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

John Ure[1]

Part One: Introduction

The collapse of the dot.com boom in year 2000 notwithstanding, electronic commerce, defined here as commercial transactions over computer-based communications networks, is here to stay. The OECD [31] provides a typical assessment: '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.' (Summary, p.2) [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 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 the US dominates world markets.[3] However, the paper assumes that as a '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 – take-off. Demand and supply will then feed each other, bringing about changes in both consumer behaviour and in the structure of the retailing sector.

The genesis of this paper [4] was knowing what to do with data collected by the Telecommunications Research Project at the University of Hong Kong in 1994, 1996, 1998, and again in 2000, which traces the growing penetration of households in Hong Kong with computers, and the percentage of these online. Beyond a purely descriptive analysis lay the possibility of modelling the data, despite so few data points, using the concept of 'critical mass'. The purpose of the paper is therefore to offer an approach to modelling the build-up to critical mass of 'frequent transactors', who are defined as having shopped online at least ten times during the year. The paper constructs a diffusion model, not so much to *pre*dict when critical mass will be reached, although the paper

---

[1] John Ure is director of the Telecommunications Research Project, Centre of Asian Studies, University of Hong Kong. Thanks are due to Jenny Wan and Chan So Kuen, current and previous research officers of the TRP, for assistance in preparing this paper, and to Peter Lovelock, TRP deputy director, for his comments on an early draft.

[2] The US Government estimates between 1995-98 ICTs accounted for 8% of GDP but were responsible for 35% of real US economic growth; see US Department of Commerce [37].

[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] A fuller version of this paper is available on the TRP website: www.trp.hku.hk which is a revised and updated version of a paper delivered to Third International Conference on Telecommunications and Electronic Commerce, Cox School of Business, Southern Methodist University, Dallas, Texas, 16-19 November 2000. See *Proceedings*, pp. 83 – 107.

does suggest this point could arrive in Hong Kong as early in 2003,[5] but to provide a benchmark for *postdiction*. How wrong the forecast turns out will be less important than how and why it was wrong. Notionally, hindsight is perfect, and is therefore an ideal basis from which to improve future models and our understanding of the process.

The paper is organized along the following lines. In part two we consider some of the conceptual and theoretical issues which ideally require modelling. The model presented in this paper is restricted by virtue of the data currently available, but it is important to place these restrictions in the context of wider influences that will eventually determine the actual rate of adoption of electronic commerce. Part two closes with reference to the actually existing scale of consumer electronic commerce in the Asia Pacific region and in Hong Kong. Part three presents the data, the model and the findings. Part four draws conclusions based on some comparative data from the Asia Pacific.

Part Two: The Issue of Critical Mass

2.1: *Theoretical Issues of Modelling*

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 set of complementary factors such as a mercantile credit system for small traders, easy-to-use software, 'always-on' broadband access, and an evolution of suitably customer-friendly 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 will be involved in online shopping, giving rise to what we might term the emergence of 'Internet households'.[6]

Some evidence to support hypothesis (c) comes from an econometric study by Emmanoulides and Hammond [13] 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-

[5] In an earlier version of this paper using data from 1999 the date was 'after 2004'.
[6] 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.' Japan's Ministry of Posts and Telecommunications [29] p.57.

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.' (p.21)

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.[7]

The diffusion of home computing is also the subject of a working paper by Goolsbee and Klenow. [17] 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.' (p.2) 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) signals that home computer adoption implies home computer online usage. Their work therefore seems to offer support to both assumptions (b) and (c) above.

For this reason, 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 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

[7] On the other hand, Stuart Esrock [14] 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)

point when demand brings forth greatly increased supply which increases choice for all online shoppers. Compare Economides. [11] [8] 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 business-to-consumer, or B2C, e-commerce take-off.

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 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. [24] S-curves become a subset of possible outcomes, for example, see Vettas. [39] [9] The third approach is evolutionary, for example explaining successful diffusion in terms of comparative advantage one technology offers over others, see Metcalf. [28]

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 [27] 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."' (p.16) Bresnahan and Trajtenberg [4] 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.' (p.85)

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

[8] 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.

[9] Vettas demonstrates an equilibrium approach that generates an S-curve closely conforming 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.

invention of the telephone network and computer networking? Or is the Web a complementary innovation designed to enhance the productivity of the Internet?[10]

Bresnahan and Greenstein [5] have used the 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.' (p.1) Using this framework, Jimeniz and Greenstein [21] 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 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).

Despite the early attention of scholars like Bain [1],[11] 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 [23] [12] This has left the role of complementary goods and 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. [13] The challenge at the market level is to not so much spotting the complementary goods and

[10] For Zwass [41**]** 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.

