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Housing prices, snow accessibility and global warming

The effects in Swiss mountain areas

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Abstract

Within this paper the neglected issue of the relation between snow, climate change and house values in Switzerland is studied. Current developments, such as global warming, will change snow lines in the future. It is unknown yet, how this will affect the property market. Using a unique dataset, consisting of 3691 observations from the Swiss mountains, the current relation between accessible snow and residential property prices is determined. The spatial model proved that the most relevant factors, related to snow, considerably affect the value of a house. Together with three climate change scenarios this information has been used to analyse the future effects of snow on house values. The results show that, based on natural snow, many ski resorts will not be snow reliable any more, at the end of this century. At the north side of the Alps it is even expected that the whole snow industry will disappear. Therefore the snow activity will be clustered even more in the south of the country. This will have huge effects on the property market in the Swiss mountains. Artificial snow does provide a solution for many areas. Making use of it, almost none of the ski resorts will become unreliable with respect to the snow conditions at the end of this century. This is an important observation for the property market and its stakeholders.

Keywords: *spatial model, snow accessibility, snow reliability, snow line, climate scenarios, house prices, Swiss mountain areas*

Master thesis

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‘‘Winners are not those who never fail, but those who never quit’’

-Edwin Louis Cole-

Preface

During my life I have visited Switzerland several times and I have to admit that I really enjoy spending my holidays over there. The silence and the natural beauty of the country are amazing to experience. Next to that it is also a great country to practice some sports. During the summer period I have cycled several times in the mountains. As a teenager I also learned skiing by taking classes in a Swiss ski resort. I really enjoy spending my time by doing it.

Recently several threats have appeared for the winter sport industry in the country. The latest one is the decision to unpeg the Swiss Franc against the Euro. It has led to a considerable rise of the national currency and therefore many tourists avoid the country. The currency issue is a threat for the short term. More long run threats are also apparent for the winter sport sector in the country. The main one is global warming because the greenhouse effect is already irreversible. As my interests are also related to the housing market I wondered what the implications of this phenomenon is for the housing market. Therefore I proposed to do my master thesis about this subject. In front of you, the final result is provided.

Without the help of several people I would not have been able to achieve this outcome. Therefore I want to thank several people. First, mister Liu, who provided me with the necessary critical feedback. It definitely made a big contribution to this study. Second, I want to thank my parents who first of all made sure that I was able to study. Next to that they always supported me and introduced me to the Swiss country. Finally I also want to thank Eline Maas who always provided me with the necessary mental support at the right moments.

Erwin Snijders

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1. Introduction

1.1 Context

The 2015 winter season has been one of the most challenging in years for the Swiss snow industry. Snow cover was bad in December and in January the national bank unpegged its currency from the Euro. This event caused an increase of the Swiss Franc by almost 30% (Spence, 2015). Tourists who already booked their ski holiday cancelled their reservation and the number of last minute bookings fell drastically compared to previous years (Swissinfo, 2015a). As a consequence, some ski resorts have cut their prices by 20% to keep attracting foreigners to their location. (Miller, 2015). This is only a short term solution because many resorts will not be viable any longer, if they are forced to reduce their prices by such an amount for many years. The forecasts with regard to the currency evolution are therefore welcomed by the snow industry. Although it is not likely that it will return to its previous level, a downward trend is predicted (Trading Economics, 2015). This is important for the Swiss residential property market, because otherwise fewer foreigners will buy Swiss properties.

Next to the fluctuation of the Swiss Franc, there are however more long term problems apparent, which contribute to the vulnerability of the Swiss ski resorts and its housing market. One of them is the downward trend which is observable in the number of Europeans visiting the country. People from those countries especially visit Switzerland because of its mountains. On the contrary, the increase of wealthy Arabs, Russians and Chinese people visiting the country, is not contributing to the sustainability of the local Swiss mountain economies. This new segment of tourists does not perform winter sports. They prefer buying luxury products instead (Duez, 2012). This is also one of the reasons why the number of skiers declined during last decade (Vanat, 2014). In addition, the demographic composition of the country also contributes to the decline in the number of people skiing in Swiss resorts. Local inhabitants are ageing and the prospects with regard to this problem are not looking promising either (Swiss Federal Statistical Office, 2015a). This implies that it will be difficult to keep the national ski ticket sale at a constant level (Vanat, 2014). Analysing the number of ski lessons per season confirms this thought; in the winter of 2002-2003, about 2.1 million half day tickets were sold at ski schools. During the 2010-2011 season this amount declined by about 150 thousand tickets (STF, 2014). Despite of the fact that the evolution of ski visitors fluctuates a lot, because of for example different snow conditions per season, a downward trend is clearly visible. If this process is going to continue it will provide a huge economic loss which will also affect the property market.

Next to these problems, the biggest expected threat for the snow industry, and therefore the local property market, is global warming. It is widely accepted that such an event is currently in progress and that it is irreversible. Therefore, this threat is the most difficult one to oppose. Because of the temperature rise, caused by the greenhouse effect, the snowline is expected to increase considerably. This could be dramatic for some ski resorts, as the local GDP of some towns depends for 80% on its tourism function. In those mountain villages winter tourists are the main contributors to this share of the local economy (OcCC, 2007). Although climate change might also give opportunities for other mountain sports, it is very unlikely that they are able to compensate the economic losses caused by the fact that snow tourists will stay away. If sufficient snow cover is no longer a certainty, tourists will ignore those villages, if their main reason for visiting the resort is to practice winter sports.

Altogether, those threats are not only important for Swiss mountain resorts. It is important for the whole country because tourism is one of the main drivers of the Swiss economy. According to the STF,[1] tourism was the fourth export sector, just behind the watchmaking industry (STF, 2014). It directly employed approximately 3% of the national workforce in 2014. Besides, the GDP of the country consists for 2.25% of touristic activity (European Comission, 2014).This position of the tourism sector in the economy is especially gathered because of the unique geographical location of the

[1] Swiss Tourism Federation

country (OECD, 2000). It endows Switzerland with many important natural assets, such as several lakes and the mountains (OECD, 2000). In combination with the high quality infrastructure, this attracts many foreign people. Another important implication of the geographical location of the country is its central position within Europe. It provides the country with a large potential pool of tourists, as holiday destinations are still largely determined by the distance towards it. Overall, the Alps are the best visited part of the country (Swissinfo, 2014). This region is mainly dependent on the income of the snow tourism as it is the case for the whole touristic sector (Tunza, 2012). This implies that both this industry and the mountain areas are highly vulnerable for the threats which are present.

As a result, all the discussed threats have the opportunity to change the residential property market in the country. If the problems cannot be brushed off it is likely that, in the future, there will be less demand for Swiss properties located in the mountains. Nowadays, many tourists buy second homes in Swiss mountain areas because of the possibility to practice winter sports. If this is no longer a certainty, in a particular ski resort, many people will not be interested in real estate at that place. The same pattern, however less drastically, will be expected considering the Swiss themselves. People living in those areas, as main resident, could prefer a property in the valleys if snow is no longer guaranteed in the mountains. Moreover, some native inhabitants also own a second home in their own country. Mountain areas are very popular because of the peaceful setting, the scenery and the possibility to practice winter sports. If this last reason will disappear in some areas, demand for houses in the mountains will fall.

Altogether, this will be important for several reasons. Changes in the property market in mountain areas will negatively affect the national economy further, than the tourism fall already will do. This is because the property market is closely related to business cycles and vice versa (Reed & Sims, 2015). Besides, it will also affect investment decisions. If snow effects house prices, climate change has the potential to ensure that some property investments would not be beneficial anymore. Furthermore, it will also have consequences for the real estate tax incomes the cantons gather. Every province has its own rules with regard to taxes, but almost all cantons do have a property tax system (Confederation, cantons and communes, 2015). Maybe the most important effect of the changing housing market in the mountain areas is that property owners might get into troubles financially. If snow effects the value of the building drastically, the financial positions of households will deteriorate. People, living in the mountains, cannot sell their house without losses which implies that they have to stay at their current property, need to take a financial loss or move to a smaller house.

