

E-Commerce Impacts on Energy Consumptions: A Conceptual Framework

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Abstract

This paper looks at the promised role of e-commerce applications that play in different stages of the environmental effect especially energy consumptions. The internet technology and electronic commerce (e-commerce) which dramatically changed the trend of information system (IS) applications in business to be internetworked e-business will be reviewed. The contribution of e-commerce on business has been identified as one of succes factors to gain companies targets. In line with information technology growth, e-commerce is also more used by business organizations around the world. The use of e-commerce have the impact on environmental effects in terms of energy consumptions. By conducting variety activities in cyber market, both customers and merchandises in particular to distributions and supply chains may decrease fuel consumptions, emissions and traffics. In the meantime, e-commerce also have a contribution on electricity consumptions associating to supporting technology of ecommerce operations.

The objective of this study is to review variety of prior studies related to ecommerce impact on energy consumptions including emission's generations and electricity demand. Using the literature survey of related studies, this paper presents the theoretical framework of energy consumption of e-commerce effects. Energy consumptions in this paper indicate with the energy consumptions during e-commerce activities including production, distribution, retailing, consumption and enabling technologies. The literature review found that these activities of e-commerce have significat contributions in positive and negative aspects. Thus, this study suggests various alternatives solutions especially in negative impacts of e-commerce doings. Finally, this study provides contributions to the upcoming research in quantitative-empirical approaches as a potential study.

Keywords: Internet, E-commerce, Energy, Emission, electricity

1. Introduction

The internet technology and electronic commerce (e-commerce) is a new era, in which dramatically changed the trend of information system (IS) applications in business to be internetworked e-business. Generating benefit using internet technology is one of the main issues facing e-commerce practitioners (Heijden & Verhagen 2003). The sale and purchase of product and services via the internet are able to obtain strategic and operational benefits in *organization* aspects, which indicate to increases competitive advantage, market penetration, innovation, generate new revenue, reduce marketing costs and attract new customers (Torkzadeh & Dhilon 2002). E-commerce provides various benefits which impact on *customers*, are to enable the acquisition of information, and to compare prices and conditions of the products from different suppliers/websites, more convenience, is quicker and low-cost (Costa 2001; Turban & King 2003). Again, the beneficial impact of e-commerce on *society* is the enhancement of living standards, reduction of energy consumption and delivery of public services (Tehrani & Karbassi 2005; Turban & King 2003). In short, as the internet era, e-commerce has been impact on customization (customers), globalization (firms) and environmental effects (society) in business organizations.

In line with environmental effects, the greatest contemporary environmental challenge is climate change (Siikavirta et. All 2003). Climate change is indicated as one of biggest environmental challenges of the 21st century. It links between climate change and Green House Gases (GHG) emissions. There are various issues in term of GHG emissions which sources of energy production, and consumption, transport, buildings, land-use change, waste

management etc. According to IPCC (ITU 2008), global GHG emissions have risen by 70 per cent between 1970 and 2004. To reduce GHG emissions, system-level innovation and changes are required. The innovative method and a new cooperation among the various stakeholders are needed, corresponding to the end product distribution and supply chain management. E-commerce usage in business organizations might offer applicable instruments for coping with the climate change (Siikavirta et. al 2003).

The utilization of e-commerce address the challenge of energy efficiency through information and communication technologies (ICT) (ITU, 2008). The e-commerce put on view that ICT used have an promised role to paly in reducing the energy intensity and increasing energy efficiency. The impcats ICT used on energy consumptions deals with the interrelated issues of energy efficiency, renewables, energy production and GHG emissions. Not only about energy efficiency, e-commerce operation also is able to save the energy in other areas (buildings, industry, and energy grid).

The body of the theory on environmental effects of e-commerce uses is expanding rapidly. Since, e-commerce is able to give a contribution on energy consumption, emission and air pollution reduction (Siikavirta et. al 2003; Tehrani & Karbassi 2005). The uses of e-commerce have direct and indirect effects on energy consumptions (Williams & Tagami 2003). The activities of e-commerce give a chance to give a contribution on environmental effects particularly in the distribution aspect. When customers purchase products and services via company's websites, decreasing the energy consumption through reduction of urban traffic and air is proceed (Tehrani & Karbassi 2005). In addition, Lake (2000) studied the impact of e-work and e-commerce on transport, the environment and the economy in European contexts, showing where significant evidence-based results have been obtained. Also, Romm (2000) investigated "a new energy economy" that corresponds with the tremendous growth of the internet and e-commerce.

