NMBU

FORWARD

This master thesis has been written to finalize two-year master' s program in Economics at the University of Life Science in Ås.

The motivation behind the topic comes from my interest in green certificates market and renewable energy. The two subjects, Energy economics and Econometrics, have established my fundamental knowledge to write this thesis.

I would like to thank my supervisor Olvar Bergland for the engagement in this paper, his guidance and challenging discussions. Further, I would like to thank Jørgen Bjørndalen for sending me useful analysis regarding the transmission rights that have been of essential help for the topic. Last but not least, I would like to thank my husband, Nikola Braatan, for being my greatest supporter during my studies.

Ås, 18 May 2016

Veselina Braatan

ABBREVIATIONS

AIB: association of issuing bodies

EU: European Union

GOO: Guarantees of Origin

GSE: Gestore Servizi dei Energitici (state owned company for GOO in Italy)

MC: Marginal cost

MV: Market value

P: price

PTR: Physical Transmission rights

SFOE: Swiss Federal Office of Energy

TR: Transmission rights

TSO: Transmission system operator

JAO: Joint allocation office

ABSTRACT

The aim of this thesis is to evaluate the role of the guarantees of origin, and consider how they affect price differences for PTR between Italy and Switzerland. This thesis seeks to investigate the possible effect that an obligatory usage of GOO can have on the PTR price between the two countries. To do this, it will use PTR auctioning theory and empirical data. The thesis will consider the period from 2012 to 2015. To do this, I used empirical models with linear regression analysis to observe time-series data. The data was collected through the Italian TSO archive of auctioned PTR, Trena for the direction Switzerland-Italy. I analyzed two models in different time frames, along with dummy variables for the GOO policy and the weekend. The first model considers the years between 2012 and 2015, with a dummy variable for the years from 2013 to 2014. The purpose is to look at the GOO's general effect in the year when the obligatory policy was still active and the year during active lawsuit against that policy. The second model considers the period between 2012 to 2013. Because it only considers the year when GOO was obligatory, the dummy variable is applied only to 2013. The analysis present data for every hour of the day, along with a lag for every day of the week. The results showed that the GOO has no significant impact on the price difference for PTR between the two countries when the regression is performed for all years. On the contrary, it suggests that the GOO has a significant effect on the price for PTR during the time of the policy that made it obligatory in 2013, and weak evidence during the court decision in 2014.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

1. INTRODUCTION

European policy makers have for the last years increasingly promoted the use of renewable energy. The countries in the region are looking for ways to find new clean sources of energy and to utilize these both on a regional and national level. The increased demand for renewable energy has led to the creation of a new market for labeling of energy from renewable sources, namely the market for GOO. GOO is a certifying tool that was created to ensure renewable sources of energy for the consumers. GOO is also a mechanism that is driven by the consumers' choice, which means that the consumers are the ones who can create demand for renewable energy. In order to ensure that each member of the EU expand renewable resources, a common registry for GOO was established through a directive 2009/28/EC (eex, 2016). This increased demand for clean energy drives the expansion in the GOO market (Hans Peter Kildal, Bergen Energi for Montel).

Europe's current electricity flow consists of residual mix that is influenced by wide variety of power stations connected or inter-connected across boarders (Trevino 2008). Because European countries are inter-connected, they can transmit electricity in case neighboring countries experience power shortages in their system. It has been possible to sell electricity across borders since the opening of the electricity market for European countries. The electricity flow across countries is traded through interconnections. Physical transmission rights are rights that are auctioned between bidders. PTR are the rights that entitle the right owner to transfer a certain amount of electricity in a specific time between bidding zones in defined direction, after the bid. The European countries have different legislation regarding GOO on a national level and their physical connection with the electricity grid. However, according to the directive 2009/28/EC, the GOO is accepted among all EU members. In case an EU member do not recognize the use of a GOO from a certain source, it should provide an objective along with the rejection decision. According to the European directive for GOO the transfer of 1 GOO is not obligated with the physical electricity flow of renewable energy in the grid (2009/28/EC). The only European country that do not follow the directive is Italy for the year 2013. The country has a law obligating the importers of GOO with actual flow of electricity, meaning that the two markets of GOO and electricity import are connected. Based on this, an interest for this thesis is the PTR prices and auctions that are possibly affected by GOO, for the region of Italy and Switzerland during the period 2013 to 2014.

In Italy, a court decision was executed on 26 November 2014, concerning that the GOO was previously used as obligatory tracking tool of renewable electricity in Italy. Each producer located in Italy, or an importing company, like the ones located in Switzerland, were obligated to feed into the grid a certain amount of energy produced from a renewable source from the national grid in the territory of Italy. In case a producer failed to deliver the requested amount of renewable energy into the grid, there was an was obligated to purchase GOO corresponding to the amount of the imported electricity. If the company failed to purchase the required amount of GOO, it received an administrative penalty fee. Since January 2013, GOO was the only tracking tool for electricity disclosure of renewable energy. However, the court found the national renewable policy regarding GOO in Italy as discriminatory, and it has been removed as an obligation in November 2014(European Union 2014).

1.1. RESEARCH QUESTIONS

In light of the court decision and because of the interest to investigate a possible effect of the GOO market on the price of PTR, this thesis seeks to answer the following research questions:

Can the GOO explain the difference in the price for transmission rights between Switzerland and Italy for the period 2012-2015?

How can an obligatory policy for using GOO in the electricity disclosure mix affect the auctions for PTR on the northern border of Italy with Switzerland?

To answer these research questions, I will investigate the possible effect that the GOO policy has on the price and auctioning for PTR. The focus is on the effect that the market for GOO has on the value of owning PTR cross-border in the region of Switzerland and Italy. In the period 2013-2014 power plants in Italy could certify their energy mix through GOO (Gestore Servizi dei Energitici Spa n.d.). Switzerland is among the leading importers of energy in Italy. The main assumption is that Switzerland could provide numerous GOO for the Italian market for a price cheaper than the local ones in Italy.

1.2. OVERVIEW OF PAPER

The research question will cover the GOO and PTR market for the region of Switzerland and Italy. In order to answer the research questions, this thesis will provide relevant background information for both markets and countries. In the theory section, the focus is on how GOO may affect the PTR value. It will also discuss the change in the auctioning, both with the presence of GOO and without considering it. To make it easier for the reader to follow, this thesis will refer to Switzerland as country A, and Italy as country B. All values used under the theoretical cases are randomly picked with no actual representation in the real world. The numbers represent a simulation of the real situation in Italy and Switzerland in terms of cross-border trade and auctioning of PTR.

The empirical model uses official data from the Italian TSO- Terna, and is based on the daily auction between Switzerland and Italy for cross-border capacities. Simple linear regression analysis with time-series data is performed based on the daily auctions for the period 2012-2015, with a dummy variable that represents the GOO policy. This allows for empirical testing of two models: the first model considers all data from 2012-2015, and the second model considers the data from 2012-2013 with a dummy variable for 2013.