The irreversible character of global warming implies that the Swiss snow industry will change in the future. Therefore, it is necessary to investigate if this will affect property values in the mountain areas. To do so, it is first necessary to study the neglected issue of the exact price effects of snow on residential property in those areas. Although it is commonly accepted that it has a positive influence on house prices, the exact effect has never been investigated in Switzerland. Hence, it is necessary to investigate this issue before analysing the future implications of the greenhouse effect for the housing market. Therefore, *the purpose of this study is to find if there is a positive relationship between snow and housing prices in Switzerland and what the effect of global warming will be in the future.*

1.2 Research overview

The research objective is divided into several parts to be able to give a clear final verdict on the studied issue. It is important to explore *what the determinants for house prices in Swiss mountain villages are and how they should be measured.* The main information is gathered using previous literature. It is especially important to clearly investigate how snow will be analysed; otherwise it would lead to misspecification. Therefore it is deliberately chosen to investigate the effect of snow which is accessible. This is done by implementing a new concept called snow accessibility and it is applied to the ski and snowboard areas in the country. This ensures that only the effects of useable snow are analysed on property values. People are mainly interested in snow, if they are able to use and access it. If it is not, individuals are not likely to buy a property in that area because of the snow available.

The determinants which should be included for this study are collected in a new dataset, consisting of 3691 observations. With those variables it is possible to conclude *what the effects of the snow determinants are on housing values.* A spatial lag model is constructed to analyse this. The asking price, of the closest neighbour in the sample is inserted as a variable to create this kind of model.[2] This ensures that location characteristics are taken into account in the analysis. A hedonic model at which it is controlled for small spatial levels, such as the village, was not possible because the snow variables belonging to the village at which the house is located are too closely related to those small spatial levels.

The outcomes of the spatial model provide an answer to the first part of the research question, which examines the effects of snow on house values. Afterwards the implications of climate change are added to the analysis. The magnitude of the greenhouse effect is essential while performing this analysis. Therefore it is investigated *what the predictions concerning temperatures and snow covering are for the Swiss mountain regions*. Previous data and information about the main climate variables will be used and discussed. Together with the help of three climate scenarios, new reliable snow lines will be estimated. This would give an overview of the winter sport resorts which will survive in the future and which will not. Using different scenarios is important because although it is accepted that global warming is present; the magnitude of the effect still leads to discussion (EPA, 2015). A reason for this is that the future behaviour of human beings is difficult to predict.

With the different scenarios it is possible to investigate *what the implications of climate change for the property market will be.* This will answer the second part of the research question. The applied approach is to discuss the results of the spatial model, together with the implications of the global warming scenarios. Linking the greenhouse effects and house prices in one model is not possible because the constructed dataset does not consist of time series data. Therefore it is impossible to withdraw conclusions if, and how, the housing market is adjusting itself towards global warming.

Altogether, those sub-questions and this approach should investigate what the effects of snow are on residential property values in Swiss mountain resorts and what the implications of global warming will be in the future. The results of this study are valuable for many parties, such as investors, property owners and the national and local governments.

1.3 Outline

This study starts with a critical review of existing literature. Afterwards the background information is discussed. In this section the required information about Switzerland, its housing market and the expected magnitude of climate change are analysed. Together, this information forms the basis of the conceptual model. This part is followed by a methodology chapter. It describes the dataset which is used and its construction. Besides, it gives a description of the data, both numerically and geographically. The next chapter shows the results from the estimated spatial model. Afterwards, in the discussion, the outcomes are linked to the climate change scenarios and the implications are analysed. The study ends with some recommendations and a conclusion.

2. Theoretical background

2.1 Literature review

The effect of both snow and climate change on housing values, has not been studied that often. Bustic, et al. (2011) conducted a research which is the closest related to this study. With the help of a time series dataset, consisting of in advance selected resorts in the United States and Canada, they did investigate the relation between the three concepts. By constructing a hedonic model they found that the amount of snow fallen in a resort, influences the value of a house. Villages where snow reliability is already low will have significant price drops, of their property values, in the future because

[2] The spatial lag model is created by taking the spatial lag of the dependent variable, which is the asking price of a house.

of the global warming effects (Bustic, et al., 2011). Drawback of the analysis is that the number of variables used is rather small. Snow is only measured by the amount which has fallen in a year. House characteristics which are included were floor space, age and the distance to the nearest cabin. The only ski area element which is included is the lift capacity. Therefore, this analysis could suffer from omitted variable bias. Besides, the study is conducted in a different part of the world, which could cause that people have different perceptions with respect to snow and winter sports, compared to Swiss people. Therefore, the willingness to pay could be different between those regions.

No other article examines this field of study that closely. In many studies snow and climate change are not linked to house prices. Feng & Humphreys (2012) did not consider snow affecting residential property values, but the price effects of sport facilities, such as soccer fields and public swimming pools available in the neighbourhood. The outcome of the paper is that there is a positive relation between the available sport facilities in the neighbourhood of a house and its value. In order to be able to make use of snow, also certain facilities are needed, such as ski cabins and prepared slopes. Other journal articles did not take property values into consideration but some have measured the willingness to pay for snow. Falk (2008), Fonner & Berrens (2014) and Allessandrini (2013) all applied a hedonic framework on ski cabin prices. All used the characteristics of the resort to investigate the effects. The difference between the studies is that Falk (2008) applied the analysis on Austrian ski resorts, Allessandrini (2013) investigated the subject at places in the Italian Alps and Fonner & Berrens (2014) have analysed areas in the United States. All three studies found rather the same results. Higher capacity and more luxury ski cabins are appreciated by skiers. Furthermore, ski resort characteristics do matter and snow conditions are important for determining ski ticket prices. Allesandrini (2013) also introduced climate change in the analysis and found that snow reliability increases the willingness to pay by skiers. The inclusion of the climate change variables is however rather questionable because only the snowfall data of the 2008-2012 winter seasons were used in the model. This is a rather small timeframe for analysing climate change. However, based on this data she concluded that in bad winter seasons, people are willing to pay more for having access to reliable snow. Global warming will reduce the amount of ski resorts where snow is guaranteed and therefore this analysis provided important notions.

Climate change has been the subject of more related studies. Elsasser & Bürki (2002) investigated the effects of it on tourism in Switzerland. They found, with the help of future temperature predictions, that the number of ski resorts which could be treated as snow reliable will deteriorate in this century. Falk (2010) investigated the same subject in Austria, but in this study the analysis is based on panel data from 1986 until 2006. Based on the number of overnight stays, the study concluded that per capita spending is higher in high-elevation resorts, than in lower ones. Besides global warming, other effects do also influence tourism in mountain villages. Marcelpoil & Francois (2009) studied the demographics of several resorts and found that densely populated areas are more popular to visit. The connection between this finding and housing values has not been made in the paper, but spatial theory predicts that house prices will be higher in those resorts (McCann, 2013).

Altogether, there have been several studies which touch upon the subject of this paper. The study of Bustic, et al. (2011) is considered as the most related one because this research investigated both the effect of climate change and snow on residential property prices together. Other papers also made a contribution on the subject but none of them was covering all related concepts at once. Therefore this study is innovative, because it has never been investigated how snow and climate change are influencing residential properties in the Swiss mountains.

Overall, the mechanism which determines the price of a good is the one of demand and supply (Wetzstein, 2005). It is possible to analyse which factors influence this process by using models which use an OLS regression method. Rosen (1974) introduced the hedonic model, for example. It measures the contribution of the characteristics of a good to its price (Renda, et al., 2013). In other words, it examines how much someone is willing to pay for a certain characteristic of that particular product. Pace et al. (1998) used the method somewhat differently. Instead of controlling for a certain spatial level, a spatial lag of the dependent variable from the closest neighbour in the sample is added to the model. This is a more accurate method, while still taking characteristics with respect to location, such as population elements, into account. This implies that important underlying concepts, such as job opportunities, available services and natural characteristics in the neighbourhood are considered by the model. Therefore, this method is also applied in this study.

2.2 Theoretical information

2.2.1 Snow accessibility

For the purpose of this study it is not sufficient to measure the amount of snow which has fallen in a certain area. The snow should be both accessible and useable; otherwise most people do not receive enough utility from it, to use it as a determinant in the decision of the location of their house. Therefore, a new concept called snow accessibility is introduced in this study and it is applied to the ski areas in the country. It is linked to those regions because, within the Swiss mountains, satisfaction from snow is especially received by practicing skiing or snowboarding; those sports are by far the most practiced ones in those areas (topendsports, 2015). The definition of snow accessibility is as follows: Accessible snow is snow which can be used and accessed easily. The degree of how accessible the snow is depends on five factors.

First, the reliability of snow in the neighbourhood is of importance. If snow is guaranteed for a certain area, it is more likely that people will choose to live or book their holiday in that area. Altitude is the main factor which influences the reliability of the snow because the main rule is that at a higher altitude temperatures are lower.