[11] Bain made early use of the logistic model to analyze consumer adoption of television.

[12] 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. The model of C.Easingwood, V.Mahajan and E.Muller [10] is examined in F.Zettelmeyer and P.Stoneman [40] where 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 [3] is a variant of Easingwood, et al. by offering an alternative specification of the time variance of the learning process.

[13] 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 [36].

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. 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. Today, it is widely used from a desktop PC with enough processing power to handle the software to support mini-video cameras, and even in the *iMode* mobile phone in Japan. 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. [30] 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[14] 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. The algorithms programming these networks to place requests and purchase orders over the Internet will enable 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, event bookings, hotel reservations, buying gasoline and so on. Smart card technology is another possible enabler of e-commerce, especially where micro-payments are involved. These developments are imminent and certainly need to be incorporated into future modelling of critical mass for B2C electronic commerce, but for the purposes of the modelling presented here they are ignored.

2.2: *E-Commerce in Asia-Pacific and the Hong Kong Context*

Although business-to-business (B2B) electronic commerce is, by definition,[15] far the greater part of national and global electronic trading, business-to-consumer (B2C) electronic commerce is likely, eventually, to become an important driver of the electronic economy. Forecasts of B2C e-commerce are abundant. For example, *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,

[14] For an account of these competing technologies, see G.Darby. [8]

[15] 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

a compound average growth rate (CAGR) of 56 per cent, steady growth but not exactly take-off. It further cites Goldman Sachs' forecast that 'electronic shopping could account for 15 – 20% of retail sales' in America by 2010. But, to keep things in perspective, as the *Second Annual Ernst & Young Internet Shopping Report*, 1998, 'a study released by shop.org and Boston Consulting Group', pointed out '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.' [16]

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 Europe and US$36.6 billion for the US, or 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.'[17] 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.[18]

Clearly, in 2001 in the Asia-Pacific, B2C is still minimal. 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.[19] This works out at less than US$30 per Internet user for the year, and less than 0.2 per cent of Hong 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.[20] As re-exports to mainland are Hong Kong's lifeblood, making up 85 per cent of goods exports, and tradeable services, mostly financial, constitute around 17 per cent of Hong Kong's total exports, it follows that revenues from online retail need to become substantial before making much impact on Hong Kong's economy.

Until the special Household Expenditure Survey of 1998, [6] the Census and Statistics Department of the Hong Kong Government collected no data on home computers or access to the Internet, but then policy changed. Now annual surveys are in place. It is the

---

[16] See www.shop.org/research/highlights.html, p.7, p.4 and p.2.

[17] *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.

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

[19] *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.

[20] *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.

Internet connection that interests the Department because that is the foundation of a market for electronic commerce. The model in part three of this paper explores that connection.

Part Three: Modelling E-Commerce in Hong Kong

3.1: *Critical Mass*

In research literature the issue of critical mass 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.[21] 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.

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 a widely used metric is making online purchases at least ten times a year.[22] (Also see below).

3.2: *Diffusion Models*

The concept of a critical mass has its roots in physics, and in particular in efforts to achieve atomic fission.[23] 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

---

[21] 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 [22], R.M. Heeler and T.P.Hustad [18] and V.Srinivasan and C.H.Mason [34].

[22] For example, Ernst & Young *Global Online Retailing* report (January 2000) and www.ida.gov.sg for Singapore.

[23] 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 [32] p. 321. (Winner of the Pulitzer Prize for Literature, 1988.)

academic writings.[24] 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 - see Paul Stoneman [35] - 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 technological change and economists. See Paul David [9].

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.[25] 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 [2] 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.[26]

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.[27] In our case, the proposition is more straightforward. Because electronic

---

[24] 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.

[25] For a summary of such restrictions, see Stanislaw Gomulka [16].

[26] For a helpful discussion of the Bass model, see chapter 8 in J.Eliashberg and G.L.Lilien [12].

[27] For example, Mark Evans [15] extends efforts to modify the Bass equation to take account asymmetries in the diffusion process.

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.[28] 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.

3.4: *The Data*

The Telecommunications Research Project (TRP) engaged the services of the Social Science Research Centre of the University of Hong Kong to conduct four 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, December 1998 and December 2000 respectively 1917, 521, 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.[29] The questionnaires for 1994 and 1998 specifically requested information of 'the main user' of the computer in the household,[30] whereas the 1996 and 2000 surveys confined themselves to the 'respondent', that is the person who was interviewed.

Finally, additional information on household computer penetration was extracted from two earlier surveys, 1991 and 1993, carried out by Institute of Asia-Pacific Studies of the Chinese University of Hong Kong, using face-to-face interviews. The Institute's findings conform quite closely with the TRP's findings, although their 1993 figure slightly exceeds the TRP's results for 1994 as Table 1 shows. See Lau Siu-kai, Lee Ming-ku, Wan Po-san and Wong Siu-lun [25], [26].

