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The impact of policy elements on the financing costs of RE investment – the case of wind power in Germany

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Abstract

Renewable energy support mechanisms affect the attractiveness of projects by influencing uncertainties in revenues or expenditures and ultimately result in a change in the financing costs. The influence of feed-in tariffs on financing costs was investigated. 26 wind onshore investors were surveyed in a conjoint analysis and the results were used in a cash flow model to quantify the impact. The introduction of premium models under a fixed remuneration tariff scheme seems to increase the financing costs considerably.

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1 Introduction and objective of the study

To combat climate change and cope with the projected depletion of fossil fuels, many countries have decided to promote the use of renewable energy (RE) sources such as solar, wind, or hydropower.

However, renewable power plants like wind turbines are often capital-intensive investments with payback periods in excess of ten years and varying yields. Support mechanisms can increase the attractiveness of such projects via two avenues: firstly, by increasing the level of support and secondly, by reducing the riskiness of the project where risk is considered to be the variability of returns. Many researchers have addressed the issue of financial risks in the context of specific types of support mechanisms. But so far, the discussion on the influence of support mechanisms has been restricted to qualitative issues.

This paper undertakes a different approach and attempts to elaborate the impact in a quantitative manner by assessing the impact of feed-in tariffs or premiums on the financing costs of German wind power investors via a stated preference approach. Investors are asked to choose between two RE projects which differ by one characteristic. The obtained values express the willingness to accept risks influenced by policy elements. Lüthi and Wüstenhagen (2010) were the first to apply such a stated preference approach to assess preferences of investors in the field of RE by facing photovoltaic (PV) investors with several policy risks. Based on their findings, PV investors regard the duration of the administrative process as the most important policy element for their investment decision, followed by the level of the feed-in tariff and the existence of a cap.

In this study, the focus is on three policy designs and their influence on financing costs. Their impact on financing cost is investigated by, firstly, conducting a survey and conjoint analysis among German wind onshore investors. Finally, a cash flow model is set up, where the results of the conjoint analysis are used to compute the impact on financing costs in terms of percentage points.

2 Renewable energy policies, investment risks and financing costs

2.1 Renewable energy policies

In general, the promotion of renewable energy relies on two avenues: the price or the quantity approach. Roughly speaking, under a price approach, the price for renewable energy is determined by the government and the produced quantity of energy by the market. In a perfect market, equilibrium occurs at the point at which the price equals the marginal costs of production. An example for this approach is the fixed feed-in tariff currently in place in Germany.

The quantity approach focuses on a target quantity set by an authority, e.g. government. The price is determined by the market and equals the marginal costs of supplying the specified quantity. One example is the quota obligation system in combination with tradable green certificates as applied in Britain, where minimum shares of renewable energy are imposed on energy suppliers. Quota obligations combined with tradable green certificates are said to be more market-based than feed-in tariffs and to lead to lower costs for renewable power (Mitchell, Bauknecht et al. 2006). However, a comparison between the UK and Germany revealed that in fact the opposite is true: The German feed-in tariff actually lead to cheaper prices paid per wind energy delivered and, moreover, although less favourable wind conditions prevail, more capacity has been installed in Germany than in the UK (Butler and Neuhoff 2008).

A further example for a quantity obligation is a tendering system. Investors submit bids specifying the selling price for power at a specified plant location. The offer with the lowest price is awarded a contract – a so-called “Power Purchasing Agreement (PPA)” for 15-20 years. Currently, Denmark applies a tendering system for offshore wind parks.

In theory, these two approaches are comparable methods for achieving diffusion targets (Menanteau, Finon et al. 2003). But in reality they diverge with respect to the achievement of objectives and in terms of attractiveness for investors. To better understand the policies’ impact on financing costs, we outline the features of the feed-in system in the following section.

2.1.1 Fixed-price feed-in tariffs

The principle of feed-in tariff (FIT) policies is to provide a guaranteed price per MWh for RE investors over a long period of time, usually 20 years. If the remuneration is independent of market prices, the policy is called a fixed-price FIT. The fixed-price option is the most commonly employed FIT policy (Klein, Held et al. 2008).

Based on technology costs, the level of remuneration is specified according to the type of technology: e.g. currently, offshore wind farms in Germany receive € 150 per MWh in the initial phase, while onshore wind receives only € 91 per MWh. In Germany, for new power plants, the level of remuneration decreases every year based on a pre-determined formula (Langniß, Diekmann et al. 2009), e.g. for onshore wind farms by 1% every year (BMU 2009). An alternative design option is front-end loading, where higher payments are offered in the first few years of the investment than in later years. In Germany, fixed FIT policies encompass a purchase guarantee such that the Distribution Network Operators (DNO) are not only obliged to connect renewable power plants to the transmission grid, but also have to purchase the produced power at fixed tariffs (Ragwitz, Held et al. 2007).

2.1.2 Feed-in premiums

In contrast, under a feed-in premium system (FIP), electricity generators sell their power on the spot market under market price conditions. In addition, the generator receives a premium payment on top of the electricity price for each MWh sold. Such market-dependent FIT policies are generally known as premium price models because a premium is added to the market price of electricity. There are several premium schemes in use, e.g. a fixed or a variable premium scheme with a cap and floor.

Under a fixed premium scheme the power generator sells the power directly on the spot market and receives an additional premium on top of the obtained spot market price for electricity. The combination of a constant premium and a variable market price means the power generator's income varies but remuneration is not entirely fixed by an institution.

To limit the price range, some countries have introduced variable FIP with caps and floors. In such models, the FIP is constant within a certain range, decreases if the market price exceeds a certain upper range, and vice versa if it falls below a lower range. For market prices above the cap, the premium is zero (cap) and the operator receives only the market price. For market prices under the lower range, the premium increases gradually in line with decreasing prices such that, in total, a kind of minimum remuneration is assured (floor). The variable premium is determined on an hourly basis.

A slight deviation of the variable FIP is currently being implemented in the Netherlands. There, the premium depends on the technology base price (reflecting generation costs) minus the wholesale price for electricity (price adjustment) (Rathmann et al. 2009). This model depends on the market price, but from an investor's perspective, the remuneration level is stable so that it can be classified within the market-independent policies (Couture and Gagnon 2010).

The variable premium model has two advantages: the floor safeguards the investor against a price decline and pending losses, while the cap prevents windfall profits for generators at the expense of the public/consumers (Ragwitz, Held et al. 2007).

2.2 Financing costs and risks

2.2.1 Average cost of capital

Wind power plants are capital-intensive investments with capital expenditures ranging from € 2.0 million to € 2.7 million for a 2 MW wind turbine (Krohn, Morthorst et al. 2009). A principal precondition for investments in such projects is a minimum rate of return that is defined as "the expected rate of return demanded by investors in common stocks or other securities subject to the same risks as the project" (Brealey, Myers et al. 2008). This definition addresses several aspects of the expected rate of return. First, it reflects the principle of opportunity costs, meaning that the expected return of the project must be sufficiently high in order to compensate investors for foregone gains from other projects. Further, the expected rate of return reflects the result of a market mechanism, the equilibrium between the demand and supply of investments. In addition, the expected returns are based on future cash flows weighted by probabilities (of occurrence) that in turn reflect uncertain outcomes, hence, risks. For an investor, the expected return on capital for putting money at risk must be greater than the opportunity cost of capital. Subsequently, it can be said that the expected return and hence the financing cost is strongly determined by the perceived risks.

