Società italiana di economia pubblica
XVI CONFERENZA

POLITICHE PUBBLICHE, SVILUPPO E CRESCITA

Pavia, Università, 7 - 8 ottobre 2004

RESOURCE RENT TAXATION –A NEW PERSPECTIVE FOR THE (SWISS)HYDROPOWER SECTOR

SILVIA BANFI, MASSIMO FILIPPINI, CORNELIA LUCHSINGER

CEPE
ETH Zentrum, WEC
CH-8092 Zürich
www.cepe.ethz.

pubblicazione internet realizzata con contributo della COMPAGNIA di San Paolo

Abstract

The electricity generation in Switzerland is mainly based on hydropower accounting for 58 percent of the total production. The exploitation of water in the hydropower sector can generate significant economic rents. These rents –the so-called resource rents - are defined by the surplus return above the value of capital, labor, materials and energy used to exploit water resources. States and regulators have different methods of procuring these rents (see, e.g., Watkins (2001)), for instance through a fixed water fee system or a resource rent tax system. The latter is usually employed in the oil extraction industry.

For many decades Swiss producers of hydropower have paid to the owners – usually the cantons – a certain fee per kW gross capacity which is fixed in accordance with the federal law at a maximum of about 52 Euro[1]. With the fixation of this fee on a kW basis, the substantial differences in cost and revenue structures and levels of the hydropower plants are not directly taken into account.

The goal of this paper is to propose a new scheme for these hydropower fees, based on the economic concept of the so-called resource rent. Basically, we propose a resource rent tax (RRT) system, which was first developed by Garnaut and Clunies Ross (1975). The basic novelty in this paper is the combination of the RRT system with the econometric estimation of the variable costs in order to overcome the asymmetric information problem and to forecast the RRT per company respectively.

[1] 80 Swiss Francs. For this paper, an exchange rate of 1.55 was assumed.

1 Introduction

In Switzerland, electricity is mainly produced by hydropower companies, which employ labor, capital and waterpower. The exploitation of this important natural resource can generate significant economic rents ("resource rents") given by the surplus return above the value of the capital, labor, materials and other inputs employed to exploit the resource (Rothman 2000).

The right to utilize the waterpower is granted to the Swiss hydropower companies by the cantonal governments. Of course, the cantonal governments seek compensation for the rights granted to use waterpower. The reason to demand payment is that there is an opportunity cost involved in the use of hydropower. This cost is the profit foregone in the best alternative use, for instance the cantons' direct use of hydropower to produce electricity.

Today, the Swiss hydropower producers pay a fixed fee per kW gross capacity of the plants, irrespective of their cost structure or revenue possibilities. The fee amounts to as much as 20%-30% (including direct taxes[2]) of the total production costs of hydropower producers.

From the economic point of view, this payment method is not satisfactory, because it does not reflect the value of the resource rent which varies considerably among the companies.[3] Indeed, this is the case because of the very heterogeneous cost structure, due, for example, to the different locations of the plants, and revenue possibilities, resulting, for instance, from different shares of peak load electricity produced by run-of-river and storage plants. Therefore, for some hydropower producers the amount of this rent can be lower or higher than the fixed fee they have to pay with the current system. From the economic point of view a resource rent tax (RRT) would be a satisfactory payment system for several reasons[4]. First, it is connected directly to the economic value of the resource and thus enhances allocative efficiency. Furthermore, it

---

[2] Which are the minor part of the total tax burden.

[3] For a discussion on the different payment methods, see Watkins (2001). See Banfi et al. (2003) for a first assessment of the magnitude of economic rent in the Swiss hydropower sector.

[4] See Copithorne et al. (1985) for a presentation and discussion of the RRT and other taxation systems or Amundsen et al. (1992) for a discussion of the application of these instruments in the (Norwegian) hydropower sector.

is -compared to other rent extraction schemes- neutral to investment decisions since marginal firms are not taxed, and thus the competitiveness of the industry is secured[5].

In the current monopolistic situation a fixed water fee system does not have an impact on the competitiveness of the hydropower companies. However, in a situation characterized by a liberalization process of the European electricity market, the current inflexible water fee system could make some hydropower companies unprofitable.[6] Moreover, given market liberalization, some hydropower producers are likely to refuse to renovate their plants in case the production costs (including water fees) can no longer be covered by the expected market prices. By contrast, if the water fees were based on the value of the resource rent, these companies - or at least part of them - would decide to renovate their plants, as long as total costs can be covered by the expected market prices[7]. Thus, in order to guarantee the long-term competitiveness of Swiss hydropower companies, it would be important to introduce a resource rent tax system.

