

The Need for Speed: Impacts of Internet Connectivity on Firm Productivity



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Background

- Some countries invest heavily to raise internet connectivity
 - E.g. Korea, Singapore
- OECD emphasises importance of broadband (BB)
 - Major NZ political parties share this view
- Domestic & international issues of a ‘digital divide’
- BUT: What is the evidence on effects of BB on productivity?

Purpose of Study

- Estimate effects of internet connectivity on firm productivity
- Distinguish between fast BB (cable), slow BB (other), no BB
- No firm-level study on effects of internet/BB
 - Internationally or in NZ
 - A few firm-level studies exist on ICT in general
 - Some internet/BB analyses at state/county aggregation in US
 - Lots of lobby group & think-tank rhetoric on effects
 - E.g. NZ Institute

Key Data Source

- Business Operations Survey 2006 (BOS06)
 - Statistics NZ survey with >80 % response rate
 - Representative of all private sector firms with ≥ 6 employees
- Randomly sampled
 - With sector & firm size strata
 - Sample weights make results representative of economy
- BOS06 linked to other LBD data on surveyed firms
- Cross-sectional data
 - But have lagged firm characteristics data (eg lagged productivity)
 - Regional identifiers enable rural/urban split

Data: BOS ICT Questions

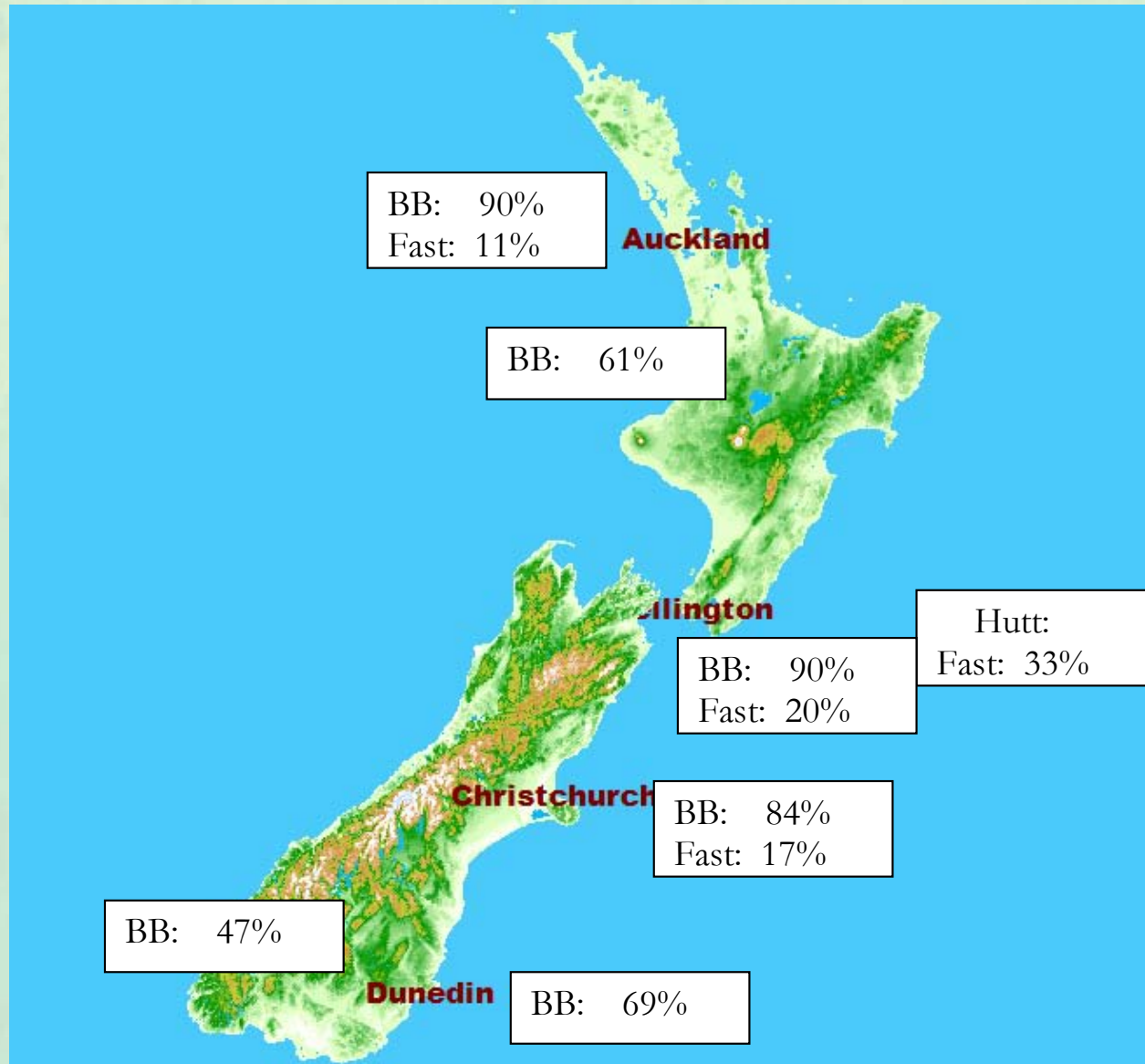
- Firms asked:
 - Whether they can access the internet or not
 - If so, do they have dial-up, BB, or don't know (DK)
 - If BB, is it:
 - Cable (defined as fast – *but can't distinguish different types of cable*) or:
 - DSL, cellular, wireless, satellite (defined as slow);
 - Don't know (DK; drop)
- Most firms have BB; small proportion have fast BB