---

[28] A study of household ownership of computers by Viswanath Venkatesh and Susan A. Brown [38] 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

[29] The 2000 questionnaire contained a total of 15 unprompted items, reduced from 23 in 1998. 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 asked 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.

[30] The resulting demographic information on age, sex, education levels , housing type and employment are included in the TRP Working Paper at www.trp.hku.hk.

Table 1

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

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.[31] 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 2 is accounted for by this fact.

Table 2

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, naturally, from one's children.

3.5: *The Internet and Online Purchasing*

Except for communications, data on home computer usage in Hong Kong is excluded from this paper, but is available on the TRP website, www.trp.hku.hk. Table 3 is a key table. It shows that 78.5 per cent of households with computers in 2000 were using them

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

for online communications, a rise of nearly 25 percentage points over 1998, which in turn was over 40 points over 1996 and 50 points over 1994. Equally 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 is 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 3

Homes with Modems used for Communications

	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.

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 4 the shift was unambiguously from bulletin boards and proprietary networks to e-mail and Web surfing (over 40 per cent, and 80 per cent of respondents respectively in 1998) via the Internet.[32] 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 4

Communications Services Used (base: households online)

Communications [1]	*BBS*	*E-mail*	*OIS*	*EDI*	*Others*	*DNK*
Valid Answers 1994	100%	50%	43.8%	12.5%	75%	
Valid Answers 1996	8.7%	73.9%	43.5%	8.7%	26.1%	39.1%
Valid Answers 1998		48.2%		8.8%	2.9%	4.4%
Valid Answers 2000		53.3%		0.8%	1.5%	

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

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%

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

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),[33] 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. The 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.

Table 5 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 5

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

Finally, we note the proportion reporting on-line purchases. Scaling up the results for 2000 suggests around 74, 000 households, or 3.5 per cent of households have purchased online. As we shall see below, this translates into around 170,000 individuals, or 2.6 per cent of the population of Hong Kong, just over Everett Rogers' 2.5 per cent of

[33] 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.

'innovators' and the first point of inflexion on the S-curve. From this perspective by 2001 the take-off of electronic commerce in Hong Kong had just begun.

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 five data points, 1992, 1994, 1996, 1998 and 2000, and applying the logistics equation, 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 2008, and 80 percent by 2005. All these computers would be modem-fitted and, it is assumed (see above and below) online.

The population base, number of households and average household size (table 6) are those given by the Census and Statistics Department of the Hong Kong Government, Special Administrative Region (China).[34]