In spite of the economic advantages, the change from a fixed fee system to an RRT is politically controversial as water fees are an important source of revenue for the cantonal governments and a change in the payment system would entail considerable regional financial effects.[8]

The objective of this paper is to discuss the introduction of a payment system based on a resource rent tax in the Swiss hydropower sector. In particular, we are interested in illustrating an innovative method of calculating the resource rent level of the companies. Instead of calculating the resource rent using the values of costs and revenues that are reported annually in the accounting books, we will present a method of calculating the resource rent by making use of the results obtained by the estimation of an econometric variable cost function, and of a simple method of predicting the revenues. We decided to follow this approach based on the prediction of

[5] For a first analysis of the competitiveness of the Swiss hydropower sector in a liberalized market see Banfi et al. (2002).

[6] Since Switzerland is not an EU member state, it does not have to implement the European Electricity Directive (2003/54/EG) relating to the gradual opening up of the electricity market. Nonetheless, the Swiss government is preparing a new law on the electricity market, which should gradually introduce more competition. Thus, it seems to be quite obvious that in Switzerland the implementation of the European directive will take place within the coming years.

[7] For an empirical analysis of the impact of a RRT on the decision to renovate the production plants see Banfi et al (2004).

[8] In some cantons, the water fees are collected by the cantonal government and by the municipalities. The income from hydropower companies - especially in the Alpine cantons- runs up to 15% of total revenues and even more. See Banfi et al. (2004).

costs and revenues, because most of the hydropower plants operating in Switzerland are organized as partner companies and, therefore, sell electricity to their owners, by fixing the price at the level of the average production costs. In this case, using the costs and revenues reported in the annual financial reports of the companies, we would get a resource rent of zero. Moreover, we would expect that the companies, in order to reduce the amount of the resource rent tax, could have an incentive to increase the level of cost inefficiency. Therefore, the basic idea of this paper is to recommend the integration of an econometric cost model and a revenue prediction model in an RRT system. This integration can reduce the asymmetric information problem about production costs and revenues the government faces when assessing the RRT.

This paper is structured as follows: in section 2 we will give an overview of the Swiss hydropower sector and illustrate the problems arising with the current (fixed) water fee system. We will then introduce the concept of resource rent and give an outline of the different rent extraction schemes. Based on these concepts, we will propose a new rent extraction scheme for the Swiss hydropower sector. In section 3 we will specify the variable cost function used for the empirical part of the analysis and illustrate the characteristics of the database. Furthermore, the empirical results are presented and discussed. In the 4^{th} section we show how the government could make use of these empirical estimations in order to assess the RRT to be paid by the companies. Finally, we will complete the paper with the main conclusions and policy implications.

2 The Swiss electricity industry

2.1 Structure

Switzerland is a federal state composed of 26 cantons and approximately 3'000 municipalities. It has a population of about 7 million and is characterized by a high degree of decentralization in the provision of public services.

About 1,100 public and private firms[9] engaged in the generation, transmission and/or distribution of electric power characterize the Swiss electricity industry. There are major differences in size and activity among these companies.

In terms of numbers, approximately 900 utilities are engaged in the distribution and provide power to local communities exclusively. Most of these utilities are public

[9] VSE, The Swiss Electricity Supply Industry Development and Structure, 1997.

and owned by the local municipalities. The remaining utilities operate within urban or regional areas (~ 200 companies). Part of this group of firms is involved in generation only and part in generation, transmission and distribution. For the latter part the amount of generated power is generally small. Approximately 80 hydropower and 5 nuclear power companies primarily organized as so-called partner companies ("Partnerwerke") are involved in the generation. It is important to note that in a partner company a shareholder has the right to claim a share of the electricity produced in accordance with the amount of their share capital. In this case, the selling price for a shareholder of a partner company is fixed at the level of the production costs. This means that the revenues of the partner companies reported in the annual economic and financial reports (and thus for most producers in the market) do not reflect the commercial value of the electricity produced. Therefore, the resource rent would be underestimated.