E-commerce might be identified having a considerable impact on transportation and reduction of energy consumptions (Tehrani et. All 2009). As transportation and supply chain activities in e-commerce, there is able to play a role to save fuel consumptions, reduce GHG emissions and electricity.

Based on above explanations, this paper presents the literature survey of numerous journals related to e-commerce activities and its impact on environment of energy consumption. The primary focus of this study centers on the following research question:

How do e-commerce uses have impact on energy consumptions in conceptual framework?

The following sections are organized as follows; presents the background of e-commerce and then it will be followed by the conceptual framework of e-commerce impact on energy consumptions. Finally, this article is ended by the conclusion of this literature survey.

2. E-commerce and Environment

2.1 E-commerce Application

Some people use the term e-commerce and e-business interchangeability; in spite of some IS experts definite in deferent meaning (Turban & King 2003). E-business has a broader meaning than e-commerce or e-commerce is a part of e-business. E-business is the use of the internet technologies to internetwork and empower business process, e-commerce, and enterprise communications and collaboration within a company and with its customers, suppliers and other business stakeholders (O'Brien 2002).

E-commerce is new field and an interdisciplinary, because of that, e-commerce subject is just developing its theoretical and scientific foundations. The key e-commerce disciplines are combination between numerous fields including marketing, management information systems, computer science, consumer behavior, finance, economics, accounting, management, business law, robotics, public administration and engineering (Turban & King 2003, p.8).

In environmental contexts, e-commerce application involves also different perspectives environmental concepts. E-commerce may sell commercial products and services in lower prices due to the lower cost of market entry and operations, less inventories, less energy consumption, pollution reduction and all things making the shorter sales

chain (Jolfson and Smith, 2000). Not only about transportation aspects causing decrease of urban traffic, but purchasing products via internet also have tremendous effects on warehousing cost, paper consumption and waste reduction with additional energy reduction due to omission of space for sale area and the related heating and cooling factors (Tehrani et. All, 2009). Therefore, e-commerce uses have important contributions related to transportation and environmental issues.

2.2 Environment Effects

Nowadays, environmental issue due to climate change is a crucial issue around the world. There is numerous different causes of environmental effects especially as a progressive and accelerating warming of the planet (ITU, 2008). It represents a threat to mankind on a similar plane to violent conflict and war, and in reality can lead to breakdown of peace due to the increased competition for the earth's resources. There is a energy consumptions in several countries around the world (Tabel 1). It depicts that oil and electricity consumptions are the major consumptions of energy around the world. In addition, this condition turn into crucial issues of environmental concern.

Table 1. Energy Consumptions

Country	Energy Final Consumption 2006 (ktoe)			
	Coal	Oil	Gas	Electricity & Others
Australia	3.494	39.240	13.253	21.898
Brunei				
Darussalam	0	514	13	258
Canada	2.951	93.315	50.682	54.246
Chile	865	11.952	1.321	8.582
China	375.586	308.054	45.062	247.565
Hong Kong, China	0	6.550	581	3.469
Indonesia	11.543	43.021	10.657	9.684
Japan	36.758	203.736	27.182	93.266
Korea	8.322	81.603	16.300	38.383
Malaysia	1.141	22.361	8.142	7.268
Mexico	1.611	73.605	14.676	23.543
New Zealand	528	6.816	1.410	4.379
Papua New Guinea	0	787	0	241
Peru	397	6.724	334	2.039
The Philippines	1.324	11.341	53	3.928
Russia	19.863	102.881	130.665	183.690
Singapore	0	12.084	108	3.059
Chinese Taipei	7.254	38.798	2.010	17.388
Thailand	7.569	34.451	2.151	10.951
United States	26.211	880.466	299.302	378.820
Viet Nam	5.528	12.294	326	5.485

Sources: Apec Energy Overview 2008, Asia Pacific Energy Research Centre

Not only about the natural resources of energy consumptions, but electricity impacts on global warming also exists since technologies used, for instance, by the millions of computer screens are left switched during overnight in offices around the world. It gives a picture of booming Information Communication Technology (ICT) uses across organizations and indeed internet uses. ICT uses, however, are able to increase energy efficiency concerning energy

utilization (Intel 2002). In the meantime, by using digital technologies give contributions of the reducing greenhouse gas (GHG) emissions in case of commercial prints (Canonico, Sekkman & Preist 2009). It shown that various publishing including book, newspaper, and megazine, can be decrease over-production and waste through newer digital press technologies. Futhermore, e-commerce indicating as a paperless activity is able to contribute on environmental effects (Abukhader & Jonson, 2003). Accordingly, the reduction of the energy consumptions indicating environmental issues around the world through e-commerce and ICT is main considered.

