Modelling Critical Mass for E-Commerce: the case of Hong Kong

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Part One: Introduction

The major economies of the world are on the threshold of electronic commerce, the ramifications of which are wide-ranging, affecting everything from the tax base of governments to content issuespornography. Enabling the diffusion of electronic commerce are new information and communications technologies (ICTs) and in particular the Internet. As a recent OECD report put it: 'Information and communication technologies (ICTs) are a pillar of the knowledge-based economy. How countries adopt and master ICT is thus key to their future economic performance… The Internet is a key driver of ICT, with more and more households and companies connecting up and using it.' [2]

The focus of this paper is on electronic retailing, or shopping online, and upon those households who are enabled to do this because they have a home computer which is connected to the Internet, and who make transactions online. Shopping online does not imply that the retailer is local, on the contrary in these early days of online retailing US companies stand out globally, a defining example being Amazon.com.[3] However, the paper assumes that as a local 'critical mass' of online *frequent* purchasers is reached, local online retailers will respond with more well-designed websites, with customer-friendly search and online transactions procedures, and with efficient delivery and after-sales services. All of these will be required to make 'etailing' - as it is somewhat inelegantly termed - fly. Demand and supply will then feed each other, bringing about changes in both consumer behaviour and in the structure of the retailing sector.

The purpose of this paper is to offer an approach to modelling the build-up to critical mass of 'frequent transactors'. The paper draws upon data collected by the Telecommunications Research Project of the University of Hong Kong (www.trp.hku.hk) to construct a diffusion model, not so much to *pre*dict when critical mass will be reached, although the paper does suggest this point will arrive in Hong Kong early in 2003[4], but to provide a benchmark for *postdiction*. How wrong the forecast turns out will be less important than how and why it was wrong. Ideally hindsight is perfect, and it is therefore an ideal basis on which to improve future models and our understanding of the process.

Forecasts of e-commerce abound. They arise from numerous sources, but most frequently from consultancy reports, and they differ widely in their prognostications. The

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[2] OECD Science, Technology and Industry Scoreboard 1999 – Benchmarking Knowledge-based Economies: Summary, p.2; see www.oecd.org//dsti/sti/stat-ana/prod/scorebd_summ.htm. The US Government estimates between 1995-98 ICTs accounted for 8% of GDP but were responsible for 35% of real US economic growth; see *Emerging Digital Economy ll*, US Department of Commerce, June 1999.

[3] According to *The Economist's* 'E-Commerce Survey', 26 February 2000, 'three-quarters of all e-commerce currently takes place in the United States. The country also accounts for 90% of commercial websites.' (p.33)

[4] In an earlier version of this paper using data from 1999 the date was 'after 2004'.

reasons are not difficult to find. Most reports are based either on time series extrapolation, or upon survey work, for example using Delphic techniques to interview business or industry specialists, and then asking them to compare their forecasts with the forecasts of their peers.[5] Extrapolation has a number of obvious problems, such as lack of data stretching sufficiently far back, and sudden shifts in parameters, for example the rapid appearance of a new technology such as DoCoMo's *iMode* mobile phone which, in the space of just one year only a few months, reached over 104 million Japanese youngsters enabling them to download music and join online 'instant messaging' services for personal communications. Another problem for extrapolation is to take account of complementary factors, such as the spread of credit cards and other forms of online payments and the attitude of local banks towards supporting smaller merchants with their online payments systems. These factors, and many others, can be accommodated in the forecasting modelsanalysis, but analysisit then becomes a major task and not a cost-effective one for commercial companies. The same problems underlie the qualitative methods used by interview-based surveys, but impressionistic approaches are more useful as indicators of intentions by the companies interviewed, and of the pace and direction of change, than they are for macro modelling.

By contrast, official estimates of e-commerce tend to be more circumspect, more policy-focused, and in many cases more methodologically concerned. A fundamental issue that always arises is the question of definitions.[6] Broadly speaking, a distinction is drawn between e-business and e-commerce, where the former refers to the entire range of network relationships that constitute an organization (internal) and its place in the world (external). So, for example, enterprise resource management (ERP - internal) or supply-chain management (external) or 'managed customer relationships' (external) are favourite topics of discussion in seminars on e-business. E-commerce is used to mean transactions activity, whether the payment itself is online or offline. In the case of offline transactions, the term e-commerce can clearly cover a multitude of long-established forms of commercial activity, indeed in principle any occasion when a telephone or a facsimile machine is used to place an order.

The more embracing the definition, the less meaningful is its measure as a means of capturing change in the way people or companies or institutions organize themselves and their relationships with the world about them. One way around this problem is to segment the economy into different categories of business or commerce. The useful shorthand used to describe these various activities goes along the lines: intermediate transactions along the value-chain or business-to-business (B2B), retailing or business-to-consumer (B2C), government procurement or business-to-government (B2G), government services as either government-to-business (G2B) or government-to-consumers or citizens, such as the payment of taxes online or applications for driving licences (G2C), and finally, the activities of citizens either as consumers, for example in e-auctions, or as communities,

[5] Organizations like PC Meter in the US undertake tracking by installing software agents in the home computers of a sample population.

[6] Definitions was a concern of *The Measurement of Electronic Commerce: ISI Cutting Edge Conference*, 6-8 December 1999, hosted by the Singapore Department of Statistics (DOS) and the Centre for Management of Innovation and Technopreneurship at the National University of Singapore, under the auspices of the International Statistical Institute (ISI). For papers, see www.singstat.gov.sg/EC, and especially James Wong and Eric Lam 'Measuring Electronic Commerce in Singapore: Methodological Issues and Survey Findings', DOS.

for example baby-sitting circles involving payments (C2C). These distinctions can then be used to analyze the structure of the Internet economy or 'networked economy'.

Using a four-tiered structure for Web activities – an Internet infrastructure layer, an applications infrastructure layer, an intermediate/market making layer and an Internet commerce layer – a 1999 study by the University of Texas, sponsored by Cisco Systems estimated a much larger than previously recorded Internet economy in the U.S. of US$301 billion, equivalent to the world's 18th largest economy just behind Switzerland. Business-to-business (B2B) transactions over the Net inevitably dwarf business-to-consumer (B2C) transactions [7] - in America by a ratio of 70:30[8] - but this fact masks the potential importance of B2C or electronic retailing, and may partly explain why 'etailing' could be underestimated by studies and surveys. The report makes the point that 'with the exception of online grocer Peapod, online grocery sales do not make up the top-100 Internet sales list. Nonetheless, we found that online grocery sales already constitute a large volume of business, a fact that has been ignored in previous studies.' [9] Usually the point implied by those who emphasize that B2B greatly exceeds B2C is that the early and *large-scale* adoption of Internet trading is by corporate business. For many it was a natural extension of electronic data interchange, or EDI.[10]

This paper focuses on the activities of households as consumers, as online transactors. The paper originated as a data-collecting exercise in 1994 to benchmark the percentage of households in Hong Kong who had a home computer and what proportion of these were online. Online in 1994 hardly meant the Internet. It meant being on a proprietary network, such as CompuServe, or a private company network from home or a university network. Going online meant either using an information service, for example Hong Kong Telecom's Datapak for online equity prices and horseracing results or, more likely, a bulletin board. Further data was collected for 1996 and 1998, and data from surveys conducted by the Chinese University of Hong Kong in 1991 and 1993 was used to construct a time series. Later, another data point for 1999 was added. A logistic curve is derived and used to project saturation of the computer market among Hong Kong households. A further logistic is derived from the percentage of households with computers that are also online, and it is concluded that by 2002 this statistic will drive the online population towards critical mass. This is the enabling factor. Finally, in the absence of reliable data, an assumption has to be made as to the numbers of *frequent* transactors and their growth rate. This is the realization factor, and on this basis critical mass is

[7] They will always do so for purely national accounting reasons. The value of final consumption is the sum total of intermediate value-added business activities that constitute the value-chain and only by double counting or taking gross estimates could B2C ever equal B2B. 'In practice, though, most Internet commerce estimates are based on sales or revenue data. Those revenues include costs of doing business thus resulting in "double counting" as the output of one e-commerce industry, e.g. advertising or payment over the Internet, is included in the "sales" figures of other e-commerce industries.' OECD 'Defining and Measuring Electronic Commerce: Towards the development of an OECD Methodology' *The Measurement of Electronic Commerce: ISI Cutting Edge Conference*, 6-8 December 1999, International Statistical Institute, p.2. See www.singstat.gov.sg/EC

[8] Morgan Stanley using IDC's total e-commerce forecast US$117 billion by 2000, broke this down into US$37 billion B2C and US$80 billion B2B. *The Internet Retailing Report*, 28 May 1997, table 4-4.

[9] "The Internet Economy Indicators' University of Texas, www.InternetIndicators.com/features.htm (p.5)

[10] This implies a portion of B2B is simply a transfer of existing business to an electronic form. Without taking this into account the growth contribution of B2B in the macroeconomy could be over-estimated, but the issue is complex because electronic communications are likely to be more productive than the business processes they substitute.

projected from 2004 onwards. Combined, these are the three components of the model presented in part three of this paper.

Part two of the paper provides some circumstantial evidence for the assumption of frequent transactor growth. It examines available comparative data on home computers and consumer purchasing online. What emerges quite strikingly are global similarities, but also the paucity of good data on ‘online shopping’. Predictably, the most detailed data comes from the US, followed by Europe and Australia, but Asia has also generated data to give us a broad picture up to 1998-99. Part four considers the development of e-commerce in terms of the emergence of complementary factors which need to be further taken into account if a more sophisticated understanding of the factors driving e-commerce are to be understood. Part four also selectively reviews recent literature on this subject.

Part Two: The Issue of Critical Mass

Forecasts of e-commerce are abundant. After reviewing 38 of them for OECD economies, Michael De Kare-Silver reaches the conclusion that electronic shopping is ‘forecast to reach critical mass and start having a serious impact by around 2005’ on the basis that the ‘mean date that emerges from this combination of research is around 2005.’ But from his own presentation of the data it would seem that he confuses the mode with the mean, which lies much further out.[11]

The Economist’s ‘E-Commerce’ survey 26 February 2000, cites Forrester’s estimate of B2C transactions in America for 1999 at around US$20 billion, and their forecast of US$184 billion by 2004, a CAGR of 56 per cent. Ernst & Young’s *Global Online Retailing* (January 2000)[12] reported a similar estimate for America in 1999 of between US$25-$30 billion, and forecast a doubling during 2000 to US$45-$50 billion. If these two CAGRs are correct, it seems at best like a steady growth than take-off. Indeed, the earlier *Second Annual Ernst & Young Internet Shopping Report*, 1998, ‘a study released by shop.org and Boston Consulting Group’, reported for ‘the last six months of 1998, online sales grew 200% with predictors that overall sales for the year would come in at between US$10 - $13 billion.’ But the shop.org report also pointed out that ‘Online revenues generated by North American-based companies for the first six months of 1998 were US$4.4 billion – less than 1% of overall retail revenue in North America.’ [13] Goldman Sachs, cited in *The Economist’s* survey, forecast ‘electronic shopping could account for 15 – 20% of retail sales’ in America by 2010. Again, this suggests a steady, rather than a staggering, rate of annual increase in North America, dropping from 200 per cent in late 1998 to an average below 30 per cent for the decade ahead.

Turning to Asia, a report by the Boston Consulting Group estimates Asia-Pacific’s e-commerce retail revenues for 1999 grew by 200 per cent to US$2.8 billion, or to just 0.1 per cent of the total retail sector. This compares with their estimates of US$3.5 billion for

[11] Michael De Kare-Silver (2000) *e-shock 2000*, Macmillan Business, London, pages 1 and 65. Unfortunately, the bar chart on page 66 that accompanies the text suggests otherwise. While it is presented in summary form only, and indeed shows the *modal* point as 2005, it also seems to show that more than 50 per cent of the forecasts hover around 2010 or much later, including over 10 per cent forecasting ‘never’.
[12] See www.e&y.com/Global_Online_Retailing
[13] See www.shop.org/research/highlights.html, p.7, p.4 and p.2.

Europe and US$36.6 billion for the US, 1.2 per cent of the American retail sector. But 94 per cent of the Asia-Pacific total was accounted for by just three economies: 54 per cent by Japan, 25 per cent by South Korea and 15 per cent by Australia. Despite these lop-sided statistics the report argues that with 'more than 10 million consumers having already bought online, and Internet use surging, the market is reaching critical mass.'[14] By contrast, the Gartner Group forecast for the fourth quarter of 1999 total consumer spending over the Internet in Asia-Pacific as-a-whole at US$845 million, with Japan now accounting for 65 per cent, Australia 15 per cent, and South Korea down to 4.8 per cent, behind Taiwan's 5.6 per cent.[15]

2.1 Households with Computers and Population Online

The first logical first step towards a critical mass of online transactors is getting online. Table 1 provides a comparison across a number of national economies of the percentage of households with at least one computer, and the percentage of the population who are thought to be users of the Internet. In reality, this latter statistic is a better guide to access than to usage, where access may be outside the home.[16] As the variety of data sources cited indicates, there is no systematic or unified method data collection - for example, by household expenditure surveys - across economies.

Table 1

Percentage of Households with Computers and Population Online

Economy	**% of Homes with Computers**	**% of Population Online**[1]
Australia	47 per cent [2](1998)	24.2 per cent [2] (1998)
Canada	54 per cent [3] (1998)	25.4 per cent [4](1999)
Hong Kong	34.per cent[4a] - 48.8 per cent [4b]- >50 per cent [4c] (1998) – 58.9 per cent[4b] (1999)	13.4 per cent [1] (1998) - 18.5 per cent [4c](1999)
Japan	25.2 per cent[5a] (1998) – 32.6 per cent [5b] - 42 per cent [5c](1999)	11.1 per cent [1] (1998) – 15.9 per cent (1999)[5d]
Malaysia	< 9 per cent [6]	3 per cent [1] (1998)
Singapore	41 per cent[7a] (1998) – 58.9 per cent[7b] (1999)	32 per cent [7c](1998)

[14] *E-tail of the Tiger: a NetBizAsia Report* by the Boston Consulting Group. See www.bcg.com/asia_online/findings.asp. The estimate of US$1.5 billion B2C for Japan is up from US$0.6 billion in 1998 estimated by the Ministry of International Trade and Industry (Miti), *Financial Times*, 30 November 1999, p.29.

[15] *South China Morning Post - Technology Post*, 5 October 1999, p.1

[16] We do have data from Australia showing that 71 per cent of Internet shoppers in the 12 months to May 1999 'were at home when making purchases or orders via the Internet' *8147.0 – Use of the Internet by Householders, Australia*: See www.abs.gov.au/websitedbs/D3110122. Estimates and projections from IDC of the proportion of total e-commerce in the US taking place from home declining from 44 per cent in 1995 to 32 per cent by 2000. (Quoted by Morgan Stanley *The Internet Retailing Report*, 28 May 1997, table 4.4.)

South Korea	15 per cent [8] (1997) – 37 per cent (1999) [10]	6.7 per cent [1] – 22 per cent [9] (1999)
Taiwan	34.6 per cent [110] (1998)	14.3 per cent [1] (1999)
UK	29 per cent [121] ('97-98) – 36 per cent [132] (1998) - 41 per cent [143] (1999)	18 per cent [1] (1998)
USA	54 per cent [154] (1999)	30.7 per cent [1] (1999)

Sources: 1. nua.iec/surveys/how_many_online/n/n; 2. Australian Bureau of Statistics; 3 AC Nielsen; 4a. Census & Statistics Department; 4b. Telecommunications Research Project; 4c. AC Nielsen; 5a. Economic Planning Agency and www.oecd.org//dsti/sti/stat-ana/prod/scorebd_toc.htm; 5b. www.mpt.go.jp/data/communications/trend_survey1998_1-1a.html; 5c. www.ida.gov.sg and Nomura Research Institute, May 1999; 5d. Nielsen/NetRatings Japan Inc. www.netratings.co.jp, *The Internet White Paper 1999*, The Internet Association of Japan; 6. Estimated from figures supplied by A.C.Nielsen; 7a. www. ec.gov.sg/ec_centre.html; 7b. www.ida.gov.sg; 7c.Percentage of adults, *Survey on General Public*, National Computer Board; 8. Ministry of Information and Communications: http://webdb.mic.go.kr:8080/english/library/main63.html; 9. Far Eastern economic Review, 17 February 2000, p.21; 10. *Korea in the New Economy*, Credit Suisse/First Boston, 16 May 2000; 110. D-G of Budget Accounting and Statistics, Executive Yuan, ROC: www.dgbasey.gov.tw/dgbas03/englisg/stat/satur.htm; 112. Government: www.statistics.gov.uk/stats/ukinfigs/stand.htm; 132. wwww.jup.com/research/eis/samples/reports/9903/eis21-05.html; 143. www.e&y.com/Global_Online_Retailing; 154. Pathfinder Study by Arbitron NewMedia reported at www.cyberatlas.com/big_picture/demographics/arbitron.html. ;

Despite the obvious disparities in these estimates, it seems evident that the high-income economies represented in the table are all showing signs of rapidly approaching or exceeding fifty per cent of their households having a computer.[17] Furthermore, they are reaching or passing the twenty-to-thirty per cent proportion of their population who have Internet access.[18] Even more to the point, the diffusion of Internet access seems to be accelerating. Singapore provides good evidence of this. 'In 1996, only 9 per cent of Singapore households had Internet access. Today, more than 42 per cent of households have Internet access.' [19] The same report points out 'In Australia, 22 per cent of households have Internet access, while in Japan the penetration rate stands at 13 per cent. In the US according to Infobeads, June 1999 & Greenfield Online Inc., Oct. 1999, 40 per cent of the households have home Internet access.'