Internet Access Mode		Weighted % of Firms
Internet access:	- none	9.16
	- dial-up only	11.08
	- broadband (total)	76.40
	- don't know/DNA	3.35
Broadband type:	- fast (cable)	7.46
	- slow (other)	68.94
No. of Firms		6,051

Data: BOS ICT Questions (cont)

- Firms asked about ICT infrastructure quality in their local area
 - E.g. BB availability, mobile phone coverage
 - Can respond bad, neither bad nor good (“mid”), good, DK
 - Good/mid/bad used as measure of local ICT quality
 - DK used as measure of firm’s knowledge about ICT/internet/BB
- If multi-plant, firm to respond where largest share of firm’s activities are

BB: Firm Uptake Rates



Which firms have BB?

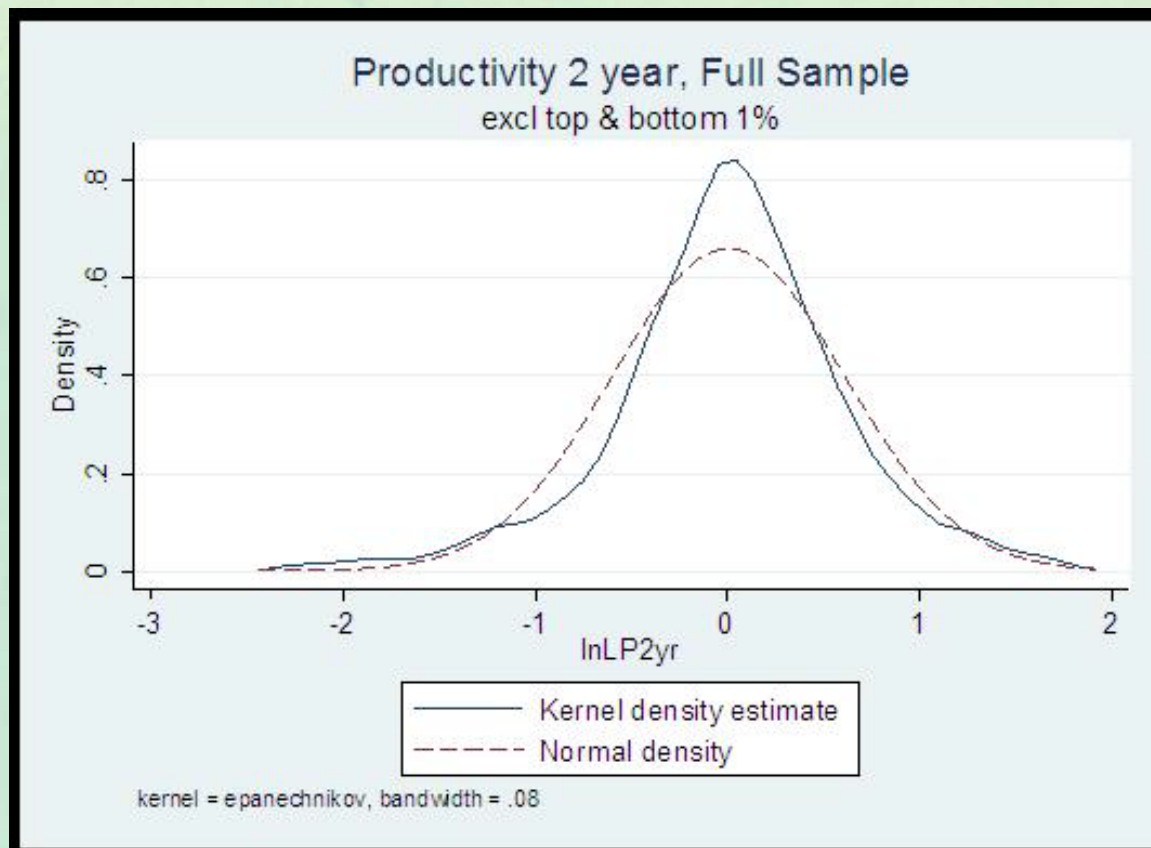
Firm characteristic	Weighted % with BB	Weighted % with fast BB
Employees: - (50, ∞)	92.02	18.23
Age (yrs): - (10, ∞)	75.88	7.63
Foreign owned	93.36	19.55
Have foreign subsidiary	91.73	19.60
Competition: - perfect comp	73.76	9.34
Conduct R&D	87.47	15.33
Knowledge Intensity (KI): - above median	79.30	8.23
Management (MGMT): - above median	84.19	9.86
Quality of ICT in area: - bad	64.48	3.32
- mid	77.21	5.77
- good	81.41	9.32
- don't know	38.87	4.05
Total	76.40	7.46

Internet Uses

Internet Use	Weighted % with BB	Weighted % with fast BB
