CARBON FOOTPRINT IN PUBLIC E-PROCUREMENT: A METHODOLOGY FOR THE MEASUREMENT OF CARBON FOOTPRINT IN THE PUBLIC PROCUREMENT SYSTEM.

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ABSTRACT. The objective of this study was to develop a methodology for the measurement of a carbon footprint in the public procurement system of Chile. For this, the contribution of e-procurement was determined by the carbon emissions generated as a product of the electric energy consumed (kWh) by the use of the e-procurement platform through the number of transactions in a year and also the duration time of operation, and this was compared with the emissions estimated if the e-procurement platform was not operating. The estimation of carbon emissions would be utilizing the emission factor of the Interconnected System of Energy for the central region of Chile (SIC) in the year 2009, which was that of 0.48 ton/MWh.

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INTRODUCTION

Currently, the public procurement has become substantial globally reaching from 8% up to 25% of a country's GDP (OCDE, 2006). The increasing demand and continuous necessities of public procurement in governments have been the reason to deploy institutions specializing in the development and intermediation of procurement systems according to correspondent technology, and operate in many cases as an online system known as e-procurement which is more than just a system for online purchasing as it employs various other elements, including electronic ordering, online bidding and tendering, reverse auctions, and integrated automatic procurement systems (Moon, 2005).

E-procurement can be referred as the process of electronically acquiring the goods and services needed for an organization's operation. It offers a real-time platform for conducting business, while providing a significant opportunity to cut costs, increase organizational effectiveness, and improve customer service (Gunasekaran & Ngai, 2008). Through electronic procurement systems such as online catalogs, governments can get useful data about national purchases as well as internal supply and demand. Undeniably, the online purchases have shown to be a useful and inexpensive instrument for transparency and to minimize the bureaucracies in getting allowances. This includes management of tenders, correspondence, bids, questions and answers, previous pricing, and multiple emails sent to multiple participants (Croom & Brandon-Jones, 2007).

In addition, this kind of procurement system allows specialized agencies to develop, manage and regulate the trade relationship between private companies and departments inside governments. Therefore, an e-procurement properly implemented, as a national system, is able to connect business processes of Ministeries and Divisions directly with suppliers, especially with small and medium enterprises (SMEs), allowing them to manage their interactions, and promote the equality between big bidders and SMEs. Furthermore, this online system allows getting statistics, census of offers and tenders as well as being a repository of reliable information for national accounts because it helps the government organize its interactions with its most crucial suppliers (CEC, 2004).

Finally, in an international framework of global warming, current trends in e-procurement are achieving a wide implementation encouraging green suppliers and transforming the public procurement into a tool that promotes sustainable procurement that subsequently supports the development of new greener economies (Walker & Brammer, 2012). Despite this, the environmental impacts of sustainable procurement on greenhouse gas (GHG) emissions remain unknown.

E-PROCUREMENT IN CHILE

Since the year 2003, according to Chilean Law Nº 19,886 *On Terms And Conditions For Administrative Supply And Service Contracts,* a modification took place in the Public Procurement Bureau (DAE, *Dirección de Aprovisionamiento del Estado*) responsible of procurement, storage and distribution of purchases towards a Public Contracts and Procurement Bureau (DCCP, *Dirección ChileCompra*) intermediary entity responsible for public procurement between the suppliers and purchasers of the State. Today with only a few exceptions, DCCP is the only governmental platform in which all Chilean institutions of the state must use in order to acquire a product or service for their institutional tasks (CPAR, 2008).

The operations, understood such as transactions in DCCP could be done under three different areas: the Framework agreement, Tendering and Direct Purchase. These three areas part of the e-procurement platform will be described next:

The Framework Agreement	Settlement made for repetitive purchases of different products and services through a public tendering carried out by DCCP after a market research has been done. The vendors awarded present their products or services in an online catalogue entitled *ChileCompra Express.* In this way any time an agency of the State needs to purchase an item offered in the online catalog, it simply "clicks the button" on the system. The Framework agreement lasts throughout a period of three years in which the vendor can

	update the products or services he provides (Singer, *et al*, 2009).
Tendering[1]	**Public Tendering:** Public offer formulated by a Public buyer to locate a vendor that has the product or service that fulfills the specifications made by the buyer. **Private Tendering:** Offer made by a Public buyer to locate specific vendors that have the product or service that is being searched for (Law 19 886, 2003).
Direct Purchase	Mechanism that is used for exceptional cases, when it is not possible to do the purchase through the online catalogue or public tendering. In these cases it is required to justify this circumstance in a well-founded resolution. The direct purchase is a purchasing system where the appeal is open to all vendors. In some exceptional cases, the system permits to choose vendors selectively or send the purchase order directly to a previously selected vendor (DCCP, 2009).