The global similarities are striking. In dozens of government agency, research and consultancy reports similar demographics emerge. Age: the young and the younger generations; gender: males as early adotpers, females in the early majority; socio-economic: initially the higher-income private residential households; education: initially the higher educated. But the speed of the diffusion process in the higher-income economies does seem to democractise Internet access and Web usage. At least this seems

[17] According to Jupiter Communications, by year-end 1998 an average of 32 per cent of households across Western Europe had a computer at home. The average for the small advanced economies of Denmark, the Netherlands, Finland, Sweden and Norway was 50 per cent, followed by Switzerland, Germany and Austria all above 40 per cent. The four Scandinavian economies also led the way with over 20 per cent of households online, followed by the Netherlands, Germany, Switzerland and the UK between 15 per cent and 11 per cent. See www.jup.com/research/eis/samples/reports/9903/eis21-05.html

[18] Estimates for Malaysia by AC.Nielsen's *Internet Users Survey* in 1999 suggest 12.8 per cent of persons 15 years and above have a computer at home. The 1991 census gives average family size as 4.3 persons, so if these persons were distributed evenly across households, which is unlikely, the (maximum) household penetration rate would be just under 9 per cent. Estimates for South Korea and Taiwan would be far higher for the principal cities.

[19] 'IT Household Survey 1999: Media Releases/2000/20Jan2000b' www.ida.gov.sg

to be true of online consumer purchasing, according to the Ernst & Young *Global Online Retailing* report (January 2000). 'Wherever we look in the world, we see that men are the early adopters of Internet shopping. That was also true in the U.S. two years ago, yet as e-shopping surges in America, women are taking their rightful place at the mouse pads. … They're already at 50 per cent of online shoppers in the U.S. – far above Australia's 41 per cent, Canada's 38 per cent, UK's 31 per cent, France's 24 per cent, and Italy's 15 per cent.' [20]

2.2 Transactors and the Frequency of Transactions

Despite the dearth of reliable and systematic data for Asia, some data is available. The AC Nielsen worldwide *Netwatch* (1999) survey based upon quota sampling techniques, interviewing persons aged 15 years and above, offers one indicator of online transactions. Table 2 selects details from Asian economies covered by the survey. Two sets of sample populations are involved, a sample of 15 years old and above who are used to estimate the percentage currently using the Internet. The sample sizes varied from 797 in the Philippines to 9,975 in Malaysia. And a sample of 15 years old and above who currently use the Internet who are used to estimate the percentage making different uses of the Internet, *including online purchase*. Here the sample sizes varied from 50 in the Philippines to 1,451 in Hong Kong**.**

Table 2

Quota Sampling of 15 Year Olds and Above Who Use the Internet

Country	Usage of Internet % (Currently Use)[1]			Purchase % Product/Service[2]		
	97	98	99	97	98	99
China (Top 3 cities)	2	5	7	6	7	7
Hong Kong	12	14	16	14	12	12
Indonesia	1	1	3	15	7	9
Malaysia	5	7	8	8	8	8

[20] See www.e&y.com/Global_Online_Retailing, p.11. It is tempting to see an explanation here of the early and later patterns of online shopping. The male gender bias towards early adoption of Internet access *as a 'technology'* being reflected in technology items, such as computer hardware and software, games, perhaps automobiles, and commercial activities such as buying stocks information and trading. The gradual *feminization* of the Web turns it into a place to purchase products for household and family use, and for building communities-of-interest, such as shopping groups, child-minding or health care groups. This perspective would offer a view that goes beyond an explanation that simply relies upon the characteristics of the products themselves, whether they are '"high-touch" and "low-touch"' 'E-Commerce Survey' *The Economist* 26 February 2000, p.9. From another perspective, Lee Sproull and Samer Faraj ('Atheism, Sex and Databases: The Net as a Social Technology') make the point that the metaphors of the early 1990s which portray the Net in terms of an 'information tool' for individuals are insufficient to grasp the growing social role, and therefore the community element, in Net usage. See Brian Kahin and James Keller, eds. 1995, *Public Access to the Internet, MIT Press*, Massachusetts, USA.

Philippines	2	8	Na	13	12	Na
Taiwan	11	13	14	5	6	6
Thailand	1	1	2	6	6	6

Source: *Netwatch* (1999) AC Nielsen, quota sampling, aged 15 and over. 1. Percentage of sample size representing population 15 years and above; 2. Percentage of sample size representing Internet users 15 years and above.

If we treat sample two as a sub-set of sample one we can get a sense of the growth of purchasing online 1997-99. For example, in the case of China (urban) the percentage of respondents reporting current Internet usage rose from 2 per cent to 7 per cent, while the percentage of respondents reporting usage *and* reporting they had purchased online rose from 6 per cent to 7 per cent. Taken at face value, this means an increase in current Internet users aged 15 years and above who have purchased online from 0.12 per cent to 0.49 per cent of the population. [21] In the case of Hong Kong, the overall rise is from 1.68 per cent to 1.92 per cent. This compares with 1.3 per cent in the 1998 TRP survey, which was based on households. See Part Three. If we use the concept of Internet households, this could imply a higher percentage of individuals in the total population had purchased online.

The other increases range from 0.4 per cent to 0.64 per cent for Malaysia, from 0.26 per cent to 0.96 per cent for the Philippines (1997-98), from 0.55 per cent to 0.84 per cent for Taiwan, and from 0.06 per cent to 0.12 per cent for Thailand. Only Indonesia records a fall, from 0.15 percent to 0.04 percent, but 1997-99 have been years of economic disaster for Indonesia. Although these figures need to be treated with considerable caution, their range suggests that all these economies are at the early ‘innovative’ stage of electronic commerce, but already are showing signs of high growth rates. What they do not show is the frequency of purchase, but the assumption is that one purchase leads to another with increasing velocity, so somewhere there is a logistic lurking behind the dynamics of purchasing.[22]

Numerous sources provide insights into how the transition from early adoption of Internet to majority usage begins to translate into online retailing. Table 3 selectively provides comparative estimates of the percentage of households with a computer, who *are* online, who *shop* online, and who are *frequent* shoppers.

Table 3

[21] The China Internet Network Information Center (CNNIC) estimated 8.9 million individual users by end-1999, up from 2.1 million a year earlier. 8.8 per cent of 200,000 people surveyed had made a purchase over the Web during year. Wee and Ramachandra claim 12.3 per cent of their sample of China Internet users made online purchases, but their random sampling was of subscribers to ISPs in China who co-operated with them, and if these were only a sub-set of all ISPs in China their random sample is unlikely to be representative of the entire Internet-using population. See Wee Keng Neo and Ramesh Ramachandra, 1999, ‘Cyberbuying in China, Hong Kong and Singapore: Tracking the profile of on-line buyers’; paper delivered to The Measurement of Electronic Commerce: ISI Cutting Edge Conference, Singapore, 6-8 December, 1999; www.singstat.gov.sg/EC

[22] Some evidence of this proposition comes from Christos Emmanoulides and Kathy Hammond (1999) ‘Internet Usage in the UK: Predictors of Active Users and Frequency of Use’ Centre for Marketing Research, London Business School, Working Paper 99-802. See below.

Percentage of Households with PCs, Online and Making Purchases over the Internet

Country	**% with PC**	**% online**	**% shopping online**	**% frequency of shopping over 12 months**	
				< 10	**10 or more**
Australia [1]	47	22	5	80	20
Canada [1]	56	21[2] – 39	9	75	15
China (Urban) [3]	11.9	20.4	4.6	na	na
Hong Kong [4]	48.8	26.2	1.3 – 7.2 [5]	na	na
Japan [6,7]	42	13	8 [8]	na	na
Singapore [9]	59	42	2.7	78 [10]	22 [10]
UK[1]	41	29	10	75	15
USA[1]	53	34 – 40 [9]	17	61	39

Sources: 1.www.e&y.com/Global_Online_Retailing; 2. Paper: Spectrum information technologies & telecommunications sectors industry, quoted www.ida.gov.sg; 3. Xueping Du (1999) 'Internet Diffusion in China' *Prometheus*, v.17.4, pp.405-420; 4. www.trp.hku.hk; 5. Estimated from AC Nielsen data in text below; 6. www.ida.gov.sg; 7. Ministry of Posts and Telecommunications, White Paper, 1999; 8. Source mislaid; 9. Five and above or below, over previous 6 months; 10. www.ida.gov.sg; and Infobeads, June 1999 and Greenfield Online Inc., October 1999.

The U.S. clearly stands out by having possibly 40 per cent of households online, and, according to these estimates, 17 per cent of households making online purchases, up from 10 per cent in 1998, and 7 per cent in 1997. [23] Of these, almost 40 per cent are 'frequent' transactors as defined by making ten or more purchases within a 12-month period, compared with 17 per cent in 1998 and 4 per cent in 1997.[24] Data for Australia is derived from the quarterly *Population Survey Monitor* published by the Australian Bureau of Statistics. Tim Power (1999) reports that in the twelve months to May 1999, 650,000 or five percent of Australian adults had used the Internet to purchase or order goods or services online, compared to 347,000 in 1998, and that 22 per cent of them had made five or more purchases over the previous year.[25]

In the case of Singapore, the Infocomm Development Authority (IDA) choose to investigate purchases over the previous six months, so here the table distinguishes between online households making five or more purchases. The frequency of transactions of those who do transact online in Singapore is comparatively high, as might be expected in a small economy where the government is actively promoting Internet usage as well as

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[23] According to *The Second Annual Ernst & Young Internet Shopping Report* which cites research by Shop.Org sponsored by the Boston Consulting Group (wysiwyg://168/http://www.shop.org/research/default.htm).

[24] See previous footnote. A year earlier almost thirty per cent of 645 respondents to the GVU *Tenth WWW User Survey* in 1998 of online Americans said they purchased over the Web on average once a month, and a further 17 per cent reportedly more frequently than that. See www.gvu.gatech.edu/gvu/user_surveys/survey-1998-10

[25] 76 per cent had also paid online. Interestingly, compared with 1998 when 28 per cent purchased only from Australia, in 1999 that figure rose to 41 per cent. Tim Power 'Electronic Commerce Statistics Collected by the ABS and Methodological Issues Encountered' ABS, paper delivered to *The Measurement of Electronic Commerce: ISI Cutting Edge Conference*, Singapore, 6-8 December, 1999; www.singstat.gov.sg/EC

access and content, but only a very low percentage of all Singaporean households (2.7 per cent) do in fact transact on the Net.[26] As the IDA puts it: ‘The main reason cited for not doing so is the preference of going to the physical retail shops for variety of products and comparison of prices (35%). This is not surprising given the love of shopping as a favorite leisure activity, the easy access to and abundance of retailing outlets among the population. Another concern is the lack of trust in submitting credit card details over the Internet expressed by 11%. This implies that the security issue will always be a concern for those who have never shopped on-line but a hurdle which can be easily overcome once they have tried to purchase on-line.’ [27] The report concludes ‘E-commerce adoption by home users is still at “early adopter” stage. On-line home shopping, which is popular in countries such as the US, has yet to make an impact in Singapore as it has attracted only 8% of total home users. On-line government transactions attracted only 14% of the total home Internet users.’ (para 6.4)

The close proximity of shops, and the pleasure people seem to take in shopping, is commonly regarded as a barrier to localized ‘etailing’ in small economies like Singapore and Hong Kong. In reverse, the same logic should suggest B2C e-commerce would first take-off in developed economies of large geographical spread like Australia, Canada and the USA. Superficially table 2 lends some support to this hypothesis, yet the position of the UK – a geographically small economy – ahead of Australia in terms of the percentage of households as transactors and, depending on the data used, possibly on a par with Canada, suggests there are more complex sets of factors at work. It is not the purpose of this paper to explore them, but clearly levels of accessibility, cost, the quantity and quality of retail websites, an environment of trust, a banking system willing to support merchant credit card accounts, and many other factors are involved.

2.3 Assumptions of the Model

This paper works with the following simplifying assumptions: that the spread of online transactions is a function of (a) the diffusion of computer-owning households, and (b) a transactions diffusion curve, which could be expressed as some function of the percentage of existing online households who are frequent transactors. A further possibility is (c) a transactions learning curve which would be some function of the length of time a household has used a computer online. Assumption (b) poses an exogenous or environmental condition, which involves a complementary set of factors which are examined in more detail in Part Four, but among other things – such as, for example, a mercantile credit system for small traders, easy-to-use software, ‘always-on’ broadband access, and so on – involves an evolution of suitable, customer-friendly online retail websites as a response to the evolution towards a critical mass of online shoppers. By contrast, assumption (c) poses an endogenous or domestic condition, implying that as members of a household become more used to going online, they gain (good) experience and (greater) confidence about online shopping. A further variant of (c) is the idea that, as more and more households acquire computers and go online, either as ‘early adopters’ or as the ‘early majority’, so it becomes more likely that several members of the household

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[26] ‘Among the respondents who are Internet users, only 11% of them have ever shopped on-line. Among them, more than half of them (58%) have ever made an on-line purchase.’ *IT Household Survey 1999*, para 4.4.a.i.

[27] *IT Household Survey 1999*, Infocomm Development Authority of Singapore, January 2000, para. 4.4.v

will be involved in online shopping, giving rise to what we might term the emergence of 'Internet households'.[28]

Some evidence to support hypothesis (c) comes from an econometric study by Emmanoulides and Hammond (1999) who explore the factors driving Internet usage patterns in the UK using NOP Research data for the period 1995-97. On usage they conclude: 'Social use at home, especially with two or more other people, is a strong predictor of current use – people who see the Internet at home with two or more other people are significantly more likely to be current users than those who use it alone or with just one other person. Even though causality cannot be assessed through this cross-sectional data, this finding may indicate that: work related needs or peer pressure is a major factor for steady Internet usage, as predicted by standard diffusion theory; PC home ownership increases the depth of adoption or usage; the presence of a domestic diffusion effect.' [29]

Specifically on the *frequency* of usage, Emmanouilides and Hammond find 'the length of time since first Internet use is a predictor with large and significant effects on usage frequency. But its effects on the utility to be a low or moderate Internet user compared with a heavy one are almost linear. This utility decreases inversely to the time elapsed since first use ... Overall, very early adopters or pioneers are more likely to be heavy users than not…' From this evidence it seems possible that the appearance of 'Internet households' or family 'peer pressure' may increase the *likelihood* of online usage, *including online shopping*, and that *frequency* of online usage – *presumably* including online shopping – is closely associated with length of experience. If this is so, then the results of Emmanouilides and Hammond would support the view that online shopping, even in small city-economies such as Singapore and Hong Kong, is constrained not by locality but by Internet access and for how long a household has been using the Internet.

The diffusion of home computing is also the subject of a working paper by Goolsbee and Klenow (1999). Using proprietary data from a December 1997 mail survey called *Technographics* (Forrester research) they 'find evidence consistent with local spillovers in home computer adoption… The data do suggest that the spillovers are concentrated in local areas and among family and friends. The spillovers appear to be greatest from experienced and intensive computer users. The spillovers do not appear to be tied to the use of any particular type of software (spreadsheets, word processors, graphics, games, family budgeting) but are highly tied to the use of email and the Internet. This is consistent with the idea that the computer serves as part of a local information or communications network.'[30] The Goolsbee and Klenow conclusion, namely that 'Internet households' and the length of experience of *using computers online* are key factors in the diffusion of home computer ownership, reflecting the role of 'network externalities' (p.7)

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[28] For example: 'Upon embarking upon Internet usage, 41.2% of the homemakers learned how to use the personal computer or to access the Internet from other family members.' *White Paper, 1999* Ministry of Posts and Telecommunications, Japan, p.57 (www.mpt.go.jp)
[29] Christos Emmanoulides and Kathy Hammond (1999) 'Internet Usage in the UK: Predictors of Active Users and Frequency of Use' Centre for Marketing Research, London Business School, Working Paper 99-802, p.21.
[30] Austan Goolsbee and Peter J.Kenow, November 1999, 'Evidence on Learning and Network Externalities in the Diffusion of Home Computers', University of Chicago, working paper. p.2.

signals that home computer adoption implies home computer online usage. Their work therefore seems to offer support to both assumptions (b) and (c) above.

