



Queensland

**The Economic Society
of Australia Inc.**

**Proceedings
of the 37th
Australian
Conference of
Economists**

**Papers
delivered at
ACE 08**



**30th September to 4th October 2008
Gold Coast Queensland Australia**

ISBN 978-0-9591806-4-0

Welcome

The Economic Society of Australia warmly welcomes you to the Gold Coast, Queensland, Australia for the 37th Australian Conference of Economists.

The Society was formed 83 years ago in 1925. At the time, the Society was opposed to declarations of policy and instead focused on open discussions and encouraging economic debate. Nothing has changed today, with the Society and the conference being at the forefront of encouraging debate.

This year we have a large number of papers dealing with Infrastructure, Central Banking and Trade.

Matters of the greatest global importance invariably boil down to be economic problems. Recent times have seen an explosion of infrastructure spending, after world-wide population growth has seen demand outpace aging supply. The world has become more globalised than at any time since World War I but the benefits of this (and the impact on our climate) has been questioned by some.

At the time of preparing for this conference we could not have known that it would have been held during the largest credit crisis since the Great Depression. The general public and politicians both look to central banks for the answers.

We are also very pleased to see a wide selection of papers ranging from applied economics to welfare economics. An A – Z of economics (well, almost).

Another feature of this conference is that we have gone out of our way to bring together economists from all walks of life, in particular from academia, government and the private sector. We are grateful to all of our sponsors, who are as diverse as the speakers.

The Organising Committee

James Dick
Khorshed Alam (Programme Chair)
Michael Knox
Greg Hall
Allan Layton
Rimu Nelson
Gudrun Meyer-Boehm
Jay Bandaralage
Paula Knight

Published November 2008
© Economic Society of Australia (Queensland) Inc
GPO Box 1170
Brisbane Queensland Australia
ecosocqld@optushome.com.au

Our Gold Sponsors



Keynote Sponsors



Unless we have specifically been requested to do otherwise, all the papers presented at the conference are published in the proceedings in full. A small number of papers will have versions that have also been made available for special editions of Journals, Economic Analysis and Policy, and the Economic Record. Authors will retain the right to seek additional publication for papers presented at the conference so long as it differs in some meaningful way from those published here.

Special Session Sponsors



The opinions expressed in the papers included in the proceedings are those of the author(s) and no responsibility can be accepted by the Economic Society of Australia Inc, Economic Society of Australia (Queensland) Inc, the publisher for any damages resulting from usage or dissemination of this work.

The Paper following forms part of - *Proceedings of the 37th Australian Conference of Economists*
ISBN 978-0-9591806-4-0

Internet Diffusion in Australia

Mei Wen

University of Sydney

First version: April 2006; This version: November 2007

Abstract: In this paper, state-quarterly panel data from the *Internet Activity Survey* conducted by the Australian Statistic Bureau are used to investigate the determinants of regional internet diffusion and the change in penetration rate. Both logistic function and the Gompertz model of technology diffusion are applied. It is found that Australian regional internet penetration rate and its changes are positively affected by per capita gross state product, negatively affected by the internet access costs, measure by consumer price index of audio-visual and computing equipment and consumer price index of audio, visual, computing and media services. Meanwhile the change in penetration rate in regions with higher initial penetration rate is smaller, *ceteris paribus*. While regional population size have a significantly positive effect on regional number of internet service provides, it does not significantly affect regional internet diffusion rate.

Key Words: logistic model, technology diffusion, internet access

JEL Classifications: O33, L86, O56, L80, L96

1 Introduction

Since the National Science Foundation (NSF) of United States opened up internet for commercial uses in 1990-1991, internet usage has been increasingly developing. From email systems for faster communication to online services including internet banking, airline ticketing, hotel booking, to online consumption of music, games, newspapers, magazines and other digital products, internet has become one of the most important platforms in Australians' daily lives. The number of worldwide internet users grew rapidly from several thousands in the beginning of 1990s, to more than 300 million in the end of the decade. By 2004, there were more than 700 million global internet users. In 2005, Australian broadband subscribers per 100 inhabitants reached 10.9 per cent with a total number of subscribers of 2,183 thousands, ranking at 17th among the OECD countries.¹

The fast global internet penetration is partly due to its commerce benefits such as cost savings from e-commerce and partly due to other social factors. While many articles documented significant reduction in transaction costs through e-commerce², the benefits become increasingly apparent to many internet users. The introduction of ATM and online banking saves customers' time substantially. When product sellers provide websites with online catalogues, consumers are able to quickly search for desired products, compare between close substitutes with information provided by different sellers and even order products online when electronic sales services are available. Indeed, with an internet connected computer, we are now able to purchase all manner of products electronically, ranging from music, books, flowers, airline tickets, and household electronics, to natural resources and machines. Meanwhile, online communication makes friends in long distance more closely related. Online auctions provides new platform of exchange. Emergence of many new types of professional intermediations reduces firms' and governments' procurement costs, which make B2B e-commerce grow much faster than B2C e-commerce. Meanwhile,

¹ See IDC (2005) and ABSa.