Overall, renewable energy projects are typically financed by debt and equity with a capital structure of 70-75% of debt and 25-30% of equity (EWEA 2009). Debt investors like banks provide loans, while equity investors provide capital from internal and/or external sources like public or private markets. Equity investors are prepared to make high-risk investments if high returns can be expected. When analysing a project, they focus on expected investment returns (Wiser and Pickle 1998). In contrast, debt investors tend to be more reluctant to take risks. The debt represents a fixed obligation and is senior to other types of capital. The loan contract offers specified interest payments and provides collaterals to cover a possible credit default. Lenders will reject a loan if a certain level of risk default is exceeded. In contrast to equity investors, they analyse the project under a worst-case scenario (Wiser and Pickle 1997). Debt investors provide capital under low risk conditions while equity investors bear the main investment risks and, hence, require a significantly higher expected rate of return than lenders.

Financing costs can be calculated by taking the weighted average of the cost of debt and the cost of equity. Also taking into account that interest payments are tax-deductable, the following formula (Equation 1) applies for the weighted average cost of capital:

Equation 1: $$WACC = r_D(1 - T_C)\frac{D}{V} + r_E\frac{E}{V}$$

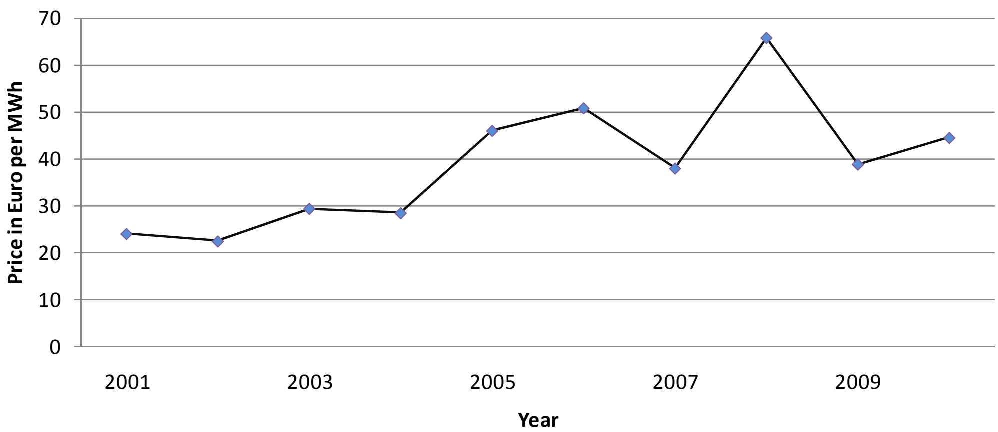
Here *D* and *E* are market values of debt and equity. *V* stands for the sum of both. r_D and r_E are the cost of debt and the cost of equity, respectively. T_c is the marginal corporate tax rate.

2.2.2 Specific investment risks for RE

Risks for RE investments encompass among others uncertainty about the market price, the quantity sold and the balancing of power (Mitchell, Bauknecht et al. 2006). As discussed in the previous section, the remuneration level of feed-in tariffs guarantees a fixed payment per produced unit of power and hence completely compensates the price risk. Under premium models, the received price consists of a fixed or variable premium plus the spot market price. Hence, price risk is more (variable premium) or less (fixed premium) limited but not fully compensated by the feed-in premium. Usually, the spot market prices for electricity vary with respect to supply and demand. Prices are low or even negative at night and high during the day (Streckiene, Martinaitis et al. 2009). On average, approx. € 4 € per MWh were paid in 2010 (EEX 2011). Besides hourly or daily fluctuations, prices also change over time depending on primary energy prices and other costs, and the overall demand and supply of electricity. Figure 1 shows the average annual spot market prices for Germany.

In the case of wind power, supply is erratic and hence not adaptable to prices. Therefore, price changes directly translate into revenue changes. Furthermore, fluctuations in wind occur on an hourly, daily, monthly and even yearly basis. So the quantity risk transfers into a revenue stream that varies even from year to year. In contrast to traditional power plants, wind turbines face no price or supply risks for fuels but they obviously depend strongly on wind yield.

Figure 1: Average annual spot market prices in Germany

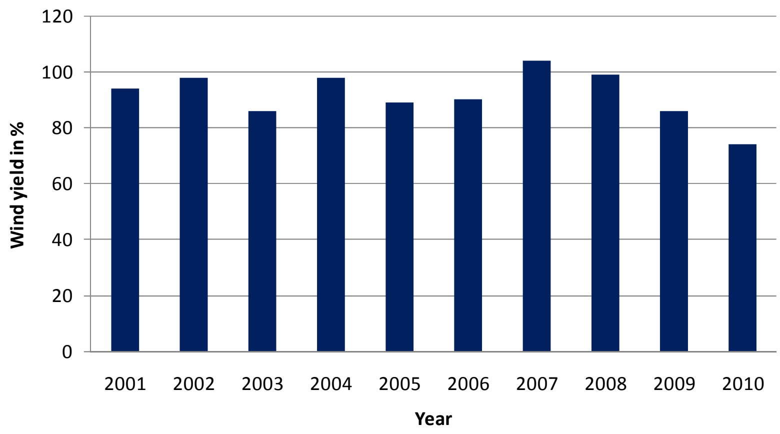


Source: Own illustration based on Streckiene et al. (2009) and EEX (2011)

Figure 2 shows the annual wind yield expressed as a percentage of the long-term mean between 2001 and 2010 in Germany. In 2010, for example, only 74% of the long term average wind yield was reached, resulting in unexpectedly low revenues for wind power generators.

The feed-in support system in Germany guarantees purchases, hence, the market risk with respect to the quantity sold is completely mitigated for renewable electricity. Further, balancing risks are reduced since RE power generators are not obliged to supply a certain load profile. They can produce energy regardless of the current demand (Mitchell, Bauknecht et al. 2006). The transmission grid operators balance supply and demand and assure that all electricity from renewable energy sources can be fed into the transmission grid. However, events like unexpected low demand or potential grid instability forces transmission grid operators to regulate or even shut down renewable energy power plants by remote control. Germany has implemented a hardship scheme to eliminate this risk. Under such a scheme, grid operators must compensate the losses of affected plants. The compensation payment is either settled by an agreement between the grid and the plant operator, or is based on the forgone remuneration minus saved disbursements (BMU 2007).