The current lack of reliable data on frequent transactors, and the almost total lack of time series data, forces us to make assumptions, as in this paper, with regards to the rate of growth of the number of 'frequent' transactors. The highly circumstantial evidence at hand suggests that the assumption that the number is roughly doubling every twelve months may be a workable one, especially beyond the more rapidly maturing US Internet economy. For example, comparing online Christmas sales revenues in the US for 1998 and 1999, the *Financial Times* of London (16 December 1999, p.18) reported on expectations of a surge: 'online sales are estimated to double to about $4bn, according to Forrester, the research group.' Of course, this refers to the value of online sales, not to the frequency, and the value is a composite of (a) increasing average expenditures per purchase by current frequent online shoppers, (b) an increasing frequency of online shopping by current online shoppers, and (c) an increasing number of online shoppers who have yet to become frequent. Looked at from the online retailers' viewpoint, this means encouraging 'repeat' business. This, in turn, implies a growing proportion of on-line shopping will be shopping for mundane items of regular purchase, such as groceries, just like off-line shopping. In other words, on-line shopping will be less exotic.

Figures from the Ernst & Young *Global Online Retailing* (January 2000) survey conducted Oct/Nov 1999 confirm the trend towards higher expenditures by online shoppers. It reports that 48 per cent of online shoppers in the US spent more than US$500 in 1999, up from 40 per cent in 1998.[31] The previous year's survey recorded an increase in online shoppers' spending more than US$300 from 26 per cent in 1997 to 35 per cent in 1998.[32] According to the report, US online sales in the last six months of 1998 grew by 200 per cent, generating total online consumer sales for the year of between US$10-13 billion. As we saw above, the 1999 report estimates the total for year-end 1999 at around US$25-30 billion, and forecasts US$45-50 billion for 2000. Very roughly an annual doubling of online shopping revenues is involved. Currently there is insufficient data to disaggregate the components of these figures into frequency of purchase, scale of purchase and number of transactors. But we did see above, table 32, referencing the same Ernst & Young report, the estimated proportion of *households* in the US who are frequent transactors - defined as making 10 or more purchases a year - rose from 4 per cent in 1997 to 17 per cent in 1998 to 39 per cent in 1999, that is increases of over 300 per cent and of 130 per cent. These seem to be the best available data we can currently get.

The question, therefore, is whether it is reasonable or not in Part Three to make the assumption, for the purposes of the model that follows, that frequently transacting households in Hong Kong will, over the short-term – the next three to five years - increase by around 100 per cent annually. In one sense it does not matter, because the purpose of the model is not to make accurate predictions but rather to lay a foundation for

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[31] See www.e&y.com/Global_Online_Retailing_-_RCP.E&Y.html. The 1997 Morgan Stanley *Internet Retailing* report projected an *average* annual expenditure per transactor of US$500 by 2000. See table 4-3.

[32] *The Second Annual Ernst & Young Internet Shopping Survey Report* www.e&y.com. The report was conducted by shop.org and the Boston Consulting Group.

looking back with hindsight to understand whether it was the model that was wrong or its assumptions. In this light the assumptions issue is trivial, although a reading of the empirical evidence is not.

Part Three: Modelling E-Commerce in Hong Kong

Hong Kong [33] directly benefits from being the primary entrepôt to mainland China. Re-exports to China are Hong Kong's lifeblood, making up 85 per cent of goods exports. By contrast tradeable services, mostly financial, constitute around 17 per cent of Hong Kong's total exports. Online retail revenues can come from both overseas and domestic sources, but as these percentages suggest, they will need to become substantial before making much impact on Hong Kong's economy.

3.1: *The Hong Kong Context*

Until the special Household Expenditure Survey of 1998,[34], the Census and Statistics Department of the government of Hong Kong, collected no data on home computers orand their access to the Internet. It was the Internet connection that interested the Department because it lays the foundations of a market for electronic commerce. Since Tim Berners-Lee's invention of the World Wide Web in 1989-90, and the diffusion of browser technology from 1993,[35] the home computer has migrated from being a standalone household item to becoming an access device to a networked world. In Hong Kong, as elsewhere, fast processors and 56 Kbps modems became standard features of all new home computers by 1998, and Internet service providers (ISPs) are plentiful and highly competitive.[36] Public awareness has been raised over recent years by endless media [37] coverage of the Internet, including specialist magazines such as *Computer Today Monthly, ComputerWorld, Network Today Monthly Computer, Internet.com, Internet Magazine, PC.com, PC Handbook, PC Home, PC World,* and by the presence of numerous computer shopping arcades which easily and rapidly clone both hardware and software.[38]

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33 The similarity between Hong Kong and Singapore can be paraphrased by the ratio of 3:1 in terms of population, land mass and GDP, so their GDP per capita is about equal, around US$25-27,000 in 1998. On the other hand, whereas both are regional hubs, Hong Kong is also entrepôt to mainland China.

34 1998 General Household Survey, Utilization *of Internet service*, Special Topics Report No.20, Census & Statistics Department, Hong Kong SAR (China) Government.

35 The diffusion of web browsing technology starting with Mosaic in 1993 was the critical step in popularizing the Web. See Tim Berners-Lee (1999) *Weaving the Web: The Past, Present and Future of the World Wide Web by its Inventor*, Orion Books, London.

36 According to Hong Kong's Office of the Telecommunications Authority (OFTA – see www.ofta.gov.hk) there were 225151 licensed ISPs by the end of October 2000November 1999, although around five dominate the market. In the absence of local call charges, ISPs are required to obtain a Public Non-Exclusive Telecommunications Services (PNETS) licence (US$96) which obliges them to pay 2.33.4 cents HK per minute (1826 cents US per hour) to the local public switched telecommunications network (PSTN) operator for local access calls by their customers. The PNETS charge has fallen from 9 cents HK per minute (72 cents US) before 1996. The dominant ISP is also the dominant PSTN carrier, Pacific Century Cyberworks/is Hongkong Telecom, purchased by PCCW from Cable & Wireless in Cable & Wireless HKT, subject to a takeover by Pacific Century Cyberworks summer, 2000at the time of writing.

37 Well over half of respondents to AC Nielsen's 1996 Hong Kong survey reported their source of Internet information as coming from newspapers, magazines and adverts. See www.acnielsen.com/hk/net/usage.htm.

38 Purchasing CDs and DVDs over the Internet, for example from Amazon.com, has the potentially interesting implication in Hong Kong of skirting around a controversial ban on parallel importing.

It is tempting to add that the penchant of Hong Kong people for portable electronic games and gadgets, for the functionality of cellphones and other wireless devices, contributes to an environment of acceptance of computer technology and the Internet, but as the data in Part Two above shows Hong Kong is not unique in its rate of adoption of computers in the home. Further, it could be argued that it's economic geography as a densely packed city-economy in which communications and activities such as going to work and going shopping are so easy to accomplish, would mitigate against the early embracing of electronic commerce. If this were so, then Hong Kong's rate of adoption of the Internet would be arrested, or confined to very specific areas of interest, such as the ubiquitous e-mail, instant messaging and chat rooms, game playing, and to regions of personal business and finance that fit particularly well the profile of Hong Kong consumers, such as online stocks trading, property dealing, overseas travel, the purchase of computer software, and for some the purchase of books from abroad. In Singapore, the Infocomm Development Authority (IDA) reports a very similar finding (see above), and yet many of these areas of purchase are also areas in which local offline trading is easily accomplished. This strongly suggests that online consumer purchasing rather than being *confined* to these areas of specific personal interest, will be *pioneered* by them.

The policy concerns of most governments, including Hong Kong, focus on how to promote and facilitate the adoption of electronic commerce in its broadest terms based on the understanding that electronic commerce offers opportunities to 'grow' existing and new markets, but equally poses threats of greater competition in home markets. For example, a 1998 study conducted on behalf of the Stock Exchange of Hong Kong (SEHK) raised the alarm that online stocks trading could pose a severe threat to the local brokerage business.[39] The Hong Kong government has is takening some steps towards promoting electronic commerce, notably by launching an Electronic Services Delivery programme under which eventually all government departments and the services they offer the public will be online, and to facilitating electronic commerce by passing the Electronic Transactions Ordinance which has, among other things, established a public key Certification Authority, under the auspices of the Hongkong Post, and given legal backing to other approved private sector CA initiatives, and legal recognition to digital signatures.[40]

Although business-to-business (B2B) electronic commerce is by far the greater part of national and global electronic trading to date, business-to-consumer (B2C) electronic commerce is likely, eventually, to become an important driver the electronic economy. As of early 2000 few estimates of B2C exist for Hong Kong. The Boston Consulting Group estimates Hong Kong's online retailing revenues at US$40 million for 1999.[41] This works out at less than US$30 per Internet user for the year, and less than 0.2 per cent of Hong

[39] *Internet Investment Services: Conclusions and Recommendations for Hong Kong*, November 1998. Given the fixed peg exchange rate between the HK dollar and the US dollar (HK$7.8:US$1) Hong Kong's prime interest rate is effectively determined by the decisions of the US Federal Reserve Board. Although interest rate competition has been is likely to be introduced in Hong Kong by the Hong Kong Monetary Authority, it remains the case that for most Hong Kong people a return on savings is to be found either on investment in property or in equities. For this reason the role of the bourse in the welfare of Hong Kong citizens is seen to be disproportionately high. Online e-trading could well break the link in this welfare equation.

[40] An earlier government initiative, but outsourced to a private sector consortium, is Tradelink, an electronic data interchange (EDI) programme which acts as a gateway between the private business sector and government departments for documents such as trade declarations.

Kong's retail trade compared with 1.2 cent in the USA, but is already above BCG's estimate of 0.1 per cent for the Asia-Pacific. The Gartner Group, in their forecast of fourth-quarter consumer Internet spending for Asia-Pacific in 1999, estimated Hong Kong's share at US$20.8 million.[42]

3.2: *Critical Mass*

One of the major difficulties governments, researchers and forecasters share in assessing the development of this market is the shortage of meaningful and reliable data. There are several reasons for this. One is the lack of shared definitions as to what constitutes electronic commerce. Is it used to refer solely to the payments part of the transaction? Can it embrace the selection and ordering process, or the delivery process, without including the payment method?[43] Where it starts and ends obviously depends upon the research question of interest, but there is not yet a consolidated body of research which shares particular questions of interest. Another problem is the difficulty of sourcing such data. Expenditure estimates based on official household expenditure surveys do not yet exist in Hong Kong, and private consultancy estimates are rarely based on large random, samples.[44] Yet another problem is simply that there is insufficient time series of data available.

At the scholarly level, the issue is most widely handled within the framework of a diffusion model, the approach adopted also by this paper and discussed below, but a diffusion model typically requires around ten years of data, which pre-dates the World Wide Web.[45] At this stage, there is no way around the shortage of data problem, but this does not mean that reasonable analysis based upon what data is available cannot yield some predictive results. Indeed, early research has the advantage of yielding insights by providing benchmarks that, with subsequent hindsight or *post*diction, can throw light upon the relationships involved in the *pre*diction. In other words, how wrong the prediction turns out to be is useful information if the underlying methodology is explicit and subjected to later critique. Naturally, even this process requires a minimum of data to be worth undertaking.

This paper is based upon researched data for the number of households in Hong Kong that have at least one home computer. As explained below, the data points refer to the years 1992, 1994, 1996, and 1998 and 2000a final data point for 1999 is also used. In addition, there is data for the number of the home computers that have modems and

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41 *E-tail of the Tiger: a NetBizAsia Report*, released 28 February 2000. The data includes online retail sales beyond Hong Kong, and includes financial brokerage commissions on stocks transactions, but excludes the value of the stocks traded.

42 *South China Morning Post - Technology Post*, 5 October 1999, p.1. Japan accounted for US$550 million, or 65 per cent, compared with the Boston Consulting Group's estimate for the year of 54 per cent. See above.

43 For example, 'Spending refers to the value of commitments for transactions made over the Internet, regardless of the actual payment mechanism.' *IT Forecaster*, International Data Corporation, 29 February 2000 – No. 839

44 Some are based on quota sampling, like ACNielsen's third expenditure survey in Hong Kong, March 1999, which targetted two thousand 15-54 year olds, providing data of indicative value. See www.acnielsen.com/news/asiapacific/hk/19990610.htm. ??????????/

45 This is the case when estimating dynamic, as opposed to static, price elasticity, an obvious requirement when dealing with a diffusion process. The point is made in Kar Yan Tam, 1996, *Dynamic Price Elasticity and the Diffusion of Mainframe Computing*, Journal of Management Information Systems, Fall, v.13.2, p.163-184; R.M. Heeler and T.P. Hustad, 1980, *Problems in predicting new product growth for consumer durables*, Management Science, October, v.26, pp.1007-1020; and V. Srinivasan and C.H. Mason, 1986, *Nonlinear least squares estimation of new product diffusion models*, Marketing Science, Spring, v.5, pp.169-178.

therefore online capability, and for the number actually used for online communications. This was vital information prior to 1998, by which time modems had become standard fitted items in all new computers. The paper aims to make a reasonable assessment of the market size for electronic commerce or online retailing in Hong Kong by modelling it. In particular, the paper considers the concept of what could constitute a 'critical mass' so far as a market for electronic commerce is concerned. The paper employs the conventional use of a logistic or 'S' curve model, but also stresses the role of complementarity as part of the necessary conditions for a critical mass for electronic commerce to take-off. The method of analysis is to use the logistic 'S' curve model in three steps. First, to project the critical mass of home computers as an embedded base from which business-to-consumer electronic commerce can grow. Second, to project the critical mass of online home computers. The argument postulates that as all new home computers have Internet capability, the rate at which households will embrace electronic commerce will be driven by the rate at which households acquire home computers multiplied by the rate at which they go online. Third, to 'guestimate' the rate of growth among those online who become 'frequent transactors'. There is no self-evident definition of 'frequent' but, as explained above, making online purchases at least ten times a year is a metric used by several sources and is adopted here.

3.3: *Diffusion Models*

The concept of a critical mass has its roots in physics, and in particular in efforts to achieve atomic fission.[46] It implies a climacteric, a point of no return, a transformation of quantity into quality, a take-off point, an entry into a period of self-sustained growth, etc. It is a widely used, popular, commonsensical term, but less often is it operationalized in academic writings.[47] Yet from a policy perspective it helps to understand when, and under what conditions, the market for electronic commerce is ready for take-off, is approaching 'critical mass'. The term is closely associated with diffusion models, and in particular with the logistic or S-curve. The S-curve, which has various guises each described by a slightly different underlying equation[48], is best known in the biological sciences, in the tracking of the diffusion or spread of disease. The process of contagion or infection became the analogy underlying an early modelling of the diffusion process by historians of

[46] In May 1939 in Paris, Francis Perrin 'published a first approximate formula for calculating the critical mass of uranium – the amount of uranium necessary to sustain a chain reaction. A lump smaller than a critical mass would be inert; a lump of critical size would explode spontaneously upon assembly. The possibility of critical mass is anchored in the fact that the surface area of a sphere increases more slowly with increasing radius than does the volume (nearly r^2 to r^3). At some particular volume, depending on the density of the material and on its cross sections for scattering, capture and fission, more neutrons should find nuclei to fission than find surface to escape from; that volume is then the critical mass.' Robert Rhodes, 1986, *The Making of the Atomic Bomb*, Penguin Books, London, p. 321. (Winner of the Pulitzer Prize for Literature, 1988.)