Second, the degree of snow accessibility is affected by the distance towards the snow. This implies that roads towards a ski cabin, or slope, are important. If this distance is larger, the utility of using snow decreases. Travel time, crowds in the areas towards the snow, possible petrol costs and potential parking costs deteriorate the satisfaction of the snow experience. Therefore people are not willing to pay as much as if the property would have been located closer to the snow.

Third, the size of the snow area is an important factor. The bigger the size, the more utility is received, because the capacity of the snow zone and the diversity of the area will both increase. Altogether this implies that more and different types of skiers are attracted which enlarges the number of services in the ski area to make the snow experience more comfortable.

Fourth, the price which has to be paid to access the snow is influencing the degree of snow accessibility. Having to pay large amounts of money to be able to access the snow will deter people to ski at that place. Therefore, higher prices also have the possibility to lower property values, because less people are likely to look for a house at those ski resorts.

The last factor which has an effect is the time period at which snow is useable. This refers to both the opening hours of the ski cabins and the duration of the season. The longer an area is open during a day, the larger the possibilities of people to make use of the snow. Furthermore, the length of the season gives people the possibility to ski for a longer period and sometimes even for the whole year. For some people this could be an extra determinant in their decision to settle at a certain place.

2.2.2 Ski resort information

The reputation of a ski resort is also influencing property values. Vanat (2014) found that foreign tourists focus on a limited amount of ski resorts while booking their holidays. People especially prefer the famous locations because they have gathered a good reputation considering several important aspects, such as snow quality and slope characteristics. Therefore, the demand for houses in those areas is higher than in other villages. Next to those highly appreciated resorts, some areas are also preferred because of its luxury status. At those places, the rich and famous, from especially other countries, have settled themselves. They came to these mountain villages because of the convenient banking rules, the tax system and the opportunity to stay in an environment at which they are not been treated as a public good. While choosing the location at which they were willing to buy a property, they took into consideration that other wealthy people were also living there. Therefore, it was ensured that the standards of living were high enough, so that it met their current living style. So, within those villages life is exclusive, as it is also possible to ski or snowboard in the neighbourhood. Therefore, the property values are higher than in other ski resorts. Besides, they are also higher in order to make sure that only the rich and famous can afford it to live over there.

Specific features of a ski area, such as the difficulty level of the ski slopes, are also important for this study. Based on factors such as the overview, the steepness, and the average snow conditions of the hill, a colour is given to a slope. Blue is considered as relatively easy, red slopes have an intermediate level and the black slopes are the most challenging. Within the ski industry it is accepted that there are mainly three types of skiers (Skis, 2012). The first class is skiing cautiously and they prefer easy slopes. The second type has moderate skills. Many skiers belong to this category and they are kind of indifferent about the difficulty level. So they are seen as all-rounders. The last group has an aggressive style, wants to reach high speeds and likes to ski individually or in small groups.

Pawlowski (2011) showed that the ticket prices are not only influenced by the size of the ski area, but also by other characteristics. Having enough places where people can relax, having faster and more luxury cabin equipment, or having a snow fun park[3] increases the price for entering the ski area. So, ticket prices also represent the available facilities within the area and not only the size of it. The OECD (2000), has also acknowledged this, by advising Swiss ski resorts to keep innovating themselves, in order to keep their comparative advantage. Doing so, some threats will be combated too. Therefore, the OECD explicitly advised to increase the supply level, by implementing the use of artificial snow. This innovation ensures that there is almost always snow available at 2°C, instead of the regular 0°C (OcCC, 2007). Therefore, many ski resorts have implemented this innovation in recent years. It should be noted that they have not equipped all their slopes with the infrastructure to produce artificial snow, which reduces the supply of slopes considerably during bad weather conditions.

Attitudes towards artificial snow are not negative, although the snow quality is not as good as natural snow. Pütz, et al. (2011) investigated the perceptions about this snow type by asking the opinion from people at different resorts. Only 3% of the participants answered that snow conditions were important for choosing their ski destination, while 88% stated that they choose their location based on the likelihood of having snow. So, research has shown that people do not mind skiing on artificial snow, as long as they are able to exercise winter sports. The disadvantage of this innovation is that the investment is quite expensive (OcCC, 2007). Many cantons therefore subsidize ski resorts when they want to implement it. Some small ski resorts located at low altitudes will not be able to earn their investments back in time (Gonseth, 2008). This is also true because the process of making artificial snow is expensive too and global warming will increase the total expenditures further. As small ski resorts at low altitudes are already not that touristic, it is economically insufficient for them to do such an investment. Other resorts can earn their investments back. This will be partly done by raising ticket prices. This is not a problem because people are willing to pay for having more reliable snow conditions, independent if it is artificial snow or not (Pütz, et al., 2011).

2.2.3 Swiss property market & general background

Constantinescu & Francke (2013) have studied multi-family rental properties in Switzerland and they found that the market is behaving in line with the macroeconomic environment in the country. In most other western economies the residential property market is characterized by the same patterns. Above, rather similar countries tend to have quite identical property markets both with respect to the behaviour of the market and the determinants of the value of the property (Égert & Mihaljek, 2007). This implies that previous literature concerning the determinants of house values is plausible to apply.

[3] A snow fun park is a place where both skiers and snowboarders have access to custom designed snow attributes, such as half-pipes.

Many studies have provided evidence of which characteristics are influencing the residential property values. Grether (1974) and Richardson, et al. (1974) provided evidence that floor space is one the most important determinants. They also showed that the number of rooms of a property and its size of the garden or balcony is having a contribution. Richardson, et al. (1974) further found that the property type does matter. Besides, age is also accepted as a determinant (Rubin, 1993). Having a swimming pool, also positively affects the value of a house (Goodman & Thibodeau, 2002).

Next to the specific characteristics of a house, also the geographical aspects contribute to the value of a house. The location of the property is the most important one with respect to this category. Visser & Dam (2006) found that controlling for a specific spatial level is considerably improving the predictability of house prices. This is because it covers the characteristics about that region, such as the population density, which is directly related to for example, job opportunities and the amount of services available in the neighbourhood. Such criteria are important for property owners. Wheaton, (1977) already provided evidence for this by analysing the subject with the bid rent theory.

Next to the similarities between the Swiss housing market and that of other western economies, there are also differences observable. One of them is that the Swiss residential properties are more often used as investment good than in other countries.[4] The banking system of the country is one of the main reasons for this. Another explanation is that the Swiss real estate market is seen as a stable one. During the recent economic crisis the country performed better than other European countries (Rilsa, 2015). Another difference is that the value of the residential properties has been traditionally high in Switzerland compared to the rest of Europe (Rilsa, 2015). The main reason for this is that income levels are high in the country (Blank, 2015). According to Eurostat (2014), Switzerland has the highest average salaries of all European countries.[5] Other reasons for the high property values are the low interest rate of last years (Credit Suisse, 2015), the increased immigration over the last decade (Crédit Agricole, 2012) and the supply characteristics in the mountain villages (Henderson, 2013). This last reason also explains the existence of the shortage of houses in mountain areas. The strict rules regarding the possession of second homes by foreigners and the related planning restrictions causes this scarceness on the property market (Expatica, 2013).[6] It is therefore not common to negotiate about the asking price in the mountain areas (Financieel Dagblad, 2009).

Some people do think that, because of the characteristics of the Swiss residential property market, a real estate bubble is apparent in the country. Ardila et al. (2015) have analysed the market to investigate if it is observable. They took all districts in the country into account but no clear evidence was provided that such a bubble exists. Some districts are however suspicious.[7] Only two of them are located close the mountain areas of the country, but they are located at the edge of the Alps.

Next to the characteristics and information of the Swiss property market, also some general background information of Switzerland is necessary to get a sufficient understanding of the determinants of Swiss property values. With respect to the location, Switzerland is dividable in three different areas; the Alps, the Jura and the Plateau. This division is based on the geographical

[4] The parts of the country where the mountains are observable are mainly used for investment purposes. At those areas most of the foreigners are situated too. Therefore the mountain areas are characterized as the most diverse with respect to the population. Within the main ski resorts this observation is the most clear. The native Swiss inhabitants are sometimes a minority compared to the foreigners who are represent in those areas.

[5] This is also the main reason why Switzerland is seen as an expensive country

[6] The restrictions concerning the foreigners which like to buy a house differ per canton. In almost all mountain areas it is however the case that people without the Swiss nationality can only buy a house from foreigners. This is the case because those properties have a so-called permit. If such a house is sold to a Swiss residential, the permit expires. In some regions there is also the possibility to get such a permit if they are buying a house from a Swiss person. This option is not that suitable and there is a restriction on the number of such transactions per year in all cantons. Therefore long waiting lists are apparent in the regions where this is possible.