The local and regional electric utilities purchase power primarily from the seven largest so-called overland companies ("Überlandwerke"). They form the backbone of the industry and own a proportion of the hydropower and nuclear plants. These larger public and private vertically integrated companies provide most of the electricity generated. They are also involved in the transmission and distribution of electricity to the final consumers and own the supraregional and the international grids. This means that these companies are the relevant international players in the exchange of electric power with neighbouring countries.

The characteristics of the Swiss sector of electric energy generation sector are best illustrated in table 1.

Table 1: Swiss electricity generation characteristics (2002)

Type of power plant	Installed capacity MW	Installed capacity in %	Annual electricity production million of kWh	Annual electricity production in %
Hydro (Run-of-river)	3'784	20.0	17'625	27.1
Hydro (Storage)	10'126	56.2	18'888	29.1
Nuclear	3'220	17.9	25'692	39.5
Thermal power plants and others	900	5.0	2'806	4.3
Total	**18'030**	**100**	**65'011**	**100**

Source: Schweizerische Elektrizitätsstatistik 2002, Swiss Federal Office of Energy, Bern, 2002. Statistik der Wasserkraftanlagen der Schweiz, 1.1.2002, Swiss Federal Office for Water and Geology.

The Swiss electricity sector is mainly based on hydropower generation (~56%) and on nuclear power generation (~40%). The production of electric power using thermal power plants or using wind or photovoltaic energy is currently limited (~4%). The run-of-river hydro power plants and the nuclear power plants are utilized principally to meet the demand for electricity at a national level during the medium and low load periods, whereas the storage and the pump storage power plants are employed to satisfy the electricity demand during the high load periods. The cantonal governments own the majority of these hydropower companies directly or indirectly (through some of the overland companies).

During the last 20 years, Switzerland has consolidated its position as European electricity peak producer and trader. Due to its advantageous geographic position, Switzerland is not only an active player in the European electricity market (the main trading partners are France, Italy, Germany and Austria) but is even a net exporter. In total the trade volume accounts for 170 percent of aggregate consumption. The geographic characteristics allow the construction of (pump) storage utilities in the alpine cantons, which sell electricity at peak times (at higher prices).

2.2 Actual water fee system and resource rent

In the Swiss hydropower sector the cantons (which hold the rights over the water power use) can raise the water fees to an actual maximum of 52 Euro/kW gross capacity, which is set by federal law. Generally, the cantons fix the water fees at this maximum level.

From an economic point of view the price for the use of a resource should be connected to the concept of economic rent or, using the term applied to natural resources, to the resource rent.[10]

A resource rent is a surplus value, i.e., the difference between the price and the average production costs of a good. In Ricardo's (1817) classical example, resource rent accrues due to the different productivity levels of different agricultural production sites. A site with less favorable characteristics will – ceteris paribus - face higher production costs, and thus make lower profits (in the case of a free market with exogenously given prices). The marginal firm will only be able to cover its production costs and not receive any resource rent. Similarly, in the hydropower sector it can be observed that some producers face ideal conditions to construct and operate a plant, whereas other firms have to build their plants in locations with more difficult site characteristics, and thus have higher investment and operation costs for a given output. The producers of these plants earn a lower resource rent in comparison with other plants operating in more favorable environmental conditions. In a competitive market, the resource rent reflects the "true economic value" of the natural resource exploited.

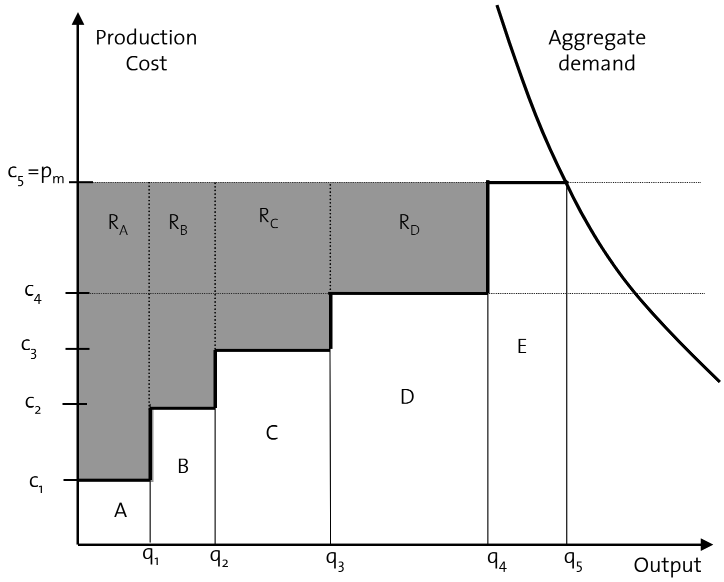
In a competitive electricity market, the concept of resource rent can be illustrated graphically using the demand and supply curves.