Figure 2: Annual wind yield in Germany



Source: Own illustration based on BWE (2010)

It is assumed that the reduction or mitigation of market and balancing risks by policy schemes translates into lower average capital costs since the expected returns on investments become fairly certain returns. This should lead to decreased capital costs due to lower perceived risks. This will be investigated in the following.

3 Methodological approach

The trade-off between risks and returns for RE investors is investigated using a stated preference approach. A conjoint analysis is conducted to study the influence of selected policy elements on the investment decision. It is important to provide a realistic and manageable decision situation to the interviewed investor. Since financing costs depend on many factors that cannot be handled appropriately or simultaneously in such a task, respondents would be overstrained by stating the influence of policy elements on financing variables directly. To avoid this problem, an additional step is interposed.

- The first step investigates the trade-off between selected RE policy elements and a common measure of spot quality. This is done by applying a conjoint analysis. A linear-additive preference model is set up to map the answers.
- The second step uses the results of the conjoint analysis in order to calculate the impact of the selected elements on financial costs by applying a traditional financial cash flow model.

3.1 Research design

3.1.1 Method of analysis

Stated preference approaches try to elicit the preferences of individuals directly by asking them to make a choice between two hypothetical options and then evaluating the given answers. Direct approaches can investigate new situations which are outside the current set of experiences or outside the data set available (Adamowicz, Louviere et al. 1994).

Conjoint analysis is a stated preference method and was developed by Luce and Turkey (1964). It was introduced into marketing literature at the beginning of the 1970s and has developed into a method that receives a lot of attention in this field. It mimics a purchase decision where the buyer is faced with products each consisting of different levels of product attributes like brand, price, colour or performance. The respondent is faced with various predetermined products, the so-called stimuli, and is asked to rank or rate them or to choose the preferred one. The method derives its name from the fact that the respondent has to <u>con</u>sider the attributes <u>joint</u>ly. By analysing the given answers, it is possible to find out what the preferences are. It is considered a decompositional approach (Alriksson and Öberg 2008).

Most of the conducted studies are marketing-oriented, and are commonly used for new product design, product optimization, price setting or market segmentation. A few studies have used conjoint analysis to study the strategic decisions of managers rather than the purchasing decisions of consumers. They assumed that the manager's investment decision is similar to the consumer's purchasing decision and that the manager also takes several attributes into consideration in his decision. For example, DeSarbo et al. (1987) tried to quantify the importance of pre-designed attributes for managers' investment decisions by interviewing 26 venture capital investors. In the field of RE investments, Lüthi and Wüstenhagen (2010) surveyed 63 European solar photovoltaic investors. By confronting them with different policy risks like tariff duration, existence of a cap, duration of the administrative process, policy stability and additionally with different remuneration levels, they were able to compute more than just the relative importance of the attributes. Furthermore, they could calculate the required compensation for certain kinds and levels of risk in terms of a monetary value, namely an increase of the remuneration level.

However, stated preference approaches have limitations; one of their main problems is the hypothetical bias. Respondents are asked to supply answers to situations or options they do not face in reality (Portney 1994). In an attempt to reduce this drawback in this study, the investor was asked to compare two investment projects and indicate how much he prefers one to the other. Thus, the answers were not statements about the probability of investing but about preferences.

Similar to the approach taken by Lüthi and Wüstenhagen, we conducted a conjoint analysis among wind power investors to investigate their preferences regarding selected policy elements. Several attributes and levels were chosen and various combinations of them, the so-called stimuli, were presented to the investor.

3.1.2 Selection of attributes and levels

Among the many different factors influencing the preference of a renewable energy investor for an investment opportunity, only a few can be addressed by a support scheme. The most important factor is uncertainty about the received remuneration. This price risk is addressed by remuneration tariffs. One can distinguish between three possible *feed-in models*. In the fixed remuneration model, the investor does not face a price risk at all since he receives a fixed tariff per generated unit of power. In a premium model, the investor receives the spot market price, which varies, plus a fixed premium. He therefore faces a certain price risk. The last model, the variable premium model, shifts some risk to the investor, but limits this risk through setting fixed caps and floors.

The expected average remuneration level of the three different hypothetical investment opportunities had to be the same in all cases, since only the inherent price risk should influence the investor's decision. The level was set at € 95 per MWh. This corresponds roughly to the remuneration paid in Germany in 2011. In the premium model, the premium is fixed. The spot market price for electricity has been € 39 on average since 2009 so the premium would have to be set at € 56 in order to add up to the total average remuneration of € 95. Due to the expected electricity price rises, the premium is said to be adjusted annually. In the variable premium model, the cap was set at € 115 and the floor at € 75. This price range of € 40 was proposed by Langniss et al. (2009).

The second attribute is a measure of profitability. It is incorporated to investigate the risk-return trade-off of investments in wind power. The levels are set at 1600, 1800 and 2000 full load hours (FLH), a common measure for expected returns.

The third attribute is a shut-down compensation. Since 2009, operators in Germany have been compensated under a hardship scheme. If the grid operator decides to shut down the wind turbine because the grid threatens to collapse, the wind power operator receives compensation for losses incurred. Without such a *shut-down compensation* mechanism, the investor would face the risk of not being able to operate the wind turbine at a certain time.

The fourth attribute is quantity balancing. Fluctuations in wind yield pose a risk to the investor because he cannot definitely know how much power the wind turbine will produce in a particular year. The resulting varying revenue could potentially be balanced by adjusting remuneration retroactively. "Quantity balancing" therefore means that the operator receives additional remuneration when wind yield was below the long-term average and has to pay back a portion of the remuneration if it was above average.

To summarise, two attributes (A and B) with three levels and two attributes (C and D) with two levels are included in the analysis. Table 1 shows the attributes and levels with the corresponding numbers.

Table 1: Attributes and levels

	Attribute	Level	#
A.	Feed-In Tariff	Fixed Remuneration	1
		Variable Premium with Cap and Floor	2
		Premium Model	3
B.	Full Load Hours	1600 FLHs	1
		1800 FLHs	2
		2000 FLHs	3
C.	Shut-Down Compensation	No Shut-Down Compensation	0
		Shut-Down Compensation	1
D.	Quantity Balancing	No Quantity Balancing	0
		Quantity Balancing	1

Source: Own illustration

3.1.3 Questionnaire design

The main part of the questionnaire consisted of the presentation of several stimuli comprising various combinations of the attribute levels. To present the investor with a realistic investment opportunity, all four attributes were included in the stimuli. Instead of presenting all 36 possible combinations of investment opportunities, a fractional factorial design of 11 stimuli was generated using the statistic programme SPSS (Addelman 1962). Investors were confronted with two investment opportunities at the same time because it is thought they can make finer distinctions when comparing two stimuli side-by-side than when they have to evaluate one investment option on its own. The second stimuli were generated by "shifting". The codes of the first stimuli (left investment option) were taken and 1 added to obtain the second stimuli (right investment option) (Chrzan and Orme 2000).[1] Table 2 shows the eleven pairs of stimuli presented to the investors.