[7] A geographical representation of those bubble districts could be found at the appendix in figure 3. Those districts which should be watched are not as suspicious as those which should be monitored.

Figure 1: A geographical map of Switzerland. *Source: STF*

characteristics of the area with respect to its natural assets and specifically its elevation[8]. In figure 1 those different areas are clearly visible. The Alps are located in the south of the country. Altogether this region covers 60% of the total county's surface (FDFA, 2015). It is characterized by its rough nature and famous mountains at which the main ski resorts are located (Alpenwild, 2015). The population density is the lowest of all three regions, because of the rough nature of the area. Figure 1 visualizes this; no big cities are located in the Alps.[9] Altogether, the general pattern in this region is that the valleys are the most populated and therefore most services, such as hospitals, cinemas and supermarkets are apparent over there. The ski resorts have somewhat less services available, but still enough to gather the necessities of life. The parts in between the valleys and the ski resorts are far less populated and travel time towards the basic facilities in life are much higher.

The Jura region is the smallest part of the country and is located along the north-west boarder of the country. It is the smallest geographical part of the country; it consists of only 10% of the national surface (FDFA, 2015). The area has a fairly low population density but it is somewhat higher than in the Alps. This is because the elevation levels are much lower in this region. Within this area, there are some ski resorts located, but those are much smaller than in the Alps and snow conditions are worse. Therefore, winter sport tourists often times ignore this part of the country.

The last part of the country is situated in the north. It is called the Plateau and it has a surface which is about one third of the whole country (FDFA, 2015). Population density is the highest in this area, as the big cities of the country are situated in this part of Switzerland. Two thirds of the population is living in the Plateau (Swissinfo, 2015b). Elevation levels are fairly low and not much infrastructure is available to practice winter sports.

Another important geographical aspect of the country, related to location, is that there are four main languages spoken.[10] It differs per region which native tongue is used. 63.7% of the population speaks German, 20.4% French, 6.5% Italian and 0.5% Romansch. (Swiss Federal Statistical Office, 2015b). All these languages are spoken in the mountain areas. As Italian, French and German are important languages in the world and as they are spoken in the neighbouring countries, it does not affect the attraction of tourists to those regions. The same is true for the parts where Romansh is spoken. Tourists do not bother about the language difference and remain visiting this area as much as the others in Switzerland (Europeforvisitors, 2015). This is because Romansh shows similarities with Italian. Furthermore, some famous ski resorts are located in the areas where this language is spoken. One of them is St. Moritz, which organized the Olympic winter Games two times.

2.3 Global warming

Ski resorts are extremely vulnerable for climate change (CH2014-Impacts, 2014). The fact that cabin tickets only represent about 15% of the daily tourist expenditure, makes this clear (Gonseth, 2008). Without any interventions which help to overcome the problems of global warming, it is accepted that the Swiss mountain villages will change; and so will its property market. It could however be that innovations, such as artificial snow are sufficient in combatting the temperature increases of the next decades. To analyse this, it is important to discuss some basic theories, historic data about relevant global warming indicators and their future predictions.

An important concept for this study is the snow line. It is defined as the boundary at which an area is covered by snow for more than 50%[11] (Kleindienst, et al., 2000). Below this altitude it is

[8] The geographical map of the country is shown in figure 1. It provides an overview of the elevation in the country. Furthermore it gives a broad view of the population density over the areas in the country.

[9] Figure 1 in the appendix gives an overview of the population density of country in 2010. It is clearly visible that the Alps are the least populated region. The only two parts which have a somewhat higher population density are the Rhône valley in the south east of the country and the area around Lugano. The Jura is somewhat, but not much more populated. The Plateau is by far the most populated region of the country.

[10] A graphical overview of the main languages spoken in Switzerland is observable in figure 5 in the appendix

[11] A schematic view of this definition of the snow line could be found in figure 2 in the appendix.

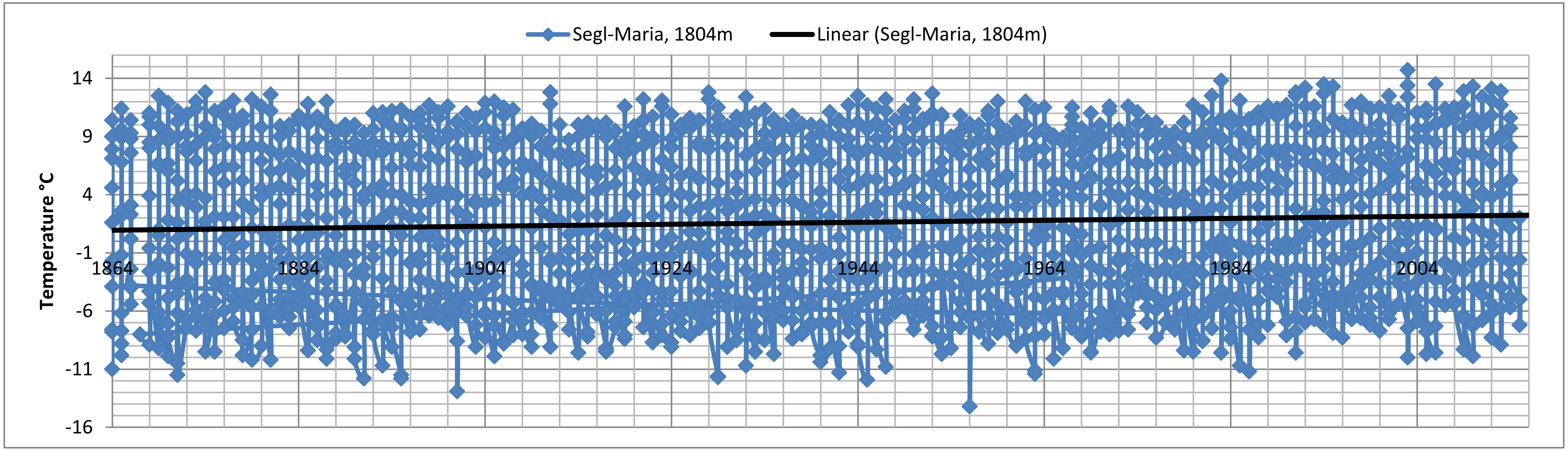

Figure 2: An overview of the average temperatures per month in Segl-Maria. *Own adaptation*

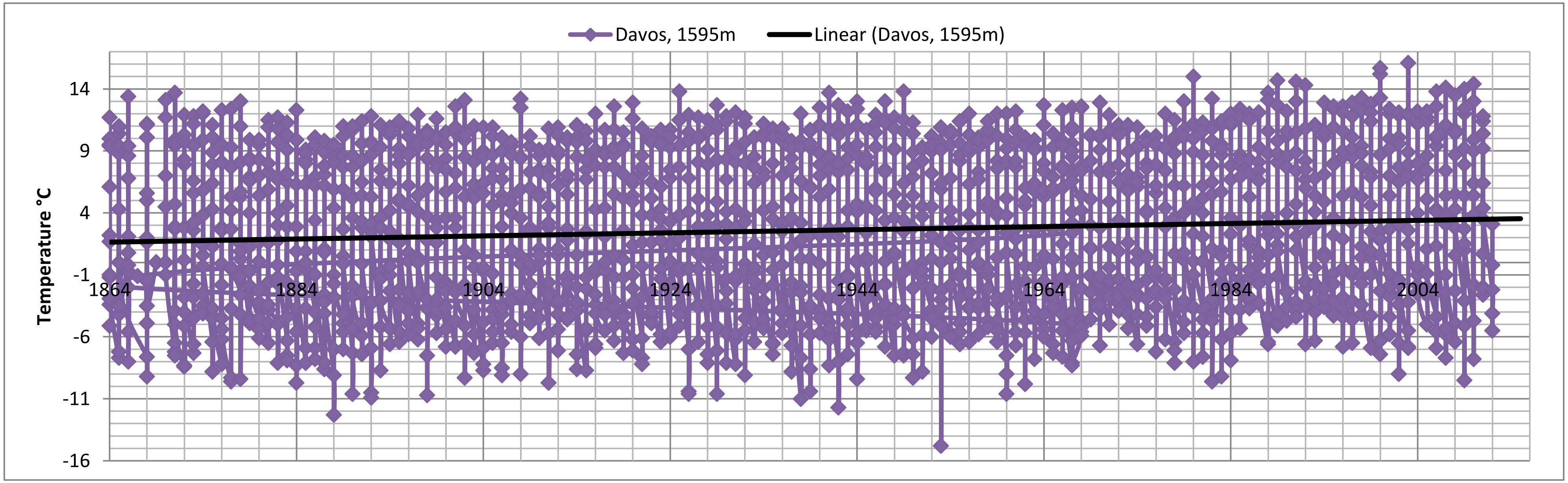

Figure 3: An overview of the average temperatures per month in Davos. *Own adaptation*