2. BACKGROUND

2.1. BACKGROUND OF GOO

According to the Directive 2009/72/EC, Article 3 (9) obligates electricity suppliers to provide information about the origin of the electricity they sell to end users (European Parliament Council of the European Union 2009). The European Union established the GOO market in 2001 as a voluntary market and an instrument to expand the renewable energy share in the total electricity consumption. Moreover, the EU intended it to serve as a tool for countries to easier set and reach their climate goals.

The GOO content is shown on the table below:

GOO
1 GOO = 1MWh = 100KWh = 1 electronically based GOO is issued

Figure 1 The GOO content (ECOHZ 2009)

A GOO has a lifetime of 12 months from the date it is issued. The lifetime includes the following steps that are executed electronically:

	GOO lifetime 12 months	
1.issuing	2.transfer	3.cancellation

Figure 2 *The Lifetime of GOO* (European Parliament Council of the European Union 2009)

During period 1 and 2, the GOO can be used to improve transparency and disclosure in the electricity market. This is because the GOO provides information about which energy source is used, its location, technology and power plant type. To ensure the transparency of the market, more information about the power plant is provided, such as its operational start date, its size and information regarding financial support for its operations (European Parliament Council of the European Union 2009).

The GOO in Europe are traded through EU members that have applied GOO registry on a national level. These national GOO registries provide information about which electricity sources are renewable. The GOO are sold and transferred across European boarders through AIB.

Norway is the country with the largest share of sold GOO, because of its hydropower producers. In Europe, the demand for GOO grew with 28% in 2015. The countries with the highest demand for GOO are Germany, Sweden, Switzerland, the Netherlands and Italy. The observations on the market for GOO shows that there is significant growth on the demand annually. This is highest in the Netherlands, with a 12% growth on the demand for GOO, which in terms of electricity is up to 42.5 TWh. Germany has the highest demand for GOO in Europe, with 87TWh. The total demand for GOO in Europe accounts for 13% of the total share of regional electricity consumption (Lindberg 2015). In practice, the GOO are independent from the physical transmission flow of electricity. However, the Italian market makes a difference because it connects the two markets of GOO and PTR in 2013. Therefore, for the purpose of this paper it is required an actual consideration of the PTR. The PTR will be defined in detail, and the assumptions regarding how it relates to the GOO will be presented.

2.2. BACKGROUND OF PTR

2.2.1. PTR AND GOO

GOO trade and the real physical flow of electricity are independent of one another because GOO is a tool to label electricity production. This makes it difficult to relate GOO and the actual electricity flow, because GOO exceeds the physical flow that goes into the grid in practice. This thesis considers the physical flow in the electricity grid as one of the methods to track the GOO, following the law in Italy that links the two markets. Therefore, to exchange renewable energy between countries in practice, their physical transmission rights and the actual flow should be considered. This thesis looks into whether it is possible to synchronize between the PTR market and GOO market in theory. It is widely known that the flow of an actual electron cannot be traced with certainty (Aasen et al. 2010), as electrons follow physical law and not the market. Physical trading can be considered as a more reliable source for examining the flow, as it represents the activity of all actors involved in the electricity market. The actors involved are as follows:

	El. market actors	
producers generating power plants	*traders/retailers* Suppliers	*end consumers*

Figure 3 Electricity market actors

2.2.2. PTR AUCTION TYPES

Auctions for PTR can be explicit or implicit, and both types are used to prevent shortages in the electricity system. Explicit auctions are used for regional inter-connection in Europe (Nordpoolspot.com n.d.). This type auctions the transmission capacity on an inter-connector, and allocates the PTR individually to each involved party, with the purpose to coordinate between different markets. The explicit auction allows defining cross border capacities as options and obligations, prior to the trade. The auctioning of capacity can occur annually, monthly and daily. Since the traded electricity is a market that is separate from the TR one, the price information between the two markets is insufficient. This lack of full information leads to incomplete utilization of the inter-connector capacity, which may cause market inefficiency, i.e. less social welfare (Nordpoolspot.com n.d.). The Nordic region utilizes implicit auction. More specifically, this applies for the countries that are part of Nordpool day – ahead market, where the capacity is used in a direction to optimize social welfare in the different biding areas. Under implicit auctioning, the cost of electricity production and certain areas' congestion costs affect the final electricity price. Generally, implicit auction is used for market coupling where the involved bidders do not bid directly on the capacities available in the grid, but rather on the energy available for their exchange area. Market coupling integrates two or more markets, with the purpose to minimize price difference between the different areas (European power exchange). An example of this is Nordpool, where multiple power exchanges are integrated with the aim to utilize the available capacity (Nordpoolspot.com n.d.)

In Switzerland and Italy, intraday auctions are utilized, which are explicit closed auction rules aimed to harmonize the cross-border trade between the countries. To coordinate the cross border trade, each country must define PTR rights. The explicit auction and the inter-connector trade for renewable electricity between Switzerland and Italy are of interest to this thesis. Therefore, a clarification of PTR in cross-border trade is provided below.

2.2.3. PTR IN CROSS-BORDER TRADE

In order for the cross-border trade to take place PTR are required. PTR are exclusive rights used to nominate certain power flow directions (cross-border contracts). The purpose of this is to change the energy's direction flow from one market to another. PTR are used to purchase and sell power in the grid. Before physical power trade between two countries can occur, the cross-border capacities must be defined, either as options or as obligations.

2.2.4. PTR OPTIONS AND OBLIGATIONS

PTR options and obligations are usually used in situations where the involved markets are coupled and defined by the day ahead market, or sold by the TSOs (Newbery & Strbac 2011). PTR options are divided in two sub categories based on two sets of conditions: use-it-or-lose-it or use-it-or-sell it conditions. The use-it- or-sell-it option entitles the rights owner to trade the capacity on the market. If it is a case of day-ahead market, the PTR that is going to be sold on the market should be nominated according to the day-ahead market's rules. This option enables the rights holder to use, or not use, the right. PTR obligations allows the PTR holder to decide a schedule for the cross-border transfer (Newbery & Strbac 2011).

2.3. CROSS – BORDER RIGHTS

The European gird system is interconnected across borders in order to ensure safety on the power market, and to minimize shortage issues. In general, markets for cross-border capacities are natural monopolies that TSOs controls (Wobben et al. 2012). The auction system allocates the rights across borders. In the case of implicit auctions, the cross-border rights are auctioned to determine transaction with price difference of electricity in two markets. When the auctioning of cross-border rights is explicit, the highest bidder with defined marginal price can attain the rights (Lajovic n.d.). The cross-border rights are limited within the transfer capacities of the inter-connector. The section below provides further information regarding the transfer capacities between Switzerland and Italy.