3. E-commerce Adoption

Shopping is a daily activities by everybody especially by household. People can go to supermarket to purchase their groceries. When the internet technology has been identified as a new trend of business activies, shopping via internet has been introduced namely electronic shopping (e-shopping).

3.1 Conventional Shopping

In conventional condition, customers are able to choose numerous stores and transportations to conduct shopping their products to and from the store. They may drive a car, ride a bicycle, walk or get a public transport. These transportations effect on increasing the production of GHG emissions. People can go to shop at various time a week, during weekday, and combination between shopping with other non-shopping related trips (Li, 2000). additionally, numerous household still use a car to transport going to shop a small number of communities and seldom people using bicycle and walking conducting a big shopping for their groceries. In general, more people drive a car for a big shopping at bigger supermarket and supplemental shopping is made in nearby stores riding a bicycle or walking. However, different transport choices represent different production of GHG emissions since depend on the distance and transport types. The Figure 1 shown the transportation of groceries in below model shopping.

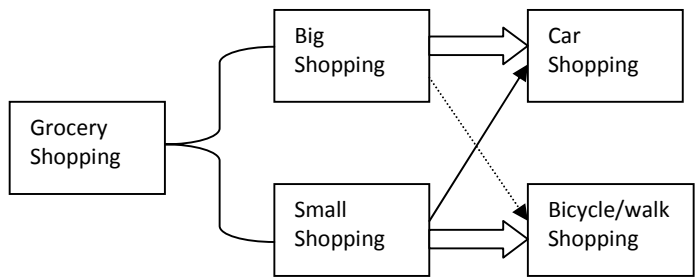


Figure 1. Model of conventional shopping trips and amount of communities (Li, 2000; pg. 5)

The above figure shown that there are two charateristics of shopping patterns are small and big shopping which might have contributions on transportation choices and emission productions.

3.2. E-Shopping

Since e-commerce arising, “the website is becoming the potential customer’s shop window on the world (May, 2000). The use e-commerce in different task including e-shopping is identified as crucial alternative approach to decrease the problems all through a big city and metropolitans. E-commerce offers several transactions of online shopping involving different group. The favour transactions are transaction of business customers (business to business/B2B) and transaction between the end customers (business to customer/B2C). There are some differences between B2B and B2C e-commerce; for instance the value of transactions, number of unit sold, complexity of website fitures and others.

E-shopping indicates with the grocery trade which illustrates the relationship between the producer, wholesaler and the retailer for B2B e-coommerce and the relationship between the producer or retailer and the end customers for B2C e-commerce. The trade chain of e-commerce activities can be described as in figure 2.

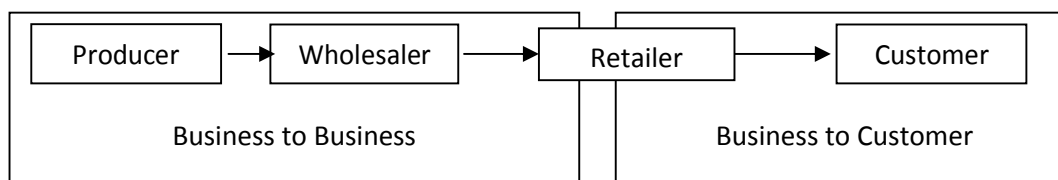


Figure 1. The trade chain of E-commerce (Li, 2000; pg. 12)

The B2B e-commerce refers to the online purchases of goods and services between business organizations. The B2B e-commerce can realize the business transaction larger than B2C e-commerce and growing rapidly. The key driving force is the lack of transactional cost and improvement of product quality or service quality.

There are some factors associated with on-line and conventional shopping that could significantly differ (Williams & Tagami 2003; pg. 100):

- Substitution of personal travel to and from retail shops with courier deliveries to homes affects transport energy. One expects that courier services should be more efficient, favoring e-commerce.
- E-commerce uses more packing than the traditional model for many goods, inducing a degree of additional energy consumption for the production of packaging.
- E-commerce vendors do not retail outlets, reducing building space and energy use in the commercial sector; however these savings could be counterbalanced by increased energy consumption in residences due to additional time spent at home.
- E-commerce vendors may enjoy a lower rate of returns and unsold inventories, thus avoiding wasted production. Scarcity of relevant data makes this a very difficult issue to address.
- A degree of additional consumption is induced when customers use income saved by use of on-line vendor. E-commerce vendors should be able to undersell traditional ones on many goods, increasing the spending power of customers. Depending on the degree of price differentials and pattern of use, the embodied energy associated with spending these savings could be substantial.