[47] A cursory review of the literature for the past year reveals several dozen articles, mostly in business magazines and journals, which employ the term. For example, an industrial cluster is defined as a critical mass in Michael Porter, 1998, '*The Adam Smith Address: Location, clusters and the 'new' microeconomics of competition*', Business Economics, January, v.33.1, pp. 7-13; Marchiori Massimo, 'The limits of Web metadata, and beyond', *Computer Networks & ISDN Systems*, April, v.30.1-7, pp.1-9 discusses the need for a metadata classification system to cope with the ever increasing volume of data on the Web, and sets out the need to estimate the critical mass required to make the such a system really useful; an anonymous article, 1998, 'The Internet Economy: Fact or Fiction?', *Accountancy*, July, v.122.1259, p.52, argues that home computer penetration in the UK has not yet reached critical mass to support a mass market, whereas Mitch Irsfeld, 1998, 'Part 4: Transformation The Last Word – Editor's Note', *InternetWeek*, 14 September, Issue 732, p.80, argues that United States Internet connections in the summer of 1998 finally did reach critical mass to support a new era of electronic commerce.

[48] See Paul Stoneman, 1983, *The Economic Analysis of Technological Change*, Oxford University Press.

technological change and economists. [49]

The seminal work in social science on diffusion theory, Everett Rogers' *The Diffusion of Innovations*, first published in 1962, established, among other things, an agreed general classification of adopters into 'Innovators', 'Early Adopters', 'Early Majority', 'Late Majority' and 'Laggards', although other scholars have juggled about with these categories. In particular, Rogers' simplified schema assumes that during the course of time the entire population will come to adopt a particular successful innovation, and the underlying distribution (of adoption) function is normal. The mathematics implied by this also impose certain strict assumptions, that, for example, restrict population growth for the duration of the diffusion process, that require a constant rate of 'contagion' or 'infection' as information about the innovation is communicated by word-of-mouth or by whatever other mechanism, and so on.[50] Nevertheless, Rogers' influence has been almighty. For example, Rogers' model was quickly taken up in the field of marketing, the most influential contribution coming from Frank Bass, in 1969. Bass[51] assumed that adopters were influenced by one of two means of communications, either by word-of-mouth, 'the innovators', or by the mass media, 'the imitators'. Although the laggards are allowed to tail off in the Bass model, the vast majority of adopters are clustered within two time frames around the mean of the underlying distribution function, which is therefore, to all intents and purposes, symmetric as in Rogers' reference model.[52]

The limitations of the Rogers' diffusion model have created an industry of academic and industry researchers modifying and adapting its insights to various markets and products.[53] In our case, the proposition is more straightforward. Because electronic commerce is a broad term rather than a technology as such, and implies the adoption of a way of doings things in general, such as shopping, rather than the object of doing something in particular, such as shopping for a specific item, we can assume that, in the course of time, everyone will adopt electronic shopping to a greater or lesser extent. It will become part of the way of life in an electronic or cyber-economy, involving everybody.[54] Since our data is very limited, with the time series for home computers covering just six years, we are, in effect, engaged in back-of-the-envelope estimations and projections. The point is therefore not to forecast the long-range scale of adoption of electronic commerce in Hong Kong, but rather to build a model which is indicative of the process which will, in part at least, drive the adoption of electronic commerce in the short-term.

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[49] See Paul David, 1975, Technical Change, Innovation and Economic Growth, Cambridge University Press.

[50] For a summary of such restrictions, see Stanislaw Gomulka, 1990, *The Theory of Technological Change and Economic Growth*, Routledge, London and New York.

[51] Frank Bass, 1969, 'A New Product Growth Model for Consumer Durables' Management Science, January, v.15, pp.215-227.

[52] For a helpful discussion of the Bass model, see chapter 8 in J.Eliashberg and G.L.Lilien, eds, 1993, *Marketing: Handbook in Operations Research and Management Science*, v.5, Elsevier Science Publishers, North-Holland, Amsterdam, London, New York and Tokyo.

[53] For example, Mark Evans, 1996, 'Aspects of maximum likelihood estimation of asymmetric growth curves', *Journal of Applied Statistics*, October, v.23.5, pp.467-492, extends efforts to modify the Bass equation to take account asymmetries in the diffusion process.

[54] A study of household ownership of computers by Viswanath Venkatesh and Susan A. Brown (1998) 'A Longitudinal Investigation of Personal Computers in Homes: Adoption Determinants and Emerging Challenges' (CSI Working Paper No.98-01) explores the distinction between 'intrinsic motivation' associated with 'hedonistic outcomes' (e.g. for fun, curiosity, etc.) as a driver of early adopters, and 'extrinsic motivation' associated with 'utilitarian outcomes' (e.g. work-related reasons, for the children, etc.) as a driver of later adopters'. Somewhat against their hypothesis they discover that even social influences and utilitarian outcomes influence early adopters. 'Specifically, status impact from possessing current technology was most important, followed by applications for fun, the influence of friends and family members, and applications for personal use.' (p.14) Available at www.slis.indiana.edu/CSI/wp98-01.html

3.4: *The Data*

The Telecommunications Research Project (TRP) used the services of the commissioned from the Social Science Research Centre of the University of Hong Kong to conduct fourthree telephone surveys on the penetration rate of computers in Hong Kong households based on random samples of households generated from telephone directories. In the surveys for December 1994, February 1996, and December 1998 and December 2000 respectively 1917, 521, and 523 and 514 telephone interviews were successfully conducted with Cantonese-speakers aged 15 or above. With these sample sizes, the sampling errors are small, for example no greater than 2.2 per cent in 1998.[55] The questionnaires for 1994 and 1998 specifically requested information of 'the main user' of the computer in the household, whereas the 1996 and 2000 surveys were more frugal, hence the demographic tables below are restricted to these two years. Finally, In additional information on household computer penetration was extracted from, two earlier surveys, for 1991 and 1993, had been carried out by Institute of Asia-Pacific Studies of the Chinese University of Hong Kong, using face-to-face interviewers. TAlthough similar, the Institute's findings conform quite closely with the TRP's findings, although their for 11993 figure slightly exceeds those of the TRP's results for 1994 as Table 4 shows. [56]

Table 4

Homes with computers

PCs per Household	*1 PC*	*2 PCs*	*3PCs*	*4PCs*	*At least 1 PC*
1991 [1]	na	na	na	Na	21.8%
1993 [1]	na	na	na	Na	27.9%
1994 [2]	25.6%	1.6%	0.2%	0.1%	27.5 %
1996 [2]	36.9%	3.1%	0.2%	0%	40.2%
1998 [2]	42.4%	5.7%	0.4%	0.2%	48.8%
2000 [2]	49.8%	12.5%	1.6%	0.4%	64.2%

Notes: 1. Institute of Asia-Pacific Studies; 2. Telecommunications Research Project

[55] The 20001998 questionnaire contained a total of 1523 unprompted items, reduced from 23 in 1998. To and to ensure the comparability of data the 1998 questionnaire items largely followed those used in 1994 and 1996, with some slight modifications of the response categories in the question of Internet usage. The 2000 questionnaire is presented in appendix 1asked more questions about online usage, broadband usage and frequency of transactions. It was of smaller size to reduce cost. All questionnaires are available upon request from the author.

[56] Lau Siu-kai, Lee Ming-ku, Wan Po-san and Wong Siu-lun (eds) *Indicators of Social Development: Hong Kong 1990* and *Indicators of Social Development: Hong Kong 1993* Institute of Asia-Pacific Studies. Chinese University of Hong Kong, Research Monograph No. 13 and 1995.

The 1991 and 1993 studies of the Institute did not include information about modems, but the TRP's data does, and is significant for the reason that by 1998 fitted modems became standard components of retailed PCs in Hong Kong as shown in Table 5.[57] A large part of the jump from 1996 to 1998 in the proportion of home PCs with modems, from 28.7 per cent to 62 per cent as shown in Table 5 is accounted for by thisat fact.

Table 5

Homes with computers with modems		
	Households with modems fitted to PCs	*Did Not Know*
1994	20.2%	18.8%
1996	28.7%	12.4%
1998	62%	8.6%

This is perhaps the single most important complementary event in the home computer environment, by enabling Internet access without imposing on the home user the search costs involved in acquiring knowledge of modems, shopping for and purchasing them, fitting them, and installing the appropriate software. The next step, registering with an ISP and installing their software, still requires user initiative, but is a far less daunting task, and one more likely to be learned from relatives, friends, colleagues and neighbours. And, of course, from one's children.

A growing 'democratization' of Internet access and usage was noted above (Part 2) and the demographics from Hong Kong seem to bear this out, at least with regard to home computer ownership. This has important implications for the *scope* of e-commerce as well as its scale. Tables 6-9 present the data on housing types, occupation, age, education and gender for the period up to 1998..

Table 6

User Hhousing Ttype					
Housing	*Public*	*Housing Scheme*	*Private*	*Village*	*Others*

[57] For this reason the question was dropped for the 2000 survey.

Valid Answers 1994	31.7%	14.3%	50%	2.2%	1.8%
Valid Answers 1998	38.7%	15.3%	43.5%	1.2%	1.2%

The significant shift in housing type is the 22 percentage points increase in the proportion of public housing tenants with a home computer, in 1998 only five points short of private tenant and owner-occupiers, excluding the 15.3 per cent middle-class Housing Scheme home-owners. Although the TRP study did not inquire into the determinants of home computer purchase, price will be only one of several factors. The degree of general publicity given to computers and their uses, especially with the Internet, mentioned above, will be one factor. Another may be the demonstration effect and learning curve that comes from using computers at work. The hypothesis would be that as computers spread in the workplace, to use Rogers' terms, from 'innovators' and 'early adopter' sectors - such as banking and finance - to 'early majority' and then 'late majority' sectors - such as retail distribution and then, perhaps, public transportation - and as they spread within each sector - from, say, the accounts and personnel departments, to procurement and then to the main operations of a company - so more and more people within the occupational hierarchy will become familiar with the computer and its attractions. Table 7 is consistent with such a view, although not proof of it.

Table 7

User Ooccupations of Major User

Occupation	*Profession & semi-professional*	*Clerical & service workers*	*Production workers*	*Students*	*Housewives*	*Others*
Valid Answers 1994	27.8%	22.2%	3.1%	39.1%	1.7%	6.1%
Valid Answers 1998	22.5%	26.9%	2%	41.8%	2.8%	4%

By 1998 the proportion of clerical and service workers among computer users had overtaken professional and semi-professional workers, but by far the largest group of users, students, increased even further as an overall proportion. This is not a surprising result, especially in light of the history of the Internet as principally an educational network for many years,[58] and is consistent with evidence from other economies. Table 8

[58] Excluding, of course, the military origins of the Internet.

confirms the age implications of this finding, with nearly 40 per cent of home computer users aged under 21 years. The figures for 1994 and 1998 are remarkably consistent, indicating that users aged between 17 and 21 in 1994 were rapidly replenished by younger users in the intervening years, so although users in age brackets above 30 years were growing in absolute numbers, they slightly fell as a proportion.

Table 8

Major user aAge of Major User

Age of major users (years	*Below 18*	*18-20*	*21-29*	*30-39*	*40-49*	*50-59*	*60+*
Valid Answers 1994	21.4%	18.2%	28.7%	21.8%	8.6%	1.1%	0.2%
Valid Answers 1998	21.8%	18.1%	29.8%	21.4%	7.7%	0.4%	0.8%

Table 9 confirms the democratization of home computer usage in terms of educational attainment.

Table 9

User eEducation levels of Major User

Education	*Primary or below*	*Secondary*	*Matriculation*	*Post-secondary: non-degree*	*Post secondary: degree*
Valid Answers 1994	2.9%	49.2%	10.2%	8.1%	29.6%
Valid Answers 1998	4.8%	53.4%	8.8%	5.2%	27.7%

There is one further demographic feature of particular significance in Table 7, the small but growing proportion of users who give their occupation as housewives. As Table 10 indicates, they are a sub-set of the growing proportion of females among home computer users,[59] and their influence on future patterns of home shopping, especially in 'Internet households' where Internet shopping becomes a shared household activity, could be significant. Table 10 confirms the shift towards gender equality in home computer usage.

Table 10

User Ggender of Major User		
Sex	Male	Female
Valid Answers 1994	71.5%	28.5%
Valid Answers 1998	63.3%	36.7%

3.5: *The Internet and Online Purchasing*

Data on the uses of home computers in Hong Kong is excluded from this paper, with the following important exception. Table 11 is a key table. It shows that 78.5 53.7 per cent of households with computers in 19982000 were using them for online communications, a rise of nearly over 4025 percentage points over 19968, which in turn was over 40 points over 1996 and and of 50 points over 1994. EquallyBut even more significant, in 1998, 86.7 per cent of homes with computers fitted with modems were using them online, a rise of nearly 50 percentage points since 1996 alone. *On the basis on this table, it iswe forecast (see below) that by 2002 all newly purchased home computers will be used for online communications, and therefore the embedded base of households equipped for electronic commerce will rise in tandem with the rise of households with computers.*

Table 11

Homes with Mmodems used for Ccommunications			
	Homes with PC modems	*Households with PCs using communications*	*Households with PC modems using communications*
Valid Answers 1994	20.2%	3.2%*	15.7%*
Valid Answers 1996	28.7%	11%	38.3%
Valid Answers 1998	62%	53.7%	86.7%
Valid Answers 2000	na	78.5%	na

* Note: in 1994 while only 11 respondents indicated they used their computers for communications, 16 subsequently indicated they used bulletin board services. The latter figure is used in tables 11 and 12.

[59] Cross-tabulation tested for correlation between expected and actual age profiles for males and females, but none emerged.

Of the households with modem-fitted computers, how did the 15.7 per cent of them in 1994, the 38.3 per cent of them in 1996, and the 86.7 per cent of them 1998, use online communications? According to Table 12 the shift was unambiguously from bulletin boards and proprietary networks to e-mail and Web surfing (over 40 per cent, and 870 per cent of respondents respectively in 1998) via the Internet.[60] Interestingly, the number of Do Not Knows (DNK) drops by two-thirds over the period, suggesting a growing general awareness. By 2000 the use of email and web surfing had risen to over 50 per cent and nearly 90 per cent respectively.

Table 12

Communications Sservices Uused (base: households onlinewith modems)

Communications [1]	*BBS*	*E-mail*	*OIS*	*EDI*	*Others*	*DNK*
Valid Answers 1994	1005.7%	507.8%	43.86.9 %	12.52%	7511.8%	26%
Valid Answers 1996	8.73.3%	73.928.3 %	43.516.7 %	8.73.3%	26.110.0 %	39.115%
Valid Answers 1998		48.2%		8.8%	2.9%	4.4%
Valid Answers 2000		53.3%		0.8%	1.5%	

Communications [2]	Internet surfing	Internet Phone	On-line purchase	Icq, chat, net meeting	Download software/ games/video
Valid Answers 1998	81%	9.5%	1.5%	na	18.2%
Valid Answers 2000	88%	0%	6.9%	33.6%	32.4%

Communications [2]	Internet surfing	Internet Phone	On-line purchase	Download software/ Games/videos
Valid Answers 1998	81%	9.5%	1.5%	18.2%
Valid Answers 2000	88%	Na	6.9%	32.4%

Notes: (1) BBS = bulletin board services; OIS = online information services; EDI = electronic data interchange; Others = for 2000 includes Icq, chatting, net meeting; DNK = did not know; (2) 'online households' defined as 'using communications', 1994-98, and as 'connected to the Internet', 2000

[60] Before its purchase by America Online, CompuServe was available in Hong Kong. AOL only began direct marketing in Hong Kong on 28th September 1999.

It is difficult to know best how to interpret the small but growing number of respondents who reported they use electronic data interchange (EDI), and although in retrospect it is likely some confused the meaning of EDI with other activities, such as file transfer, it is also worth noting that many small and medium sized enterprises (SMEs) operate as SOHOs (Small Office, Home Office),[61] and it is conceivable they are import/export traders using the Tradelink government gateway, or one of the several EDI service providers in Hong Kong. We have to take the figures at face value, although should also note that in the 2000 survey the figure slumps to 0.8 per cent. But tThe idea that 42,000 households in Hong Kong, or 8.2 per cent of households, used Internet telephony in 1998 does stretch credibility. The software is available for individual use, and some of Hong Kong's callback operators used Internet to route their traffic, but it is more likely that at least some of the respondents were unclear as to the meaning of the term 'Internet telephone'. None of the respondents in 2000 mentioned IP telephony.If not, it would be a very interesting result.

Table 13 summarizes the findings over the period of the various surveys of households online as a percentage of all households in Hong Kong. The data includes the findings of a mini-survey by the TRP in 1999.

Table 13

Percentage of Households Online	
Date of Survey	Households Online
December 2000	50.4 per cent
September 1999	40.4 per cent
December 1998	26.2 per cent
February 1996	4.4 per cent
December 1994	0.88 per cent

[61] Hong Kong's Government Information Centre estimates 280,000 SMEs as of March 1999, accounting for 98 per cent of all establishments and 60 per cent of the workforce. SMEs are defined in Hong Kong as companies employing less than 100 persons in manufacturing and less than 50 in non-manufacturing. Most are involved in the importing and exporting trades. See www.sme.gcn.gov.hk.