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1 In cases of only two levels, 0 was shifted to 1 and 1 was shifted to 0. In cases of three levels, 1 was shifted to 2, 2 to 3 and 3 to 1

The investors were asked to state which investment they would prefer. A Likert-scale with seven options was presented under the two investment options, ranging from “strongly prefer left” to “Strongly prefer right”. The option in the middle of the scale meant “indifferent”. Investors marked their preference for one of the options.

In addition to the conjoint tasks, five questions were asked about the background of the company and the investor.

Table 2: Presented stimuli

Conjoint	Left investment option				Right investment option			
#	A.	B.	C.	D.	A.	B.	C.	D.
1	1	2	0	0	2	3	1	1
2	3	1	0	1	1	2	1	0
3	1	3	1	0	2	1	0	1
4	2	3	0	1	3	1	1	0
5	1	1	1	1	2	2	0	0
6	3	2	1	1	1	3	0	0
7	3	3	1	0	1	1	0	1
8	2	2	1	1	3	3	0	0
9	2	1	1	0	3	2	0	1
10	3	2	1	0	1	3	0	1
11	2	2	0	0	3	3	1	1

Source: Own illustration

3.2 Conjoint analysis (CJA)

In order to investigate the risk-return trade-off made by investors, an appropriate utility model has to be set up. Starting from microeconomic consumption theory, Lancaster (1966) argued that the utility from a good comes not from the consumption of the good itself, but from the characteristics of that good. Each good has several characteristics and shares some of them with other goods. The value of a good then stems from the values of the characteristics.

According to random utility theory, not all the determinants of utility derived by individuals can be observed by researchers. Besides the observable section there is a stochastic section, which is not observable (Louviere, Hensher et al. 2000). Furthermore, a compensatory model has to be assumed.

In this approach, the overall utility of one good is constructed by simply adding the utilities of the characteristics involved. The characteristics of a good such as price, colour, or brand are called attributes and the parameter value of an attribute reflects the level ($10, $12 or $14 for the attribute 'price') in the CJA. The utilities of attributes are called "part-worths". A "low" level of one attribute can thus be compensated by a "high" level of another attribute.

Instead of analysing consumption behaviour, this study investigates the preferences of investors. It is therefore assumed that, similar to a purchase decision, the investor takes all the characteristics (attributes) of the investment project into consideration and is able to state his preference.

In this analysis three attributes capture risk (price and performance risk) and one attribute reflects profitability aspects. The *shut-down compensation* is either paid or not, likewise some options receive *quantity balancing* and others not. A linear vector model is appropriate for these attributes with just two levels each. The three levels of the attribute *full load hours* can also be represented with the vector model by reducing it to just two levels. Since the difference between 1600 and 1800 FLHs is exactly the same as the difference between 1800 and 2000 FLHs, it is assumed that the difference in utility (linear) is also the same. Therefore, the levels of FLH have been changed into a two level attribute by using only "additional 200 FLH" and "no additional FLH".

The attribute, *feed-in tariff,* is a categorical attribute, so the vector model is not applicable here. But it is possible to apply the vector model by using two dummy variables. The part-worth *feed-in tariff* is adapted by creating two auxiliary attributes for the feed-in attribute. This is done by splitting the feed-in attribute into two two-level attributes: "Variable Premium" and "Premium (levels: "yes" and "no").

Including all levels of an attribute in the model would yield perfect correlation between the independent variables. This is called the "dummy variable trap". To avoid it, the first level of each attribute is dropped (Greene 2008). Hence, the utility *V* for an investor of project *p* can be expressed (Equation 2) as:

Equation 2:

$$V_p = \alpha_0 + \alpha_1\, V.Prem._p + \alpha_2\, Prem._p + \alpha_3\, FLH_p + \alpha_4\, Comp._p + \alpha_5\, Bal._p + \theta_p\ ,$$

where θ_p is the unobservable error term of the model with $E[\theta_p]=0$.

The coefficients α_1, α_2, α_3 α_4 and α_5 are interpreted as the part-worths to the investor. The coefficient α_3 is the part-worth of having additional 200 FLHs. The other coefficients indicate the contribution or value of having a variable premium model, a premium model, shut-down compensation and quantity balancing offered in the investment project instead of the attributes of the base project which are *fixed remuneration*, *1600 FLHs*, *no shut-down compensation* and *no quantity balancing*. The coding of all eleven stimuli is depicted in the two left columns of Table 3.

Table 3: Coding of stimuli

Conjoint	Left investment option					Right investment option					Independent Variables				
#	*V. Prem.*	*Prem.*	*FLH*	*Comp.*	*Bal.*	*V. Prem.*	*Prem.*	*FLH*	*Comp.*	*Bal.*	*V. Prem.*	*Prem.*	*FLH*	*Comp.*	*Bal.*
1	0	0	1	0	0	1	0	2	1	1	-1	0	-1	-1	-1
2	0	1	0	0	1	0	0	1	1	0	0	1	-1	-1	1
3	0	0	2	1	0	1	0	0	0	1	-1	0	2	1	-1
4	1	0	2	0	1	0	1	0	1	0	1	-1	2	-1	1
5	0	0	0	1	1	1	0	1	0	0	-1	0	-1	1	1
6	0	1	1	1	1	0	0	2	0	0	0	1	-1	1	1
7	0	1	2	1	0	0	0	0	0	1	0	1	2	1	-1
8	1	0	1	1	1	0	1	2	0	0	1	-1	-1	1	1
9	1	0	0	1	0	0	1	1	0	1	1	-1	-1	1	-1
10	0	1	1	1	0	0	0	2	0	1	0	1	-1	1	-1
11	1	0	1	0	0	0	1	2	1	1	1	-1	-1	-1	-1

Source: own illustration

For the interview, the investor was asked to compare two projects and state his preference on a Likert-scale with seven response options. Depending on the levels of the attributes, one of the two investment options displayed is supposed to be preferred by the interviewed investor. The range was limited to seven gradations to ensure that the investor can make fine discriminations (Meyer and Booker 1991).

The answer can be interpreted as the change in utility moving from the right project to the left project. Subtracting the utility of the right project from the utility of the left project leads to Equation 3:

Equation 3

$$\Delta V_{l-r} = \alpha_1\, V.Prem._{l-r} + \alpha_2\, Prem._{l-r} + \alpha_3\, FLH_{l-r} + \alpha_4\, Comp._{l-r} + \alpha_5\, Bal._{l-r} + \theta_{l-r}$$

The parameter α_0 of the base investment project disappears, since there is no difference in utility between the two projects if all attributes have the same level (Miguel, Ryan et al. 2000). This is also depicted in Table 3 (right column), where the codes of the right-hand side investment option are subtracted from the left-hand side option in order to obtain the coding of the independent variables as shown in Equation 3 (Steiner 2007). The model only measures main effects. Interaction terms are not included; they are assumed to be zero.