4. E-commerce Impacts on Energy Consumptions

E-commerce is regarded as one of several marketing tools, including the use of the internet, to assist inter-organizational activities, for instances marketing, ordering, and related service activities. There are numerous applications of e-commerce transactions such as business-to-business (B2B) and business-to-customer (B2C); B2B covers the flow of products from suppliers to manufacturers to wholesalers to retailers, while B2C covers the flow of products from the retailers to the end customers. It is related to the use of information technology (IT), information communication technology and internet. A concluding remark for the above is that study performing of environmental implications of internet or environmental implications of IT is not considered as assessment of e-commerce alone, since all e-commerce interactions using IT, ICT, internet and other e-commerce applications (e-logistic, e-supply chain, e-fulfillment and e-procurement) are provided (Abukhader & Jonson, 2003).

Table 2. Summary of studies regarding the e-commerce impacts on environment

Studies	Tools	Demarcations	Concerns	Results
Tehrani et. Al, 2009	e-shopping	Supermarket goods	Iranian Society	Reduction of shopping trip, energy consumption & air pollution.
Weber & Matthews, 2008	Long-distance distribution	Food production	USA	Some food type are much less GHG intensive
Peng, Li & Zhang, 2005	Intranet & Extranet	E-commerce	The world trend	Positive and negative implications
Tehrani & Karbassi, 2005	Home shopping	Grocery	Tehran city	Reduction of urban traffic & air pollution

Abukhader & Jonson, 2003	Life Cycle Assesment (LCA)	ICT	The world trend	Advantagous & damaging effects to the environment
Siikavirta et. Al, 2003	e-grocery home delivery strategies	Food production & consumption system	Finland	Reduction of traffic and GHG emissions
Sui & Rejeski, 2002	conceptual study	ICT	Global scale	Positive & negative impacts on e-commerce
Reijnders & Hoogeveen, 2001	Logistics	Online-sales	Ducth online computer reseller	Energy use per article sold by online computer reseller is lower.

There are some findings from the literature study toward the ecommerce effects on energy consumptions. These are summarized in Table 2 and are given details in following sections. In Table below shown that prior studies found the main contribution of ecommerce for environmetal effects is the reduction of GHG emissions due to saving fuel consumptions especially reducing the traffic.

The literature found that some viewpoints of different studies taking energy consumption as a major basis for measuring the environmental implications of e-commerce. Energy uses as a focus of discussion might bring different results if taken in more micro level. The energy focus of e-commerce applications is related to fuel (oil) and power (electricity) consumptions. According to Table 2, majority of previous studies are more focus on saving oil consumptions on distribution reduction, consequently, production of GHG emissions of e-commerce activities will be able to reduced. Again, it shown that the e-commerce impact in delivery groceries to home-doors, which means studies in e-shopping, e-groceries, long-distance distributions and home shopping. Unlike oil consumptions, power consumptions of e-commerce activities are still bring controversy. In detail, we discus relevant topics of energy consumptions of e-commerce as positive and negative impacts in following sections.

4.1. The positive impacts of e-commerce on energy consumptions

The numerous positive impacts of e-commerce uses on energy consumptions and their implications for GHG emissions are summarized in Table 3 and are described in more detail in the following sections. Table 3 depict that supply chain activities give some options of e-commerce impact on energy consumptions. In detail related to supply chain is explained as a follow (Siikavirta et.al. 2008);

Sourcing

The use of e-commerce are identified as a generating of electronic merket (e-market) places, search for new suppliers using information technology to enhance current supplier relationships. E-market give a chance to do more transactions between suppliers and customers. Companies can “*replace inventory with information*”, as they use rapid and efficient information of suppliers’ sharing to speeded up process. In contrast, e-commerce is able to reduce or increase GHG emissions from transportations, based on its distances and modes. In addition, e-commerce forces on supplier relationships have two different affects: firstly, it may affect the distance of product transported (raw material or components) and secondly, it may cut down overproduction since the re-engineering of the sourceing process.