Figure 1 shows the production situation of five different companies that operate in different regions with constant returns to scale. Firms A, B C, D and E differ only in the average production costs. The equilibrium price is determined by the intersection of the aggregate demand and supply curves.

---

[10] **Resource rent** can be divided mainly into **two different kinds**: differential and scarcity rent. Differential rent arises because of (innate) differences of production sites, as described before, whereas scarcity rent emanates from the restricted supply of the good, due to natural or political circumstances. Both kinds of rent arise from the characteristics of the natural resource and their sum is therefore called "resource rent". See van Kooten and Bulte (2000) for a discussion.

Figure 1: Different producers and resource rent (marginal costs=average costs)



In Figure 1 producer E is the marginal producer in this setting, and thus just covers his average/marginal costs at market price *p*. Any other producer showing higher production costs will thus not be able to cover his costs at this price and therefore not participate in the market. Producers A, B, C and D do earn a resource rent in this situation, since their production costs are lower than the effective market price. These rents indicated by R_A to R_D identify the difference between the effective market price (p_m=c_5) and the respective production costs.[11]

The current payment method for the use of hydropower applied in Switzerland is a fixed fee per kW gross capacity and, therefore, is not based on the resource rent concept. Hence, an alternative pricing scheme should be considered in order to promote the efficiency and competitiveness of this sector.

2.3 Alternative rent extraction scheme

There are a variety of rent extraction mechanisms, an overview and evaluation of these different approaches is given by Watkins (2001), for example. In the following we will concentrate on the so-called resource rent tax (RRT), first put forward by Garnaut and Clunies Ross (1975), which is the concept we propose in order to fix the price hydropower producers have to pay to the owner of the resource (the government). A resource pricing based on the RRT is, from an economic point of view, the best pricing

[11] Of course, it could also be possible to present a situation with two types of electricity demand: peak and off-peak demand. In such a situation, the economic rent of firms A, B , C, D and E would vary with time.

scheme, because it is connected directly to the economic value of the resource. Therefore, the RRT can strengthen the competitiveness of the companies in a liberalized market (protecting marginal producers). Furthermore, it is neutral to investments and flexible in a changing economic environment[12].

There are two main approaches to the implementation of a RRT in the hydropower sector:

1. A cash-flow based approach, which addresses the hydropower project as a whole and applies when the accumulated revenues exceed accumulated costs (taking into account the respective interest rate). In this system, an "immediate" depreciation takes place and thus the tax is paid only after several years of operation of the hydropower plant.
2. An RRT based on profits, which is very similar to a profit tax but includes an annual depreciation plus deductible cost of capital in the calculation of the resource rent.

The cash-flow based approach could be implemented for new power plants and would, especially in a deregulated market, lower the risk of such long-term investments. In fact, the companies pay a resource rent tax only if positive net returns are gained. However, in a situation where the power plants are already running, the second approach would be more appropriate, since, otherwise, one would have to get information on past investments, expenditures and amortizations. In most situations this might not be feasible.

Due to the fact that in our study we are interested in the introduction of a RRT for the current Swiss hydropower companies, and that in the coming years the numbers of new investments in new hydropower production sites will be very low, we decided to adopt the second approach for our computations.

When implementing an RRT, it is, first of all, necessary to define the costs of hydropower producers and the relevant revenues.

Regarding production costs, it has to be decided which cost components are to be considered and how they are to be defined. One crucial point is the definition of capital costs: For the resource rent, the capital costs should include some "reasonable" rates of

[12] See Watkins (2001) or Banfi et al. (2004) for a more detailed comparison of the different taxation approaches using the relevant appraisal criteria.

return for external and equity capital.[13] It must be pointed out that the only difference between the quantitative definition of the resource rent and the company profit[14] lies in the different assessments of the capital cost components (the costs of equity capital are not considered in the calculation of the profits).