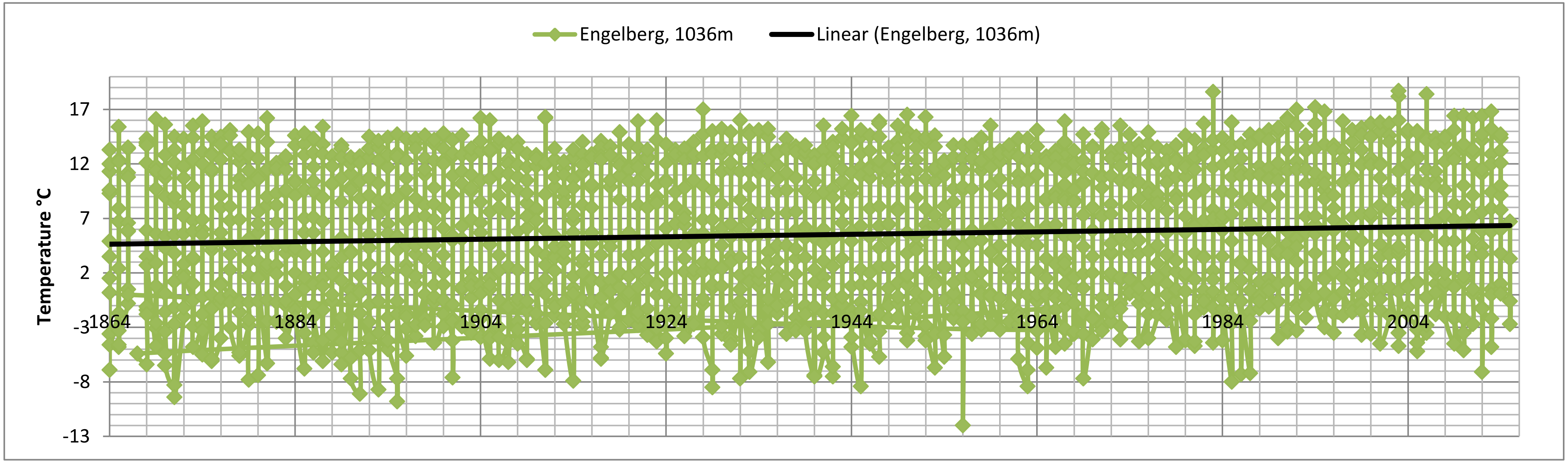

Figure 4: An overview of the average temperatures per month in Engelberg. *Own adaptation*

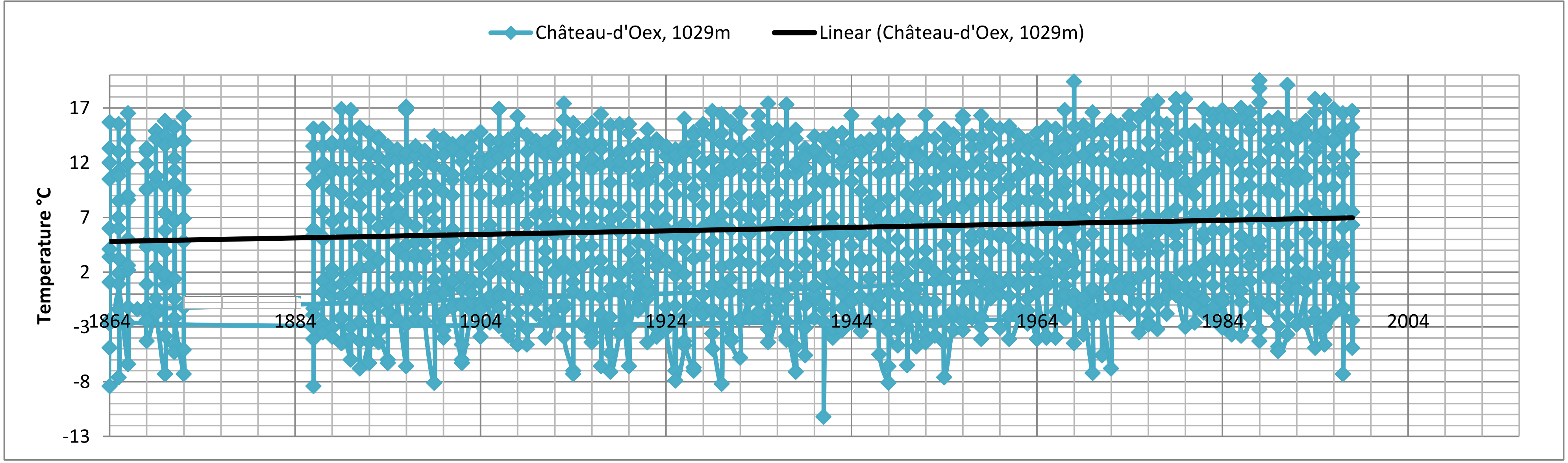

Figure 5: An overview of the average temperatures per month in Château-d'Oex . *Own adaptation*

impossible to ski or snowboard. For practicing those sports, 30 centimetres of snow is required (SLF, 2015). Therefore, the reliable snow line concept is of greatest importance to this study. It is the snow line at which a minimum snow cover of 30 to 50 centimetres is present for at least 100 days during the period from December 1st until April 15, for at least 7 out of 10 winters (Elsasser & Messerli, 2001). If a ski resort is situated at an altitude above this line, it is much more attractive to tourists and Swiss people which have to travel before they can have access to the snow. Therefore, it is this concept which is taken into account, in this study, to analyse if the property market is affected due to global warming, in mountain areas, or not.

Historic data needs to be analysed to find the main factors, which influence the reliable snow line. The Swiss meteorological office publishes data from weather stations within the country. Four of them are located in the Alps and one of the affairs they are measuring is the average temperature per month, which is done since 1864 (MeteoSwiss, 2015).[12] This information is represented in figures 2-5.[13] Overall, they show some clear patterns. First, the average temperature is indeed rising over the years, which is shown by the black trend lines. Second, the total average temperature increase is rather the same, between the meteorological stations.[14] Third, the highest peaks are observed during recent years while the lowest average temperatures are observed during earlier periods. Fourth, analysing the weather stations of figure 4 and 5, which are located at nearly the same altitude, no clear evidence is found that significant regional differences do exist.[15] Previous studies have found divergent outcomes based on the idea that there are regional differences apparent.

Next to analysing temperatures, snowfall is also an indicator which is often times used to prove the presence of global warming. A study based on data from 1860 until 2005, found that the average snow decrease was nearly 0.22 cm a year (Seiz & Foppa, 2007). This indicates that nowadays, almost 32 centimetres less snow is falling compared to almost 150 years ago. Although the average annual amount of snow is about 4 meters, this still represents a drop of around 7.5%. Other studies analysed the subject differently. Latersner (2002) investigated the snow depth[16] from 1931 until 2000 in Switzerland and found some clear patterns.[17] First, a good winter with respect to snow depth, does not lead to the same conditions in the next year. Second, when several years are grouped together, it is observed that the periods with above average snow depths are found during two time periods; the late 1960s and from the late 1970s until the middle 1980s. Bad snow conditions are found in other periods. The most recent years included in the study, show a considerably long time period of bad snow depths and those years are extra special because the snow levels are the lowest ever observed. Third, comparing the findings of Latersner with figures 2-5 in this study, it appears that winters with high temperatures have on average low snow depths. The opposite is also true.

Analysing the size of the glaciers in the country also indicates that temperature increases are playing the biggest role in the changing snow conditions. In the period 1890-1980 the glaciers

[12] The four stations are: Château-d'Oex, Davos, Engelberg and Segl-Maria. Only the Château-d'Oex station has not been used during the whole period, which is 1864-2015. That is why figure 5 has some gaps in the representation

[13] The stations are ranked based on altitude. The highest located one is presented first. This is Segl-Maria. Afterwards the second highest is presented and so forth.

[14] The differences between the beginning and the end date of the trend lines are rounded: 0.9°C for Segl-Maria, 1.3°C for Davos, 1.2°C for Engelberg and 1.3°C for Château-d'Oex.

[15] Both stations, which represent figure 4 and 5, have a rather similar temperature increase. In 1864 both locations had an average temperature of about 4.9°C and in 2000 it increased to 6.5 °C in Engelberg and to 6.6°C in Châteux-d'Oex. Peaks are occurring at different dates, but the overall pattern seems rather similar. Although, the highest and lowest peaks are observed at different years, the average temperature increase is rather the same.

