Computer Networks and TFP : Some Preliminary Results

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The views expressed in this presentation are those of the authors and not necessarily those of the U.S. Census Bureau.

Overview

1. Motivation – LP vs. TFP
2. Summary of previous research
3. Computer networks and TFP
4. Further research on TFP

Motivation: LP vs. TFP

Strong link between computer networks and LP

- Atrostic and Nguyen (Economic Inquiry, 2005)
- Atrostic and Nguyen (NBER CRIW volume, forthcoming 2007)
- Atrostic and Nguyen, (Diewert *et al.,* eds., forthcoming, 2007)

Does strong empirical link hold for TFP?

Productivity Measures: LP vs. TFP

Labor Productivity: LP = Q/L

+ Easy to measure; data on Q, L are more accurate and reliable compared to other data

- LP only partial productivity measure

Total Factor Productivity: TFP = Q/f(X)

+ Theoretically correct: includes all inputs

- Some inputs hard to measure (K)

- Some inputs not measured

Previous Research: 1

Model 1: q = f(k, m, CNET, Z)

- **q= Q/L , k = K/ L, m=M/L**
- **CNET=computer network**
- **Z = vector of control variables (ind, size, mu , new…)**
- **CNET = F(RLP_{92}, $Skill_{92}$, $Comp_{92}$, MU, IND)**

Estimation: OLS & 2-Stage

Data: 1999 Computer Network Use Survey

- Supplement to 1999 Annual Survey of Manufactures
- Presence of computer network, how network is used
- 38,000 respondents
- Link to ASM, Census of Manufactures

Previous Results: 1

Results: Significant and positive link between LP (Q/L) and computer networks

- OLS: 3.7% (gross output)
  7.5% (value added)
- 2-stage: 7.2% (10^{th} – 90^{th} percentiles)

Previous Research: 1

Estimated Network coefficients

	OLS Estimates+		Two-stage Estimates+
	Gross Output	Value Added	
Network	0.037*	0.075*	--
Pr(Network)	--	--	0.669*
N	29,480	29,480	10,496

* = significant at the 1% level
+ = Estimates taken from Table 1

Previous Research: 1

Comments: Two issues

- Book value of capital may not be good proxy for capital services
- No separate measure of computer capital

Previous Research: 2

Model 2: $q = f(k_{nc}, k_c, m, CNET, Z)$

k_{nc} = non-computer capital

k_c = computer capital

Data: sample of 849 plants new in 1997

For new plants, book value of capital and computer investment are good proxies K_{nc} and K_C .

$K(t) = (1-d)K(t-1) + IN(t)$;

For new plants, $K(t-1)=0 \Rightarrow K(t) = IN(t)$

Previous Research: 2

Results: Significant and positive link between LP (Q/L) and CNET

OLS: productivity about 12% higher at plants with networks

	New plants		All plants
	with K_c	without K_c	with K_c
Network	0.117*	0.136*	0.004
N	849	849	12,386

*= significant at the 1 % level
+= taken from Table 2.

Previous Research: 2

Comments:

- “Computer Networks” too broad
- All ways of using computer networks may not be equally productive
- Examine data on distinct network uses

Previous Research: 3

Model 3: q = f(k,l,m, EBProcesses, Z)
EBProcesses = E-Business processes

- Two sets of E-Business Processes:
  - Group 1 (7 processes): Design; Catalog; Demand projections; Order status; Production Schedules; Inventory; Logistic or Transportation
  - Group 2 (5 processes): Purchasing; Product Order; Production Management; Logistics; Communication and Support.
- Intensity indexes for each group: Index1 = 1 process; index2 = 2 processes, etc.

E-Business Processes Positively Linked to Labor Productivity

- Some individual EB processes
  - such as processes facilitating communication and support, inventory, catalog and purchasing
- Increasing intensity (use of multiple processes) => higher LP

Some E-Business Processes Linked with Productivity

Group of Five Processes	
Purchasing	0.0259*
Product orders	-0.0048
Production management	-0.0058
Logistics	0.0276*
Communication & support	0.0236*
Group of Seven Processes	
Design	-0.0158*
Catalog	0.0082+
Demand projection	0.0110+
Order status	-0.0096
Production schedules	0.0108
Inventory data	0.0269*
Logistics/transportation	0.0251*

* = significant at the 1% level
+ = significant at the 10% level

Productivity Increases with E-Business Processes Intensity

Group of Five Processes	
Index=1	0.0091
Index=2	0.0347*
Index=3	0.0407*
Index=4	0.0546*
Index=5	0.0607*
Group of Seven Processes	
Index=1	0.0074*
Index=2	-0.0070
Index=3	0.0125
Index=4	0.0281*
Index=5	0.0472*
Index=6	0.0405*
Index=7	0.0385*

* = significant at the 1% level

Previous Research: 3

Comments:

Looks only at labor productivity (partial productivity)

Should use TFP as a measure of productivity

Computer Networks and TFP

$Q = A \bullet f(X)$

$\ln TFP = \ln A = \ln Q - \ln Q^*$

Q^* = estimated output (based on an estimated production function)

Translog Production Function

$$\ln Q = a_0 + a_k \ln K + a_l \ln L + a_m \ln M +$$
$$0.5a_{kk} (\ln K)^2 + 0.5a_{ll} (\ln L)^2 + 0.5a_{mm} (\ln M)^2 +$$
$$a_{kl} \ln K \ln L + a_{km} \ln K \ln M + a_{lm} \ln L \ln M$$

Translog reduces to Cobb-Douglas if

$a_{ij} = a_{ji} = 0$ for i,j = K,L,M

TFP Regression

$$\text{Ln TFP} = a_0 + a_1\,\text{CNET} + a_2 \ln(K/L) + a_3 \ln(\text{Lquality}) + a_4 \ln(\text{Size}) + a_5 \text{MU} + \sum b_j \text{IND}_j$$

$j = 1,2,\ldots$

Lquality = wage rates as proxy labor quality

Preliminary Results

Estimated coefficients for the Network variable +				
	All Plants +		New Plants +	
	CD	TL	CD	TL
Network	0.0436*	0.0419*	0.0869*	0.0664*
N	30,892	30,892	1,717	1,717

***=significant at the 1% level**

\+ = from Tables 6 and 7

Further Research

1. Endogenous computer networks
2. Computer uses (business processes)
3. Separate computer input measures
4. Your suggestions