Table 1: Operation Areas of DCCP

REGISTRATION TO THE E-PROCUREMENT SYSTEM

All companies that are interested in being a vendor for the State must log on to www.mercadopublico.cl and fill in the required form. They are asked to provide general information about the company and name a specific person as a main user, who will manage the password to sign up the company within the system. Signing up is free and it then allows companies to participate in the public market by sending their bids. Additionally, companies have the option to sign up in the official registry of State vendors for Chile, www.chileproveedores.cl. Membership in this website is approximately 60 USD a year and it certifies that the company is currently able to be a contractor for the State. The membership also allows companies to have their information uploaded in digital format

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[1] Tendering is also classified in respect of its total amount, where it is divided into three groups: L1: < 100 UTM (USD); LE: 100 – 1000 UTM (USD) and LP: >1000 UTM (USD)

so as they don't have to resend their documents every time they want to bid or are contracted (DCCP, 2011).

In the present time, there are approximately 410,000 companies that have signed up in the basic registry. 100,000 of these are active. There are also 43,000 companies signed up in the official registry. Nevertheless, bids still seem to be the main indicator of the real participation of companies within the public procurement system. 57,000 of the 103,000 enrolled companies send bids. An average of 6.3 bids per tender was received in 2011. An estimated average sending time per vendor, considering all vendors that make transactions in 2 years, is approximately 18 months. There are also an estimated 43% of new companies every year who send bids (DCCP, 2011).

IMPACT OF E-PROCUREMENT SYSTEM IN CHILE

In relation to economic and social impacts of Chilean e-procurement, throughout 2011 the DCCP`s e-procurement platform assisted 885 institutions of the State in transactions for $8.0 billion Dollars which states for 3.5 of the GDP bided (DCCP, 2011). This e-procurement system provide those who use it a set of monitoring tools to help control costs and assure maximum supplier performance (Singer, *et al*, 2009). Indeed, it provides an organized way to keep an open line of communication with potential suppliers during a business process (Croom & Brandon-Jones, 2007). Furthermore, the system allows managers to confirm pricing, and a leverage previous agreement to assure each new price bided is more competitive than the last (Gunasekaran & Ngai, 2008).

Current public procurement policy encourages sustainable procurement, awarding companies with social and environmental awareness. The supplier whom provided some kind of certification regarding these issues have the opportunity to achieve higher places in the ranking on e-catalogue as well as obtaining a 5% of total points for evaluation weights by tender (Walker & Brammer, 2007). However, the environmental impacts of this public policy still remain unknown. Therefore, the objective of this study was to develop a methodology to estimate the carbon footprint in the public procurement system of Chile.

METHODOLOGY

The methodology was focused on measuring the Carbon emissions into the atmosphere, generated mainly by the electric power consumption, based on GHG Protocol. The GHG Protocol Corporate Accounting and Reporting Standard help companies and other organizations to identify, calculate, and report GHG emissions. According to the GHG protocol, there are three main scopes that need to be determinate which are described in the following table:

Scope	Characteristics
1	Includes direct emissions product of different operations within a function to carry out a task, as for example, the emissions due to the combustion of fossil fuels, or the gasses emanated from a cooling system for a server network.
2	This scope covers indirect emissions that are due to the electric power consumed, needed for an operative system to carry out a task.
3	Includes indirect emissions due to the manufacture of products or resources needed for the functioning of an operative system to carry out a task, as for example, computers, paper, or IT equipment. For e-procurement this scope also involves the emissions due to the user's connection time to the online service out of office hours.

Table 2: Scope Characteristics applied to E-procurement

To determine the different scopes, as first approach was acquiring operational information of different aspects the e-procurement system comprises. Through the acquirement of the operational information, it was feasible to classify the activities of e-procurement that depict the platform's annual activities as well as its emissions, and in this way facilitate the estimation of the direct or indirect carbon emissions implicated into different scopes. These scopes enable an estimation of the carbon emissions implicated as a whole e-procurement system by GHG protocol (fig 1).