Finally, we note the proportion reporting on-line purchases. Scaling up the results for By 2000 suggests around 740,000, 0001998 nearly 6,700 households, or 3.5 1.3 per cent of households those with modem-fitted computers, claimed to have purchased online. This contrasts with 6,700 households, or 1.3 per cent, in 1988. As we shall see below, this probably translates into around 1760,000 individuals, or 2.640.75 per cent of the population of Hong Kong, just over . If we compare this with Everett Rogers' 2.5 per cent of 'innovators' and the first point of inflexion on the S-curve. F, from thise perspective by of 2001end-20001998 the take-off of electronic commerce in Hong Kong had only just begunstill hasd some years to go, but is getting close..

3.6: *S-Curves and the Data: towards Critical Mass*

Our earliest data points, from the Institute of Asia-Pacific Studies, relate to 1991 and 1993. To bring them into line with the two-yearly data collected by the *Telecommunications Research Project* we assume a simple average of the two years for 1992. Given the low levels of computer penetration involved, this is less draconian than it would be for later years. With fiveour data points, 1992, 1994, 1996, and 1998 and 2000, and applying the logistics equation,[62] using SPSS, we arrive at the following cumulative S-curve (graph A) and the corresponding underlying adoption distribution function (graph B).

The model is given by the equation: Y = 1 / (1/u + (b0 * (b1 * t))) or ln (1/Y – 1/u) = ln (b0 + (ln (b1) * t)) where *u* is the upper boundary value. This says, that Y's cumulative approach towards 1 is some function of (a) time, *t*, and (b) the proportion of households that already have computers, *u*, as expressed by the coefficient, *b*. It should be noted that the assumed penetration rate is 100 per cent (that is, Y approaches 1) in accordance with the assumption that everyone, in this case every household, will become involved in the electronic economy. In the case of graph A, other things being equal, saturation level (at least one computer in every home) would be reached by 2020, but 90 per cent penetration would be reached by 200810, and 80 percent by 20056. All these computers would be modem-fitted and, it is assumed (see above and below), online.

The model is given by the equation: Y = 1 / (1/u + (b0 * (b1 * t))) or ln (1/Y – 1/u) = ln(b0 + (ln(b1) * t)) where *u* is the upper boundary value. This says, that Y's approach towards 1 is some function of (a) time, *t*, and (b) the proportion of households that already have computers, *u*, as expressed by the coefficient, *b*.

The population base, number of households and average household size (table 14) are those given by the Census and Statistics Department of the Hong Kong Government, Special Administrative Region (China).[63]

Table 14

[62] The model is given by the equation: Y = 1 / (1/u + (b0 * (b1 * t))) or ln (1/Y – 1/u) = ln(b0 + (ln(b1) * t)) where u is the upper boundary value.

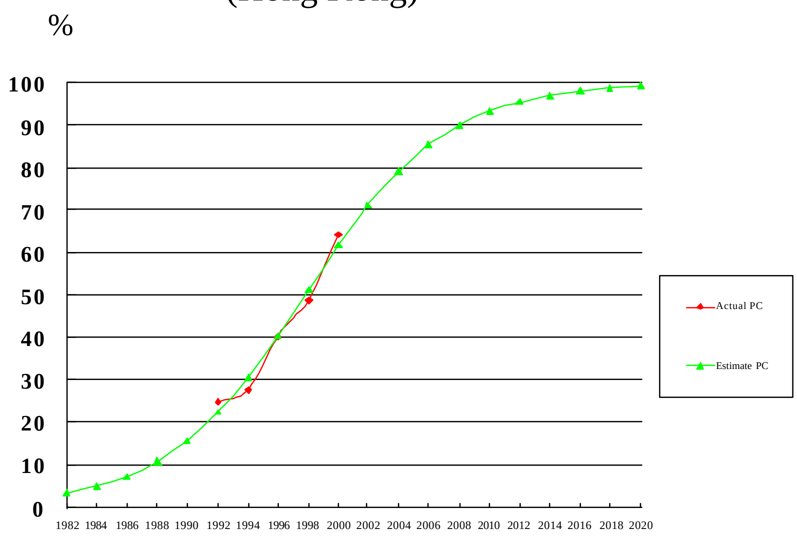
[63] Data on population and average household size as measured by 'resident population' is available in *Population and Household Statistics Analysed by District Council District, 2000*, CenusCensus and Statistics Department, Hong Kong Special Administrative Region, People's RepubicRepublic of China, December 2000.

Year	Population (Mid-Year)	Households (Oct-Dec)	Average Household Size
2000	6.,8665.6 million	2,146,000 (est.)	3.2
1999	6.,7621.6 million	2,108,000	3.2
1998	6.687 million	2,042,000	3.3
1996	6.484 million	1,907,000	3.4
1994	6.,035.4 million	1,762,000	3.4

Source: www.info.gov.hk/censtatd/home.html

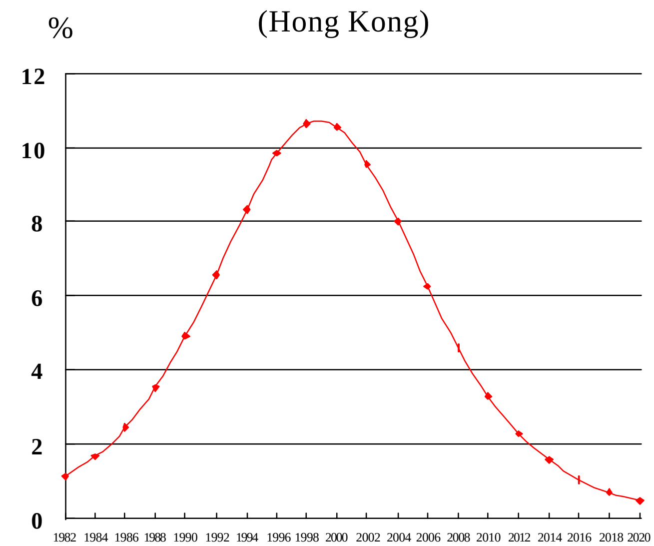
Graphs A and B

Household PC Penetration Rate
(Hong Kong)



Note: Assume an upper bound of 100%

Bi-annual change in percentage of
households with computers
(Hong Kong)



From graph A it is clear that, in terms of households with computers, Hong Kong has well surpassed the inflexion point marking critical mass. By 2000, 64.2 per cent of households or nearly approximately 11,3860,000 households owned at least one computer. In the early phase of Internet adoption most households rely upon a single telephone line to connect to the Internet, so the household is an appropriate unit to measure the rate of diffusion. But for measuring the potential of the B2C e-commerce market the individual online consumer is the more appropriate unit. We estimate below that in households with online computers an average of 2.4 persons use the Internet, compared to the average household size in Hong Kong of 3.2.[64] Rogers uses the first and second standard deviations from the mean of the distribution function to identify the inflexion points which delineate the Innovators (the first 2.5 per cent) from the Early Adopters (the second 13.5 per cent) from the Early Majority (the third 34 per cent).[65] Using 1998 data, these categories would correspond to 74,0005349 ,000 households as Innovators, 38328664,600 households as Early Adopters of computers, a further 963720666,400 households as Early Majority. Since 64.248.8 per cent of households, or approximately 1,360,000956,000 households, owned at least one computer in 20001998 it is clear Hong Kong has, by 1999, well surpassed reached the inflexion point on the S-curve in graph A.[66]

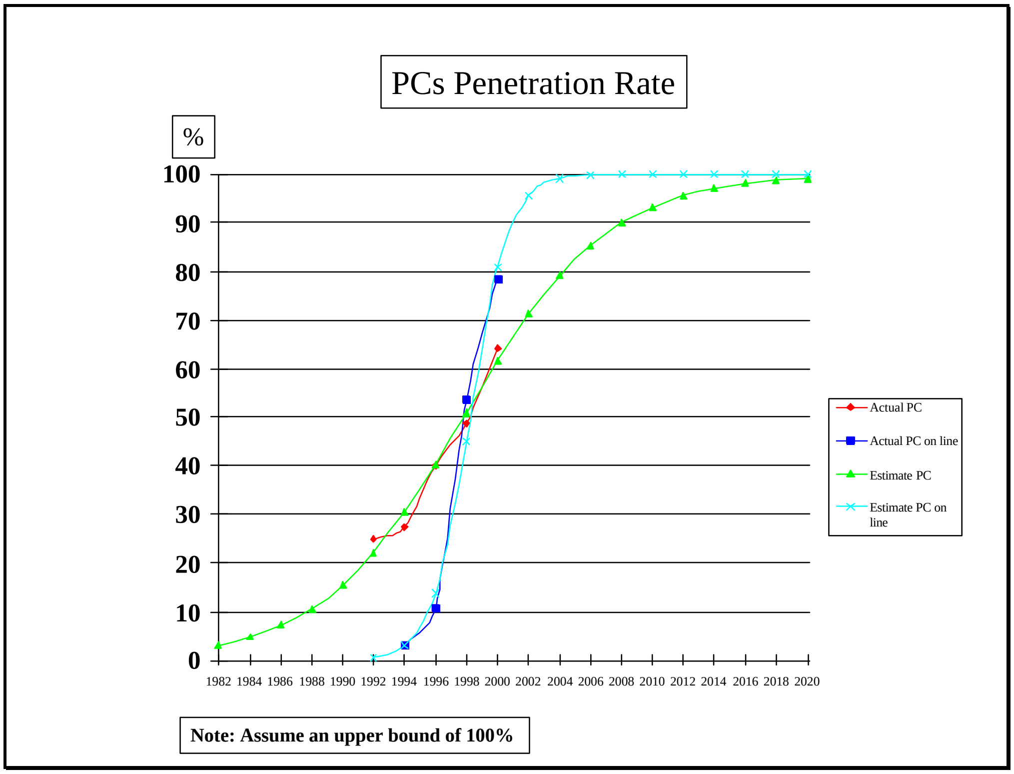
The second stage of the analysis is to graph the logistic curve of the diffusion of home computers online, for which we have data points for 1994, 1996, and 1998 and 2000. In graph C we superimpose this S-curve over the S-curve (graph A) of home computer penetration to juxtapose the two. It should be noted that the scale up to 100 per cent in graph C uses two separate bases, the first for the curve representing the percentage of total households that have computers, the second for the curve representing the percentage online of those households that have computers.

Graph C

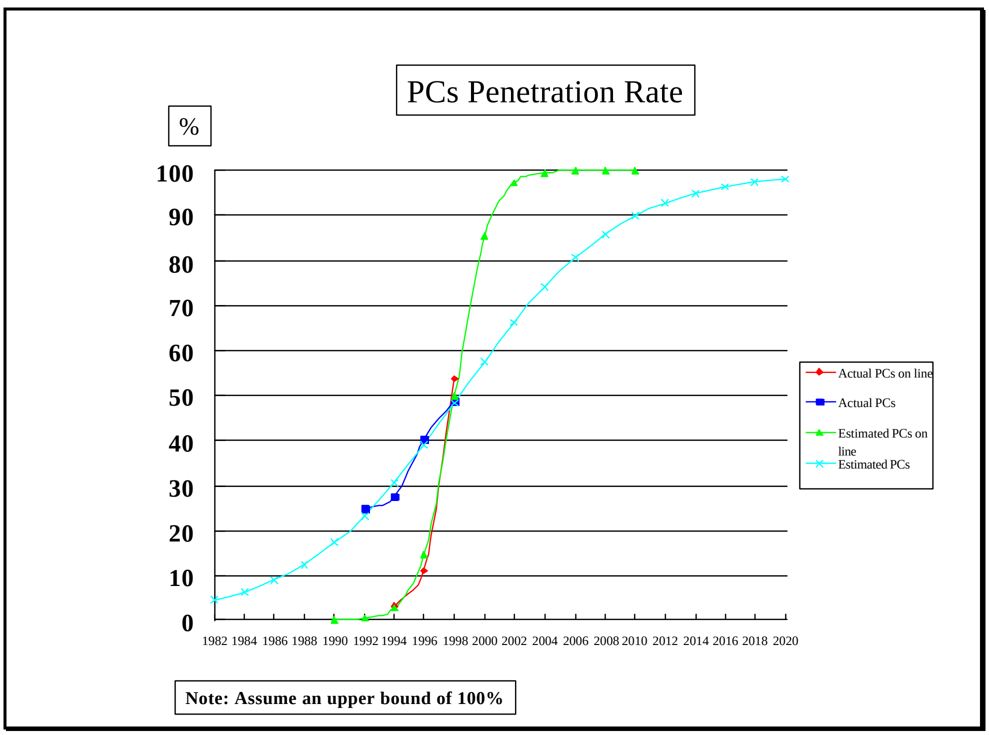
64

65 See Everett Rogers, 1983, *The Diffusion of Innovations*, Collier Macmillan Publishers, London, chapter 7, p.247.

66 Data on population and average household size as measured by 'resident population' is available in *Population and Household Statistics Analysed by District Council District, 2000*, CenusCensus and Statistics Department, Hong Kong Special Administrative Region, People's RepubicRepublic of China, December 2000.



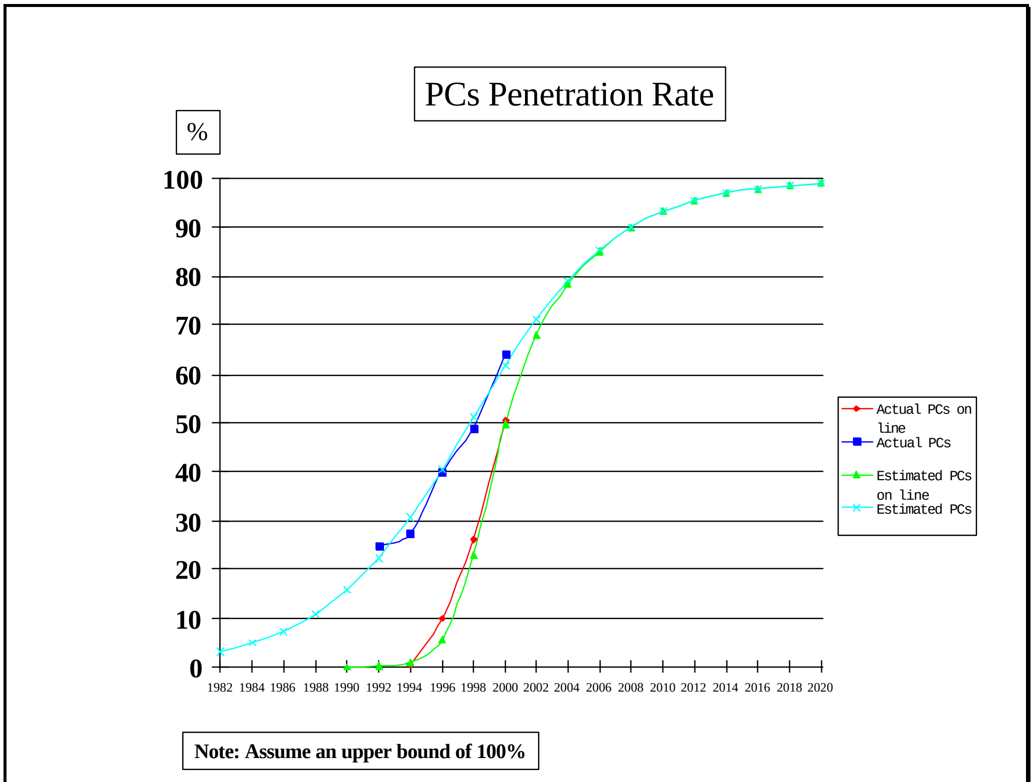
PCs Penetration Rate
%
100
90
80
70
60
50
40
30
20
10
0
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020
Actual PC
Actual PC on line
Estimate PC
Estimate PC on line
Note: Assume an upper bound of 100%