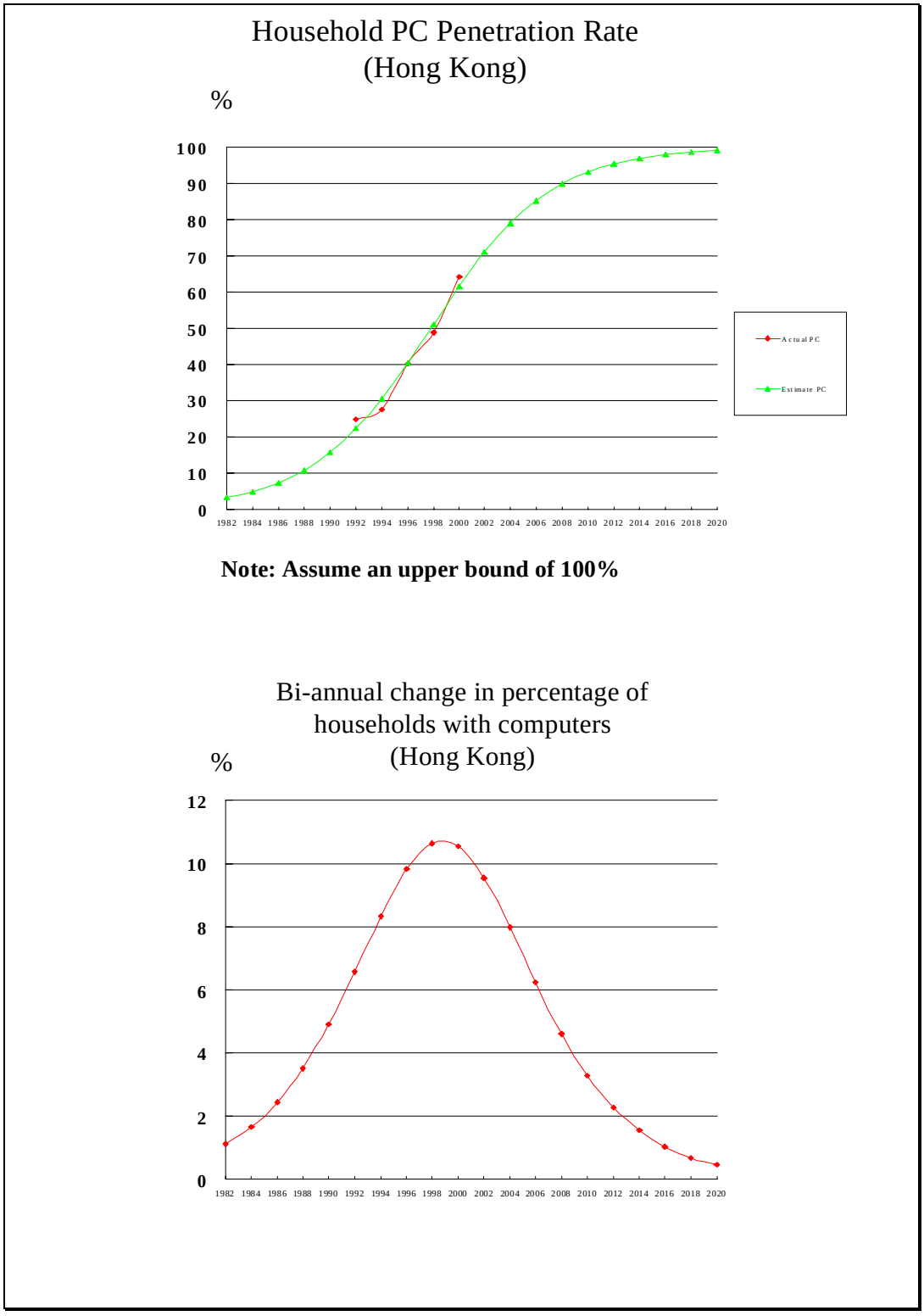
Table 6

Year	Population (Mid-Year)	Households (Oct-Dec)	Average Household Size
2000	6.866 million	2,146,000 (est.)	3.2
1999	6.762 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 million	1,762,000	3.4

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

[34] Data on population and average household size as measured by 'resident population' is available in Census and Statistics Department [7].

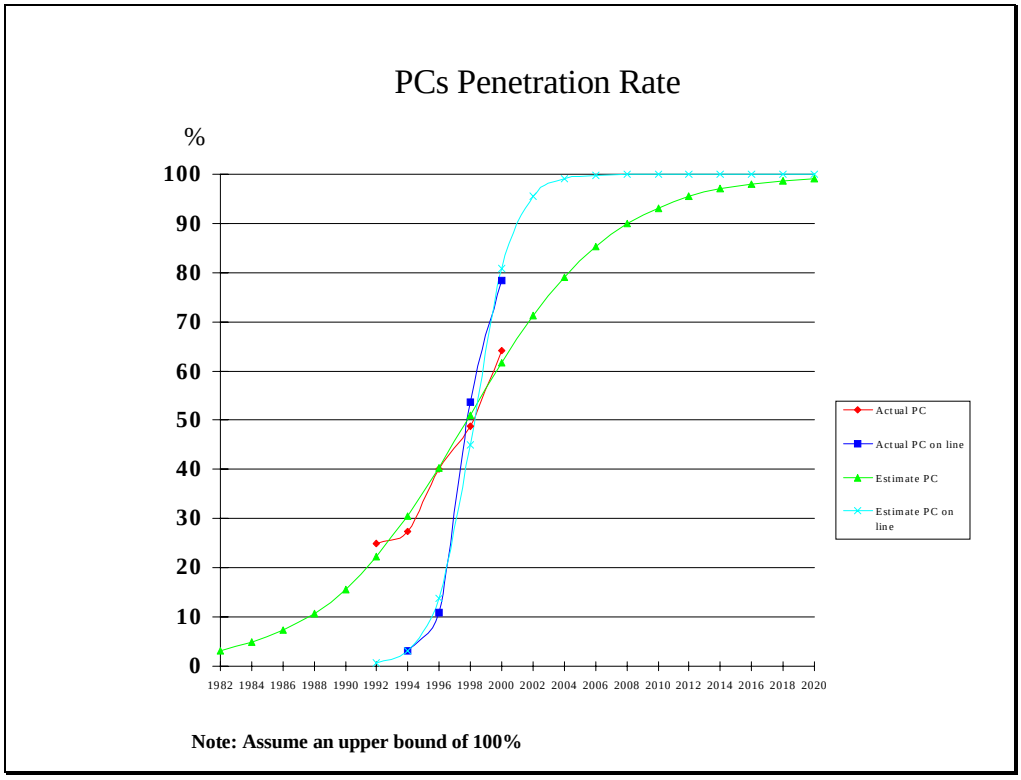
Graphs A and B



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 1,380,000 households owned at least one computer.