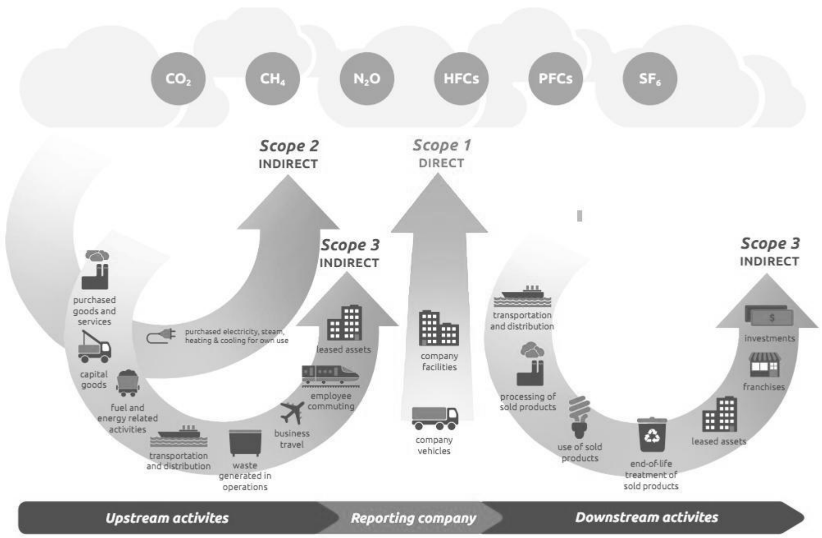

Figure 1 Scopes GHG Protocol
(Source: GHG Protocol, 2011).

To determine emissions related to the platform that supports e-procurement all resources needed and used for the platform, as well as, the carbon footprint of servers and energy consumed were considered. Scope 1, are direct emissions associated with sources used by the platform (e-procurement), these were considered as negligible because they are not directly linked to fuel oil consumption. Only, fugitive emissions from refrigerants used in cooling systems on servers were considered in this scope.

Regarding scope 2, these are indirect emissions related to e-procurement system linked to the electric power consumed. However, the total electric power consumed is the power supporting the platform (kWh), known as the baseline, plus the power consumed due to all transactions "out office hours" induced by the continual service of e-procurement. The emissions due to the power consumed because of all transactions "out office hours" is considered as scope 3 (described below), because it is a downstream activity. To determine the electric power consumption due to transactions, variables such as users connection time to the platform and the amount of users connected per hour were considered.

To determine the total emission, the electric power consumed was converted to carbon dioxide equivalent emissions measured as $tonCO_2e$ as an emission factor (FE). In this research, the FE was obtained from an estimation of the Interconnected System of Energy (SIC) that supports the central region of Chile. The FE was that of 0.48 ton CO_2e / MWh (ICONTEC, 2010).

SCENARIOS AND ASSUMPTIONS IN CARBON FOOTPRINT'S DETERMINATION

Firstly, an ideal scenario with a series of suppositions that depicts the standard functioning of e-procurement system is needed. Within these assumptions the contribution of each component in the procurement system to the overall carbon emissions will be evaluated.

E-Procurement platform: This is the online service where the transactions for the acquirement of a product or service for institutional purposes are carried out between the State and suppliers. In this research, the platform will divide in two: Server Network and IT Support.

1) **Server Network**: It is a system composed by a group of computers in conjunction with other IT equipment that provide an online service to users on their own computers. The assumption for this scenario will be that the server network delivers a continual service of 24 hours a day, 7 days of the week. Blackouts will be considered as negligible.

2) **IT Support**: Area in charge of supporting the correct functioning within the standards required for this kind of platform. The IT support includes the physical operation of the system, as well as the logistics behind every operation within the e-procurement process, as part of the service provided. The assumption here is to consider fixed working hours of 40 hours per week as the operation time for the IT support. Therefore, as the time has a direct influence

on its electric power consumption, indirect carbon emissions due to IT support should reflect its specific power consumption pattern.

In the measurement of the carbon footprint for online platform all three scopes are considered. Scope 1 concerns the physical aspect of required cooling system for the correct functioning of the Server network; the platform's scope 2 involves the indirect emissions due to electric power consumption including that consumed by the servers, functioning to deliver online service as well as, the IT support required for the platform. Finally, the platform's scope 3, involves the emissions for the manufacturing or extraction of all resources needed for the correct functioning of the e-procurement system. Therefore, these are resources that are not linked in a direct manner with the service that the e-procurement platform delivers. Theoretical data based on literature will be used to determine the carbon footprint linked to the manufacturing of a standard computer.

SCENARIOS AND ASSUMPTIONS ON USE OF PLATFORM PER TRANSACTIONS

In getting the carbon footprint linked to e-procurement some assumptions of transactions hours are needed. Having already an estimation of the CO_2 emissions for the functioning of the e-procurement system, it should also come into consideration as part of the carbon footprint calculation, the emissions for which the e-procurement service can be regarded as responsible. Emissions by users connected "out office hours" to the platform can be regarded as responsibility of the online service. It should be noted as well that weekends were considered as part of the "out of office hour" transactions.