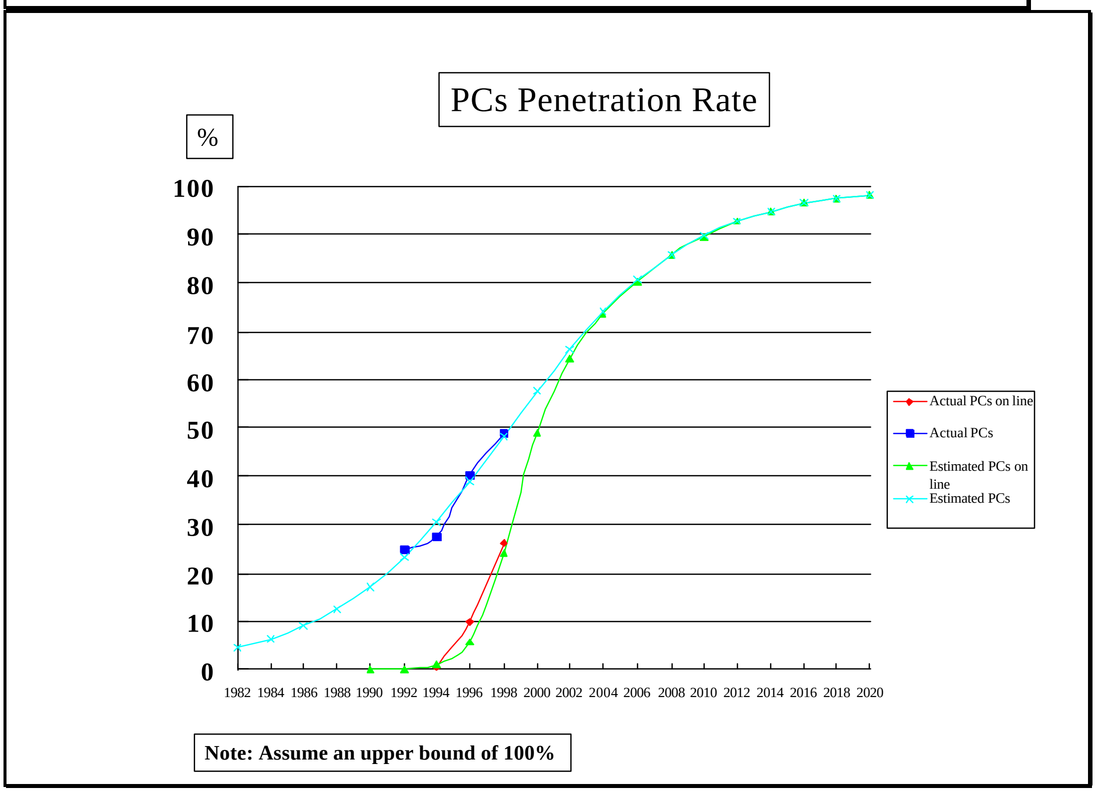


PCs Penetration Rate
%
100
90
80
70
60
50
40
30
20
10
0
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020
Actual PCs on line
Actual PCs
Estimated PCs on line
Estimated PCs
Note: Assume an upper bound of 100%

In terms of critical mass, by 2002 some 96 per cent of home computers will be online, and evidently the addressable population for electronic commerce willEvidently rise to over 99 per cent , by 2002 some 97 per cent of households withme computers would be online, and by 2004 over 99 per centby 2004. On this basis, it would seem by 2002 from 2001-2 onwards home computer networking over the Internet will be driven almost entirely by the rate of diffusion of home computers, which will reach over 70 5 per cent of all homes by 20024, over 80 per cent by 2004, and and 80 per 90 per cent by 20086. This is illustrated in graph D which converts the base of the percentage of computers online to the percentage of all households online.

Graph D


PCs Penetration Rate
%
100
90
80
70
60
50
40
30
20
10
0
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020
Actual PCs on line
Actual PCs
Estimated PCs on line
Estimated PCs
Note: Assume an upper bound of 100%


PCs Penetration Rate
%
100
90
80
70
60
50
40
30
20
10
0
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020
Actual PCs on line
Actual PCs
Estimated PCs on line
Estimated PCs
Note: Assume an upper bound of 100%

This scenario, of course, assumes no acceleration in the diffusion rate due to factors not present in the current data. Dramatic falls in hardware andor software prices, or rapid shifts in technology, or a rush of highly publicized online purchasing or trading opportunities, or the coming online of government services, could all shift the S-curve in graph A upwards.

In the early phase of Internet adoption most households rely upon a single telephone line to connect to the Internet, so the household is an appropriate unit to measure the rate of diffusion. But for measuring the potential of B2C e-commerce the individual online consumer is the more appropriate unit. Table 154 reproduces from the TRP December 2000 survey data on the number of users per household of online home computers. A total of 621 users were spread over 259 households, an average of 2.4 per household, which compares with an average household size in Hong Kong of 3.2 persons.

Table 154

Users per household of online home computers, December 2000

Online home computers	Households with one or more users of an online home computer				Total
	1 user	2 users	3 users	4 + users	
1	48	83	41	20	192
2	3	28	17	8	56
3		2	2	4	8
4 +		2			2
Missing case					1
Total homes	51	115	60	32	259
Total users	51	230	180	160[1]	621

Note: 1. Assumes average of 5 users

Theis figure of 2.4 can be closely collaborated as follows. According to the Office of the Telecommunications Authority (OFTA) the ISPs reported between them 683,000 individual Internet accounts in Hong Kong by March 1999. A.C. Nielsen’s third annual Hong Kong study,[67] also March 1999, based upon a survey of 2,000 people aged between 15 and 54 years, estimates that seven per cent of these shared the account with three or more persons, 12 per cent with two persons, 19 per cent with one other person. On this basis there may have been as many a 1.2 million individual Internet users. From this estimate we can further conclude that, of the approximately 55335,000 households with computers online - 26.2 per cent of the all households - an average of 2.24

[67] www.acnielsen.com/news/asiapacific/hk/19990610.htm

householdfamily members, from an average householdfamily size in 1999 of 3.3, were using online communications.[68]

Rogers uses the first and second standard deviations from the mean of the distribution function to identify the inflexion points which delineate the Innovators (the first 2.5 per cent) from the Early Adopters (the second 13.5 per cent) from the Early Majority (the third 34 per cent).[69] Using 2000 data, and either 2.2 or 2.4 users per household, these categories would correspond to 72-78,000 households as Innovators, an additional 386-420,000 households as Early Adopters of computers, and a further 970-1,000,000 households as Early Majority. In terms of critical mass, the addressable population for electronic commerce will rise to 100 per cent of households with computers just beyond 2004, and as of 1998 the inflexion point between Innovators and Early Adopters is 2.5 per cent, or 49,000 households. The moment of take-off, or exponential growth comes at 16 per cent, or 313,600 households. As over 1 million,000514,000 households, or 50.4 per cent of the total, are already online by 2000, the basis forfor a critical mass ofof electronic commerce already exists.

The third stage of the But argument impliesthese figures assume all online members of the householdsfamily are are, or will become, be, transactors. The 2000 TRP survey found that 6.93.5 per cent of online online households (3.5 per cent of all households) had purchased online, compared with 1.5 1.3 per cent (0.4 per cent of all households) in 1998. These figures translate into approximately 7537,000, 000 households and just under 87,000, 000 households respectively, an annual increase of 130 per cent an annual increase of 300 percent. The The

According to the Office of the Telecommunications Authority (OFTA) the ISPs reported between them 683,000 individual Internet accounts in Hong Kong by March 1999. AC Nielsen's third annual Hong Kong study[70], also March 1999, based upon a survey of 2,000 people aged between 15 and 54 years, further estimates that seven per cent of these shared the account with three or more persons, 12 per cent with two persons, 19 per cent with one other person. On this basis, there may have been as many a 1.2 million individual Internet users, and from this estimate we can further conclude that, of the 514,000 households with computers online, an average of 2.3 family members, from the 3.3 average family size, were using online communications.[71] AC Nielsen's study of March 1999 further reported that nine per cent of their sample, equivalent to 110,000 Internet users, had 'ever purchased products' online, compared with 50,000 reported in their 1998 survey. The discrepancy between these two survey results is particularly striking for 1998, where the TRP data translates into around 19,000 individuals.[72] The A.C.Nielsen data suggests an annual doubling, and that would take a 2000 projection of

[68] The Hong Kong SAR Government *1998 General Household Expenditure Survey* found the family size of households with computers to be 3.6, above the Hong Kong average of 3.3.

[69] See Everett Rogers, 1983, *The Diffusion of Innovations*, Collier Macmillan Publishers, London, chapter 7, p.247.

[70] www.acnielsen.com/news/asiapacific/hk/19990610.htm

[71] The Hong Kong SAR Government *1998 General Household Expenditure Survey* found the family size of households with computers to be 3.6, above the Hong Kong average of 3.3.

[72] The explanation of the difference may lie in the methodology. The TRP telephone surveys did not use prompt questions, so respondents who had made online purchases would need to volunteer this information. Thus, the TRP survey may under-estimate the number of households who have 'ever purchased products' online.

their data to 220,000 individuals, whereas the TRP data for 2000 translates into 180,000 individuals, still a large absolute gap but proportionally much smaller.Although there remains a large discrepancy between the findings, since the TRP data would translate into less than 90,000 individual Internet uses in 2000 and to around only 16,000 in 1998,[73] we may infer. This compares with only 1.3 per cent of households – an implied 6,684 households or, using the above conversion rate of 2.3, around 16,000 individuals - in the TRP survey for 1998. This is a very large discrepancy that cannot be explained by a difference in timing, since AC Nielsen's 1998 survey reported 50,000.[74]

But what we may infer from this data AC Nielsen's survey is the possibility of a 100 per cent annual increase in transactors between 1997 and 1998. Is an annual doubling of online transactors a reasonable assumption? Table 4-3 in Morgan Stanley (1997) *The Internet Retailing Report*, provides a set of projections [75] of Web users world wide rising from 9 million in 1995 to 157 million by 2000, and the percentage transacting online rising from 10 per cent to 45 per cent, that is a CAGR of 139 per cent. An annual doubling in the case of Hong Kong may not be too far fetched, and certainly seems more reasonable than a higher estimate.

The question of critical mass comes down to a question of how many individuals of families with online home computers need to be frequent transactors, and by when. If we assume that 2.3 family members per household online is a ceiling, and the critical mass requires 16 per cent of the total population to be transactors, then by 2004 approximately over 1.1 millionone million transactors are required. This translates to nearlyaround 480,000between 430,000 – 450,000 households. A simple way to see how quickly this critical mass can be reached is to assume an annual doubling of households who are online transactors from the 75,0006,684 implied by the TRP's survey findings in 20001998. By the end of 20034 the figure reaches 600,427,776000 households, above or critical mass. On the other hand, if we assume a slower rate of growth, just fifty per cent per annum, then critical mass is reached before the end of 2005.

This leaves open the question of what percentage of these transactors are, or will be, frequent transactors. And to the question of frequency we can add the equally important issue of average expenditure per purchase. Evidence from Ernst & Young's *Global Online Retailing* report (January 2000) - see table 3 and footnote 30 – for the USA suggests that frequency and average annual online shopping expenditure are positively related. Online shoppers spending more than US$300 rose from 26 per cent in 1997 to 35 per cent in 1998, and spending more than US$500 rose from 40 per cent in 1998 to 48 per cent in 1999. There is not yet any data for Hong Kong recording average online shopping expenditures, and TRP data on frequency only exists for 2000, as shown in table 16.

[73] The explanation of the difference may lie in the methodology. The TRP telephone surveys did not use prompt questions, so respondents who had made online purchases would need to volunteer this information. Thus, the TRP survey may under-estimate the number of households who have 'ever purchased products' online.

[74] The explanation of the difference may lie in the methodology. The TRP telephone surveys did not use prompt questions, so respondents who had made online purchases would need to volunteer this information. Thus, the TRP survey may under-estimate the number of households who have 'ever purchased products' online.

[75] 'Using our instincts and experiences to make reasonable assumptions', Morgan Stanley, *The Internet Retailing Report*, 28 May 1997, p. 4-3.

Table 16

Frequency of online shopping from TRP survey 2000

No. of times order online	Frequency	Percentage
Once	1	6.7%
Twice	3	20.0%
Four times	1	6.7%
Five times	2	13.3%
10 times or above	6	40.0%
DK	2	13.3%

Forty per cent of respondents who reported shopping online can be classified as ‘frequent transactors’ as having reported ten or more transactions times over the previous year, but the sample size is very small, just 15 cases from the total. Excluded is the trading of stocks by two of these respondents and by three additional respondents who reported trading stocks but no other purchasing activity. Without more data on the frequency of transactions, and better insight into the relationship between the percentage of online shoppers and the frequency of shopping, it is only possible to project from assumptions. In the USA data from the Ernst & Young report – see footnote 23 - suggests the frequency of online purchases rose by over 400 per cent 1997-1998 (from 4 per cent to 17 per cent) and by 235 per cent 1998-1999 (to 40 per cent). What is clear is that the timescale for critical mass is quite sensitive to the assumptions made, as shown by the examples in table 17.

Table 17

	Frequency growth assumption	Transactions growth assumptions	Critical mass
1	40 per cent ceiling	100 per cent per annum	end 2004
2	40 per cent ceiling	50 per cent per annum	2008
3	10% annual growth of ceiling	50 per cent per annum	2006

A far better understanding of the dynamics influencing online shopping is required, not least of the complementary factors that will drive Internet usage.[76] One very interesting result that emerged from the TRP 2000 survey was that 33.6 per cent of Internet users claimed to be using broadband connections. At first sight this figure seems high, but OFTA’s figure for Internet dial-up account holders for November 2000 (see www.ofta.gov.hk) is 13 per cent, and using the estimate of 2.3 users per household, this

[76] Stuart Esrock (1999) *Online Shopping: To Buy or Not to Buy?* lists Rogers' five ‘attributes of innovation’ as relative advantage, compatibility, complexity, observability and trialability, and, using a non-random sample, concludes “the key to generating wider diffusion of this innovation lies in more than just the issue of access to the technology, as has been previously suggested.” (p.8; see http://acjournal.org/holdings/vol2/Iss3/articles/Online_Shopping.htm.)

translates to 30 per cent of users. Iamasia, an Internet survey company, reported finding 28 per cent in the last quarter of 2000. (*Internet Audience Measurement Asia*, 11 January 2001). It would seem that one third of Internet dial-up users may indeed be using broadband connections. Part Four below reviews this, and other complementary factors that need to be taken into account. But most of all, there is a need for more data.

Part Four: Complementary and Environmental Factors

If we looked backwards to a decade that saw computers and wireless mobile phones in use, people engaging in electronic commerce and the term ‘cyber’ gain popular appeal we would be looking at the 1940s. The first two were confined to secretive military use, the telephone was widely used for making purchase inquiries and orders, and the term cybernetics [77] was in circulation referring to machines with positive feedback mechanisms which became the robots widely used in the automation of industry during the 1950s and 1960s. The rebirth of cyber as in cyberspace [78] has, during the 1990s become synonymous with the *interactive* capabilities of a world of digitized electronic communications represented by the Internet. And yet the genesis of information communications technologies (ICTs) in use at the turn of this century have a history and, insofar as they grew from obscure beginnings, a pre-history. What determines in their respective histories their point of convergence to become the basis for mass e-commerce?

The question of interest is how to determine and assess the influence of complementary factors in determining when a major innovative technology becomes a driving force and a characteristic of the society or economy-as-a whole? The problematic of this paper, how to model (and therefore how to conceptualize) critical mass for e-commerce, very much requires an understanding of how this question can be answered. Space does not permit a thorough discussion, nor a complete review of the mountain of literature that exists on this subject, but the issue is so important it does demand some preliminary observations.

It is well understood that the widespread adoption, that is diffusion, of a product or engagement in an activity, such as on-line shopping, involves a set of complementary factors in the process. Various categories of complementary factors can be identified. One would be complementary technology or innovations which extend the range of an application, or improve the performance of a particular driving technology, or just make it user-friendlier. For example, before ‘plug-and-play’ telephone sockets and video-equipment of a portable size, teleconferencing was an expensive activity restricted to specially equipped studios, and therefore confined in its usage. Today, it is widely used

[77] ‘Underlying this is the concept of feedback control which involves three distinct sub-processes: the ability to inspect and measure (or “sense” as it is commonly known), the evaluation of this measurement in relation to a theory (or algorithm) of the process, followed by some form of reaction if a response is required. It is this particular form of automation which was christened with the name cybernetics (literally “the art of the steersman”, from the Greek *kybernetes* steersman) by an influential American mathematician Norbert Wiener in 1947.’ R.Kaplinsky, 1984, *Automation: the technology and society*, Longman, London, pp.19-20.