² See Borenstein and Saloner (2001), Lucking-Reiley and Spulber (2001), United Nations (2001, 2004), for example.

Australian productivity increase due to use of ICT technology and relevant innovations are also well documented in OECD (2003) and Productivity Commission (2004).

Commercially-related internet activities depend on the number of internet providers and increasingly more internet adoption. According to *Internet Activity Survey* conducted by Australian Bureau of Statistics (ABS, Sep. 2000 – Mar 2005), in March quarter of 2005, there were 689 Internet Service Providers (ISPs), 2.42 million access lines, and 5.98 million internet subscribers in Australia. Data downloaded reached 14,124 million MBs. While access to internet brings people numerous benefits, home and office access requires the purchase of computers and linkage to the internet while travelers and some domestic consumers may use internet in internet bars.

Using American semi-annual data from 1989 to 1997, Madden, Coble-Neal and Savage (2004) investigates determinants of internet penetration. It finds that US internet penetration is largely explained by internet costs (measured by index of real computer and information processing costs), real per capita gross domestic product, number of computers connected to the internet, and time trend. In their investigation of cross-country diffusion of the internet, Kiiski and Pohjola (2002) also finds that the observed growth in computer hosts per capita is best explained by countries' per capita GDP and internet access cost. As there is no similar study on the determinants of Australian regional internet diffusion yet, this paper is to use ABS's Survey data on quarterly internet activities to explore the determinants of state and territory internet penetration.

2 Development of Internet hosts

Since September 2000, ABS conducted 12 quarterly surveys on Australian internet activities. Most of the surveys were conducted in March and September quarters while there were also two surveys for the December quarter of 2000 and June quarter of 2001. The data reports quarterly internet activities including number of ISPs,

number of access lines, number of subscribers and data downloaded by state and territory. The survey data shows that while the number of internet subscribers has been steadily increasing, the number of internet hosts (ISPs) decreased from 718 in September 2000 to 689 in March 2005. This is closely related to the break of bubbles in IT sector in 2000. A simple regression of the log of regional ISPs on estimated regional population³ reveals that the log of regional ISPs is positively related to the log value of regional population size as shown in table 1. As basic infrastructure for internet connection, development of regional ISPs and increasing services provided by each internet service provider is a prerequisite for rapid development of internet activity. Although the total number of Australian internet hosts (ISPs) decreased from 718 in September 2000 to 689 in March 2005, regional number of ISPs is still positively correlated to regional population size with a general increasing population size. When considering changes of regional ISPs over time, it can be seen that the regional number of internet service providers tends to decrease since the 3rd quarter 2003, fixing the effect of regional population size as shown in the regression in Regression 1.

Regression 1 Determinants of Regional ISPs

Dependent Variable: Log Value of Number of Internet Service Providers				
Explanatory Variables	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-5.891919	0.301423	-19.54698	0.0000
Dummy for 2 nd quarter of 2005, 1 st and 3 rd quarter of 2004, and 3 rd quarter of 2003	-0.148982	0.055615	-2.678825	0.0087
Log(N)	0.728865	0.021251	34.29824	0.0000
Number of Observations	96			
R-squared	0.927044			
Adjusted R-squared	0.925475			
Log likelihood	-4.208394			
F-statistic	590.8687			
Durbin-Watson statistic	1.641510			

³ The population data is drawn from ABS*b*.

3 Regional Internet Penetration Rate

Similar to Madden, Coble-Neal and Savage (2004), a logit model is firstly adopted to investigate Australian regional internet penetration rate. In Madden, Coble-Neal and Savage (2004), semi-annual data from 1989 to 1997 was used to investigate the American internet penetration rate. Let PR be the number of computers connected to the internet via full-time, part time, direct or dial-up connections divided by the population. In the following logistic model

$$\ln\left(\frac{PR}{1-PR}\right) = \alpha + \beta_1 RPC_t + \beta_2 RY_t + \beta_3 N_{t-1} + \beta_4 T_{t-1} + u_t \quad (1),$$

they use real price of computers RPC , real per capita income RY , lagged value of network size N_{t-1} , the number of computers connected to the internet via full-time, part time, direct or dial-up connections, and the time trend T_{t-1} (catching technology change) to explain the American internet penetration rate. In this section, above-mentioned Australian internet quarterly activity survey data from September 2000 will be used to investigate regional (state and territory) internet penetration rate. Using the survey data on all internet subscribers of each state or territory, regional consumer price indices of audio-visual and computing equipment, regional consumer price index of audio, visual, computing and media services, we get the following Regression 2.⁴