As a first step, total emissions of all users connected to the platform per hour were calculated. This measurement allows estimating a mean value of emissions per user connected on the e-procurement system. To determine how much emission were due to the use of the platform "out of office hours" the measurement must consider emissions per connections to the platform outside working hours defined by DCCP previously.

To estimate the total emissions of the users connected, data provided by DCCP was used, this data permitted to measure the number of users per their time of connection. Subsequently to the total sum calculated, the connections “in office hours” were subtracted and, from this new data it was possible to obtain the power consumed by the users “out office hours”. These resulting emissions are a consequence of the online service that facilitates public e-procurement throughout 24 hours a day, everyday of the week.

The measurement allowed the calculation of the emissions that come from the users of the e-procurement service. This result was then added to the already estimated CO_2 emissions for the functioning of the system. Through this approach the global measurement of the carbon footprint for the e-procurement system is estimated.

ESTIMATION OF EMISSIONS IF THE E-PROCUREMENT WAS NOT OPERATING

In order to understand the scale of the carbon footprint when it comes to a change of operation policies, in this specific case the operation of e-procurement, it is necessary to make a comparison between the emission of e-procurement and the emissions of all the processes that are carried out for a traditional procurement without the services that e-procurement offers. For this study the indicator used for the comparison was specifically the amount of forms used for a transaction. In one side e-procurement offers the whole process online, meaning that the ideal scenario is no printed forms. On the other hand traditional procurement needs printed forms and transportation of the representative in order to make a transaction. Hence the analysis will be between the carbon footprints of a transaction through the e-procurement in comparison with that of a traditional procurement. The factors used for the estimation of the carbon footprint of transactions in the traditional procurement process will be firstly through an average number of papers used for a standard form in a transaction, which is that of 34 papers. Secondly considering the literature available, three emission factors for the carbon footprint of a sheet of paper (A4) will be utilized to represent the spectrum of different possibilities in Chile; these are (a) $3.20\text{x}10^{-6}$

(tCO_2); (b) $6.04x10^{-6}$ (tCO_2); and (c) $10.8x10^{-6}$ (tCO_2). This estimation will give three different results of carbon footprints for the counterpart of the "out of office hours" transactions in a traditional procurement process that will then be compared to the carbon footprint of e-procurement to understand the efficiency of the different processes. The three existing emission factors and their details are categorized in the following table:

Emission Factor	Emissions per sheet of A4 paper (tCO_2)
a	$3.20x10^{-6}$
b	$6.04x10^{-6}$
c	$10.8x10^{-6}$

Table 3: Details of the three different CO_2 emission factors considered.

SET OF EQUATIONS

Equation 1.0: Carbon Footprint in E-Procurement

$$G_T = Gb + Gp_i$$

G_T: Total emissions of the e-procurement service (tCO_2e).
Gb : Emissions of the e-procurement platform (tCO_2e).
Gp_i: Emissions due to the total sessions or transactions on the e-procurement platform (tCO_2e).

Equation 1.1: Carbon Footprint of the E-Procurement Platform

$$Gb = (Es + Ee + Ei)Fe + Gs$$

G_b: Emissions of the e-procurement platform (tCO_2e)
E_s: Electric power consumption of the server network (MWh)
E_e: Electric power consumption of the cooling system for the server network (MWh)
E_i : Electric power consumption of the IT support system (MWh)
F_e: Emission factor of the Interconnected System of Energy (SIC) that supports the central region of Chile (tCO_2e/MWh).
G_s: Direct emissions due to activities of the server network (tCO_2e)

Equation 1.2: Carbon Footprint of Transactions in "*n*" number of days

$$* \sum_{i=m}^{n} Gpi = Gp_m + Gp_{m+1} + Gp_{m+2} + Gp_n$$

G_{pi}: Emissions due to the sessions or transactions on the e-procurement platform in "n" number of days (tCO_2e).

Equation 1.2.1: Carbon Footprint of Transactions in one day

[2] $$Gp = N \cdot Ec \cdot Fe$$

G_p: Emissions due to the sessions or transactions on the e-procurement platform in one day (tCO_2e).
N: Amount of sessions or transactions
E_c: Electric power consumption of a standard computer [3] (MWh)
F_e: Emission factor of the Interconnected System of Energy (SIC) that supports the central region of Chile (tCO_2e/MWh).