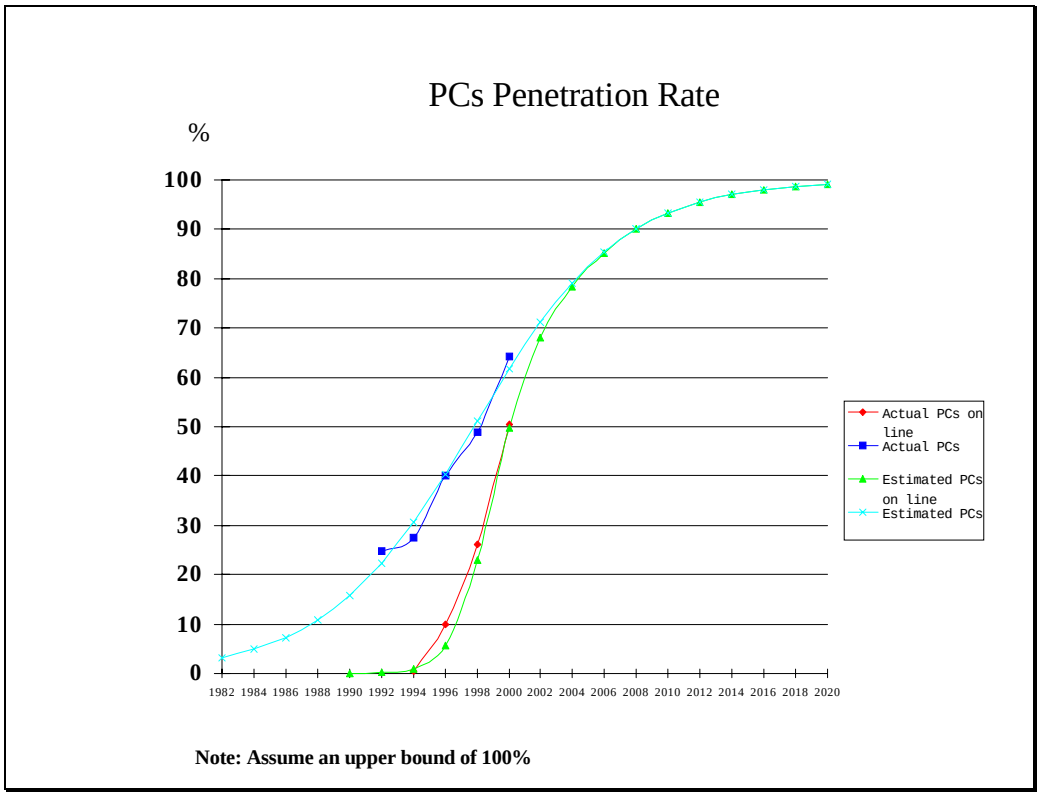
The second stage of the analysis is to graph the logistic curve of the diffusion of home computers online, for which we have data points for 1994, 1996, 1998 and 2000. In graph C we superimpose this S-curve over the S-curve (graph A) of home computer penetration to juxtapose the two. It should be noted 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



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 will rise to over 99 per cent of households with computers by 2004. On this basis, it would seem 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 per cent of all homes by 2002, over 80 per cent by 2004, and 90 per cent by 2008. 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



This scenario, of course, assumes no acceleration in the diffusion rate due to factors not present in the current data. Dramatic falls in hardware and 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 7 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 7

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

The 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,[35] 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 535,000 households with computers online - 26.2 per cent of the all households - an average of 2.24 household members, from an average household size in 1999 of 3.3, were using online communications.[36]

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).[37] 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. As over 1 million households, or 50.4 per cent of the total, are already online by 2000, the basis for a critical mass of electronic commerce already exists.

The third stage of the argument implies all online members of households are, or will become, transactors. The 2000 TRP survey found that 6.9 per cent of online households (3.5 per cent of all households) had purchased online, compared with 1.5 per cent (0.4 per

[35] www.acnielsen.com/news/asiapacific/hk/19990610.htm
[36] 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. See Census and Statistics **[xx]**.
[37] See Everett Rogers [33] chapter 7, p.247.

cent of all households) in 1998.[38] These figures translate into approximately 75, 000 households and 8, 000 households respectively, an annual increase of 300 percent. The AC Nielsen's study of March 1999 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. [39] The A.C.Nielsen data suggests an annual doubling, and that would take a 2000 projection of 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. 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 [40] 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 1.1 million transactors are required. This translates to nearly 480,000 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 75,000 implied by the TRP's survey findings in 2000. By the end of 2003 the figure reaches 600,000 households, above 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. Evidence from Ernst & Young's *Global Online Retailing* report (January 2000) - see table 11 below – 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 8.