A further assumption has to be made regarding the dependent variable. It is assumed that the distances between the seven answers (at the Likert-scale) are the same: The dependent variable is scaled at intervals. By doing so, it is possible to apply a metric approach. Here, ordinary least squares (OLS) regression is applied to estimate equation 1. The dependent variable is coded with numbers ranging from +3 indicating ‘Strongly Prefer Left’ to -3 indicating ‘Strongly Prefer Right’.

The coefficients resulting from the regression are used to compute the rate of substitution. Let *Δ* $Variable_i$ and *Δ* $Variable_j$ be the changes in Variable i and in Variable j. By assumption, the change in utility (*Δ* V) must be zero. Rearranging the equation (Equation 4) shows an expression known as the marginal rate of substitution (MRS) between the variables *i* and *j* (Varian 1992). Since *full load hours* is one of the attributes, its coefficient can be used as the numeraire. This implies that the MRS can be interpreted as average willingness-to-accept (WTA). These values are expressed in units of profitability, namely FLHs. The willingness to accept level 1 instead of having level 0 (base investment option) is calculated with the following formula (Equation 4):

Equation 4:

$$\frac{\partial V}{\partial\, Variable_i}\,\Delta\, Variable_i + \frac{\partial V}{\partial Variable_j}\,\Delta\, Variable_j = 0$$

$$\frac{\Delta\, Variable_j}{\Delta\, Variable_i} = -\frac{\partial V /_{\partial Variable_i}}{\partial V /_{\partial Variable_j}} = -\frac{\alpha_i}{\alpha_j} = MRS$$

The ratio of the coefficients is multiplied by 200 because the difference between two levels of the attribute *full load hours* is 200 FLHs.

If the formula leads to a negative result, it is multiplied by (-1) and is then called “willingness-to-pay (WTP)”. The WTP for *shut-down compensation* and *quantity balancing* is calculated this way.

So far, conjoint analysis asks investors to rate several hypothetical investment projects. Based on the given answers, the contribution of each project’s attribute to the overall preference level can be explored. By using a metric approach, it is even possible to measure the trade-off between risk and return. The last step, computing the impact on financing costs, is undertaken with the help of a traditional cash flow model.

3.3 Cash flow model

The cash flow model is a basic tool for investors to analyse the profitability of a project in order to facilitate the investment decision. The WTA and WTP values obtained via the conjoint analysis are inserted in order to measure the impact of RE policy elements on financing costs.

The cash flow model assesses the internal rate of return (IRR) of a fictional 2 MW onshore wind power project with a 20-year investment life (Wiser 1997) and tracks yearly revenues from selling power and expenses for maintenance and taxes. Krohn et al. (2009) describe a typical 2 MW wind turbine installed in Europe. In the scenario, costs are adopted from Krohn and therefore assumed to add up to € 2.5 million.

During the wind turbine's lifetime the fictionally generated power is fed into the power grid and generates revenue depending on power quantity and price. The calculation based on 1600 FLHs (base level of the conjoint analysis) results in 3200 MWh produced power per year. The price for wind power is € 95 per MWh in accordance with the conjoint questionnaire and the feed-in tariff for onshore wind in Germany in 2011. Revenues are therefore € 304,000 per year. The price of wind power is assumed to be the same over the whole lifetime since even under the premium models, the total remuneration is assumed to add up on average to € 95 per MWh.

O&M costs are assumed to be € 14.5 per MWh over the whole lifetime, so that O&M expenses are € 46,400 per year. In Germany, operators are obliged to depreciate wind turbines linearly over 16 years, which equals € 156,250 per year in the present case. The pre-tax profit can now be calculated by subtracting depreciation and O&M costs from revenues. A tax burden of 37.5% is assumed (Franke and Hax 2009). Changes in working capital are ignored as are debt payments.

Depreciation is not a real cash flow and has to be added to profit-after-tax to calculate the free cash flow (FCF) for every period t. The final calculation is depicted in Equation 5.

Equation 5:

$$FCF = \text{FLHs} * \text{rated power} * (1 - \text{tax rate})(\text{remuneration level} - \text{O\&M costs}) + \text{tax rate} * \text{depreciation}$$

$$= \begin{cases} € \, 100.625 * FLHs + \begin{cases} € \, 58593.75 \text{ for } t = 1, \dots, 16 \\ 0 \text{ for } t = 17, \dots, 20 \end{cases} \\ 0 \; otherwise \end{cases}$$

Having done this, it is possible to then compute the internal rate of return (IRR) using the following formula:

Equation 6: $$\sum_t \frac{Free\ Cash\ Flow_t}{(1+IRR)^t} - I_0 = 0$$

where I_0 is the initial investment of € 2.5 million.

The internal rate of return is the discount rate at which the net present value is zero and measures the profitability of a project. In the present case with 1600 FLHs, the IRR is 5.68%. Table 4 shows the cash flow model.

Table 4: Cash flow model

t [years]	0	1 - 16	17 - 20
Produced Power (MWh)		3,200	3,200
Remuneration per MWh		€ 95	€ 95
Sales		€ 304,000	€ 304,000
Investment Costs	-€ 2,500,000		
O&M Costs		€ 46,400	€ 46,400
Linear Depreciation		€ 156,250	
Pre-tax profit		€ 101,350	€ 257,600
Taxes at 37,5%		€ 38,006	€ 96,600
Profit-after-tax		€ 63,344	€ 161,000
Free Cash Flow	-€ 2,500,000	€ 219,594	€ 161,000
IRR	5.68%		

Source: Own calculation

The IRR can be viewed in this case as a function of *FLHs* and the amount of the initial investment I_0 $(IRR = f(FLHs, I_0))$. It depends positively on *FLHs* meaning that an increase in full load hours leads to an increase in *IRR*.

The obtained WTA values from the conjoint analysis can be added to 1600 FLHs. The new figure represents the total full load hours the investor requires the investment project to offer in order to have the same utility as the other project. By increasing *FLHs,* the *IRR* increases as well. This increase is seen as the impact of financing costs resulting from changes in the support mechanism.

The weighted average cost of capital is calculated based on Equation 1 by using the IRR as cost of debt and equity.

4 Results of conjoint and cash-flow analysis

4.1 Sample and data

Participants in the survey were onshore wind investors. Of particular interest were investors who had made or were planning to make investments in countries other than Germany. These investors were regarded as being better suited to evaluating the risks stemming from different feed-in tariffs. To limit the targeted selection, only investors from Germany were asked to participate.

Beginning in September 2010 relevant companies were contacted by phone and invited to participate in the online survey. The link to the survey was sent by email immediately after the phone-call and a reminder was sent after one week. 46 respondents logged on to the survey website and 22 completed the questionnaire. The dropouts may have been the result of the length of the questionnaire, which took about 15 minutes to complete. Another reason could have been the relatively difficult investment decision task. Unfortunately two of the respondents did not actually state their preferences; they marked themselves as being indifferent in all conjoint tasks. Their answers were deleted from the data set.