Firm has a webpage	90.20	11.48
Purchased G&S on internet	91.33	10.35
Entered new export market	91.80	14.13
% of sales made over internet:**		
- 0	70.66	5.50
- (0, 25]	93.15	11.68
- (25, 100]	82.63	20.75
% internet sales international:		
- 0	92.18	8.49
- (0, 25]	91.51	22.15
- (25, 100]	81.71	16.13
% sales from tourism:		
- 0	76.36	6.95
- (0, 25]	75.64	4.21
- (25, 100]	78.34	19.62
Total	76.40	7.46

Data: LBD

- Firms linked to LBD for value added (VA), employment (RME)
- Labour productivity (LP) cf 4-digit industry (2 yr smoothed)
- $\ln LP$ is approx normally distributed



Data: LBD

- Also use other LBD data:
 - Size (RME)
 - Age of firm
 - Location of firm (within groups of TA's)
 - Whether foreign-owned
 - Whether have foreign subsidiary
- Use LBD longitudinal properties to obtain lagged RME & LP for estimation
 - avoids endogeneity bias (BB adoption causing firm to grow)
 - & controls for past productivity affecting internet choice

Data: Knowledge Intensity

- High KI industries need good connectivity
- Form KI variables from whole BOS sample (3-digit level)
 - $KI2 = (\text{managers \& professionals} + \text{tech's \& assoc prof's}) / \text{total staff}$
 - Gives cardinal measure of KI (not just high or low; cf most intl measures)