---

[38] This compares with 7 per cent of Hong Kong Internet users reported by Taylor Nelson Sofres *Interactive Global Commerce Report, 2000.*

[39] 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.

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

Table 8

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 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 16 above) 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 9.

Table 9

	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. 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, which is consistent with possibly 2.3 users per household using each account. Iamasia, an Internet survey company, reported a finding of 28 per cent broadband users 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, and we can speculate here that this will be an important encouragement to the use of the Internet for electronic commerce.

Part Four: Conclusion

This paper has demonstrated the spread of computers in households in Hong Kong and the growing percentage of these online, and the early beginnings of online purchasing by those who are online. The aim of the paper was to project these trends into the near future to determine the earliest likely date for the arrival of critical mass in the market, not so much as a prediction but as a benchmark against which subsequent developments, and additional data, can be compared.[41] The aim has been to present a model that can be improved, but which can also be applied to similar city-economies. The significance of comparisons, especially of regional comparisons, is that critical mass for electronic commerce ultimately cannot be a concept isolated from trade-in-services. A growth of attractive online retail sites in Kuala Lumpur or Shanghai, in Singapore or Taipei, in Seoul or Tokyo, will encourage consumers in Hong Kong to shop online. Equally, demand from these locations will encourage Hong Kong merchants to go online.

Table 10 provides an overview of various estimates from recent years of the percentage of households with computers in selected middle and high income Asia-Pacific economies, with North America and the UK added for comparison. The table also records the percentage of Internet subscribers in the population. It should be remembered that there are around 2.3 users for every household Internet account in Hong Kong, so user figures will be substantially higher than subscribers, especially because the data also excludes pre-paid Internet card holders, a fast growing segment of the market in the developing countries especially.

Table 10

Percentage of Households with Computers and Population Online – Various Estimates

Economy	**% of Homes with Computers**	**% of Population Internet Subscribers**[1]
Australia	47 per cent [2] (1998)	24.2 per cent [2] (1998) – 39.4 per cent [1] (2000)
Canada	54 per cent [3] (1998)	42.8 per cent [1] (1999)
Hong Kong	34.per cent[4a] - 48.8 per cent [4b]- >50 per cent [4c] (1998) – 58.9 per cent [4b] (1999) – 64.2 per cent[4b] (2000)	13.4 per cent [1] (1998) - 18.5 per cent [4c] (1999) – 38 per cent [4d] (2000)
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 [5d] (1999) – 21.4 per cent [1] (2000)
Malaysia	< 9 per cent [6] (1999) - < 20 per cent [6] (2000)	3 per cent [1] (1998) – 6.9 per cent [1] (2000)

[41] In contrast to the assumptions in this paper, Ironmonger, Lloyd-Smith and Soupourmas [20] project for Australia a saturation level of 88.2 per cent of households with computers, predicting a penetration level of only 67.8 of all households by 2005.

Singapore	41 per cent[7a] (1998) – 58.9 per cent[7b] (1999)	32 per cent [7c] (1998) – 41.9 per cent[1] (2000)
South Korea	15 per cent [8] (1997) – 37 per cent [9] (1999)	6.7 per cent [1] – 22 per cent [10] (1999) – 32.3 per cent [1] (2000)
Taiwan	34.6 per cent [11] (1998)	14.3 per cent [1] (1999) – 28.8 per cent [1] (2000)
UK	29 per cent [12] ('97-98) – 36 per cent[13] (1998) - 41 per cent[14] (1999)	18 per cent [1] (1998) – 33.6 per cent [1] (2000)
USA	54 per cent [15] (1999)	30.7 per cent [1] (1999) – 55.8 per cent [1] (2000)

Sources: 1. www.nua.ie/surveys/how_many_online/n ; 2. Australian Bureau of Statistics; 3 AC Nielsen; 4a. Census & Statistics Department; 4b. Telecommunications Research Project; 4c. AC Nielsen; 4d. Office of Telecommunications Authority, www.ofta.gov.hk; 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. *Korea in the New Economy*, Credit Suisse/First Boston, 16 May 2000; 10 Far Eastern economic Review, 17 February 2000, p.21; 11. D-G of Budget Accounting and Statistics, Executive Yuan, ROC: www.dgbasey.gov.tw/dgbas03/englisg/stat/satur.htm ; 12. Government: www.statistics.gov.uk/stats/ukinfigs/stand.htm ; 13. www.jup.com/research/eis ; 14. www.e&y.com/Global_Online_Retailing ; 15. Pathfinder Study by Arbitron NewMedia reported at www.cyberatlas.com/big_picture/demographics/arbitron.html.