In order to calculate the RRT, the government could use two approaches. In the first approach the government could directly use the information on total costs and total revenues presented in the annual reports of the hydropower companies. As already discussed, the main problems of this method in the Swiss hydropower sector are:

a) Most of the power companies are partner companies, which supply electricity to their owners, who bear the production costs. Other producers have long-term contracts with prices that are not disclosed to the public. As a consequence, the revenues reported nowadays do not reflect the market prices and accordingly the scarcity of the resource.

b) The existence of cost inefficiency in the hydropower production could reduce the amount of the resource rent to be collected by the government.

To solve these problems (at least partially), in this paper we propose to compute the RRT using a simple model to predict the values of the total revenues and, using an econometric model, to forecast the variable costs. An estimation of total costs would make less sense, since, due to the long-term time horizon of the investments (50-80 years), the capital costs of existing plants can be considered fixed[15].

Taking all these considerations into account, we arrive at a general formula for the resource rent and the resource rent tax, respectively, that can be applied for the Swiss hydropower market.

Resource Rent = **Assumed** Revenues – deductible capital costs – **forecasted** variable costs

[13] The definition of the rate of return of outside capital raises usually less problems since there exist market respectively book values for it.

[14] Besides the conceptual ones, like understanding the rent as the value of the resource, etc.

[15] As a mean of minimal monitoring, one could limit the allowed capital costs at an upper limit for the rate-of return (including a risk premium) and control for special depreciation.

$$\text{RRT} = \textbf{\%} * (\textbf{Assumed} \text{ Revenues} - \text{deductible capital costs} - \textbf{forecasted} \text{ variable costs}) \qquad (1)$$

In order to estimate the RRT that could be realized in a hypothetical liberalized market, we need to define both a model for the prediction of the revenues, which will be shortly described in this section, and a model for the prediction of the costs, which will be illustrated in more detail in the next section.

In the case of a liberalized market, the prices are exogenously given and can be observed. In order to compute the RRT, the total revenue can be estimated using the individual (modeled) load production curves of the hydropower companies and various hypothetical market prices for the different load periods. From the technical statistics on the Swiss hydropower plants, for instance, combined with the annual production (stated in the annual reports), we can compute the average production in the last few years for the different load periods. Using this information combined with information on the market price, it was possible to simulate the potential revenues of a plant. Of course, we are aware that this is a relatively simple revenue estimation method. However, in this paper the focus of attention is the study of a more complex method of estimating the costs.

Table 2 displays the prices that were assumed in this paper for 6 load times: peak/mean/base load in summer or wintertime.

Table 2: Hypothetical middle-to long-term prices per load time

cts./kWh	Peak load winter	Mean load winter	Base load winter	Peak load summer	Mean load summer	Base load summer
Prices	9.59	3.37	3.11	4.70	3.11	2.72

We are aware that price assumptions are always controversial, but the main aim of this paper is to show what an alternative RRT approach could look like and estimate the (potential) magnitude of the resource rent in the Swiss hydropower sector. As our table has mainly an illustrative character, it is appropriate to assume future prices for the computation of the rent.

3 Specification of the variable cost function for the hydropower plants

The main costs of operating a hydropower company comprise the costs of building and maintaining the dam, the steel lined pressure shaft, the power house and the turbines. Moreover, these costs may depend upon the size of the reservoir, the morphology of the territory, the type of the hydropower plant (storage or run-of-river), the location of the building with the turbines as well as the number of plants operated by a single company. In fact, the Swiss hydropower companies partly operate several plants located in the same region. Therefore, an analysis of the cost structure of these companies should take account of the fact that the same quantities of electricity can be produced using several plants and/or different types of plants (storage, pump-storage and run-of-river). In the cost model specification it is therefore important to introduce some variables related to both the type of the power plants employed in the production and the organization of the companies.

In the variable cost model of the hydropower plants we consider one single output. Inputs consist primarily of labor, material and the quasi-fixed input capital. The variable cost function recognizes the disequilibrium in that the quantity of physical capital cannot be adjusted to achieve a minimum total cost in the short run for a given set of input prices and the quantity of outputs.