[16] Snow depth is the total depth of both old and new snow on the ground

[17] The patterns are visualized in figure 7 in the appendix. It shows the deviation from the average snow depth per year, for the period 1931-1999.

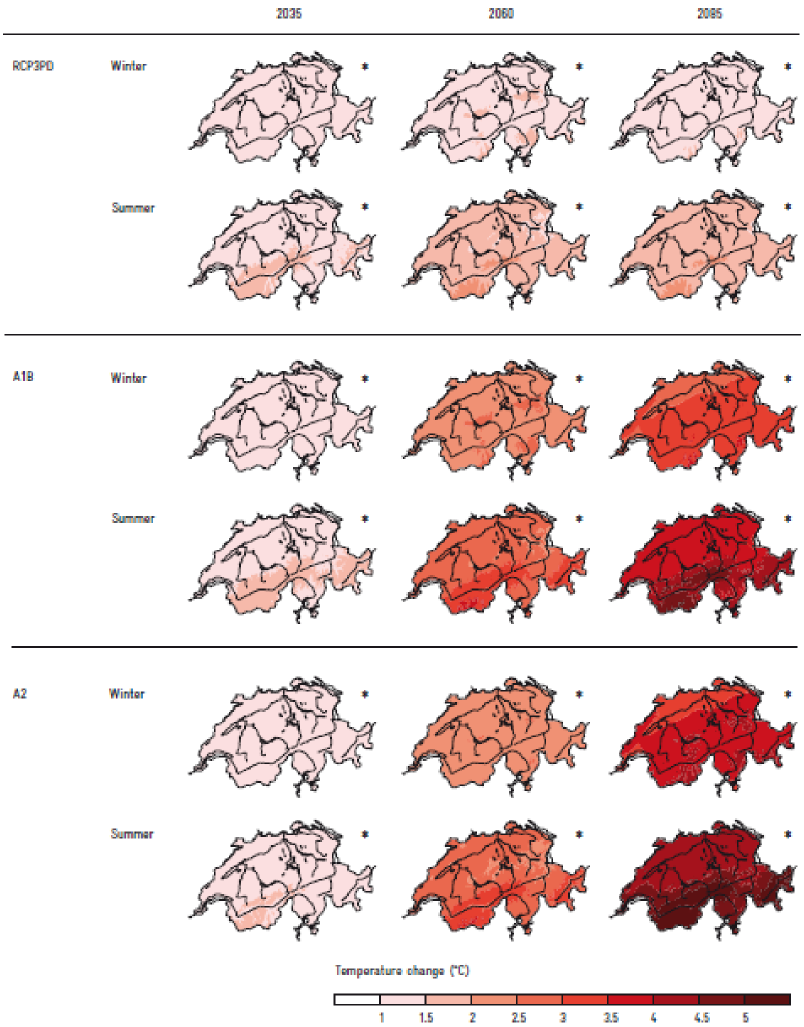

Figure 6: Temperature increases for the different climate change scenarios for three periods of this century.
Source: CH2011-Impacts

in the Alps lost 30-40% of their area and about 50% of its total mass. In the period 1980-1995 another 10% of the remaining part has vanished (Climate adaptation, 2015). Comparing this tendency with the trend lines of figures 2-5, it appears that the temperature is also the main determinant which causes the glaciers to decrease. Overall, it is therefore valid to work with future temperature increases in order to predict future reliable snow lines.

To do so, it is important to know the relation between temperature and altitude. Weather specialists proved that the temperature declines by 6°C, if one is at a 1000 meter higher altitude (On the snow, 2011). Other specialist agreed, by stating that at a nice weather day, the temperature decline per 100 meters is between 0.5 and 0.6°C (Bergbahnen-werfenweng, 2015).

Hantal & Maurer (2011) found that the snowline in 2000 was equal to 641 meters. During the last fifteen years this threshold has been raised. As the average temperature increase per decade is 0.14°C (Climate adaptation, 2015), it is therefore expected that it increased by about 35 meters. To fulfil the requirements of the snow reliability concept, this altitude should be further increased by somewhat less than 100 meters (Hantel & Maurer, 2011). Therefore, when rounding[18] at 50 or 100 meters is applied, it is acceptable to set 750 meters as altitude of the current average reliable snow line.[19]

[18] Rounding with respect to snowlines will always be done on 50 or 100 meters in this study.

[19] The 750 meters reliable snow line was already rounded up. Since 0.14*1.5 is equal to 0.21°C the snow line would probably have went up by 35 meter. So to be accurately the average reliable snow line would be: 641m + < 100m + 35m = < 776 meter. So rounding to 750 meters is fine.

Future predictions, with respect to temperature increases and the magnitude of it, are made by several studies. The precise effects are however difficult to predict because climate change is dependent on many variables. The most important one is the level of greenhouse gas concentration in the atmosphere (EPA, 2015). Therefore, three scenarios have been estimated for this century in Switzerland, which are called: RCP3PD, A1B and A2.[20] The implications of them are analysed at three future clustered time periods: 2020-2049, 2045-2074 and 2070-2099[21]. This has been done because this time period is scientifically accepted for analysing climate change (CH2014-Impacts, 2014).

In figure 6, expected future temperature increases are visualized for both the winter and summer season. Some minor regional differences can be observed, but it is assumed that they are not apparent in this study. This is because researchers do not agree if it is present and the predicted temperature differences, in figure 6, are not known for each specific village. It is visualized that the first scenario, RCP3PD, is the most positive scenario for ski resorts. This is because it predicts that the rate of greenhouse gasses will decline in the near future. The temperature will, however, still rise by about 1°C this century, according to these estimates. This reveals the evidence that global warming is irreversible. The second scenario, called A1B, is the moderate one. The A2 scenario is the most extreme one. It predicts temperature increases during the winter season of almost 4°C in 2100.

With this information, future reliable snow lines are calculated and they are shown in table 1. [22] It is clear that the further ahead, the more divergent the results are. By the end of this century it will not be possible to ski or snowboard below 950 meters, for more than 100 days, during 7 out of 10 winters. In the most extreme scenario, the cut-off point is at 1400 meters, which is an increase of 650 meters compared to the current reliable snow line. This will have a massive impact on the regions which do not have snow guaranteed any longer. Some ski resorts will disappear and some will be only open when snow conditions are sufficient. This implicates that foreign tourists will stay away from those destinations. In the end, winter resorts will, as a consequence, be clustered (OcCC, 2007).

Artificial snow could be an innovation which will be a solution for some ski resorts. If this technology is apparent the reliable snow line decreases with 333 meters. The new decisive altitudes are represented in table 1 for the different scenarios and points in time.[23] Altogether, the results show that having no facilities to make artificial snow is dangerous for many ski resorts. Using this innovation will however be probably not enough to keep the reliable snow line at the current level. Only in the most positive scenario the reliable snow line, with artificial snow, will decrease compared to the current cut-off point.

Overall, the discussed future temperature increases, will also cause that snow abundant winters will become incidental in the moderate and extreme scenario, next to the change in reliable snow lines. They will not disappear totally, but the chance of having one is reduced to 5% in 2100. (Beniston & al., 2011). At that same time, glaciers will have lost 90% of its volume (CH2014-Impacts, 2014). Some will disappear and the ones left will only have a small ice mass above the altitude of 3000 meters (CH2014-Impacts, 2014).

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[20] The underlying assumptions from the scenarios about the level of greenhouse gas concentration in the air could be found in figure 4 of the appendix. Source: CH2011-Impacts (2011).

[21] While discussing the predicted future impacts, the mean of those periods is often used. This implies that 2035 belongs to the first clustered group, 2060 to the second and 2085 to the last one.

[22] Calculations for the new snow lines could be found in table 5 of the appendix. They are rounded to the closest 50 meters.

[23] The Art. S. Abbreviation stands for Artificial snow Scenario. It means that if the village could make use of artificial snow facilities the reliable snow line would be at this level.