2.4. CROSS – BORDER TRANSFER CAPACITIES: ITALY AND SWITZERLAND

Cross – border transfer capacities between Italy and Switzerland are allocated to be up to 4.2GW (Patrian 2015). These grid capacities are assigned by Rete Electtrica,Nazionale SpA (Terna) and Swissgrid. The auctions that distributes the cross-border transmission capacities are explicit, and occur on an annually, monthly and/or daily basis. These auctions are handled by JAO S.A., which is the allocation office for cross-border capacities. In order to increase the usage of cross-border capacities, the two TSOs, which are Terna for Italy and Swissgrid for Switzerland, are part of the intraday explicit auctions on the border between the two countries. The auctions are two sided, with a Switzerland-Italy and Italy-Switzerland direction. This thesis has collected data from the Switzerland- Italy direction. Swissgrid is the TSO responsible for the Switzerland-Italy auctioning, and if the direction is from Italy to Switzerland, the Italian Terna is the responsible TSO. These TSOs are the main auction operators for PTR, depending on the auction's direction.

The intra-day auctions are explicit closed auctions, where the capacity is auctioned on intra-day basis. In this type of auction, the TSOs' obligations are to provide the capacities available to the participants. Once the capacities are allocated, the participants pay the amount they must pay from the auction. Next, the PTR are distributed to the auction's participants.

3. ELECTRICITY MARKETS AND GOO: SWITZERLAND AND ITALY

Section 3 presents the characteristics of the Swiss and Italian power markets, with the purpose to briefly explain their differences in terms of energy sources. This is necessarily for the further discussion of the GOO market between the two countries.

3.1. SWITZERLAND

The electricity market in Switzerland is similar to the Norwegian one, as it relies on a large share of hydropower plants. According to the Swiss Federal Office of Energy (2016), hydropower accounts for 54.2% of the electricity produced domestically, which makes hydropower Switzerland's most important energy source. Nuclear power is the second most important source, accounting for 39.1% of the electricity produced. Other renewable energy sources accounts for 7% of total share. In 2013, 60% of domestically produced electricity came from hydropower sources (Bundesamt für Energie 2014). The consumption is 50% as large as the world's average per GDP. Switzerland's high demand for energy has made independent on foreign imports of energy sources (Lucerne University of Applied Sciences and Arts 2014). The country has developed strong connections with foreign countries, and it is considered as transitory land for electricity. Switzerland trade electricity with its neighboring countries, which are Germany, France, Italy and Austria.

In 2013, the Swiss Federal Office of Energy (SFOE) announced that it planned to replace the nuclear power with alternative sources, mainly solar and winter power (Bundesamt für Energie 2013). To accomplish this goal, Swiss grid expect to invest in infrastructure in the next 10 years.

3.1.1. SWITZERLAND NATIONAL ELECTRICITY SOURCE DISCLOSURE - GOO

The GOO in Switzerland are used for disclosure. They can be traded as long as they are valid, but once expired, the GOO are included in the country's calculations of the national residual mix.

The lifetime of a GOO is 12 months after its release date, but in some special cases, the GOO life time is extended until May in the next calendar year. Such extension can be required in case of disclosure requests. Once a device is entitled for GOO, it can use it in its production for the next 5 years. Once registered for GOO, a power plant is subject to inspection, maintenance and must follow guidelines for handling errors (Swissgrid Ltd 2013). The process is as follows:

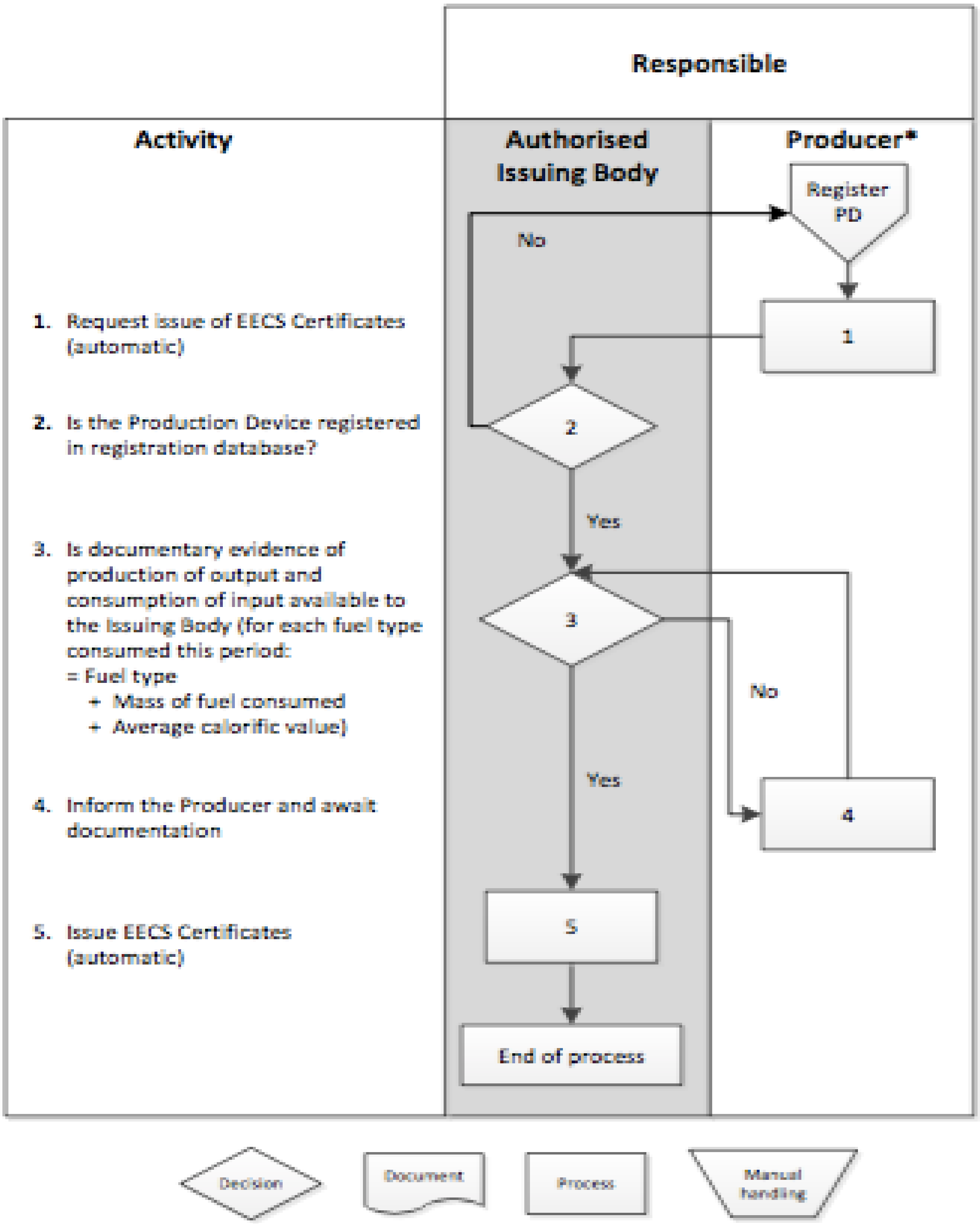

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Figure 4 Process for authorization for GOO in Switzerland (Swissgrid Ltd 2013)

3.2. ITALY

The Italian power market is a net importer of electricity, and is the largest net importer in the world. The two main importers of electricity in the country are Switzerland and France. Natural gas, oil and hydropower electricity are the main sources of electricity power imported in Italy. Italy imports natural gas, which accounts for 50% of the produced electricity in the country (TERNA 2016). Italy's electricity sector does not use nuclear power, because of the disaster in Chernobyl in 1987. The Italian international grid connector connects the country with several lines to (12) Switzerland and (4) France (TERNA 2016).