The firm's variable cost of operating a hydropower plant can then be represented by the cost function:

$$VC = V(Q, N, P_L, C, D_{RR}, D_S, D_{PS}, T) \qquad (2)$$

where V*C* represents variable cost, *Q* is the output represented by the total number of GWh produced and *N* is the number of plants. P_L stands for the prices of labour and C for the capital stock described as the book value of the companies. Unfortunately, we could not consider the price of material in the model specification (1) due to lack of data.[16]

Finally, we introduced 3 dummy variables (D_{RR}, D_S, D_{PS}) in the model to control for differences in cost among different types of hydropower plants used by the companies: run-of-river, storage and pump-storage plants. T, the time trend, is included as a way of capturing the effects of neutral technical change.

The properties of cost function (1) are that it is concave and linearly homogeneous in input prices, non-decreasing in input prices and output, and, regarding capital stock, non-increasing[17].

---

[16] The effect of this input price on cost is considered in the constant.

[17] See Cornes (1992), p. 106.

As in numerous other studies for the electric utility industry, we specify the cost function in a Cobb-Douglas form, which means we assume a constant marginal rate of technical substitution between the input factors. The cost function to be estimated then is:

$$\ln(VC) = \alpha_0 + \alpha_Q \ln Q + \alpha_N \ln N + \alpha_{PL} \ln P_L + \alpha_C \ln C + \alpha_{RR} D_{RR}, + \alpha_S D_S + \alpha_{PS} D_{PS} + \alpha_T D_T \qquad (3).$$

3.1 Data Set

The model is estimated with panel data from a sample of Swiss hydropower companies. Our study is principally based on a database created by using different sources: the Swiss Federal Statistical Office's value added statistics ("Wertschöpfungsstatistik"), the Swiss Federal Energy Office's financial statistics ("Finanzstatistik") and a database created by the Center of Energy Policy and Economics by collecting annual financial and economic reports of the companies. Additional technical information was taken from a database on this sector built up by the Federal Office for Water and Geology.

After this information was collected and the data sets were merged, the final data set consisted of a sample of 60 hydropower companies. However, some of these had to be excluded from the econometric analysis due to missing data. Model (2) has been estimated using an unbalanced panel data set, which includes 42 companies observed over a period of 7 years.

The total variable cost per year is equated to the sum of labor, operations (including material) and energy costs. Average annual wage rates are estimated by dividing the labor expenditure by the number of employees. Unfortunately, no information is available to define a price for the use of materials. The capital stock is defined as the book value as reported in the annual financial reports of the companies.[18]

3.2 Empirical results

Equation (3) has been estimated using the error components (EC) model[19] and compared to the OLS model. The estimated coefficients and their t-values of the cost

---

[18] No data were available which would allow the calculation of the capital stock using the perpetual inventory method.

[19] It was not possible to estimate a fixed effects model because of the time-invariant (technical and dummies) explanatory variables included in the model.

model (2) are presented in Table 3. The estimated function is well behaved. Most of the parameter estimates are statistically significant.

A well-defined variable cost function should be increasing with respect to output and input prices, concave with respect to input prices and non-increasing with respect to capital stock.

Since total cost and the regressors are in logarithms and have been normalized, the coefficients are interpretable as cost elasticities. All these coefficients show the expected signs and are highly significant.

The output elasticity is positive and implies that an increase in the production will raise the variable/total cost. A 1% increase in the quantity of electricity produced will increase the variable cost by approximately 0.5% in both models (OLS and GLS). This result implies that the Swiss hydropower plants are characterized by economies of utilization.[20]

The labor cost share is positive, implying that the cost function is increasing in this input factor.

The cost elasticity with respect to the number of plants is positive and indicates that an increase in the production units will raise variable/total cost of a hydropower company by about 30%.

The coefficient of capital stock is not significantly different from zero in the GLS estimation, but slightly positive and significant when estimated with OLS. This result indicates, as normally expected in cost theory, that a marginal increase in the capital stock only results in relatively small raises in variable costs. However, this result has to be interpreted carefully because of the kind of proxy variable used in the model for the capital stock.