Equation 1.3 Carbon Footprint of transaction through paper forms in one day

$$Gt = N \cdot P \cdot Gf$$

G_t: Emissions due to the transactions through paper form in one day (tCO_2e).
N: Amount of sessions or transactions
P: Average amount of paper in one transaction form
G_f: Emissions due to the manufacture of one sheet of paper (tCO_2e)

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[2] Note: According to the Assumption on use of platform per transaction mentioned previously in this study, the estimation for the Carbon Footprint of transactions will be calculated using only the amount of transactions done out of office hours.

[3] Note: The electric power consumption of a standard computer was estimated according to an average desktop, integrated computers (234×10^{-6} MWh).

RESULTS

According to the power consumed by a server network in one year, the Carbon footprint of the e-procurement platform is estimated to be:

- **119.7 tCO_2e/year**

Furthermore the Carbon footprint of "out of office hours" transaction through e-procurement was that of:

- **855.8 tCO_2e/year**

This last calculation was made considering 7,619,740 "out office hour" transactions in one year. Hence, the total CO2 emissions corresponding to e-procurement in one year would be:

- **975.5 tCO_2e/year**

In accordance to the three different emission factors of the carbon footprint for "out of office hour" transactions in a traditional procurement process described earlier, and also considering a number of 7,619,740 "out office hour" transactions in one year, the results were the following:

1. **For emission factor (a): 829 tCO_2e/year**
2. **For emission factor (b): 1564.8 tCO_2e/year**
3. **For emission factor (c): 2797.9 tCO_2e/year**

Carbon footprint of e-procurement	Carbon footprint of traditional procurement
975.5 tCO_2e/year	829 tCO_2e/year using emission factor (a)
	1,564.8 tCO_2e/yeaar using emission factor (b)

	2,797.9 tCO_2e/year using emission factor (c)

Table 4: Comparison of Carbon footprints

DISCUSSION

The findings in this study show that e-procurement is a service that provides less bureaucratic procedures, as well as quicker and more direct communication within the process of a transaction. These lead to fewer CO_2 emissions due to transportation of representatives, or in the delivery of various forms, as well as providing fast solutions to errors or questions without the need of travel, as it is an online service.

Furthermore the e-procurement service ideally is done without the need to print a single sheet of paper form, which can also lower the CO2 emissions of a transaction, as there is no need for paper and its emissions for the manufacturing process and transportation. This is can be observed in the results (table 4), where two of three possible results show how e-procurement is efficient in lowering CO_2 emissions when it was compared in the "out of office hour" transactions. As it can be seen in figure 2 result (b) using a standard emission per paper is nearly twice that of the emission from the e-procurement service and, result (c) is nearly threefold over the e-procurement service's CO_2 emissions. This is mainly because of the amount of sheets of paper per transaction form and the level of emissions of CO_2 per sheet of paper.

However it should come into consideration that e-procurement provides an online service that can be accessed from any computer 24 hours a day, 7 days a week, making it available at all times. This is useful for transaction processes, but on the other hand it also creates a similar situation to that of a rebound effect. Where because it is easier and more accessible for users from anywhere without fixed operating hours, there are more activities carried out for a transaction process within a day, as well as more hours during a day to use the service. This leads to a higher consumption of electric power, which in turn increases the carbon footprint of the e-procurement process.

A representation of this rebound effect can be observed in table 4 where in result (a) the emissions due to transactions through paper forms are less than the CO_2 emissions generated by the e-procurement service. The minimization of the carbon footprint in the manufacturing of paper could also be, in part, because of activities such as reforestation and a company's electric power independence through self-generation, using sub products such as biomass combustion. Both the rebound effect, a reflection of the user's new habits within a transaction process in e-procurement, plus a lowering of emissions generated per paper due to different possible activities created to minimize and compensate the carbon footprint of the paper manufacturing, can lead to a situation such as result (a), where it would appear that traditional procurement has a smaller carbon footprint than e-procurement.

If the situation according to result (a) occurs, then a considerable alternative to mitigate and reduce the carbon footprint of the paper procurement system would be to make it more efficient. A proper approach to make paper procurement more efficient would be to cut down the amount of paper used in a transaction form. This could be by setting a standard number of sheets or a maximum amount of paper according to the category of the tendering. In this way it would be possible to manage this aspect of a transaction procedure, which in turn will have an effect on the carbon emissions of paper.

In another aspect, for further research it would be proper also to revise the option of having fixed transaction hours within the e-procurement process and observe if it minimizes the possibility of a rebound effect in transaction activities and in this way reduce the carbon footprint of the e-procurement system.

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