Public companies and independent control authorities are the key authors operating in the Italian power market. The role of the government is to involve in operating the transmission activity. There is authorization system to guarantee for the distribution activities. The power market in Italy is a complex system with competitive characteristics (TERNA 2016).

Actors with a key role on the Italian market are the national transmission network manager, the electricity ex- change manager, unique buyer, network owner, electricity producers.

The power market in Italy is subdivided into:

a) Electricity market: day-ahead and adjustment market

b) Transmission service market

The government in Italy controls the main producers of electricity and owns the grid.

This thesis' main assumption is that the production of electricity in Italy is linked to costly sources. Therefore, it will look into the inter-connector trade and the PTR ownership, to investigate whether the actual flow of clean energy can be present if Italy buy GOO from its neighboring country Switzerland.

3.2.1. ITALY NATIONAL ELECTRICITY SOURCE DISCLOSURE - GOO

Followed by the proposing of the disclosure obligation in Italy in 2007, it became a law. In 2009, "Fuel Mix Disclosure Degree" was implemented with the purpose to calculate "residual mix and suppliers mix". The calculation method was provided by GSE issued on 3.01.2013 (Italian power exchange operator) (Gestore Servizi dei Energitici Spa 2013). Furthermore, the GSE became the legal authority responsible for issuing GOO in Italy. During 2012, the Italian government introduced a new support scheme for renewable energy production sources. This new support scheme required a change in the rules that define the energy mix from suppliers to consumers. This change of the rules was linked to implementing a procedure for qualifying power plants, as well as introducing GOO and its use (European Parliament Council of the European Union 2009, Art.31(2)). The proposal was approved on 25.01.2013. Thus, from 2013, GOO become the main tracking tool for electricity disclosure of renewable energy in Italy (RE-DISSII, 2015).

In December 2013, GSE connected its GOO registry to AIB hub that was used further for exports/imports of GOO. The calculations of the national residual mix in Italy also include the imported GOO. GOO that are imported from other countries should be included in the calculations, to avoid double counting. Such measures are required to guarantee that the GOO are used correctly according to the electricity disclosure and the residual mix. Moreover, the exporting country should exclude the GOO from the residual mix of its country, to ensure that they are only used only on Italy's territory (RE-DISSII, 2015).

The table below provides an overview of the GOO market in Italy for the period of 2011-2014 ("activity of GSE for EECS certificates ")(RE-DISSII, 2015)

GOO Statistics: Italy 2011-2014

	Issued	exported	transferred	import	cancelled	expired
2011	0	6 082 593	7 830 240	3 865 125	18 591 512	0
2012	0	4 388 067	5 718 098	4 320 814	12 815 302	0
2013	13 936 018	408 579	6 248 711	871 957	3 202 298	0
2014	27 435 216	2 104 246	45 611 330	6 430 277	31 614 057	1 581 010

Table 1 GOO Statistics Italy (Association of Issuing Bodies AiSBL 2016)

Public information for the GOO imported from Switzerland for the listed years is not available, thus the paper considers the policy for GOO electricity disclosure as a factor that can affect the PTR and the price difference cross-border for Switzerland and Italy.

3.3. SWITZERLAND – ITALY

Transmission lines physically connect the markets of Switzerland and Italy, and a set of power lines inter-connects their transmission networks. An auction is organized daily, monthly or annually to determine the rights on the physical transmission lines for each direction and for each of the inter-connections. The auction is closed explicit, and involves the TSOs and the market participants. The market price on each side can influence the auction. This thesis uses data from the daily auctions in the direction Switzerland-Italy, considering that Switzerland is one of the major exporters of electricity for Italy.

4. THEORETHICAL MODELING OF THE GOO MARKET

This theoretical model is divided into three cases that review the simulation of the market and the effect of the PTR value.

Case I and II

The theory for Case I and Case II are based on the paper “Characteristics of congestion management methods” by the European Commission (European Commision Directorate- General for Energy and Transport n.d.) and is modified according to the needs of this paper.

4.1. CASE I: GOO ARE IGNORED

T case will ignore the GOO, and consider the two countries and their inter-connected capacities. The purpose of this case is to observe how the implicit and explicit auction would work in theory. The same purpose persists for the PTR: is it the case of PTR options or PTR obligations

In this case, country A and country B both have a demand for electricity 2000MW.

MC = unit cost (this is not a realistic assumption, but will be used for the example).

Country A: is the exporting country with cheap generating power supply (Switzerland).

Country B: is the importing country with expensive generating power supply (Italy).

All numbers listed in the cases below are random and do not represent reality.

Country A have 4 generating stations:

	Capacities	EUR/MWh
Aa	400	20
Ab	400	25
Ac	450	30
Ad	500	35

Table 2 Generating Stations for A

The dominant price on the market for country A is 35EUR. This is the price needed to provide the supply of 2000 MW.

Country B has 3 generating stations:

	Capacities	EUR/MWh
Ba	700	30
Bb	400	40
Bc	400	45

Table 3 Generating stations B

The dominant price for country B is 45 EUR.

The electricity generated in country A can be used to reduce the prices in country B.

To make the case more realistic, this thesis assumes that transfer capacities are limited.

The capacity available in the inter-connector between A and B is 200 MW.

There are many ways to deal with scarce capacities, and for the purpose of this case, an explicit and implicit auction are taken into account. The case does not consider TSOs costs for organizing the auctions and administrative expenses and losses in the grid.

4.1.1. EXPLICIT AUCTION:

The economic rent between the two countries is 10 EUR/ MWh.

The electricity generators in country A will be interested to bid and sell their electricity in country B. This allows them to receive the higher price of 45 EUR/ MWh instead of 35 EUR/MWh. Consequently, the assumption is that in the inter-connector, the price is bid up to 10 EUR/MWh. Generator Ad will make an offer of 44 EUR/MWh and the generators that are in B will become:

	Capacities	EUR/MWh
Ba	700	30
Bb	400	40
Ad	200	44
Bc	400	45

Table 4 Explicit Auction

The inter-connector will affect the dominant electricity price and it will be reduced to 44 EUR/MWh.