Besides the online survey, some investors were asked to participate directly on-site. Six respondents agreed to fill out the questionnaire right away. By October 2010, 26 participants had completed the survey in a suitable way. 25 respondents completed all eleven conjoint tasks; one respondent missed one task, so that the final data set contains of 285 given answers.

Table 5 summarises the answers of the first part of the interview given by 26 respondents.

Table 5: Descriptive summary

			Relative frequency
Question 1	The type of your firm is best described by	Specialized project developer	15.4%
		Vertically integrated project developer	26.9%
		Bank	42.3%
		Utility or Network Operator	11.5%
		Other	3.8%
		Response Rate	100.0%
Question 2	The focus of your firm lies on	Planning phase only	0.0%
		Construction phase only	0.0%
		Operation phase only	0.0%
		Full project cycle	92.3%
		Other	7.7%
		Response Rate	100.0%
Question 3	Your firm invests annually in onshore wind projects	1 - 9 Million €	0.0%
		10 - 99 Million €	46.2%
		100 - 499 Million €	38.5%
		500 - 999 Million €	0.0%
		More than 1 Billion €	3.8%
		Response Rate	88.5%
Question 4	How many years have you personally been in the business of onshore wind projects?	2 years or less	26.9%
		3 - 5 years	23.1%
		6 - 9 years	11.5%
		10 years or more	38.5%
		Response Rate	100.0%
Question 5	In which countries have you made investments?	Germany	96.2%
		Other countries	69.2%
		Response Rate	100.0%

Source: Own illustration

4.2 Conjoint analysis

Part 2 of the questionnaire consists of the actual conjoint analysis. Participants were asked to state their preference. Two investment projects were presented to them at a time and they had to state which investment they preferred. The answers to the conjoint tasks were used to assess the trade-off between risks and return facing investors. The utility model of Equation 2 was estimated by ordinary least squares (OLS). The regression through the origin was performed on the stated conjoint answers.

It was hereby assumed that the dependent variable is scaled at intervals. This means that the differences between all seven response options are regarded as being exactly the same. Dropping this assumption and applying an ordinal scale does not seem to change the result according to Green and Srinivasan (1978). It has to be mentioned, however, that the response options were narrowed. This limitation could not be avoided.

It was furthermore ignored that one respondent had completed eleven tasks and that 26 respondents participated. The dataset was handled as though the answers were independent of each other. First, part-worth utilities and willingness-to-accept values were computed for all the respondents. In a second step, the dataset was split up into debt investors and equity investors in order to analyse potential differences. The computed variance inflation factors (VIF) indicated that the dummy variable trap was successfully avoided (Wooldridge 2009)[2]. Table 6 displays the results of the model.

The analysis shows that the utility model has an R-squared of 42.8% and an adjusted R-squared of 41.6%. Thus, less than half of the variation in the preference statements can be explained by the five independent variables. This is comparable with the adjusted R-squared of a conjoint analysis conducted by Stärk et al. (2002). The F-test shows that the model is significant at the 99%-level, but this is not surprising since there cannot be any variables other than the ones included to explain the dependent variable. All variables are highly statistically significant at the 1% level[3]. For an overview of the results per investor group see Annex.

2 The VIF is a statistic to determine the severity of multicollinearity.

3 Homoskedasticity justifies the usual F-tests and t-tests. The Breusch-Pagan test confirmed homoskedasticity.

Table 6: Regression results – all interviewees

Independent Variables	Coefficient	Confidence Intervall		VIF
VPrem	-1.070	-1.327	-0.813	1.439
Prem	-1.046	-1.289	-0.803	1.463
FLH	0.618	0.490	0.747	1.026
Comp	0.458	0.282	0.634	1.055
Bal	0.267	0.092	0.442	1.045
Observations	285			
F Stat	41.823			
R-squared	42.8%			
Adjusted R-squared	41.6%			

Source: Own calculation

The part-worth utilities

The variable 'V.Prem.' represents the part-worth value for moving from *fixed remuneration* towards a *variable premium with cap and floor*. The investment has higher risks as a result of this shift since price risk is imposed on the investor. The coefficient has the value -1.070. The sign is negative as expected, meaning that overall utility decreases by this value.

The variable 'Prem.' represents the part-worth for moving from *fixed remuneration* towards a *premium model*. This model imposes full price uncertainty on investors because remuneration is not limited by a cap or floor. The coefficient has the value -1.046, which is roughly as high as the coefficient for the variable 'V.Prem', even though the premium model imposes a higher risk on investors.

The variable 'FLH' measures the part-worth for increasing the annual *full load hours* by 200 full load hours, i.e. the profitability of the project increases. The coefficient has the value 0.618. The sign is positive, meaning that higher values of full load hours are preferred, which matches theory.

The variable 'Comp.' represents the part-worth for receiving *shut-down compensation* payments in the case of an enforced shut-down of the wind turbine due to potential grid instability. The coefficient has the value 0.458. The sign is positive as expected, since the compensation scheme guarantees that revenues are independent of enforced shut-downs of the wind turbine.

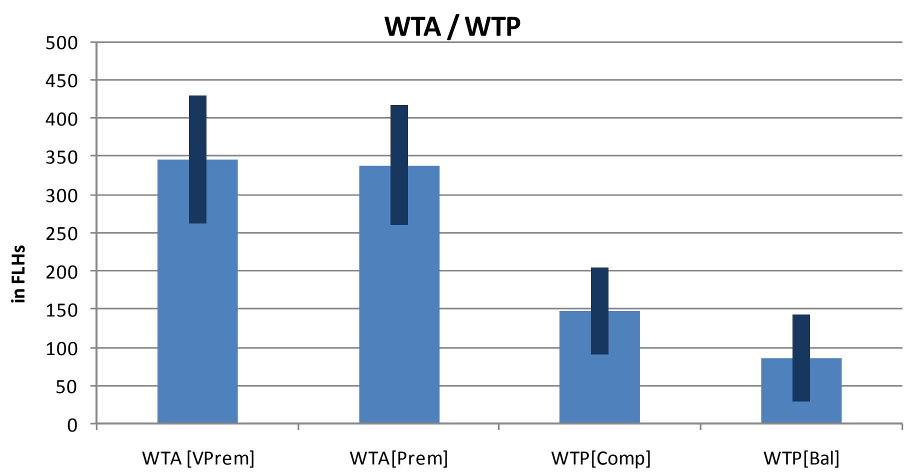
The last variable 'Bal.' measures the part-worth for participating in *quantity balancing*. This means that investors receive more remuneration per MWh in years with low wind yield and less remuneration per MWh in years with high wind yield. The resulting revenue stream will therefore fluctuate less and uncertainties about wind yield are compensated. The coefficient has the value 0.267. The sign is positive as expected.

The last three part-worths increase the overall utility of the project while the first two part-worths decrease utility compared to the baseline investment (fixed feed in tariff, 1600 FLH, no compensation, no balancing).