What is striking about these figures is convergence. Almost all the economies are rapidly approaching or exceeding fifty per cent of household penetration of computers, and similarly with the percentage of the population online. Malaysia, the lowest income country represented in the table, has the lowest penetration rates, but grew by over one hundred per cent 1998-1999. South Korea was a late starter but is now full steam ahead. Japan has for long been a manufacturer and exporter of computers, but not a major user, and now that is changing. The lack of household Internet access in Japan is no doubt a major reason for the phenomenal success of DoCoMo's Internet-access *iMode* mobile phone.

Table 10 indicates that the basis for a *regional* critical mass for electronic commerce is within sight. But, as this paper has stressed, the last link in the chain of reasoning is the vital one: how many people actually transact online and do so frequently? The data is scarce, but Table 11 assembles some of it for 1999. There are some minor variations in the household penetration rates as show in table 10 owing to a different data source.

Table 11

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 of part three above; 6. www.ida.gov.sg; 7. Ministry of Posts and Telecommunications, White Paper, 1999; 8. Source mislaid; 9. www.ida.gov.sg; and Infobeads, June 1999 and Greenfield Online Inc., October 1999; 10. Five and above or below, over previous 6 months.

The U.S.A. clearly stands out, 17 per cent of households making online purchases, up from 10 per cent in 1998, and 7 per cent in 1997. [42] 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.[43] Data for Australia is derived from the quarterly *Population Survey Monitor* published by the Australian Bureau of Statistics. Tim Power 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.[44]

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

[42] According to *The Second Annual Ernst & Young Internet Shopping Report* which cites research by Shop.Org (http://www.shop.org/research/default.htm) sponsored by the Boston Consulting Group.
[43] ibid. A year earlier almost thirty per cent of 645 respondents to the GVU *Tenth WWW User Survey* in 1998 (www.gvu.gatech.edu/gvu/user_surveys/survey-1998-10) 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.
[44] 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

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 access and content, but only a very low percentage of all Singaporean households (2.7 per cent) do in fact transact on the Net.[45] As the IDA [19] 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.' (para. 4.4.v) 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 IDA's commentary is a sober assessment of the current status of B2C online transactions in Singapore, and could equally apply to Hong Kong and Asia-Pacific in general. But snapshot pictures do not tell the whole story, and this paper has attempted to highlight some of the dynamics that will lead to the arrival of critical mass for electronic commerce. Tables 10 and 11 provide insufficient data to apply the model presented here to these other economies, but with more research and more data the model can easily be extended, and with it the idea of critical mass as a regional as well as a local issue.

[45] '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.' IDA [19], para 4.4.a.i.

References

1. Bain, A. (1964) *The Growth of Television Ownership in the UK since the War: A Lognormal Model*, Cambridge, Cambridge University Press.
2. Bass, F. (1969) 'A New Product Growth Model for Consumer Durables', *Management Science*, January, v.15, pp.215-227.
3. Bewley, R. and D.Fiebig (1988) 'A Flexible Logistic Growth Model with Applications in Telecommunications' *International Journal of Forecasting*, v.4, pp.177-192.
4. Bresnahan, T. 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
5. Bresnahan, T. and S.Greenstein (1996) 'Technical Progress and Co-Invention in Computing and in the Uses of Computers' *Brookings Papers: Microeconomics 1996*, pp.1-77
6. Census and Statistics Department (1998) *1998 General Household Survey, Utilization of Internet Service: Special Topics Report No.20*, Hong Kong SAR Government, People's Republic of China.
7. Census and Statistics Department (2000) *Population and Household Statistics Analysed by District Council District, 2000*, Hong Kong SAR Government, People's Republic of China, December.
8. Darby, G. (1999) 'Bridging wireless and wired networks: smart phone operating systems, IP convergence and market segmentation' *Info*, v.6, December, pp.563-576.
9. David, P. (1975) *Technical Change, Innovation and Economic Growth*, Cambridge University Press
10. Easingwood, C., 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.
11. Economides, N. (1996) 'The Economics of networks' *International Journal of Industrial Organization*, v.14, pp. 673-699.
12. Eliashberg, J. and G.L.Lilien (1993) eds. *Marketing: Handbook in Operations Research and Management Science*, v.5, Elsevier Science Publishers, North-Holland, Amsterdam, London, New York and Tokyo.
13. Emmanoulides, C. and K. 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.
14. Esrock, S. (1999) 'Online Shopping: To Buy or Not to Buy?' *American Communication Journal*, v.2.3: http://acjournal.org/holdings/vol2/Iss3/articles/Online_Shopping.htm
15. Evans, M. (1996) 'Aspects of maximum likelihood estimation of asymmetric growth curves', *Journal of Applied Statistics*, October, v.23.5, pp.467-492,
16. Gomulka, S. (1990) *The Theory of Technological Change and Economic Growth*, Routledge, London and New York.