4.1.2. IMPLICIT AUCTION:

The case of implicit auction can be considered as very close to market splitting or market coupling.

The electricity price in this type of auctioning mechanism reflects costs of energy and the cost of congestions for each area (Wobben et al. 2012). This example will follow the previous case with two countries. It will consider the same number of generators, capacities and unit per MWh, and investigate the change for each country.

The TSO will add an additional charge for the generating companies in country A, who will bid on the market in country B. The purpose of this is that a significant number of bids will be priced out of the bidding process. In the example, this thesis assumes 5EUR additional tax.

Country A	Capacity	EUR/MWh
Aa	400	20
Ab	400	25
Ac	450	30
Ad	500	35

Table 5 Implicit Auction A

Country B	Capacity	EUR/MWh
Aa	200	25
Ba	400	40
Bb	400	45

Table 6 Implicit auction B

The winner from the bidding process in country A now has the lowest price. In the first example, explicit auction the winner is the marginal producer. The TSO will gain economic rent of 5 EUR/MWh.

The value of PTR for the cross border trade between A and B before GOO will now be presented.

Average price A: 27.5 EUR/MWh

B: 38.33 EUR/MWh

Transmission cost for the operator: 5 EUR/MWh

In order to define the value of PTR from A to B point the hourly prices for the market are needed.

Prices at A can be assumed to be constant cost for the example.

Prices at B can be assumed to vary according to the usage in peak and off-peak hours.

Therefore, the value is calculated by the difference in the prices per hour between A and B, as well as considering peak or off-peak hours.

For the value of PTR to be positive, the price in A and B should be above the average for the market price.

4.2. CASE II: GOO ARE INCLUDED

This case illustrates the affects from increased demand for GOO in country A and B. The purpose is to observe how the implicit and explicit auction would change when GOO affects the demand for imports from country A to country B. The same will be applied for the PTR, and the case will illustrate the effect from matching GOO with R for the power market between A and B.

To improve the understanding of the case, the thesis assumes that country A is high support provider for GOO, while country B is a low support provider.

Country A have 4 generating stations each of them provide GOO:

Aa	GOO
Ab	GOO
Ac	GOO
Ad	GOO

Table 7 Generating stations, A with GOO

For country A: GOO surplus is exceeding its target

Country B has only one generating station that can provide GOO:

Ba	-
Bb	-
Bc	GOO

Table 8 Generating stations, B with GOO

For country B we observe GOO deficit due to low-support level.

If there are no restrictions and the GOO is used only to label electricity, but not obligated to deliver actual clean energy flow, companies from A will prefer to operate in B and to sell their GOO

If GOO are linked to physical transmission of electricity, the GOO market will be restricted because of the grid's limited capacities. If the capacities are 200MWh, the GOO will not go beyond this capacity. As a result, PTR and GOO will merge into one market. This affects the GOO market due to the limited capacities that come from the actual transmission capacities. The supply declines while the demand remains high, which equals an inefficient market.

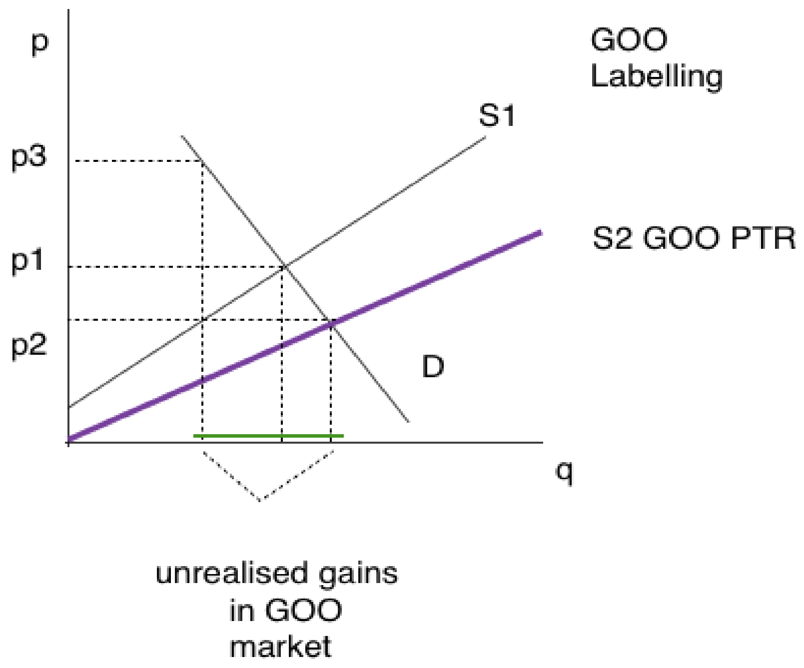

Figure 5 Unrealized gains in GOO market.

S1: Supply of GOO on a market with labelling usage of the certificates.

S2: Supply for GOO on a market where GOO are linked to PTR. The demand on the market for GOO remain the same.

p1: price of GOO on a market where the GOO is used as labelling.

p2: price for GOO on a market where the GOO is linked to PTR and there is enough capacities to deliver the demanded number of GOO.

p3: the real price for GOO on a market linked to PTR.

Following the basic micro principles, making the flow of green electricity realistic, i.e. linked to PTR will rise the prices for GOO due to limited supply. There will be a loss of unrealized sales of GOO as the demand will remain the same.

In order for the market to be efficient new investments in transmission capacities should be considered.

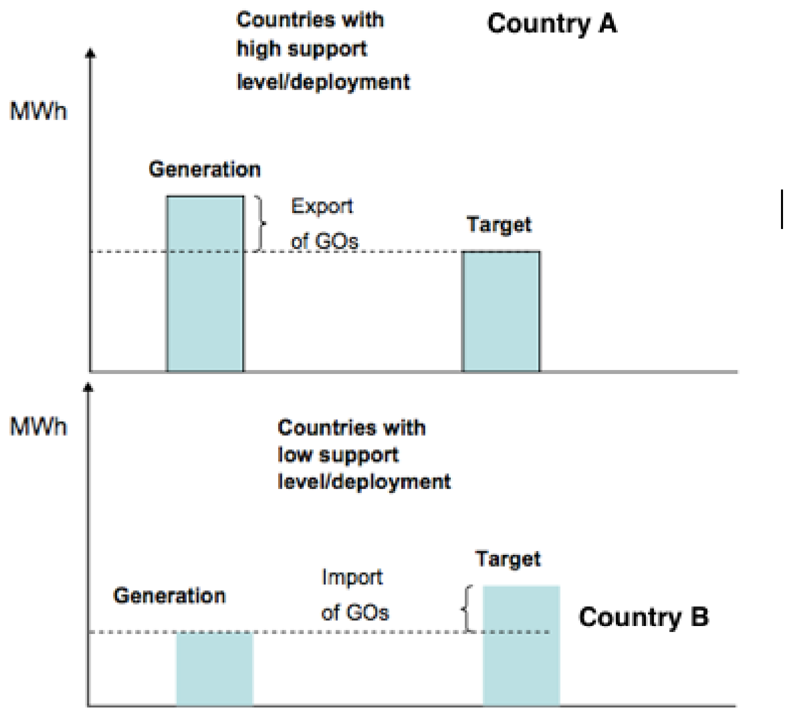

Figure 6 GOO labelling propose (Ragwitz et al. 2009)**: Modifies according to the purpose of this papper.**

This figure illustrates the case where the GOO are used to label electricity, but does not consider the actual physical flow. It shows the effect in country A and B.