[78] The term was coined in the early 1980s by William Gibson in his sci-fi novel *Neuromancer*, a depiction of a hi-tech future, of an hallucinatory ‘matrix’, a virtual world composed entirely of data.

from a desktop PC, and already by end 1999 four million Japanese customers, especially young people, were using Internet-based video in NTT DoCoMo's *iMode* wireless cellphone for personal communications.[79]

A second category would be the widespread acquisition or adoption of complementary goods or services. For example, in China home ownership is a new phenomenon that is driving the demand for household consumables, including home computers. In Hong Kong the early consumer marketing of portable wireless telephones was for use in automobiles. Two further categories are perhaps better termed 'complementary environmental factors'. The first would comprise the effects of State policies, laws and regulations designed either to promote and facilitate, or to hinder the adoption of a particular technology or activity. The other would contain important socio-economic factors such as demographics, income levels, community organization and cultures, and 'lifestyles' - 'consumer behaviour' in old-fashioned economic terms.

4.1: Complementary Technologies

Complementary technologies have been given various labels, such as 'micro-inventions' Mokyr (1990) [80] 'incremental technologies' Freeman (1987, 1994) [81, 82] and in the model of Besnahan and Trajtenberg[83] they are identified as taking place in 'application sectors'. In all cases particular 'driving' technologies, classically the steam engine, are given pride of place because they are seen as having a widespread and transformative influence, an influence which extends beyond technology into all aspects of social life and organization. These driving technologies are variously referred to as 'macro', 'radical' and 'general purpose technologies' or GPTs, or in the case of Lipsey and Bekar (1994) [84], 'enabling technologies'.

In the endeavour of (micro and macro) economic modelling three approaches are prevalent. The first is the 'epidemic model' or 'logistic model' used in this paper which invariably gives rise to some variant of an S-curve. The model, which is commonly used in the study of product diffusion, characterizes diffusion as a process of disequilibrium up

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79 'Japanese Internet Tsunami' *Financial Times Survey* 3 March 2000.

80 'The approach I adopt here is that techniques - in the narrow sense of the word, namely knowledge of how to produce a good or service in a specific way – are analogues of species, and that changes in them have an evolutionary character.' J.Mokyr, 1990, *The Lever of Riches: Technological Creativity and Economic Progress*, Oxford University Press, p275. Mokyr uses the distinction within evolutionary theory between 'steady state growth' and 'mutation and selection' as a metaphor for micro and macro invention.

81 The debates of the 1950s and 1960s about the diffusion of new technologies focused either upon the job-displacement effects of 'automation', upon the job-creation effects of the IT industry, or upon the growth of new knowledge-based occupations across industries. Freeman's use of the concept 'techno-economic paradigm' aims to capture the insights of all three, but to embrace also a much wider range of issues such as industrial restructuring and the undulating patterns of long-term economic growth. See C. Freeman, 1987, 'Information Technology and Change in Techno-Economic Paradigm' as chapter 4 in C.Freeman and L.Soete, eds, 1987, Technical Change and Full Employment, Basil Blackwell, Oxford.

82 Freeman has also used a wider taxonomy for innovations: 'systematic', 'major', 'minor', 'incremental' and 'unrecorded'. For a survey of the neo-Schumpeterian literature on innovation, see C.Freeman 'Critical Survey: The economics of technical change' *Cambridge Journal of Economics*, v.18, 1994, pp.463-514.

83 T.F.Besnahan and M.Trajtenberg, 1992, 'General Purpose Technologies: Engines of Growth?', 7 *NBER Working Paper*, 4148; and 1999, *Journal of Econometrics*, v.65, pp.83-108.

84 R.Lipsey and C.Bekar, 1994, 'A structuralist view of technical change and economic growth', Bell Canada Papers on Economic and Public Policy, v.3. Proceedings of the Bell Canada Conference, Queen's University, Kingston: John Deutsch Institute.

to the point where saturation is achieved, and for this reason is shunned by equilibrium theorists who prefer models based upon some form of cost-benefit trade-off (discrete-choice or probit models) at each point in time to explain different take-up rates over the lifetime of an innovation. See M.Karshenas and P.Stoneman (1995).[85] S-curves become a subset of possible outcomes, for example, see Vettas (1998). [86] The third approach is evolutionary, for example explaining successful diffusion in terms of comparative advantage one technology offers over others, see Metcalf (1995).[87]

All the models and conceptualizations have problems. For example, in the case of models, apart from lack of data, there remain numerous problems of model specification. For example, there is no guarantee that the specification of the equation underpinning the S-curve used in our model is appropriate. But the problems at the level of conceptualization remain very real as well. Take the example of a General Purpose Technology. Lipsey, Bekar and Carlaw (1998) [88] summarize a GPT technology as defined by 'having three characteristics: pervasiveness, technological dynamism, and innovational complementarities. Pervasiveness means that a GPT is used in many downstream sectors because it provides a generic function, such as rotary motion. Technological dynamism results from its potential to support continuous innovational effects and learning, which allows for large increases in efficiency in the GPT over time. Innovational complementarities exist because "… productivity of R&D in the downstream sectors increases as a consequence of innovation in the GPT and vice versa."' Besnahan and Trajtenberg (1992) regard a GPT in any era 'as critical in fostering technical advance in a wide range of user industries, and presumably in "driving" the growth of the whole economy.' [89]

No great leap in imagination is required to identify the invention of the Internet as a GPT, but doubt may be cast over the apparently clear distinction that is drawn between what is a GPT and what is a complementary innovation. What is the World Wide Web? Another GPT ? The *real* GPT, whereas the Internet is a complementary innovation to the invention of the telephone network and computer networking? Or is the Web a complementary innovation designed to enhance the productivity of the Internet?[90] In a modelling of critical mass it would seem advisable to focus on those aspects of a technology which accentuate the benefits of networking. The networking 'externality' of the Internet is most obvious in the use of email and instant messaging which is directly

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85 See M.Karshenas and P.Stoneman 'Technological Diffusion' as chapter 7 in P.Stoneman, ed., 1995, *Handbook of the Economics of Innovation and Technological Change*, Blackwell, Oxford, England.

86 Vettas demonstrates an equilibrium approach that generates an S-curve closely conmforming to common observation, and involving a process of 'bilateral-learning' on the part of suppliers and users in which information becomes an 'externality' that accelerates adoption. See N.Vettas "Demand and supply in new markets: diffusion with bilateral learning' *RAND Journal of Economics*, v.29.1, Spring 1998, pp.215-233.

87 See S.Metcalf 'The Economic Foundations of Economic Policy: Equilibrium and Evolutionary Perspectives' as chapter 11 in P.Stoneman, ed., 1995, *Handbook of the Economics of Innovation and Technological Change*, Blackwell, Oxford, England.

88 R.Lipsey, C.Bekar and K.Carlaw, 1998, 'What Requires Explanation?' chapter 2 in E.Helpman (ed.), 1998, *General Purpose Technologies and Economic Growth*, MIT Press, Cambridge, Mass. and London.

89 T.F.Besnahan and M.Trajtenberg, 1992, 'General Purpose Technologies: Engines of Growth?', 7 *NBER Working Paper*, 4148; and 1999, *Journal of Econometrics*, v.65, p.85.

90 For Zwass, who notes 'the main question of E-commerce today is how to convert Web-surfers from browsers into consumers', the Web is a 'subset' of the Internet. See V.Zwass, 1996, Electronic Commerce: Structures and Issues', *International Journal of Electronic Commerce*, v.1.1, pp.3-23.

analogous to the use of a telephone network. The more people who join it the more valuable the network becomes to those already on it, and the more attractive it becomes to those not yet on it. Here the S-curve is just leaping to get out. But there are slightly less obvious networking effects. Individuals or households who shop online are not directly enhancing value for other online shoppers, but indirectly they may be considered doing so precisely because they hasten the point of critical mass, which is a point when demand brings forth greatly increased supply which increases choice for all online shoppers. Compare Economides (1996). [91] So here we reach the conclusion that introducing the concept of 'critical mass' shifts the focus of analysis, and the role of complements, away from the gradual accretion of demand implied by the continuous S-curve and towards a climacteric reaction of supply to demand. Only when this happens does B2C e-commerce take-off.

Harris (1998) [92] provides an analysis of the Internet as a GPT focusing on the economies of scale associated with 'network economics'. He concludes that small regional economies have little to fear from the Internet precisely because network economics brings external benefits to be enjoyed by all participants. His caveat, however, is that this will benefit small regional economies which otherwise are already attractive to foreign investors or customers. On the contrary, the losers from the network effects of the Internet will be the unskilled, which translated into the theme of this paper are equivalent to businesses which cannot adapt to e-business and e-commerce. In our analysis, this will become critical beyond the point of critical mass as outlined above. It should be emphasized this does *not* necessarily imply that businesses based on 'bricks' lose out to those based on 'clicks', rather that all markets, intermediary and consumer, are effected by the Internet. An example below of the convenience stores in Japan will illustrate how the 'bricks' and the 'clicks' can complement one another in a new commercial environment.

Bresnahan and Greenstein (1996) have extended the thinking about GPTs one step further by stressing the role of 'co-invention' where users, 'through their own experimentation and discovery, make technology more valuable.' [93] Using this framework, Jimeniz and Greenstein (1998) [94] discuss the role of complementary 'co-invention' for online shopping to reach critical mass, a necessary condition they name a 'nested diffusion process.' They distinguish between the 'innovators' and 'early adopters' for whom online shopping is a 'continuous innovation, or one in which they could easily adopt without drastic changes in behaviour' (p.297), and later comers to online shopping for whom a major effort of learning or adjustment is necessary. As an example of online shopping by 'innovators' and 'early adopters' in the US they point out that '41% of all Internet users in 1996 had

[91] Economides discusses the role of 'indirect externalities' in his broader discussion of 'compatibility' between complementary goods, where 'compatibility' is defined as complementary goods which 'are costlessly combinable'. If combination is costless, then the cost-benefit decision will favour adoption which in turn creates economies of scale among suppliers and thereby benefits to all users. See N.Economides, 1996, The Economics of networks' *International Journal of Industrial Organization*, v.14, pp. 673-699.
[92] R.Harris, 1998, 'The Internet as GPT' chapter 6 in E.Helpman (ed.), 1998, *General Purpose Technologies and Economic Growth*, MIT Press, Cambridge, Mass. and London
[93] T.Bresnahan and S.Greenstein, 1996, 'Technical Progress and Co-Invention in Computing and in the Uses of Computers' *Brookings Papers: Microeconomics 1996*, pp.1-77
[94] Ed Jimeniz and Shane Greenstein (1998) 'The Emerging Internet Retailing Market as a Nested Diffusion Process' International Journal of Innovation Management, v.2.3, September, pp. 281-308.

purchased software online and 18% had purchased hardware.' (p.295) The implication being that the spread of online shopping to a wider range of products and services involving the 'early majority' will be a whole different story. Indeed their conclusion is that 'it is apparent that online shopping will reach a plateau in diffusion until technological advances allow mainstream customers to adopt the technology' (p.298).

This view seems unwarranted, partly because 'co-invention' in the uses of the Internet for commerce, including consumer-to-consumer or C2C, does seem to be a strong influence in the US. But also because their conclusion seems overly influenced by static theoretical presumptions in many of the papers developed around GPT theory that the initial invention of the GPT and the early associated complementary R&D, invention and innovation gives rise to a temporary 'output slowdown' as, for instance, resources are diverted from production to R&D. See G.Grossman and E.Helpman (1998). [95] Even Besnahan and Trajtenberg in their 1999 paper posit a 'key hypothesis is that institutions display much more inertia than leading technologies. Thus, as a GPT era comes to a close and new GPT's emerge, an economy may "get stuck" with the wrong institutions…' (p.104). Some of these explanations for hiatus in the diffusion process are stylized facts of how an economy is thought to work in practice, while others are contingent upon the historical ruts into which a particular society may fall. But it would seem that neither has much bearing upon the means and mechanisms through which e-commerce is spreading.

4.2 Complementary Goods and Services

Despite the early attention of scholars like Bain (1964),[96] economists have generally devoted their attention to the study of innovation diffusion in intermediate products and process technologies, leaving the field of consumer durables to marketing researchers, see Karshenas and Stoneman (1992) [97] This has left the role of complementary goods and

[95] G.Grossman and E.Helpman, 'A Time to Sow and a Time to Reap: Growth Based on General Purpose Technologies' and 'Diffusion of General Purpose Technologies' chapters 3-4, in E.Helpman (ed.), 1998, *General Purpose Technologies and Economic Growth*, MIT Press, Cambridge, Mass. and London.

[96] Bain made early use of the logistic model to analyze consumer adoption of television. See A. Bain, 1964, *The Growth of Television Ownership in the UK since the War: A Lognormal Model*, Cambridge, Cambridge University Press.

[97] Karshenas and Stoneman criticize the logistic model as inherently privileging endogenous influences on diffusion, in particular the assumption of an epidemic of information, learning or emulation. In essence, what may be termed the coefficient of epidemic is time invariant. In their example of the purchase of colour television sets they distinguish *within their model* between the acquisition of the information or the 'desire to acquire' (the epidemic model) and the actual decision to acquire (the cost-benefit, probit or discrete-choice model) where they determine the latter by three economic variables: price, disposable income, and credit conditions. In other examples the influence of complementary goods could be used. See M.Karshenas and P.Stoneman, 1992, 'A Flexible Model of Technological Diffusion Incorporating Economic Factors with an Application to the Spread of Colour Television Ownership in the UK', *Journal of Forecasting*, v.11, pp. 577-60. The model of C.Easingwood, V.Mahajan and E.Muller, 1983, 'A Nonuniform Influence Innovation Diffusion Model of New Product Acceptance' *Technological Forecasting and Social Changes*, v.22, 199-213, is examined in F.Zettelmeyer and P.Stoneman, 1993, 'Testing Alternative Models of New Product Diffusion', *Economics of Innovation and New Technology*, v.2, pp.283-308. They drop the assumption that the coefficient of epidemic is time invariant, or as Zettlelmeyer and Stoneman put it 'the entire stock of adopters may actively contribute to the learning process.' (p.306) and this frees up the epidemic model from its logistic straightjacket of symmetry to give better estimates of actual diffusion processes. The FLOG model in R.Bewley and D.Fiebig, 1988, 'A Flexible Logistic Growth Model with Applications in Telecommunications' *International Journal of Forecasting*, v.4, pp.177-192, is a variant of Easingwood, et al. by offering an alternative specification of the time variance of the learning process.

services rather neglected although correlation between complementary products is easy to spot, but see Stoneman and Toivanen (1997) who model the accumulated stock of a complementary technology as an exogenous influence upon the adoption rate. [98] The challenge at the market level is to not so much spotting the complementary goods and services but knowing what combination of product standards and technologies embodied in complementary products is necessary and sufficient to accelerate demand to critical mass proportions, and when and how such combinations are likely to come about. The example given above of video-conferencing needing equipment manufacturers and telephone companies to develop ‘plug-and-play’ standards, and desktop computers with a processing power able to handle the software to support mini-video cameras is an illustration. Online shopping also needs a set of complementary standards and technologies embodied in products before it can take-off as a mass activity.

This again stresses the importance of the supply side of the equation as being complementary, although whether the supply of a particular technology is proactive or reactive to demand is another issue. See Mowery and Rosenberg (1982) [99] A good example of a supply side issue is the advent of third generation mobile telephony, a broadband technology which offers ‘always on’ and ‘always there’. It is being introduced with a number of possible and competing protocols for a Web-based graphical interface [100] and with protocols such as ‘Bluetooth’ designed to allow devices with embedded programmable chips, such as digital cameras, computers, printing machines, vending machines, to communicate directly with one another. Instantly, many home devices can be networked, and each and all can be linked to the Internet. Already many domestic and consumer items are being manufactured Internet-enabled, from refrigerators to the family automobile, and even from the collar of the family dog to personal apparel. The algorithms programming these networks to place requests and purchase orders over the Net will govern part of B2C e-commerce. Mobile Internet especially is seen within the industry as a potential driver of many e-commerce applications, such as mobile banking and stocks trading, cinema and travel bookings, hotel reservations, buying petrol and so on. Smart card technology is another possible enabler of e-commerce, especially where micro-payments are involved. Hong Kong, like all of Asia, may be two to three years behind the US in all this gadgetry, but like dog years, Internet time, is foreshortened.

4.3 Complementary Environment and State Policies

The promotion and facilitation of e-commerce is, for obvious reasons, a common policy aim of most governments. This raises a number of questions. First, is there any evidence that state encouragement of e-commerce, by word or by deed, for example by government itself going online, makes a difference to either the extent and rate of

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[98] Stoneman in particular is associated with economic diffusion models which distinguish between rank (for example, company size, household income), stock (for example, past and current acquisition levels), order (for example, costs and benefits to early or late adopters) and epidemic influences. The stock variable can pick up cross technology or complementary effects, as in the case of the diffusion of computer machines tools in P.Stoneman and O.Toivanen, 1997, ‘The Diffusion of Multiple Technologies: An Empirical Study’, *Economics of Innovation and New Technology*, v.5, pp.1-17.