Industry - 3 digit*	KI2**
Business Services - KI	0.7498
Services to Finance and Insurance	0.4805
Health Services	0.4422
Finance & Insurance	0.4220
Electricity, Gas & Water Supply	0.4122
Education	0.4096
Business Services	0.3912
Community Services	0.1493
Textile, Clothing, Footwear, Leather Mfg	0.1398
Accommodation, Cafes & Restaurants	0.1294
Services to Agric, Hunting and Trapping	0.1238
Wood & Paper Product Manufacturing	0.1226
Food Retailing	0.0999
Road Transport	0.0892

Data: Management Quality, et al

- Well-managed firms likely to have good connectivity
 - Form MGMT variable for each firm from 10 BOS questions on firm's HR practices
- Competition
 - Use BOS questions on market structure (perf comp vs other)
- Research & development
 - Use BOS question on whether firm conducts R&D

Methodology: 1

- Estimate whether BB adoption affects firm productivity
- Estimate model to predict whether firm adopts BB or not (probit)
 - Use propensity score matching
 - Match firms with BB to firms without BB according to PS from probit
 - 2 separate matching approaches (kernel & strata) for robustness
 - Check matched firms are statistically alike in all other respects
 - “Balancing hypothesis”
- Compare productivity differences across all matches:
 - Gives ATT (average treatment effect for treated firms)
 - i.e. estimated productivity differential due to BB adoption (vs ‘None’)

Methodology: 2

- Estimate whether BB type affects firm productivity
- Conduct ordered probit (fast, slow, none); find ATT's for:
 - Fast vs Slow
 - Slow vs None
- Raises issues of:
 - Regional variations (very few firms with fast BB in rural areas)
 - What to do with multi-site firms (which site)?

Regional Issues

- Cities generally have higher BB adoption than rural areas
- Form dummy variable based on 2001 population density:
 - HiDen = 1 for 14 TA's with $\text{pop}/\text{km}^2 \geq 214$ (Palm Nth) + Dunedin City
 - LoDen = all others
- Two estimation approaches:
 - Include HiDen as dummy variable with all firms in probits
 - Split samples with different estimates entirely for HiDen & LoDen TA's
 - Estimate ordered probit (fast/slow/none) only for HiDen
- Address multi-plant firms by:
 - Using full sample (attribute firm to largest RME site) $N \approx 6,000$
 - Using smaller sample, only for single plant firms $N \approx 4,000$
- In addition, ICT quality question measures local ICT quality

Predicting BB Adoption

- Estimate BB adoption on:

	<u>Sign:</u>
SIZE, SIZE ² (both lagged)	+ (but diminishing)
AGE	-
ICT-GOOD, ICT-BAD, ICT-DK	+, -, -
PERFECT-COMP	-
FOR-OWNED, FOR-SUBSID	+, +
R&D, KI2, MGMT	+, +, +
HiDEN	+
PRODUCTIVITY (lagged)	(-)
- Most variables significant predictors for most samples (exc. productivity)
- Balancing hypothesis passed for most equations
 - can legitimately match treated against untreated firms

Treatment Effects (ATT)

- Find significant treatment effects from adopting BB vs None
 - Approximately 10% (step) productivity improvement
 - Similar for full sample & single plant sample
 - Slightly larger for rural than urban (significant in both)
- First study internationally to estimate this impact
- No significant effects of fast vs slow BB
 - May be due to imperfect definition of fast BB
 - Or to smaller sample sizes
 - Or to insufficient time for benefits to flow through
 - &/or few firms in NZ yet able to fully exploit fast BB capabilities
 - Or to no material effects!

Conclusions

- Results imply importance of enabling firm BB access
 - of any form
- May be slightly more important in rural areas
 - Both urban & rural firms benefit
 - But no cost-benefit done here
- Jury still out on impacts of fast BB roll-outs
 - Must use judgement about future uses & risk of not having fast BB

Possibilities Going Forward

- Use BOS08 with 2nd iteration of ICT module
 - Longitudinal
 - Opportunity to observe actual transition into treatment
 - However number of transitioning firms may be small
- Examine if ATT's vary by industry, etc
- Examine if firms learn from others in region or sector