4.3. CASE III: THE EFFECT OF GOO ON PTR

This case investigates how the GOO affects the price for PTR between country A and country B. It assumes that markets between PTR and GOO are linked for the cross border trade.

Country A: he exporting country with cheap generating power supply and clean energy production sources, which can easier acquire GOO.

Country B: is the importing country with expensive generating power supply, less clean sources of energy compared to A, which have difficulties in acquiring GOO, resulting in a low number of GOO compared to A.

Speculation for the assumption: prices for GOO in A < prices for GOO in B

The two tables below represent the two linked markets for PTR and GOO for each country:

country A	capacities	EUR/MWh	GOO
Aa	400	20	+
Ab	400	25	+
Ac	450	30	+
Ad	500	35	+

Table 9 PTR and GOO in country A

Country B	capacities	EUR/MWh	GOO
Ba	700	30	-
Bb	400	40	-
BC	*400*	*45*	+

Table 10 PTR and GOO in country B

In reality, the public cannot access information regarding GOO per generator and generator's prices. Therefore, the thesis considers GOO as a factor that adds additional costs to the generators' electricity price, initially stated in Case I.

The prices in A and B will depend on the peak and off-peak periods.

	A	B
peak	50 EUR/MWh	80 EUR/MWh
off-peak	20 EUR/MWh	30 EUR/MWh

Table 11 Price dependence on peak and off-peak hours

Value of PTR before GOO:

PTR value = peak EUR/MWh. % lost in transmission/ % earned by congestion. hours electricity transferred

PTR value = off-peak EUR/MWh. % lost in transmission/ % earned by congestion. hours electricity transferred
(Bjørndalen & Naper 2014)

Based on the Bjørndalen and Naper paper, here the value of PTR after GOO linked physically is presented:

PTR value = peak EUR/MWh. % lost in transmission/ % earned by congestion. hours electricity transferred price GOO/MWh.

PTR value = off-peak EUR/MWh. % lost in transmission/ % earned by congestion. hours electricity transferred price GOO/MWh.

The value of PTR before GOO and after GOO will increase with the amount required per GOO/MWh.

Given the initial information for case III country A is a low cost producer compared to country B, therefore MC of generation in A < B.

country A prices: P1

country B prices: P2

Under market with perfect competition characteristics:

P1 = MC

P2 = MC

P1 < P2

Binding transmission capacities leads to a market where the value is more than 0.

Market value of PTR: MV

The net price P1 = P2 – MV (Joskow & Tirole 2000).

The value of PTR: MV = P2 - P1

Adding the GOO: MV = P2 GOO(bought) - P1. GOO (sold)

Equilibrium condition: MV = P2* - P1*

The GOO in A is linked directly to PTR, and should use the capacity up to K (total capacity).

The result of this is market inefficiency in country B. The electricity production in B is more expensive than in A, and lacks sufficient number of GOO to cover the market demand. However, in country A there is cheaper green electricity and more generators that operate with GOO. If expensive energy is not substituted with cheaper energy, the market is inefficient. This makes it more profitable for generators in A to acquire rights for the PTR cross-border trade between A and B, as the electricity produced in A is cheaper to produce and can be resold locally for B with GOO. The flow of clean electricity directly linked to GOO will increase the total number of GOO used in B, acquiring a raise in the total GOO number

Assumption III

(a): GOO is used just for labelling

Country A: cheaper price for GOO

Country B: government impose a tax if local generators to not acquire GOO.

p of GOO in B > p of GOO in A

number of GOO in B < number of GOO in A

If the GOO market between country A and B is not regulated, the result may be overloading with GOO ex post.

Assumption III

(b): GOO market linked to PTR market

Fixed capacity K = 200MWh

1MWh = 1 GOO

Total 200 GOO possibility to trade between A and B

generators in B have interest to acquire the rights on PTR to maximize profit

generators in A have interest in increasing the price of GOO, as the maximum amount of GOO is now filled, and it is impossible to go beyond this. They may increase the price up to the level of the price for GOO in B. In theory, this will increase the value of the PTR, when linked with GOO directly as the factors that determine the value of PTR will be higher than in the case where the GOO are used only for labelling.

5. EMPIRICAL MODEL

This chapter will clarify and discuss the empirical models. In order to estimate how the GOO influences the price for PTR between Switzerland and Italy, a linear regression analysis with time series and a dummy variable will be used for the two models. The dummy variable that represent the Italian policy for obligatory purchase of GOO, is tested for significance from 2012-2015, with 24 hours estimation 7 days of the week, applying dummy variable for the years 2013-2014. The same regression is run and tested for significance for the period 2012-2013, in which case the dummy variable is applied for 2013. The main hypothesis tested through the regression analysis is the significance level of the dummy variable. If the result is positive and significant, this supports that the GOO policy has an effect on a certain period. If this is not the case, the hypothesis may be rejected.
Below is the general model for linear regressions for time series data (Wooldridge 2014, Ch11, p.325):

$$y_t = \beta_0 + \beta_1 x_{t1} + \ldots + \beta_k x_t k + k_t$$

The equation for the analysis is interpreted as follows:

$$pptr_t = \beta_0 + \sum \beta kpdiff\, t_k + \gamma_d goo \ldots + \varepsilon_t$$

Substituting the (t) with the number of the observed hours, which results in 24 linear equations corresponding to each hour of the day. The regressions are run two times, once for the whole data set and once for the period before 2014.

All 48 estimations for GOO can be found in an appendix 1, where it is represented by the dummy variable dgoo. The do file used for the regressions can be found in appendix 2.
Note: the p-value is significant on the 5% significance level for the regression analysis.

5.1. DATA

The data was manually collected through TSO – Ternas' official website. The archive of the statistical data is located under the import/export database, under the subcategory "Auction Results and usage of the interconnection capacity- daily auction results" (TERNA 2016). The daily auction statistics include hourly information on daily basis, regarding the trade of the interconnected capacities in direction Switzerland-Italy. Moreover, information regarding the daily auctions between Italy-Switzerland is available, but this thesis will not consider this data.