According to Regression 2, Australian regional internet diffusion rate is positively related to per capita gross state product value, negatively related to regional consumer price index of audio-visual and computing equipment. Regional consumer price index of audio, visual, computing and media services also generates negative effect on regional internet diffusion rate while its cross effect with regional consumer price index of audio-visual and computing equipment is positive. In step-wise regression processes, it is found that the regional population size does not significantly affect regional internet diffusion rate, which does not show in the final regression result. With consideration of region dummies and survey period dummies, it is found that Queensland has the highest intercept,

⁴ Summary statistics of the variables used in this paper are given in Table 1 in Appendix.

followed by New South Wales and Victoria, then South Australia, Tasmania, ACT, and the last Western Australia. In addition, the regional penetration rate declines since 2004, *ceteris paribus*.

Regression 2 Determinants of Regional Internet Penetration Rate (1)

Dependent Variable: DEPI				
Explanatory Variables	Coefficient	Std. Error	t-Statistic	Prob.
Dummy for NSW and VIC	0.584946	0.113447	5.156095	0.0000
Dummy for Queensland	0.600537	0.119259	5.035584	0.0000
Dummy for South Australia	0.268014	0.082018	3.267724	0.0016
Dummy for TAS	0.196666	0.068949	2.852353	0.0054
Dummy for WA	-0.395182	0.042585	-9.279854	0.0000
Y	0.086341	0.012054	7.163150	0.0000
CPI_AVCEquip	-0.085274	0.015274	-5.583068	0.0000
CPI_AVCMservices	-0.010298	0.002720	-3.785343	0.0003
Cross-effect of the CPI of CPI_AVCEquip and CPI_AVCMservices	0.000551	0.000140	3.937096	0.0002
Dummy for 1 st quarter of 2005	-0.249976	0.087265	-2.864544	0.0053
Dummy for 1 st and 3 rd quarter of 2004	-0.214718	0.062382	-3.441965	0.0009
Number of observations		96		
R-squared		0.800918		
Adjusted R-squared		0.782611		
Log likelihood		69.12791		
F-statistics		43.75060		
Durbin-Watson statistics		1.950888		

To further confirm that the effect of the above factors, a model similar to the Gompertz model in Kiiski and Pohjola (2002) is investigated. Let PR_{it} be the ratio of regional internet subscribers to regional population in state i at time t and PR^*_i be the equilibrium level of internet penetration rate of region i . Kiiski and Pohjola (2002) argue that the equilibrium level of internet hosts per capital is a function of at least one basic demand-side variables, e.g. the level of income Y_{it} and the cost of internet access P_{it} in country i . As Gompertz model of technology diffusion specifies that change in the adoption rate over time is a kind of adjustments toward equilibrium, hence, the following model

$$\ln PR_{it} - \ln PR_{it-1} = \beta_{i0} + \beta_{i1} \ln Y_{it} + \beta_{i2} \ln P_{it} + \beta_{i3} \ln PR_{it-1} \quad (2)$$

is specified for testing. Similar to the logistic model, it is expected that $\beta_{i1} > 0$, $\beta_{i2} < 0$, and $\beta_{i3} < 0$. Using chain value measure of gross state product as Y_{it} , consumer price index of audio, visual and computing equipments as P_{it} , I get the following Regression 3.

Regression 3

Determinants of Internet Penetration Rate (2)

Dependent Variable: Log(PR) -Log(PR_1)				
Explanatory Variable	Coefficient	Std. Error	t-Statistic	Prob.
log value of $PR_{i,t}$ for consecutive quarterly observations	-0.458818	0.073637	-6.230779	0.0000
log value of $PR_{i,t}$ for observations quarterly observations with half a year survey interim	-0.400733	0.048665	-8.234588	0.0000
log value of $Y_{i,t}$ for consecutive quarterly observations	0.026720	0.035339	0.756104	0.4520
log value of $Y_{i,t}$ for observations quarterly observations with half a year survey interim	0.108515	0.026586	4.081639	0.0001
CPI_AVCEquip for consecutive quarterly observations	-0.198929	0.041338	-4.812265	0.0000
CPI_AVCEquip for observations with half a year survey interim	-0.226122	0.031283	-7.228353	0.0000
Dummy for 3 rd quarter of 2004	0.051894	0.017909	2.897573	0.0050
Dummy for 3 rd quarter of 2003	0.035571	0.018290	1.944842	0.0556
Dummy for 1 st quarter of 2003	0.101217	0.018429	5.492115	0.0000
Dummy for 3 rd quarter of 2002	0.048282	0.018657	2.587804	0.0116
Dummy for NSW	0.040507	0.016117	2.513380	0.0142
Dummy for VIC	0.064395	0.016804	3.832079	0.0003
Dummy for QLD	0.035167	0.016361	2.149450	0.0349
Dummy for NT in 1 st and 3 rd quarter of 2004, 1 st and 3 rd quarter of 2003, and 3 rd quarter of 2002	-0.234225	0.026791	-8.742525	0.0000
Dummy for ACT in 3 rd quarter of 2004, 1 st quarter of 2003, and 3 rd quarter of 2002	0.199278	0.030621	6.507966	0.0000
Number of observations		88		
R-squared		0.766381		
Adjusted R-squared		0.721578		
Log likelihood		159.1745		
F-Statistics		19.83798		
D-W Statistics		2.020678		