[99] C.Mowery and N.Rosenberg, ‘The influence of market demand upon innovation: a critical review of some recent empirical studies’ chapter 10 in N.Rosenberg, ed., 1992, *Inside the Black Box: Technology and Economics*, Cambridge, Cambridge University Press.

[100] For an account of these competing technologies, see G.Darby (1999) ‘Bridging wireless and wired networks: smart phone operating systems, IP convergence and market segmentation’ Info, v1.6, December, pp.563-576.

diffusion of B2B or B2C? Second, does legislation to provide data security and protection, to set up public key infrastructures, to give legal backing to certification authorities and to digital signatures on contracts, and to extend consumer protection laws into the world of electronic commerce, have any significance influence on the spread of e-commerce? If so, does this extend significantly to B2C? Third, on what basis should governments think of intervening in the setting of industry standards? Clearly, standards in ICT markets are of crucial importance when interconnection and interoperability of hardware, software and networking is needed. These research questions, among others, such as the issue of taxation and e-commerce, are beginning to draw attention.

Undoubtedly the focus of most state policy towards new technology over the years has been on industrial policy rather than on consumer policy, and the state of the consumer market has been left to the realms of macro-management of the economy and competition law. In Hong Kong there has been no industrial policy to speak of and no competition law as such, although the licence conditions of telecommunications network operators contain clauses empowering the regulator to act against anti-competitive practices. On the other hand the Hong Kong government has been active in promotion and facilitation which has become a major theme of the annual *Policy Address* of the Chief Executive of Hong Kong, SAR since the return of Hong Kong to Chinese sovereignty in 1997. But as users rather than inventors of information technology the innovative comparative advantage of Hong Kong companies lies in finding new ways to apply IT. For example a local company, Champion Technologies, pioneered the use of Chinese language software in pagers which greatly extended the use of the pager as a tool of communication among Hong Kong's Cantonese-speaking population.

Since the mid-1990s there has been a turnaround in the Government's policy of putting itself online, see Ure (2000)[101] and as of 20010 an Electronic Services Delivery (ESD) programme is being implemented which will eventually place all G2C services online as well as B2G and G2B. A visit to *www.info.gov.hk* is a good way to discover all this. It is expected this will encourage the diffusion of online information exchange and, to a lesser degree, transactions online, but by how much has not been modelled. We noted earlier that in the case of Singapore, where the government has heavily promoted the concept of putting everyone online in the 'Intelligent Island', a very low percentage of those online actually transact online. The limits of government influence are therefore important to gauge. For example, Teo, Tan and Wong (1998)[102] using a five-point Likert scale questionnaire divided companies in Singapore into three groups, (a) those not online, (b) those online but without a website, (c) those online with a website, and concluded that the degree of government support offered companies was not a differentiator between those with and without websites. At the same time they report that all three groups agreed on the importance of state influence on Internet adoption in Singapore. Website adoption

[101] J.Ure 'Hong Kong' in M.Hukill, R.Ono and C.Vallath eds. 2000, *Electronic Communication Convergence: Policy Challenges in Asia*, Sage Publications, New Delhi

[102] T.Teo, M.Tan and K.B.Wong, 1998, A Contingency Model of Internet Adoption in Singapore', *International Journal of Electronic Commerce*, v.2.2, pp.95-118.

however is not necessarily a good indicator of e-commerce as most sites may be used only for passive advertising. See DTI (1999). [103]

Like Singapore, Malaysia and an increasing number of Asian economies, Hong Kong has legislation covering all the security and legal issues mentioned above, but the issue here is how important is this for B2C. All the early evidence suggests that security fears about giving credit card details over the Web is a major inhibitor of online shopping, but the common view is probably that of the IDA in Singapore, as cited in Part 2 above. Most online shoppers may be reluctant at first to give credit card details but that barrier is soon overcome. This is partly an issue of trust based upon experience, and it therefore follows that regular purchases from familiar merchants, which constitute the bulk of most purchases offline, are likely to go online without too much consumer resistance. There is no *a priori* reason to see online risk as more daunting that offline risk.

Intuitively the issue of standards is perhaps the most tangible when it comes to providing a complementary environment for consumers who need to use IT to access and surf the Web with a minimum of friction. The most standards-regulated sector of ICT has been the telecommunications industry, but the Internet wave that has engulfed it is propelled by the least standards-regulated IT sector, while the third sector, broadcast media is shifting rapidly from national standards, PAL, NTSC, SECAM, to standards for cable modems and TV set-top boxes yet-to-be determined within the industry. As small economies such as Hong Kong have no influence in standards setting, the best option is the requirement of interoperability of protocols and interconnection where the 'essential facilities doctrine' applies to bottlenecks in public networks and access to them. Surprisingly little academic research focus has been applied to the standards question, perhaps because the data is extremely slippery. See Mowery (1995) and David and Greenstein (1990). [104] What appears to be a winning standard one year can be easily by-passed the next. Furthermore, most standards involve trade-offs of one kind or another, for example price versus performance, reliability versus versatility, and different trade-offs make sense to different people, which could suggest an argument for discrete-choice models rather that synoptic models. On the other hand, there are clearly powerful externalities associated with the achievement of standards in areas such as consumer goods, both on the supply side (economies of scale leading to lower costs and prices) and the demand side (lower transactions costs of accessing the Web). This raises the question of should governments try to encourage standards setting and can they do it without inhibiting, by foreclosing on, further innovation, see David (1987) [105]. In the case of Hong Kong the recommendation in March 1999 of the Information Infrastructure Advisory Committee (IIAC) of the Office of the Telecommunications Authority (OTFA, the

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103 *UK Government Study: Moving into the Information Age, 1999*, European Telework Department, Department of Trade and Industry, www.eto.org.uk/eustats/ukb-mark.htm compares percentages of companies within selected OECD economies actually *using* websites to promote online sales as opposed to those just maintaining a website.

104 D.Mowery, 'The Practice of Technology Policy' as chapter 12, P.Stoneman, 1995, *Handbook of the Economics of Innovation and Technological Change*, Oxford, Blackwell; P.A.David and S.Greenstein, 'The economics of compatibility standards: an introduction to recent research' *Economics of Innovation and New Technology*, v.1 pp.3-42

105 P.A.David, 'Some new standards for the economics of standardization in the information age' in P.Dasgupta and P.Stoneman, eds, 1987, *Economic Policy and Technological Performance*, Cambridge, Cambridge University Press.

regulator) was not to impose a standard on cable modems and TV set top boxes, although interoperability was recommended as a policy objective.[106]

4.4 Complementary Environment and Socio-Economic Demographics

The early and later patterns of adoption of the Internet are well known and have been rehearsed above in terms of age, income, occupation, housing type and gender. So is the profile of typically popular online items of purchase, although regional variation is evident. Table 1853 summarizes the rank ordering of categories of online purchase across six economies, Australia, Canada, France, Italy, UK and USA, surveyed in *Global Online Retailing*, Ernst & Young (January, 2000).

Table 1853

Categories of Online Purchases	Rank Orderings from 20 Categories [1]
Books, computers and computer products, CDs	Within 1-4 range
Air tickets, events tickets, films and video, hotel reservations, magazines, apparel	Within 4-13 range
Food & drink, electronic products, flowers, art	Within 5-20 range
Financial services, toys, sports goods, vehicle purchase, vehicle rentals, health and cosmetic products, household items	Within 10-20 range [2]

Notes: 1. Excludes 'Other'; 2. Financial services are ranked fourth in the case of Australia.

The range of rank ordering indicated in the table reflects country variations. For example, the purchase of art online was ranked eighth in Italy and nineteenth in the UK, whereas the online purchase of electronic products was ranked fifth in the US and seventeenth in Italy. The one outlying item is 'financial services' which in the case of Australia ranked fourth. This accords with the findings of *E-tail of the Tiger* (reported above) for Asian-Pacific economies, Australia and New Zealand, Japan and Korea, China, Hong Kong, Taiwan, Singapore, Indonesia, Malaysia, the Philippines, Thailand and India, by the Boston Consulting Group (2000). The report ranks financial services second to computer hardware and software, and ahead of travel and books/magazines. The report also stresses the most successful online retailers are those operating multichannel sales outlets rather than relying exclusively on the Net.

[106] The author is a member of the IIAC. See *www.ofta.gov.hk, and www.gcn.itbb.gov.hk*.

TRP data collected for Hong Kong in 2000 generally conforms, but with three significant differences, as shown in table 19.

Table 19

Types of Goods Ordered Online in 2000 by Hong Kong Households

Categories of Purchased Items	*% Households Making Purchases Online*
Food/beverages/Groceries	40.0%
Stocks	33.3%
Books	26.7%
Computers or computer products	13.3%
Household items/Furniture	13.3%
Clothing/Apparel/Footwear	6.7%
Health and cosmetic products	6.7%
Event tickets (movie/show/concert tickets)	6.7%
Others	13.3%
DNK	13.3%

Groceries lead the list. Two major grocery chains dominate the market in Hong Kong, and both have heavily promoted online sales. Stocks trading, unsurprisingly, come second. The third item which figures more heavily in Hong Kong's online shopping list are household items, particularly furniture, but this may be a transient phenomenon as the firm promoting these sales, *Admart*, went out of business during 2000. By contrast, IKEA, a popular middle-range furniture store, has not yet offered online purchasing.

Hoffman, Novak and Chatterjee (1996) [107] introduce a useful taxonomy of retail websites relevant at the time of research. They distinguish between 'Destination Sites' and 'Web Traffic Control Sites'. Destination sites, which compete 'for consumers' share of visits on the Web', include online storefronts, Internet presence sites and content sites; while Web traffic control sites 'function to direct consumers to these various Destination Sites', and include malls, incentive sites and search agents. Their work is interesting because they include both elements of supply and demand in their framework. Citing Gupta (1995)[108] on the side of demand they stress: 'Accumulated industry experience and anecdotal evidence strongly support the contention that the primary barrier to consumer adoption of the Web as a commercial medium is ease of access', the drivers of which include 'high speed access (the "bandwidth" problem), ease of finding a service provider, and the diffusion of the computer hardware/software/modem bundle into the home.' On the supply side the

[107] D.Hoffman, T.Novak and P.Chatterjee, 1996, *Project 2000: Research Program on Marketing in Computer-Mediated Environments*, Owen Graduate School of Management, Vanberbilt University, www.ascusc.org/jcmc/vol1/issue3/hoffman.html
[108] S.Gupta, 1995, *HERMES: A research project on the commercial uses of the World Wide Web*. www.umich.edu/~sgupta/hermes/ Gupta found that obtaining purchase-related information was the preferred Web activity.

‘main challenges for marketers are to attract visitors to the site and generate significant repeat visits… Awareness leads to trial or the initial site visit so that the trial problem depends on the “Web Traffic Control”. However, sites will only be successful in the long run if they generate repeat traffic, which is far more difficult to achieve than trial.’ In a competitive environment, at the micro-level this problem will be unending, but at the macro-level it may be interpreted, in terms of critical mass, as the point where there are sufficient numbers of potential outline shoppers to warrant a major new entry of retail websites and of investment specifically directed at attracting repeat visits.

The evidence to date shows online shopping slowly but surely gathering momentum in the leading OECD economies. Two questions arise. First, will the same patterns of slow and then faster growth (the logistic) replicate in each economy, or will ‘globalization’ change them in any significant ways? In many ways the Internet is synonymous with globalization because anyone with access can reach any website. In practice, of course, there are numerous mediating restrictions, some political such as curbs on international access, some economic such as low incomes or lack of credit cards, some cultural, such as language barriers. Second, as the demographic characteristics of Internet users begin to mirror society at large, will offline shopping characteristics be simply transferred to online?

Starting from either question a further question arises. How will *local* retailing online and *local* offline retailing influence one another? There are two immediate issues here, how are goods that are ordered online paid for? And how are they delivered? Examples from Hong Kong, China and Japan are instructive. In Hong Kong in 1999, *Admart*, is an 1999 online retail start-up by local entrepreneur Jimmy Lai who also owns Hong Kong’s best selling Chinese-language tabloid newspaper, *Apple Daily*, began operating . *Admart* operates t hrough a fleet of distinctively coloured delivery vans to homes. Many households in ost of its customers in Hong Kong will employ a domestic helper during working hours, so there is usually someone at home to receive the delivery. The model worked so far as deliveries were concerned, but the revenues were insufficient to protect *Admart* from the collapse of the dot.com boom in 2000. In China, two surveys for Q-east.com [109] available in February 2000 showed that of 138 retail websites in one survey (survey one) and 360 retail websites in another (survey two) vendors had their own websites through which orders and/or payments could be made in 17 per cent and 12 per cent of cases respectively, while the remainder advertised through ‘public’ sites. Of the 71 major merchandise sites in the first survey and the 191 in the second, 27 per cent and 25 per cent respectively allowed for online payments, but 42 per cent and 54 per cent operated as cash-on-delivery, a manageable system in urban centres, but not so easy in suburbs and beyond. The most common delivery system in the first survey remained mail out after the receipt of payment.

Japan is different again, and has developed its own interesting combination of ‘bricks’ and ‘clicks‘. As a *Financial Times* survey out it: ‘One key difference between Japanese and US online retailing models is the reluctance of Japanese consumers to use their credit card over the Internet or over the telephone. So convenience stores, with their sprawling

[109] Made available to the author through private communication.

network of outlets, are providing a crucial role as a pick-up and payment centre.'[110] This is a commercial development, but also a social one. It engages a wider network or community of people in an activity that is new to most of them, and this is likely to accelerate the diffusion process.

How complementary factors impact on the diffusion process is a question that has important implications both for forecasters and planners and for public policy strategists. Innovations that have limited applications, or simply fail to take off, in one period often successfully return in a new guise when the conditions are right. In this paper the concept of critical mass implies more than simply a necessary number of potential online shoppers, it implies also a sufficient environment of complementary factors.

Part 5: Conclusion

This paper has demonstrated a method to model the point of critical mass of frequent online consumers using data from Hong Kong. The model has three layers to it: the estimated number of computer-enabled households in Hong Kong, the proportion of those Internet-enabled, and the proportion of online households who are frequent transactors. Critical mass is first defined in terms of the traditional logistic approach as the second inflexion point on the S curve, and second in terms of the underlying conceptual model as the point at which demand calls forth supply. The argument is that as the number of frequent online shoppers approaches critical mass a growing number of retailers will enter the online market, or will extend and improve their online facilities and services. Demand and supply then feed each other. By bringing supply as well as demand into the framework of analysis, the use of the term 'critical mass' in this dual sense goes some way in addressing a criticism of the traditional epidemic model, namely that it privileges endogenous influences on the diffusion process. In the course of developing the model Hong Kong data collected by the Telecommunications Research Project is presented, and comparable data on household computer ownership, Internet usage and online shopping from other economies, including Asian economies, is included.

The paper quotes a number of other studies concerned with the diffusion of household computers, of households online and the frequency of usage, noting that both endogenous factors and exogenous factors have been found relevant. On the basis of this limited evidence the paper suggests the concept of 'Internet households' in which online usage is partly a shared family experience and where this could be an influence on the character of online shopping. This point is also related to the growing number of women, including those describing themselves as 'housewives', who are using the Internet. The paper also makes reference to research which finds the 'spillover effects' of local community 'networking' (use of e-mail and the Internet) in the US to be an influential exogenous factor in home computer adoption.

The paper notes that few studies by economists have explicitly addressed diffusion issues in markets for consumer products. A notable recent exception is the work of Stoneman

[110] 'Japanese Internet Tsunami' *Financial Times*, 3 March 2000, p.3. See also *White Paper, 1999* www.mpt.go.jp.

who models the influence of exogenous complementary variables by estimating the impact of stocks of complementary technologies on the diffusion rate. The influence of complementary factors is strongly argued in this paper, and while it does not attempt to model them it does offer some initial thoughts on their role. In particular, the paper argues the need to examine the conditions and circumstances under which a combined set of complementary factors themselves become critical to the diffusion of business-to-consumer electronic commerce.

Finally, it is stressed that the purpose of the model and its *prediction* is to offer insights into the factors influencing the diffusion of B2C and how they themselves diffuse and under what influences. It is hoped with the benefit of perfect hindsight, or *postdiction* a understand the failings and weaknesses of the model will be forthcoming with the aim of building a better and certainly richer one for future understanding of the processes at work. Econometric work will be an essential component of any such extension.

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