17. Goolsbee, A. and P.J.Kenow (1999) 'Evidence on Learning and Network Externalities in the Diffusion of Home Computers', University of Chicago, working paper, November.
18. Heeler , R.M.and T.P.Hustad (1980)'Problems in predicting new product growth for consumer durables', *Management Science*, October, v.26, pp.1007-1020.
19. Infocomm Development Authority of Singapore (2000) *IT Household Survey 1999*.
20. Ironmonger, D.S., C.W.Lloyd-Smith and F.Soupourmas (2000) 'New Products of the 1980s and 1990s: The Diffusion of Household Technology in the Decade 1985-1995' *Prometheus*, v.18.4, pp.403-415.
21. Jimeniz E. and S. Greenstein (1998) 'The Emerging Internet Retailing Market as a Nested Diffusion Process' *International Journal of Innovation Management*, v.2.3, September, pp. 281-308.
22. 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.
23. Karshenas, M. 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.
24. Karshenas, M. and P.Stoneman (1995) 'Technological Diffusion' as chapter 7 in Stoneman, P. (1995) ed. *Handbook of the Economics of Innovation and Technological Change*, Blackwell, Oxford, England.
25. Lau Siu-kai, Lee Ming-ku, Wan Po-san and Wong Siu-lun (1993) eds. *Indicators of Social Development: Hong Kong 1990* , Institute of Asia-Pacific Studies, Chinese University of Hong Kong, Research Monograph No. 13.
26. Lau, Siu-kai, Lee Ming-ku, Wan Po-san and Wong Siu-lun (1995) eds. *Indicators of Social Development: Hong Kong 1993*, Institute of Asia-Pacific Studies, Chinese University of Hong Kong.
27. Lipsey, R., Bekar, C. and K.Carlaw (1998) 'What Requires Explanation?' chapter 2 in Helpman, E. (1998) ed. *General Purpose Technologies and Economic Growth*, MIT Press, Cambridge, Mass. and London.
28. Metcalf, S. (1995) 'The Economic Foundations of Economic Policy: Equilibrium and Evolutionary Perspectives' as chapter 11 in P.Stoneman (1995) ed. *Handbook of the Economics of Innovation and Technological Change*, Blackwell, Oxford, England.
29. Ministry of Posts and Telecommunications (1999) *White Paper, 1999* Tokyo, Japan. See www.mpt.go.jp
30. Mowery, C. and N.Rosenberg (1982) 'The influence of market demand upon innovation: a critical review of some recent empirical studies' as chapter 10 in Rosenberg, N. (1992) ed. *Inside the Black Box: Technology and Economics*, Cambridge, Cambridge University Press.
31. OECD (1999) *Science, Technology and Industry Scoreboard 1999 – Benchmarking Knowledge-based Economies*. See www.oecd.org//dsti/sti/stat-ana/prod/scorebd_summ.htm.
32. Rhodes, R. (1986) *The Making of the Atomic Bomb*, Penguin Books, London.
33. Rogers, E. (1983) *The Diffusion of Innovations*, Collier Macmillan Publishers, London.
34. Srinivasan, V. and C.H.Mason (1986) 'Nonlinear least squares estimation of new product diffusion models', *Marketing Science*, Spring, v.5, pp.169-178.

35. Stoneman, P. (1983) *The Economic Analysis of Technological Change*, Oxford University Press.
36. Stoneman, P. and O.Toivanen (1997) 'The Diffusion of Multiple Technologies: An Empirical Study', *Economics of Innovation and New Technology*, v.5, pp.1-17.
37. US Department of Commerce (1999) *Emerging Digital Economy ll*, Washing ton, D.C., USA.
38. Venkatesh, V. and S. A. Brown (1998) 'A Longitudinal Investigation of Personal Computers in Homes: Adoption Determinants and Emerging Challenges', Indiana University, CSI Working Paper No.98-01, available at www.slis.indiana.edu/CSI/wp98-01.html
39. Vettas, N. (1998) 'Demand and supply in new markets: diffusion with bilateral learning' *RAND Journal of Economics*, v.29.1, Spring, pp.215-233.
40. Zettelmeyer, F. and P.Stoneman (1993) 'Testing Alternative Models of New Product Diffusion', *Economics of Innovation and New Technology*, v.2, pp.283-308.
41. Zwass, V. (1996) 'Electronic Commerce: Structures and Issues', *International Journal of Electronic Commerce*, v.1.1, pp.3-23.