Future reliable snow lines						
	2035	2035 Art. S.	2060	2060 Art. S.	2085	2085 Art. S.
RCP3P3	900m	550m	950m	600m	950m	600m
A1B	900m	550m	1150m	800m	1250m	900m
A2	900m	550m	1150m	800m	1400m	1100m

Table 1: New reliable snow lines based on different climate change scenarios and both natural and artificial snow

3. Data & Methodology

3.1 Dataset

The dataset used in this research has been especially constructed for the purpose of this thesis. This approach has been chosen because no useful transaction data of Swiss residential properties was available. Therefore, an alternative plan had to be considered which resulted in the unique dataset. It has been chosen to analyse current real estate advertisements in order to gather the necessary information about the value of the properties and their characteristics. This is a method which has been used more often in related studies. Asking prices are seen as a surrogate for transaction prices and therefore it is accepted to use this approach (Rodriquez & Mojica, 2009). Besides, using this kind of data is also appropriate because of the scarcity on the Swiss housing market in the mountain areas.

In order to avoid time differences in the dataset, all observations are gathered at the same point in time. Several thousand online residential property advertisements were saved at the same moment and analysed afterwards. So the time differences which are notable in the dataset are negligible; some properties may be for sale for just one day, while others are already on the market for a longer time period. The properties which are already for sale for quite a while, should however, make sure that their price is still in line with the market.

The final version of the dataset consists of information from 3691 observations, after the removal of the outliers and the withdrawal of the houses from which not all the necessary characteristics were known. It has been chosen to include as many potential explanatory variables as possible in the dataset. The information has been retrieved from many different sources.[24] The asking prices and all the house characteristics were collected from online advertisements. Those come from the real estate agents Engel & Völkers, Homegate and Immo-Hélène. Most of the observations are however retrieved from immoscout24.[25] At this source, different kinds of actors are able to publish a residential property. Both individuals and real estate agents are using it. In order to make sure that all properties are indeed reliable and in line with the market, a premium of CHF149[26] per 14 days is requested to make an advertisement visible. This secures that only residential properties are online for which the main purpose is selling. Besides, because of this necessary payment, it is ensured that the main suppliers of residential properties are real estate agents. As ImmoScout24 is the most popular and well-known online source of property advertisements, many brokers have chosen to also show their properties over here.

Next to the property information and characteristics, other potential control variables are withdrawn from the national statistical office. The population data of the municipality, district, and canton at which a certain property is located, is retrieved from this source. This information is not

[24] An overview of all included variables in the dataset, together with their source could be found in table 1 of the appendix

[25] The URLs of the websites from which the online advertisements are gathered are: http://www.engelvoelkers.com, http://www.homegate.ch, http://www.immo-helene.ch & http://www.immoscout24.ch.

[26] CHF is the worldwide used abbreviation for the Swiss Franc

available for villages. In order to have an alternative, it has been investigated, with the help of Google maps, how many supermarket concerns are observed in a particular village.

The data about the snow characteristics of the property has been observed with the help of four sources. First, Google Earth provides the information about the altitude at which a certain village or property is located. This will be an important indicator for the snow reliability of the ski resort. The elevation of the village has been measured by considering the middle of the village. If possible, the altitude of the property has been investigated by studying the location, with the exact address. If the precise location was unknown, the elevation of the village was used because this information is a good proxy.[27] This had to be done for almost half of the dataset because many online advertisements were not providing the exact address of the property.

Second, the ANWB route planner has calculated the distance towards the snow. The use of this planner is valid because it is a well-known company which also has access to all road maps in Switzerland. Again, the proxy has been used, if the address of the house was not known.

Third, Bergfex provides the necessary information about the ski resorts to which a property belongs.[28] It is a source which offers information about many characteristics of all the winter sport areas, in several countries over the world. The facts, which it for example provides, are: the number of cabins, the number of slopes together with its difficulty level and their size, the length of the ski season and the different ticket prices.

Finally, several online articles provided the dataset with information. The Telegraph announces the best Swiss ski resorts every year and the information of the 2014-2015 winter season is included. Besides, to determine if a village has a luxury status, two articles are used together.[29] Only if both sources proclaimed that a town is luxury it is included as such a place.

The approach used to link a property in the dataset to a certain ski resort is as follows: if a property is located within a village where it is possible to get access to a ski cabin or slope, it is linked with that particular area. If none of them are available in the city it has been analysed which ski resort was located the closest from that village, no matter the size of that area. This implies that the assumption is made that house owners only go skiing in the nearest ski area and that they are not switching between resorts. Not all ski areas which are located in Switzerland are taken into account. Though, it has been made sure that villages are only linked to a certain ski area if that one is indeed the closest. In the final dataset, 88 out of the in total 211 ski areas are inserted.[30] This is because some ski resorts are dividable into a couple of smaller ski areas. This implies that if you buy a ticket for a smaller ski area, you will only have access to a certain amount of cabins. In this study, it is assumed that everyone buys a ticket for the biggest ski area in the region. This is because people will have better accessibility if the snow area is bigger. Furthermore, it has been chosen to focus on the Alps in the dataset, because this region is mainly used for practicing winter sports. In the Jura, the importance of the industry is minor and far less tourists visit this part of the country. So, the majority of ski resorts in the country are included.

A last note is that it is unknown, for many properties in the sample, if it contains a permit, so that it could be sold to foreigners. Therefore, it is assumed that it does not affect house prices.

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[27] For a property to be inserted in the dataset of this study, all necessary information for the analysis should be observable. The absence of the exact address of a certain property is the only exception. For almost half of the houses this information was not observable. The information, related to the address, is too important to leave it out of the study. Above, using a proxy is a suitable alternative and should provide the study with no significantly other results, compared to a case were all exact addresses were known.

[28] It has been chosen to relate snow accessibility only to ski resorts. Skiing, snowboarding and other snow sports which could be done by accessing a ski area are the most practiced winter sports in Switzerland and in the world as a whole. Skiing is by far the most popular winter sport in Switzerland. This assumption makes the analysis more clear.

[29] Those sources are: http://www.luxuryskitrips.com and http://www.aluxurytravelblog.com

[30] An overview of all 211 ski resorts in the country could be found at figure 6 of appendix I.

3.2 Empirical Methodology

Not all data which has been gathered could be included in the analysis. It has been specifically investigated which variables and transformations were needed for the purpose of this study, while the solidness of the spatial model has been taken into account simultaneously. This is also one of the reasons why different models have been constructed in this paper. The asking price of a residential property is the dependent variable of the analysis. This information is gathered from the online advertisements and transformed with the natural log.

The variables which should check the degree of snow accessibility have been deliberately chosen, so that they stay the closest to the theory. To check for the reliability of the snow, the altitude of the property is inserted in the analysis. Next to this raw data, it has also been categorized per 100 meters, so that it is possible to insert it as a dummy variable in the model. The base level is lower than 500 meters, while the highest category is higher than 1900 meters. All the properties which are located on elevations in between are categorized per 100 meter.

The distance towards the snow is measured by three variables. First, it has been investigated if a property is located within a village at which snow could be accessed; this implies that it has been analysed if the village of the property has a ski cabin or ski slope which goes to the town. There has not been made a separation because it is closely related.[31] Many observations have both a cabin and a slope which goes to the village. A small amount has only the opportunity to ski to the village and very few only have a cabin in the village. Second, the distance component is measured more closely by investigating the distance of the properties towards the ski cabin. If it is located next to, or within 100 meters from a ski slope, with the possibility to enter it, the distance is measured towards that slope. Only properties which are located within a distance of 25 kilometres are taken into account, otherwise they are not useful for this study. Properties at further distances are probably not attractive for people who also want to buy it to have access to snow. If someone is living further away it is not likely that he or she is skiing frequently. Third, an interaction variable has been established to control for the difference in price effects, with respect to distance, for ski resorts which are announced to be the best in the country and those who are not. It is very likely that such a difference exists and therefore it is necessary to control for it; otherwise the distance effect cannot be measured adequately.

To check the effect of the size component of snow accessibility, the number of ski slopes has been used in one of the models. This is often closely related to the number of skiable kilometres in the area. However, if a skier has to choose between having more slopes to access and having longer ones, it is assumable that this person will chose the first option. A reason for this is that people would have to wait longer at the less available cabins in the ski area, if they picked the second option. Another reason is that more slopes will imply that there is a more diverse supply of ski slopes. The size of the ski area could however also be measured more closely by also taking the difficulty level of the slopes into account.

The price at which the snow could be accessed is analysed by inserting the one day ticket price for an adult, in the ski resort. All cabins in the country do offer such a ticket and therefore these prices have been used in the spatial model. Including the ticket prices, is however controlling for more than snow accessibility. The prices are based on the characteristics of a ski area. Skiers are for example willing to pay more for reliable snow and therefore resorts with artificial snow equipment can ask higher prices (Falk, 2008). Other examples of facilities which will lead to higher prices are: fun parks, having enough restaurants and rest places, fast and luxury cabins and having transport facilities towards and within the ski village. The main determinant of the ticket prices is the size of the area. This is already included in the analysis but because the correlation between ticket prices and size is not too high, it is evident that the price is

[31] A correlation matrix of the variables could be found table 6 of the appendix

determined by more than size alone. That some of the included determinants for the ticket prices are beyond the scope of snow accessibility does not matter for the analysis because the money still has to be paid by everyone. If it is getting too expensive for some people to go skiing in an area with lots of facilities, they will not spend their leisure time anymore at that resort.