Each day the data is distributed based on the following variables: "hour, ATC, total requested capacities in MW, total allocated capacities in MW, auction price in EUR/MW, the number of the participants in the auction for that day, number of PTR holders, number of auction, bids and hour" (TERNA 2016). The data, estimations and simulations used are based on the dates 1 January 2012-31 December 2015. The GOO policy that possibly affect the prices for PTR is the external factor that influences the data set. Other external factors such as temperature, seasonality, electricity production and others will be excluded from the observations and discussions in this paper. The independent variable is the price of the PTR (pptr), and the dependent variable for the dataset is price difference between Italy and Switzerland (pdiff), both divided into 24 sub-variables to reflect every hour in the day. To understand the data better, the table below provides an overview of the variables used in the empirical model.

Variable	Label
pitaly	Prices Italy
pswiss	Prices Switzerland
pdiff	Price difference between Switzerland and Italy
pptr	Price physical transmission rights
dgoo	Policy for GOO in Italy
wkend	weekend

Table 12 Variables and labels

The variables pitaly, pswiss, pdiff, pptr present the different hours as follows: pitaly1 to pitaly24, pswiss1 to pswiss24, pdiff1 to pdiff24, pptr1 to pptr24. In total 96 variables for pitaly, pswiss,pdiff and pptr.

5.2. RESULTS

Model I

When running the regression for all years (2012-2015) and applying the dummy variable of GOO for the years 2013-2014, the result shows that the dummy variable GOO policy is not significant for all hours, except 21h and 22h. Therefore, the evidence for that the variables pptr(t) and pdiff(t) are affected by the GOO policy in Italy is weak. Therefore, the effect on prices for PTR is weak, and cannot be considered as a factor that influences increased price difference between Italy and Switzerland in certain hours. Consequently, the hypothesis is rejected for 1h-20h and 23h-24h, meaning that the GOO policy has no effect on price differences during the listed hours. All variables for this model are listed in Table 13 below.

Hour	Est.	Std. Error
1	.383	.466
2	.053	.432
3	.266	.440
4	.371	.445
5	.459	.457
6	.233	.451
7	.225	.472
8	.318	.557
9	.230	.585
10	.277	.588
11	- .169	.567
12	- .201	.518
13	- .728	.440
14	- .558	.436
15	- .466	.489
16	- .253	.539
17	.038	.564
18	.355	.577
19	.164	.572
20	.593	.639
21	1.430	.633
22	1.196	.575
23	.574	.454
24	.617	.417

Table 13 Model I for the period: (1jan2012,31dec2015)

Model II

In this case the observed variables are from the period between 2012-2013. The GOO policy is positive and significant for the following hours:21h- 7h and 17h and 18h. In this model the GOO increase the price for the PTR, and the price difference between Italy and Switzerland for these hours. The presence of the policy for electricity disclosure through GOO, increases the effect, and more hours are influenced by the policy. For the hours 8h-16h and 19h and 20h, the hypothesis is rejected, which s means that no additional effect from the GOO policy is prevalent. The data and the values of the coefficient and the standard error are provided below in Table. 14.

Hour	Est.	Std. Error
1	2.046	.730
2	1.483	.685
3	1.946	.695
4	1.992	.693
5	2.159	.691
6	1.736	.692
7	1.529	.760
8	1.749	1.002
9	1.168	1.045
10	1.682	.976
11	1.443	.887
12	1.524	.786
13	.711	.690
14	.981	.613
15	.922	.732
16	1.169	.791
17	1.838	.798
18	1.940	.927
19	1.491	1.039
20	2.048	1.162
21	3.341	1.025
22	3.397	.926
23	2.481	.706
24	2.605	.615

Table 14 Model II for the period: (1jan2012 - 31dec2013)

5.3. DISCUSSION

The results show that the GOO policy present in 2013 make a significant impact on the number of hours affected. However, at the same time the hypothesis was rejected for most hours when GOO was applied as a dummy for both 2013 and 2014. Consequently, during the year followed by the lawsuit and the court decision that revoked the policy, the dummy variable cannot be used to illustrate the effect on the PTR price, and to discuss the price difference on the interconnectors between Switzerland and Italy. One possible reason for this may be that the GOO policy was not active during the whole year in 2014, and it was canceled by a law decision. Unfortunately, since no earlier research investigates the relation between the GOO and PTR, these results cannot be compared with earlier findings. In 2013, not all hours are affected, but the price of PTR and the price difference in the daily auctions between Switzerland and Italy are still higher than in model I. The two models are tested for serial autocorrelation that was present in the data. For this purpose, HAC estimator is used to overcome serial autocorrelation and heteroscedasticity in the models. The presented results in the previous sections are after Newey-West test, which increases the standard error values.
The reason why some hours are significant while others are not, is because of the price difference for the PTR in the two countries. In the cases where the p-value is highly significant, the difference is largest (21h-1h). Therefore, it can be assumed that the GOO are transferred during hours with lower price for using the PTR. However, there is no available specific information regarding how much is traded across the border in a particular time. Therefore, the volume of the contracts after the auctioning of PTR is unknown, and more details regarding this direction cannot be provided. To support this assumption, the thesis follows the example of (Joskow & Tirole 2000), where two countries are connected with transmission line, with fixed capacity in the grid. In the example, one country is located in the north, which in this case would represent Switzerland. The other country is located in South, and this would represent Italy. In light of Joskow and Tirole's model, the marginal production of electricity in Switzerland, the transfer and the GOO should be cheaper than the marginal cost of producing the electricity in Italy. Therefore, the significant hours affected by the GOO policy should be the hours with lowest marginal cost for the electricity producers from Switzerland- This means that Swiss electricity exporters selling to Italy use the cheapest hours of the auctioning, to feed into the grid the desired number of GOO. For the Swiss companies that exports import electricity in Italy, it is only a question about when is the right time during the 24 hours to transfer the electricity, which accounts for a small part of the total volume in a typical year. When it comes to

the data, it is possible to achieve better results if the analysis includes more factors. Therefore, suggestions for future research may be to add the data from daily auctions in the direction Italy-Switzerland, and to test for seasonality effect, or to add congestion management as a factor affecting the daily PTR auctions. When it comes to congestion management, this thesis assumes that in case of congestion on the lines, owners of the transmission grid benefit from the value of GOO. Because the two TSOs, Swissgrid and Terna, have agreements with one another regarding how to split the cost and the rights on the grid, it is impossible to conclude whether Switzerland or Italy benefits from this.