In Regression 3, it can be seen that change in the log-value of penetration rates is negatively related the lag value of last period penetration rate. The effect is significant at 0.01 level no matter the survey interim is three months or six months. Meanwhile, the log value of one period lagged regional per capita gross state product generates positive effect on the dependent variable, this effect is highly significant for consecutive quarterly observation, but insignificant for observations with half a year survey interim. Meanwhile, consumer price index of audio, visual, and computing equipment significantly and negatively affect the change in the log-value of penetration rates. The

magnitudes of the effect are different for consecutive quarterly observation and observations with half a year interim. Observations with a half a year interim show a stronger negative effect. In addition, there are shifts in constant during survey periods and over states shown by the effect of survey period dummies, state dummies and some cross effects. Compared with Regression 2, the structural changes show that Victoria has the highest constant in changes of the internet penetration rate, follow by New South Wales, and then Queensland.

4 Concluding Remarks

The above empirical studies show that Australian regional internet penetration rate and its changes are positively affected by per capita gross state product, negatively affected by the internet access costs, measure by consumer price index of audio-visual and computing equipment and consumer price index of audio, visual, computing and media services. Meanwhile the change in penetration rate in regions with higher initial penetration rate is smaller, *ceteris paribus*. While regional population size have a significantly positive effect on regional number of internet service provides, it does not significantly affect regional internet diffusion rate.

References

- Australian Bureau of Statistics (ABSa) (Sep. 2000 – Mar 2005), *Internet Activity* (Australia), Canberra: Australia Bureau of Statistics.
- _____ (ABSb), *Population: Australian States and Territories*, www.abs.gov.au.
- Borenstein, S., Saloner, G., (2001), “Economics and electronic commerce”, *Journal of Economic Perspective*, 15, 3-12.
- International Data Corporation (IDC) (2005), *40 Years of IT - Looking Back, Looking Ahead*, an IDC special edition of executive white paper, www.idc.com.
- Kiiski, a. and M. Pohjola (2002), “Cross-country diffusion of Internet,” *Information Economics and Policy*, 14, 297-310.
- Lucking-Reiley, D., Spulber, D. F., 2001. Business-to-business electronic commerce. *Journal of Economic Perspective* 15, 55-68.
- Madden, G. Coble-Neal, G. and S. J. Savage (2004), “United States Internet Penetration,” *Applied Economic Letters*, 11, 529-532.
- OCED (2003), *ICT and Economic Growth: Evidence from OECD countries, Industries and Firms*, OECD, Paris
- Productivity Commission (2004), *ICT Use and Productivity: A Synthesis from Studies of Australian Firms*, Canberra: Productivity Commission Research Paper.
- United Nations (2001, 2004), *E-commerce and Development Report 2001* (2004), United Nations Conference on Trade and Development, www.unctas.org/ecommerce.

Appendix

Table 1 Summary Statistics

Variable	Definition	Sample Size	Mean	Standard Deviation
LnISPs	Log value of Internet service providers	96	4.344605	0.940901
s	Log value of the number of internet subscribers ('000)	96	-1.487572	0.198755
s ₋₁	Log value of the one-period lagged number of subscribers ('000)	88	-1.507291	0.187721
N	Regional Population from ABS2	96	2461168	2238943
PR	Ratio of the regional number of internet subscribers including dial-up and non dial-up to regional population	96	0.230573	0.049406
<i>l</i>	Log(PR/(1-PR))	96	-1.1223275	0.265334
CPI_AVCEquip	Consumer price index of audio-visual and computing equipment	96	48.02917	9.160498
CPI_AVCMservices	Consumer price index of audio-visual, computing and media services	96	106.4771	6.233449
cpi_avcequip	Log value of CPI_AVCEquip	96	3.850962	0.213219
cpi_avcmservices	Log value of CPI_AVCMservices	96	4.666227	0.058731
Y	Per Capita Gross state product , chain value measure (dollars)	96	11201	3105