The dummy variable DSP (storage pump plant) has a significant positive coefficient. This result implies that the storage pump hydropower plants show higher

---

[20] Caves and Christensen (1988) define a measure of utilization economies as unity divided by a proportional increase in variable cost resulting from a proportional increase in output holding the capital stock constant. Thus, economies of utilization represent variable cost changes when output is increased with capacity constant. According to this definition, we define economies of utilization (EU_{VC}) as $EU_{VC} = \frac{1}{\frac{\partial \ln VC}{\partial \ln y}}$. We talk of economies of utilization if EU_{VC} is greater than 1 and, accordingly, identify diseconomies of utilization if EU_{VC} is below 1. In the case of $EU_{VC} = 1$, no economies or diseconomies of utilization are existing.

variable costs than storage and run-of-river hydropower plants, respectively.[21] This result is not surprising, because storage pump plants consume a large amount of electricity to pump the water into the reservoir. The dummy variables DS (storage plant) does not have a significant coefficient.

Finally, turning to the question of technological progress, Table 3 indicates that there is evidence of a small negative time shift of the variable cost function in the GLS model. Thus, the negative coefficient of T indicates that the Swiss hydropower companies underwent progressive technical change during the period considered in the analysis.

Table 3: Estimation results of the Cobb-Douglas cost function

	GLS		OLS	
	Coefficients	**t-Values**	**Coefficients**	**t-Values**
LnQ	0.51	8.51***	0.50	13.42***
LnP_L	0.20	2.69***	0.21	2.07**
LnC	0.01	0.59	0.13	4.23***
LnN	0.33	3.09***	0.27	5.40***
S_nop	0.10	0.68	0.05	0.71
S_pmp	0.56	3.39***	0.35	4.53***
Time	-0.031	-4.87***	-0.01	-1.11
Constant	9.68	10.86***	7.48	6.65***
R^2	0.83		0.84	

, *: significantly different from zero at the 95% or 99% confidence level.

4 Use of the cost estimations in the determination of the RRT

As discussed in section 2, the results obtained from the estimation of variable costs can be used by the government to predict variable costs of individual hydropower companies. The predicted variable costs can, therefore, be used in equation (1) to calculate the individual RRT to be collected by the government. Of course, for the computation of (1) the government should also predict the revenues as suggested in section 2.

[21] The variable D_{RR} does not appear in the table because it is taken as reference, in order to avoid the dummy variable trap.

In this paper we have prepared a forecast that involves the prediction of variable costs in one year using the GLS-estimation[22] based on the data prior to that year. Thus, a one-year-ahead forecast is considered. In this prediction the actual values of explanatory variables are used. The forecasts are based on the optimal predictor for error component models given in Baillie and Baltagi (1999).[23]

For each hydropower company, a 95 percent confidence interval for the predicted variable costs has been calculated. The lower and upper values of this interval are then used to estimate the individual RRT for 2002 using formula (1).[24]

In table 4 we present, for illustrative purposes, the results of the computation of the RRT for four representative hydropower companies in our sample. In the first column we state the values of the resource rent tax (RRT_1) calculated by using the predicted revenues and the information on costs included in the annual economic and financial reports. The second and third columns present the lower and upper bounds of the individual resource rent tax (RRT_2) computed by using the forecasted individual variable costs.

Table 4: Examples for the estimated intervals of the resource for different firms (in Mill. Euro)

Mill. €	RRT_1 (based on costs of the annual reports)	Lower level of RRT_2 (based on GLS cost estimations)	Upper level of RRT_2 (based on GLS cost estimations)
Firm 1 (Run-of river)	9.9	8.0	10.1
Firm 2 (Run-of river)	2.1	3.5	4.5
Firm 3 (Storage)	36.0	34.6	37.5
Firm 4 (Pump-Storage)	28.7	27.5	31.4

The values reported in table 4 show that for 3 companies, RRT_1 lies within the estimated RRT intervals. For company 2, however, the value of RRT_1 is lower than the value of the RRT_2 calculated using the results obtained in the econometric cost model.

---

[22] We refrained from making forecasts based on the OLS results since the coefficients are very similar and the GLS model is considered to give more consistent results.

[23] For more details see page 256 of Baillie and Baltagi (1999). For an application of this method developed for the Swiss electricity distributors see also Farsi and Filippini (2004).

[24] For the computation of the RRT we assumed a 100% rent capture by the government.

In general, the analysis shows that over 20 % of the companies in our sample indicate a value of the RRT_1 lower than RRT_2 (lower level), whereas two companies show a value of RRT_1 higher than RRT_2 (upper level).