These above e-commerce activities also making contributions on electricity demand, in terms of inventory spaces and warehouses needed. When e-commerce has reduced inventory level (Margretta 1998), it represented that the need of inventory space and warehouse was reduced as well. Accordingly, decreasing inventory and warehouse needed are able to reduce power consumptions in business organizations.

Production

E-commerce activities are very concern on costs and lead time. This situation shown in which pull-controlled manufacturing for production companies (Prouty 2000). Production’s companies try in tight procedures and instructions of production process, consequently, the productions more accurately and overproduction can be minimized. Regarding to international supply chain, e-commerce sometime is not practicable for the lean production (Levy 1997). The main point of international supply chain is feasible to

have production facilities close to the suppliers and the customers to keep a good image globally. Based on closed supplier of international supply chain, it has cut down line distributions of companies products and its consequently, transportation have shorter lines and is able to reduce emission productions. Additionally, e-commerce can work to reduce of inventories. The inventory level is managed by a datawarehouse program employing automatic order processing and ordering towards their suppliers (Li, 2000).

Distribution

Supply chain for e-commerce may help companies to go beyond integration and join small supply-chain communities (Siikarvita, 2003). It is believed, that the development of adaptive supply chain is through sharing with other companies. Beside that, outsourcing of supply chain is more adaptable and scalable of distribution process. It means outsourcing and the short-term partnerships is able to more efficiently in doing e-commerce distributions. When distributions more efficient and fluent cooperation, companies are able to reduce the GHG emissions through transportation flows..

Using radio-frequency identification (RFID) to solve problem related to increased complexity of logistiscs is a attracted way out. The RFID is a wireless identification technology which is employed to achieve significantly faster and more accurate sorting and distribution (Nelms 1999). When all shipments are marked using RFID tags, the shorting can be done with minimum manual intervention. Therefore, this condition is able to reduce the cost of sorting and constructively transform the balance of the trade-off between sorting and transportation.

Retail

The warehouse in B2B and B2C e-commerce may contain far more products persquare meter than a conventional retail store. That warehouse also is able to use far less energy persquare meter than a conventional retail store. Again, product sold via the internet would likely consume less energy per product tha traditional retail-based sales (Romm, Rosenfeld, Herrman,1999). Generally, e-commerce offers to deliver the good to customer’s home. Thus, the service providers may handle the transportation of goods to customer’s home much more efficiently than customer could. In brief, reducing the distance driven and lower GHG emissions, supported that customers do not drive their cars more for other purposes.

Consumption

E-commerce may allow the retailer to sell more goods and services to the customers. E-commerce companies also enable to offer replenishment service to customers or even coordonate deliveries with planned household activities (Siikarvita 2003). By integrating between customers and e-commerce companies, it can help make the supplier’s own process more efficient, and environmental efficiency. Further more, e-commerce offers the possibility of disseminating environmental and social information toward product and services to customers. Transforms in the demand for products and services to customers may effect the emissions from the whole supply chain, through environmentally sensitive product choice.

Table 3. E-commerce Activities and positive impacts on Energy Consumptions

Activities	Potential Postive Impacts of e-commerce
Sourcing and Production	Reduction of Overproduction
	Reduction of Inventory level
	Eliminate mistakes
	Improve forecasting
	Distribution distances of supplies
Distribution	Increase utilization of capacity
	Avoided duplicate of resources
	Avoided unnecessary transport
Retail	Less waste of products

	Home delivery
	Warehouses and websites instead of stores
Consumption	Possibility for decision based on environmental information
	Possibility for interaction with the supplier to make the whole chain more efficient
Just-in-time	Reducing number of inventory performed
	Reducing carrying costs
	Reducing waste altogether

Source: ITU 2008; Li, 2000; Siikavirta et. Al, 2000

4.2. Negative impact of e-commerce on energy consumptions

Regarding with e-commerce environment, it is important to understand what kind of potential issues related to environmental impact those issues might bring. In which way the company giving contribution for more sustainable e-commerce will analyzed in this sections.

Appliances for E-commerce activities

Undertaking e-commerce activities, the companies need to provide more computers, cables, servers and other appliances for a extranet environment and internet connections (Li, 2000). Together with company's needs, customers also need to purchase more appliances for the internet access and personal computer. As the results, all appliances needs much electricity. The network infrastructure is also of high demanding. Thus, the waste from the old computer and its appliances wiil increase the amount of the waste and the energy used for waste transport and treatment.