Willingness-to-accept and willingness-to-pay

To facilitate the interpretation of the results and to investigate the trade-off between risks and return, the investors' willingness to accept certain risks (WTA) was calculated using Equation 4. Results are presented in Figure 3. The base investment option offers neither shut-down compensation nor quantity balancing, which are both favoured by investors. These part worth values consequently yield a negative value, so that the results has to be interpreted as the willingness to pay (WTP) for receiving compensation and participating in quantity balancing, while the ratios of the part-worths for premium or variable premium are positive, indicating the willingness to accept an increased risk (WTA).

Figure 3: WTA and WTP values



Source: Own illustration.
Note: the dark blue bars indicate the values of the 95% confidence interval.

The analysis shows that an investment project with a variable premium has to offer 346 full load hours more on average than a fixed remuneration model – ceteris paribus – in order to attract investors to the same extent. This represents an increase in power production of 22% compared to the base investment offering only 1600 full load hours. Applying the values of the 95% confidence interval, the FLH range between 263 and 429 FLHs.

The willingness to accept the premium model is similarly high (338 FLHs) with a range between 260 and 417 FLHs resulting in an increase of power generation by 21%. Limiting the price risk by setting a cap and a floor does not apparently have any smaller effect than the change to a premium scheme without cap and floor.

Subsequently, changing from a fixed remuneration scheme with a guaranteed price for 20 years to one with a premium and, hence, fluctuating remuneration requires compensating the rising price risk by higher expected wind yields.

Shut-down compensation protects investors against unexpected revenue defaults resulting from the enforced shut-downs of wind turbines in cases of potential grid instability. On average investors agree to waive 148 FLHs (with a range between 91 and 205 FLHs) in order to reduce performance. This is a decrease of 9% in power output in comparison to the investment offering 1600 FLHs.

The last risk incorporated in the conjoint analysis is uncertainty about wind yield. This is addressed through quantity balancing. On average investors have a willingness-to-pay of about 86 FLHs (with a range between 30 and 143 FLHs) to shift this type of risk. This is equivalent to a decrease of 5% of power output. Currently, this policy element is not implemented, so the benefits of such an instrument may be unclear to investors. Johnson and Desvousges (1997) point out that respondents may pay only limited (if any) attention to unfamiliar attributes.

4.3 Cash flow model

The WTA and WTP represent key values for the traditional cash flow model, which assesses the impact of the analysed mechanism elements on financing costs. The FLH estimates are added to the base level of the attribute *full load hours* (1600) to obtain the overall FLHs the investor requires for the alternative. By inserting the figures in the cash flow model, the corresponding IRR values are computed. The difference between the IRR of the baseline investment and the respective alternatives (premium, compensation, balancing) shows the required increase in IRR to compensate for the changes (risks). Table 7 displays the results.

Table 7: Impact on IRR

Variable	WTA [FLHs]	FLHs	IRR	Δ IRR
V.Prem.	346	1946	7.67%	1.99%
Prem.	338	1938	7.63%	1.95%
Comp.	-148	1452	4.78%	-0.90%
Bal.	-86	1514	5.16%	-0.52%

Source: Own calculation

An investment with a variable premium (cap and floor) scheme has to offer 346 additional full load hours in comparison to the base investment option making 1946 FLHs in total. A wind power investment with this energy production has an IRR of 7.67% – ceteris paribus. This is 1.99 percentage points higher than the baseline investment with an IRR of 5.68%. Introducing a premium model causes a rise of 1.95 percentage points, slightly below the impact of a variable premium model. Changing the feed-in tariff therefore causes a rise in IRR of between 1.95 and 1.99 percentage points.

Ragwitz et al. (2007) conducted a study on the effectiveness and efficiency of currently applied RES support measures in the European Union. In doing so they assumed that the premium model would raise financing costs by 1.05 percentage points compared to a fixed feed-in tariff. However, the specific design of the applied premium models is not completely comparable.

As discussed above, the baseline investment option is riskier than the alternative investment with the fourth variable "Comp." and the fifth variable "Bal.". WTA is therefore negative and can be regarded as the willingness-to-pay (WTP). When offering shut-down compensation, the IRR decreases by 0.90 percentage points and by about 0.52 points if the investor benefits from quantity balancing.

The dataset was also divided into two subsets: debt investors (120 answers) and equity investors (165 answers). The same procedure in both groups has been applied. A Chow test was conducted to investigate whether a structural change exists. There is evidence that the coefficients of the two subsets do indeed differ (Greene 2008). Table 8 shows the impact on the IRR (for the WTP/WTA see Figure 4 in Annex).

Table 8: Impact on IRR of subsets

Variable	Δ IRR		Δ WACC
	Debt Investor	Equity Investor	
V.Prem.	3.12%	1.56%	1.85%
Prem.	3.96%	1.17%	2.15%
Comp.	-1.57%	-0.66%	-0.90%
Bal.	-1.10%	-0.31%	-0.60%

Source: Own calculation

Debt investors are known to be generally more risk averse. Therefore their reactions (WTA and WTP values) on changes (premium, compensation or balancing) are expected to be more significant. The results confirm this assumption; their WTA and WTP values are in general higher than those of equity investors. Theory states that debt investors are more interested in stable returns than in potentially high returns. Here we learn, that lenders seem to be willing to waive a certain share of profitability in order to lower the riskiness of the project. But debt costs are generally fixed for a given period and already lower than equity costs. The change in IRR can interpreted as a change in the interest rate which is offered to operators. Besides the focus on interest, from the lenders' perspective other adaptations are also possible, e.g. higher equity shares or changes in the payback period, etc., all affecting the capital costs.

From the equity investor's perspective, the key decision variables are the cash flow and the expected return on equity. Since they provide capital that is subordinated to loans, their share in the project is more at stake than debtors' capital. Equity investors seem to be concerned about risks and are willing to accept a shift from a fixed tariff to a premium scheme when profitability increases.

Calculating the WACC[4] reveals an additional financing cost between 185 and 215 basis points (bp) for a variable premium or premium scheme.

4 Equity share: 0.3, debt share 0.7

5 Conclusion

Countries all over the world have introduced various mechanisms to support renewable energies. Much research is being done to identify the risks which can potentially be addressed by such mechanisms. This work investigated three elements of feed-in scheme and analysed their influence on the riskiness of renewable energy projects. Conducting a conjoint analysis among 26 onshore wind power investors in Germany and subsequently applying a cash flow model allowed us to quantify the impact of various mechanisms on financing costs.

We were able to show that changing a fixed feed-in tariff into a variable premium model with cap and floor seems to increase financing costs by 1.85 percentage points and by 2.15 points when turning it into a premium model. Investors tend to be willingly to trade price certainty against profitability. Langniß et al. (2009) proposed introducing a premium model instead of the fixed feed-in tariff currently applied in Germany to improve the integration of renewable energies into the power market. Shifting the tariff towards more market-based instruments does not come without a cost however. Introducing premium models seems to raise financing costs, leading to potentially lower installed capacities – ceteris paribus. Statements from the interviewed wind power investors about the potential transition towards more market-based instruments support this hypothesis. While investors are well aware of the need to adjust the feed-in tariff, they are all concerned about financing. One stated: “May jeopardize bankability”, which is a felicitous description of the problem.