6. CONCLUSION

Based on the empirical results, this thesis concludes that the GOO policy in Italy can be included as a factor that explains the higher price for the transmission rights in the direction Switzerland-Italy in year 2013. However, no strong evidence suggested that the GOO policy affected the prices in the period 2012-2015. Moreover, the policy that made it obligatory to use GOO in the electricity disclosure mix may influence the auctions for PTR on the northern border of Italy with Switzerland. According to the theoretical framework of congestion management, the country with the lowest marginal cost of electricity generation and GOO distribution has an interest to attain PTR and benefit in case of congestion on the lines. As stated in the discussion chapter, due to the volume of the market, it cannot be known with certainty who owns the PTR and at what time. Thus, it is impossible to conclude with certainty that Switzerland was the country who profited from the GOO policy in 2013. It may be the case that Switzerland profited, but at the same time, this is not necessarily the case. However, the increased demand for GOO and the law that make its use obligatory, leads to a change in the explicit auction between the two countries. This may give an advantage to the exporting country, in this case Switzerland, if Switzerland acquired the PTR during the hours where it was cheaper to transfer cross-border. Still, this policy limits the market capacities within the capacity of the grid. The theoretical model illustrated that there is market inefficiency for the GOO market when linked to PTR, and that the PTR value is generally higher when linked to GOO market. The Italian GOO policy has the potential to lead to speculations of the price for GOO and increase the price of PTR, if more countries accept it. No numbers can be provided to support this assumption, because of the privacy restrictions on the GOO markets prices. Furthermore, based on the whole data set and the dummy variable applied for 2013-2014, this thesis concludes that there is weak evidence supporting that the GOO policy affects the price for PTR and that it influences the price difference between Switzerland and Italy. On the other hand, during 2013, the GOO policy did to some extent, with exceptions, made an impact during off-peak hours. Based on this rational reasoning, it may be the case that the electricity transfer with GOO occurs during the hours when it is cheaper to transfer electricity. At the same time, it still fulfills the obligation to feed in the grid certain number of GOO.

The intention behind including GOO in the electricity mix disclosure as obligatory tool is to increase the demand of renewable energy through the end consumers. In the case of Italy and Switzerland, it is critical for the balance of the electricity market to have companies that import GOO labelled electricity to Italy, during the time the policy is intact. However, a consequence of the active

GOO policy directly linked with the physical flows is that it leads to unrealized gains from the sale of GOO. It is possible for this thesis to conclude that using GOO as a labeling tool provides more flexibility to promote renewable energy and to trade across countries.

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APPENDIX I

1jan2012 -31dec2015

Variable	hour_1	hour_2	hour_3	hour_4	hour_5
dgoo	.38340358	.05341749	.26609174	.37134069	.45963431
	.46648415	.4324789	.44092684	.44543696	.45781445
	0.82	0.12	0.60	0.83	1.00
	0.4113	0.9017	0.5463	0.4046	0.3156

Variable	hour_6	hour_7	hour_8	hour_9	hour_10
dgoo	.2331752	.22529905	.31830364	.23010364	.2773381
	.45101611	.47256881	.55773342	.58533705	.58833661
	0.52	0.48	0.57	0.39	0.47
	0.6052	0.6336	0.5683	0.6943	0.6374

Variable	hour_11	hour_12	hour_13	hour_14	hour_15
dgoo	-.1695416	-.20139196	-.72807798	-.55843544	-.46609811
	.56777077	.5181455	.44028784	.43655584	.48965109
	-0.30	-0.39	-1.65	-1.28	-0.95
	0.7653	0.6976	0.0984	0.2010	0.3413

Variable	hour_16	hour_17	hour_18	hour_19	hour_20
dgoo	-.25325868	.03813047	.35575773	.1642956	.59373513
	.53952077	.56483492	.57708429	.57276081	.63921617
	-0.47	0.07	0.62	0.29	0.93
	0.6388	0.9462	0.5377	0.7743	0.3531

Variable	hour_21	hour_22	hour_23	hour_24
dgoo	1.4304163	1.1969276	.57430557	.61779679
	.63356293	.57528286	.45493883	.4176655
	2.26	2.08	1.26	1.48
	0.0241	0.0376	0.2070	0.1393

1jan2012-31dec2013

Variable	hour_1	hour_2	hour_3	hour_4	hour_5
dgoo	2.0461306	1.4831102	1.9467815	1.9924038	2.1599754
	.73077904	.68556893	.69588676	.69311223	.69124785
	2.80	2.16	2.80	2.87	3.12
	0.0052	0.0308	0.0053	0.0042	0.0019

Variable	hour_6	hour_7	hour_8	hour_9	hour_10
dgoo	1.7364399	1.5298312	1.7493733	1.1685439	1.6823953
	.69284473	.76091806	1.0024778	1.0457986	.97652923
	2.51	2.01	1.75	1.12	1.72
	0.0124	0.0448	0.0814	0.2642	0.0854

Variable	hour_11	hour_12	hour_13	hour_14	hour_15
dgoo	1.4436353	1.5247169	.71124266	.9816675	.9223019
	.88773229	.78607495	.69085771	.61378998	.73252519
	1.63	1.94	1.03	1.60	1.26
	0.1043	0.0528	0.3036	0.1102	0.2084

Variable	hour_16	hour_17	hour_18	hour_19	hour_20
dgoo	1.1694141	1.8387554	1.940163	1.4912115	2.0480513
	.79119368	.79887292	.92758961	1.0396528	1.1629454
	1.48	2.30	2.09	1.43	1.76
	0.1398	0.0216	0.0368	0.1519	0.0787

Variable	hour_21	hour_22	hour_23	hour_24
dgoo	3.3416392	3.3973318	2.4817418	2.6053583
	1.0255189	.92647463	.70662732	.61587252
	3.26	3.67	3.51	4.23
	0.0012	0.0003	0.0005	0.0000

APPENDIX II

A.

```
/* Master Thesis Veselina Braatan ----------------------------- */
/* -- TEST_GOO                                          -- */
/* ------------------------------------------------------------ */
log using test_goo-3x, replace
// fetch data
use "./dta/ptr_goo.dta"
keep if tin(1jan2012,31dec2015)
tab year
gen wkend = day>5


generate byte dgoo = tin(1jan2013,31dec2014)
label var dgoo "GOO-PTR linkage in place"
format dgoo %3.0f
tab year dgoo


forvalues h = 1/24 {
   reg pptr`h' l(1/7).pdiff`h' dgoo wkend
   estat bgodfrey, nomiss0
}




forvalues h = 1/24 {
```

```
  newey pptr`h' l(1/7).pdiff`h' dgoo wkend, lag(7)
  est store hour_`h'
}

est table *, keep(dgoo) b se t p
log close
translate test_goo-3x.smcl test_goo-3x.pdf
exit
```

B.

```
log using test_goo-5x, replace
// fetch data
use "./dta/ptr_goo.dta"
keep if tin(1jan2012,31dec2013)
tab year
gen wkend = day>5

generate byte dgoo = tin(1jan2013,31dec2014)
label var dgoo "GOO-PTR linkage in place"
format dgoo %3.0f

//Regression for the period before2014
forvalues h = 1/24 {
 reg pptr`h' l(1/7).pdiff`h' dgoo wkend
estat bgodfrey, nomiss0
}
```

```
forvalues h = 1/24 {
  newey pptr`h' l(1/7).pdiff`h' dgoo wkend, lag(7)
  est store hour_`h'
}

est table *, keep(dgoo) b se t p
log close
translate test_goo-5x.smcl test_goo-5x.pdf
exit
```

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