.007*	0.040**
	(0.008)	(0.004)	(0.010)
IT Capital, Owned $k_{t_c}^I$	0.011**	0.008**	0.018**
	(0.005)	(0.004)	(0.005)
IT Capital, Outsourced $k_{t_c}^O$	0.008	0.007	0.017
	(0.006)	(0.006)	(0.013)

$* : p < 0.05, ** : p < 0.01$

Interpretation-Ownership

- Hospital ownership influenced the outsourced IT investment, but this different IT adoption behavior may not lead to productivity.
- Owned IT was positively associated with hospital productivity, but not outsourced IT in all three ownership.
    - Government hospitals have the largest effect of owned IT on productivity

DPD estimates by bed size and time frame

	$\leq$ 173 beds	>173 beds	$\leq$ 2001	$\geq$ 2002
l_t	.668**	.826**	.460**	.784**
	(.075)	(.044)	(.148)	(.047)
k_t	.139**	.112**	.220**	.145**
	(.033)	(.026)	(.093)	(.027)
l_t^c	.022**	.007**	.012**	.020*
	(.007)	(.005)	(.028)	(.007)
k_t^{cI}	.009**	.021**	-0.012	.020**
	(.005)	(.004)	(.017)	(.004)
k_t^{cO}	.013**	.007	.050*	.016**
	(.007)	(.006)	(.025)	(.006)

$* : p < 0.05, ** : p < 0.01$

Bed size and time frame

- Bed Size
  - Smaller hospitals have a significant productivity gain from outsourced IT capital, which is bigger than owned IT capital.
  - Larger hospitals have productivity gain only from owned IT capital, not from outsourced IT.
  - Information Technology is an attractive candidate for outsourcing for many small and medium sized firms
- Time frame
  - Outsourced IT was more productive in earlier than later period.
  - Owned IT did not lead to productivity gain in the early period,
  - The early period is mitigating practice because the learning is slow, supplier capabilities are not fully tested.

DPD estimates by percent of outsourced IT

	Percent of	outsourced IT	over total IT
	$\leq$ 50%	50%<X <80%	$\geq$80%
l_t	.773**	.665**	.709**
	(.028)	(.037)	(.038)
k_t	.144**	.192**	.127**
	(.020)	(.022)	(.025)
l_t^c	.024**	.014**	.025**
	(.007)	(.006)	(.005)
k_t^{cI}	.028**	.012**	0.014
	(.004)	(.005)	(.003)
k_t^{cO}	.004	.014**	.004
	(.005)	(.007)	(.006)

$* : p < 0.05, ** : p < 0.01$

Percent of outsourced IT over total IT

- Hospital with more than 50 percent and less than 80 percent of outsourced IT over overall IT had a significant gain from outsourced IT.
- Hospital with not too much of outsourced IT had a significant productivity gain from outsourced IT.

Conclusions - IT value

- Outsourced IT is significantly associated with hospitals productivity
  - Short term marginal product of outsourced IT is almost two times larger than that of owned IT.
  - Long-run marginal product of owned IT is large than that of outsourced IT
- It implies that hospital may invest more outsourced IT to improve productivity in the short run

Conclusions - Ownership and Bed size

- Ownership
  - Owned IT was positively associated with hospital productivity, but not outsourced IT in all three ownership.
- Bed Size
  - Smaller hospitals have a significant productivity gain from outsourced IT capital
  - Larger hospitals have productivity gain only from owned IT capital, not from outsourced IT.

Conclusions - Time frame and Percent of outsourced IT

- Time frame
  - Outsourced IT was more productive in earlier than later period.
  - Owned IT did not lead to productivity gain in the early period,
- Percent of outsourced IT over total IT
  - Hospital with not too much of outsourced IT had a significant productivity gain from outsourced IT.

Thank you

IT labor and IT capital Variables in OSHPD Data

- $L_c = SW_t + B_t + F_t$
  SW : Salaries and Wages
  B : Employee Benefits
  F : Professional Fees

- $K_c^I = OE_t + PC_t$
- $K_c^O = PS_t + LR_t$
  PS : purchased service
  LR : leases and rentals
  OE : other direct expenditure
  PC : physical IT capital

We can obtain a consistent GMM estimator of β by minimizing the following;

$J_N = (\frac{1}{N}\sum_{i=1}^{N} u_i' z_i) W_N^{-1} (\frac{1}{N}\sum_{i=1}^{N} z_i' u_i)$

where $W_N = \begin{pmatrix} W_1 & 0 \\ 0 & W_2 \end{pmatrix}$, $W_1 = \sum z_{1i}' \Delta v_i \Delta v_i' z_{1i}$ and $W_2 = \sum_1^N z_{2i}' z_{2i}$.

$$z_{1i} = \begin{pmatrix} y_{i1} & x_{i1} & 0 & 0 & 0 & .. & 0 & .. & 0 & 0 & .. & 0 \\ 0 & y_{i1} & y_{i2} & x_{i1} & x_{i2} & .. & 0 & .. & 0 & 0 & .. & 0 \\ . & . & . & . & . & .. & . & .. & . & . & .. & . \\ 0 & 0 & 0 & 0 & 0 & . & y_{i1} & .. & y_{iT-1} & x_{i1} & .. & x_{iT-1} \end{pmatrix}$$

$$z_{2i} = \begin{pmatrix} \Delta y_{i1} & \Delta x_{i1} & 0 & 0 & 0 & .. & 0 & 0 \\ 0 & 0 & \Delta y_{i2} & \Delta x_{i2} & 0 & .. & 0 & 0 \\ . & . & . & . & . & .. & . & . \\ 0 & 0 & 0 & 0 & 0 & .. & \Delta y_{iT-1} & \Delta x_{iT-1} \end{pmatrix}$$