The two other investigated elements were *shut-down compensation* and *quantity balancing*. Incorporating a hardship scheme to compensate the operator for losses suffered due to enforced shutdowns as done in Germany in 2009 seems to reduce financing costs by 0.90 percentage points. This result might be interesting for countries with grid problems to increase the attractiveness of investments. Offering quantity balancing to reduce fluctuations in revenue seems to decrease financing costs by 0.60 percentage points. This result suggests that it is worth discussing this element although the impact would not be fairly large.

This work investigated the quantitative influence on financing costs using a stated preference approach. Although there are arguments for and against the method employed here, it can still make a valuable contribution to the assessment of different FIT policies.

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7 Annex

Annex: Detailled results of the CJA:

Summary: all investors

Regressions-Statistik	
Multipler Korrelationskoeffizient	0.653865445
Bestimmtheitsmaß	0.427540021
Adjustiertes Bestimmtheitsmaß	0.415790592
Standardfehler	1.470046401
Beobachtungen	285

ANOVA

	Freiheitsgrade (df)	*Quadratsummen (SS)*	*Mittlere Quadratsumme (MS)*	*Prüfgröße (F)*	*F krit*
Regression	5	451.9098017	90.38196034	41.82343222	4.63107E-32
Residue	280	**605.0901983**	2.161036422		
Gesamt	285	1057			

	Koeffizienten	*Standardfehler*	*t-Statistik*	*P-Wert*	*Untere 95%*	*Obere 95%*
Schnittpunkt	0					
VPrem	**-1.070012387**	0.130733469	-8.184685965	9.70116E-15	-1.327357617	-0.81266716
Prem	**-1.04606044**	0.123587756	-8.464110661	1.46481E-15	-1.289339531	-0.80278135
FLH	**0.618339527**	0.065366734	9.45954441	1.31859E-18	0.489666912	0.74701214
Comp	**0.458193913**	0.089440683	5.122880298	5.61122E-07	0.282132393	0.63425543
Bal	**0.266993773**	0.089000049	2.999928378	0.002943432	0.091799629	0.44218792

Summary: Debt Investors

Regressions-Statistik	
Multipler Korrelationskoeffizient	0.646648893
Bestimmtheitsmaß	0.418154791
Adjustiertes Bestimmtheitsmaß	0.389221045
Standardfehler	1.469835555
Beobachtungen	120

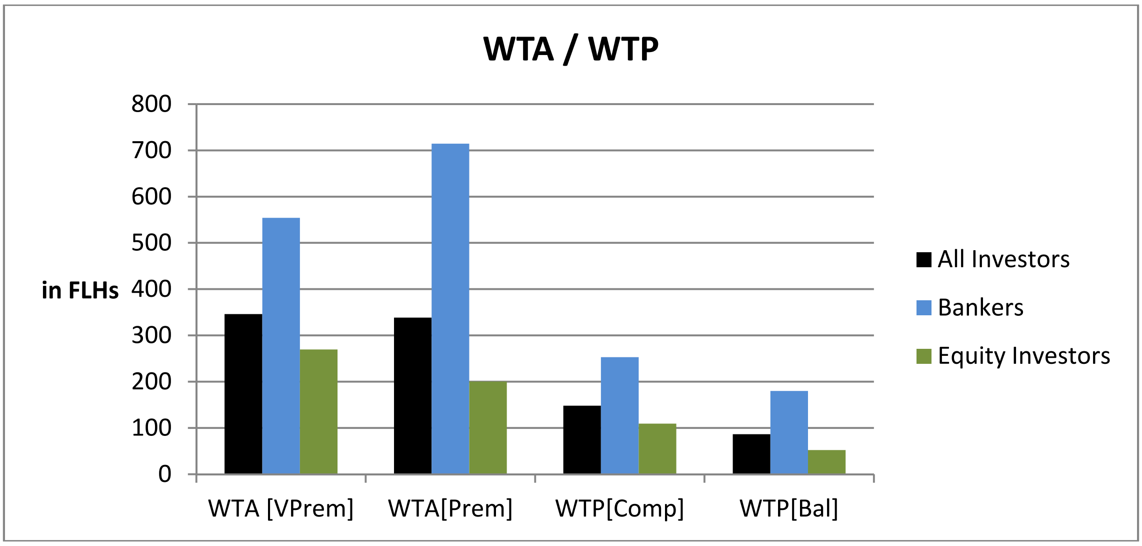
ANOVA

	Freiheitsgrade (df)	*Quadratsummen (SS)*	*Mittlere Quadratsumme (MS)*	*Prüfgröße (F)*	*F krit*
Regression	5	178.5520958	35.71041916	16.52941375	3.0088E-12
Residue	115	**248.4479042**	2.160416558		
Gesamt	120	427			

	Koeffizienten	*Standardfehler*	*t-Statistik*	*P-Wert*	*Untere 95%*	*Obere 95%*
Schnittpunkt	0					
VPrem	**-1.088901709**	0.201288753	-5.40965003	3.48339E-07	-1.48761598	-0.69018744
Prem	**-1.403373622**	0.190750011	-7.35713521	3.00815E-11	-1.78121267	-1.02553457
FLH	**0.392935703**	0.100644376	3.904199286	0.000159859	0.19357857	0.59229284
Comp	**0.496936162**	0.137635956	3.610511225	0.000454089	0.22430583	0.76956649
Bal	**0.353234793**	0.13724891	2.57368014	0.011333366	0.08137113	0.62509846

Summary: Equity Investors						
Regressions-Statistik						
Multipler Korrelationsko	0.70499741					
Bestimmtheitsmaß	0.497021349					
Adjustiertes Bestimmthe	0.478196882					
Standardfehler	1.407294724					
Beobachtungen	165					
ANOVA						
	Freiheitsgrade (df)	*Quadratsummen (SS)*	*Mittlere Quadratsumme (MS)*	*Prüfgröße (F)*	*F krit*	
Regression	5	313.1234497	62.62468994	31.62099051	2.8657E-22	
Residue	160	**316.8765503**	1.980478439			
Gesamt	165	630				
	Koeffizienten	*Standardfehler*	*t-Statistik*	*P-Wert*	*Untere 95%*	*Obere 95%*
Schnittpunkt	0					
VPrem	**-1.057476614**	0.164581814	-6.425233695	1.4398E-09	-1.38250949	-0.73244374
Prem	**-0.786000456**	0.155315832	-5.060658964	1.1359E-06	-1.09273393	-0.47926698
FLH	**0.784293863**	0.082290907	9.530747603	2.47568E-17	0.62177743	0.9468103
Comp	**0.429048597**	0.112641358	3.80897928	0.000198549	0.20659301	0.65150419
Bal	**0.205010267**	0.111916968	1.83180683	0.068839737	-0.01601472	0.42603526

Figure 4: WTA and WTP for all investors, debt and equity investors



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