From this empirical analysis we are now able to derive certain implications for the policy makers. For instance, the government in charge of collecting the RRT could apply the following rule: the value of RRT_1 can be approved of if it is not lower than within an acceptable range of the estimated RRT_2. Otherwise, the amount of the resource rent tax can be renegotiated on condition that the company justifies its excessive variable costs before any revision. In case of disagreement the government performs a more detailed analysis with additional information from individual companies and offers a new proposal for the RRT. The probability of disagreement and the flexibility of the government depend, of course, on the predictive power of the adopted econometric models and of the revenue model. Of course, we are aware that the model utilized for the prediction of the revenues is simple and could be substituted by a more sophisticated model.[25] However, the purpose of this paper has been to develop a precise model to forecast the costs and not the revenues.

5 Conclusions

Natural resource extraction can generate an economic rent, i.e. a surplus profit due to a difference between the price at which the resource can be sold and its extraction costs. This so-called resource rent should be the basis for fixing the price for the use of the resource.

In contrast to this optimal rent extraction scheme, the water fees currently paid by Swiss hydropower producers are basically fixed amounts to be paid per kW gross capacity. One major disadvantage of this system is that hydropower plants which cover just their production costs (including the returns on capital), would abandon production in the long run.

The results of this paper show that:

- in order to guarantee the long term competitiveness of Swiss hydropower companies it would be important to introduce a resource rent tax system;

[25] For instance, a model that includes also a stochastic component in the commercial utilization of the electricity production could be developed.

- the values of the resource rent and of the RRT vary between hydropower companies;
- in the computation of the RRT, the use of the results obtained from the econometric estimation of a variable cost function and from a simple revenue prediction model seems to be an attractive approach, because it contributes to the reduction of the information asymmetry between the government and the companies.

The analysis reported in this paper shows that there is room for a constructive and innovative change in the method of payment of fees for the use of waterpower (by the Swiss hydropower companies). Of course, from a scientific point of view, a more sophisticated model should be developed to forecast the revenues.

References:

Amundsen, E.S., Andersen, C. and Sannarnes, J.G. (1992), Rent Taxes on Norwegian Hydropower Generation, The Energy Journal, Vol.13, No.1.

Baillie, Richard T. and Baltagi, Badi H. (1999), Prediction from the Regression Model with One-way Error Component, in: Hsiao, C., Lahiri, K., Lee, L.-F. and Pesaran, M.H., Analysis of Panels and Limited Dependent Variable Models, Cambridge: Cambridge University Press, p. 255-267.

Baltagi, B.H. (2002), Econometrics, 3rd edition, Springer.

Banfi, S., Filippini, M. and Müller, A. (2003), An Estimation of the Swiss Hydropower Rent. Energy Policy (article in press).

Banfi, S., Filippini, M., Luchsinger, C. and Müller, A. (2004), Bedeutung der Wasserzinse in der Schweiz und Möglichkeiten einer Flexibilisierung, vdf Hochschulverlag, Zürich.

Banfi, S., Filippini M., Luchsinger C. (2002), Deregulation of the Swiss Electricity Industry: Short-run Implication for the Hydropower Sector, Electricity Journal, 6, p. 69-77.

Copithorne, L., Macfayden, A. and Bell, B. (1985), Revenue Sharing and the Efficient Valuation of Natural Resources, Canadian Public Policy, XI, p.4635-478.

Cornes, R. (1992), Duality and Modern Economics, Cambridge, 1992.

Farsi, M. and Filippini, M. (2004), Regulation and Measuring Cost Efficiency with Panel Data Models: Application to Electricity Distribution Utilities, Review of Industrial Organization (forthcoming).

Garnaut, R. and Clunies Ross, A. (1975), Uncertainty, risk aversion and the taxing of natural resource projects, The Economic Journal 85 (338): p. F272-287.

Greene, William H. (2003), Econometric Analysis, 5th edition, Prentice Hall.

Ricardo, D. (1817), On the Principles of Political Economy, and Taxation, John Murray, London.

Rothman, M. (2000), Measuring and apportioning rents from hydroelectric power developments, World Bank Discussion Paper, No.419.

Van Kooten, G. C. and E. H. Bulte (2000), The economics of nature: managing biological assets, Malden, Mass, Blackwell.

Watkins, G. C. (2001), Altlantic petroleum royalties: fair deal of raw deal? The AIMS (Atlantic Institute for Market Studies) Oil and Gas Papers, Paper No. 2 (51 p.).