The use of ICT for e-commerce, however, can help the business to achieve more efficient operation. E-commerce activities particularly, B2B e-commerce will be able to reduce paper consumption, inventory, storage, warehouse and related transportation which indicate the energy and resource saving. Although, these saving and expenditure on e-commerce's appliances will be provided, it is diffucult to make a reliable comparison. The key solution of this condition is to imply the best use of potential efficiency brought by ICTs. The logistic and management design of e-commerce companies will contribute for such an energy and resource saving (Sui & Rejeski, 2002).

Inefficient operation in warehouse

The energy consumption per commodity stored in the online store's warehouse may increase since the volume of the turnover is much lower than the storage capacity of the warehouse. For the reason that is the based energy consumptions for the lighting, heating, cooling and freezing facilities are fixed. Smaller amount of inventories stored in the warehouse indicates the higher energy consumption per item. In this case, inefficient operation would be happen when the online sales are low and the market penetration of e-grocery trade is low.

The alternative solution of such inefficient operation is to increase the amount of inventory's turnover. The online sales might increase if the market penetration of online trade also increases. It illustrates that the market penetration is important to be a active trade of ecommerce activities. Because of that, the online store, conventional store, other online stores, customers and government have significant roles on the market penetration of online stores. For instances, store should do a reliable marketing technique to attract more potential customers; the competition between online store and conventional store; government's policy will also affect the e-commerce development. Therefore, not only e-commerce sales will increase, but also the turnover of the store will increase as well.

Effect of Just In Time (JIT) system

The negative impact on JIT delivery system is using more energy intensive transport in order to catch the time. JIT system concern about time to fulfill the customer orders, eventhough, truck are not full and the empty return condition (Romm, Rosenfeld, Herrman, 1999). The company which apply JIT system, is more likely to choose the faster transport, for example truch rather than train, plan rather than ship. Such

faster transports will consume more energy than slower transports. The amount of product per order will be smaller in JIT delivery than stock orders. The transport for smaller amount of the product will be less efficient than the bigger amount since it will be able to lead to empty space in delivery transport. Then, the empty space will be waste. The empty transport return by increment of transport frequency will also increase and its consequences, energy consumption and emission will be increased.

The potential solution of better delivery system could be the co-ordinated distribution. The joint delivery with other delivery for full load, make JIT system more efficient and effective. The transport company and internet-based auction company can co-operate to achieve a more efficient delivery system.

Overlapped deliveries

This condition will be happen when customer orders from more than one online store at same time, and each online store have different delivery agency which will sent to same customers (Li, 2000). As those many delivery arrive at same place, their route might be overlapped. If there are numerous deliveries arrive at the same time, it means a number of the vehicle passed by same place, noise pollution and GHG emission might increase. The reliable solution can be offered by the government agency to act as the coordinator for such co-operation between the online store and delivery agency. Again, the transport company is the one which will be in charge of the delivery.

The distribution of product flows concerns to shortening of delivery lead times. In line with e-commerce, the online customers frequently demand faster deliveries with little or no delivery charge (Jedd, 2000). As consequences, e-commerce should offer a shorter delivery in response to the shorter delivery of competitors. The shortening of relevant delivery lead times impact on many, particularly multinational companies which may solve the problem by switching from land and sea transportation to airfreight. The switch to airfreight may increase the environmental effects of e-commerce significantly, since airfreight is environmentally much more damaging than road, rail, or sea transportation (Harrari, 1999). Nonetheless, by switching to airfreight depends on the value of goods in relation to their weight and volume.

Table 4. E-commerce Activities and negative impacts on Energy Consumptions

Activities	Potential Negative Impacts of e-commerce
Appliances	Increase electricity needs
	Increase amount of waste (old computer)
	Increase for waste transport and treatment
	Increase heating or cooling
Warehouse	Increase fix costs per unit product (decrease unit persquare)
Just-in-time	Decrease transportation capacity (Inefficient)
	Increase transportation needs
Delivery	Increase overlapped delivery
	Increase the traffic
	Increase number of vehicle on the road
	Increase use of airfreight

Source: ITU 2008; Li, 2000; Siikavirta et. Al, 2000

5. Conclusion

The literature study exposed many possibilities for e-commerce impacts of environmental issues. E-commerce is a new innovative way conducting business activities using the internet technology. In this paper, some potential positive and negative impacts were identified. The majority of positive impacts related to reduction of GHG emissions due to reduction of delivery activities is as main issue. In the meantime, the negative impact of e-commerce is in relation to power consumption (electricity) during operating/running internet systems and also supporting systems during undertaking e-commerce activities. Further study related to e-shopping in a certain sector empirically is required.

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