In order to measure the time period component of the snow accessibility concept, two variables are needed. First, having a glacier provides the people living in such an area with the possibility to ski in summer too. This implies that it is possible to ski for much more weeks in those areas than in other resorts. Between the ski resorts without glacier, the length of the ski seasons is not that different. Most places open their cabins in the beginning or middle of December and close somewhere in April. Therefore it is only possible to control for having access to a glacier, which is included as a dummy variable. Second, the possibility to ski in the evening enlarges the time period during a day at which someone is able to ski. As this is not possible in all areas it has been inserted in the model as a dummy too.

Next to the snow accessibility variables, reputation is also included in the model. This is important for mountain villages because it attracts more foreign tourists. The telegraph determines every year the best resorts in the country by looking at ten different categories. This results in ten different best ski resorts for each category (Gill & Watts, 2014).[32] In this study it has been chosen to treat them equally by including them together as a dummy. The same has been done with respect to the luxury status of a mountain village.

Besides the reputation of a ski resort, other control variables with respect to location are included in the model. This implies that, the price of the closest neighbour in the dataset is also a variable which is inserted. This makes the model a spatial one. For those observations without exact address, again the proxy has been used. Next to this, it has been chosen to check for more specific neighbourhood characteristics. Therefore, the population in the municipality is inserted. This should control for job opportunities, available services and the infrastructure quality in the neighbourhood. Municipalities are, however, often fragmented in Swiss mountain areas, indicating that it consists of some villages which are located quite far away from each other.[33] Therefore the number of supermarkets within a village is also included. Having no supermarket in the village implies that a rather large distance has to be covered to get access to the necessities of life and other important services. Next to this it is also included if the village is bordered to water, which means that there is a lake or something similar close by. If a property is located to a small area of water within a village, that particular house is also considered like this, while others in the village are not. This variable is included because people like to have water around in the neighbourhood (Baranzini & Schaerer, 2007). Above, it is appreciated by people to have a view over the water.

All other control variables are related to the characteristics of the properties. The included variables with respect to this are: the floor space, the number of rooms, the size of the balcony or terrace if present, the size of the garden if present, the type of the property and the age of the house. Analysing the data led to the conclusion that this last variable should be transformed. The relation between the age of a house and the asking price is non-linear.[34] Therefore both age and the square of age are included in the model. Other variables measuring housing characteristics were not available for a large group of observations or causing multicollinearity.

[32] An overview of the categories, together with the best ski resorts could be found in table 4 of the appendix

[33] An example of such a municipality is Ormont-Dessous. It consists of six villages: Le Sépey, Cergnat, La Forclaz, La combollaz, Les Voëttes and Les Mosses. The core centres of the village are located at quite a distance from each other. That is also the reason why these villages belong to three different ski areas.

[34] The scatterplot of age related to asking price could be found in figure 7 in the appendix

3.3 Spatial model

With all the discussed variables three different spatial models have been established by using the OLS multiple regression method. It has been taken into account that it has to fulfil the corresponding assumptions. If satisfied, it indicates that the parameters of the model are having the right values, the variance among all these unbiased estimators is as small as possible and the t-statistics could be perfectly used to test the hypotheses of this study (Kerckhoffs, 2013). Only the assumption which states that there should be a constant error variance in the model is violated. Therefore, the standard errors have been made robust in all three models. All other assumptions are satisfied, also the one of no perfect collinearity. It has also been made sure that no multicollinearity is observed in the model. The VIF is used as determinant to include or exclude a variable from the model (Wooldridge, 2009). The cut-off point which is retained is that of 10, or 0.1 if the inverse of the VIF has been applied.

It has been specifically chosen to use a spatial model for two reasons. First, such a model is known as a method which is highly suitable for this kind of studies as it gives clear interpretable results, while also explaining much of the variation. Second, other models which could have been used, could not measure the neighborhood characteristics as detailed as this model does. A hedonic model, with a detailed spatial level, such as the village, as one of the variables, was not applicable because the snow accessibility variables are very specific. They are the same for only a few villages and properties in this sample and therefore correlation would be too high, with misspecifications as a result.

The three models which have been constructed were deliberately chosen. The first model is without the snow accessibility and snow related variables in order to make the magnitude of those effects visible in the other two models. The second regression equation includes all snow related parameters, but they are measured not very specifically. Model three measures some of the concepts more thoroughly. If this last model is written down, it looks like equation (1)

$$LN(ASK)_i = \beta_0 + \beta_1 Z_i + \beta_2 LUX_i + \beta_3 BEST_i + \beta_4 ALT\,Dummies_i + \beta_5\,S\_BLUE_i + \beta_6\,S\_RED_i + \beta_7\,S\_BLACK_i + \beta_7 GLA_i + \beta_8 LN(T\_PR)_i + \beta_9 NIGHT_i + \beta_{10} DIS + \beta_{11} BEST_i * DIS_i + \beta_{12} LN(CL\_P)_i + \mu_i \quad (1)$$

Z stands for the control variables included such as the location characteristics and the elements of the house. The other betas are representing the snow characteristics belonging to the property. LN(CL_P) is the variable which makes the model a spatial one; it measures the price of the closest neighbour in the sample. So it is a spatial lag of the dependent variable. The error term is defined by μ in equation (1). The subscript i in the model stands for the observation.[35] It represents all the characteristics of one of the 3691 observations included in the analysis.

This model and its slightly adjusted forms, should provide evidence if house prices are affected by snow or not. If this is the case, the estimated results will be linked to the global warming theory to analyse the future effects and its implications for the residential real estate market in Switzerland.

3.4 Descriptive statistics

The descriptive statistics of the variables included in the model are represented in table 2.[36] Overall, the data which is used in this study is rather representative. The average price of a house in Switzerland is CHF800,000 (lenews, 2015). In the south of the country property prices are somewhat higher (Credit Suisse, 2015). Therefore, the average asking price of CHF874.427.50 is

[35] i stands for the characteristics of one of the particular observations in the sample. In total there are 3691 observations involved in the analysis. In models with distance involved in it this amount is reduced to 1833. It is represented in all multiple regression models.

[36] The meaning of the abbreviations in this and other tables in this thesis could be found in table 2 of the appendix

Descriptive statistics						
Variable	**Description**		**Mean**	**Standard deviation**	**Minimum**	**Maximum**
ASK	Asking price	CHF	874,427.50	1,011,504.00	65,000	13,000,000
FLR	Floor space	m^2	116.33	68.28	13	695
RMS	Rooms		4.22	1.71	1	10
LOT	Lot size	m^2	345.82	710.82	15	17,615
AGE	Age		28.40	42.60	0	562
SUP	Supermarket		1.66	1.55	0	8
POP_M	Population municipality		4,469.59	3,914.85	28	34,350
CL_P	Asking price closest property	CHF	899,551.52	1,272,959.27	67,000	12,000,000
SLP	Slopes		39.6	38.93	1	285
S_BLUE	Blues slopes		16.24	19.64	1	153
S_RED	Red slopes		17.58	16.25	0	100
S_BLACK	Black slopes		5.78	7.35	0	33
T_PR	Ticket price	CHF	55.69	11.56	24	79
ALT	Altitude	m	1,182.66	396.05	108	2147
DIS	Distance to nearest cabin	km	3.692	4.766	0.01	25

Variable	Dummy		Percentage %	Observations
TYPE	Property type			
APP		Appartment	61.07	2254
CHA		Chalet	29.13	1075
STU		Studio	4.60	170
DUP		Duplex	5.20	192
SWIM	Swimmingpool			
		Yes	2.84	105
		No	97.16	3586
WATER	Property close to water			
		Yes	8.34	308
		No	91.66	3383
LUX	Luxury reputation village			
		Yes	8.45	312
		No	91.55	3379
BEST	Best ski resort reputation			
		Yes	29.07	1073
		No	70.93	2618
SKI_CAB	Skiing until or ski cabin in village			
		Yes	65.00	2399
		No	35.00	1292
GLA	Glacier			
		Yes	8.91	329
		No	91.09	3362
NIGHT	Night skiing			
		Yes	45.57	1682
		No	54.43	2009
Note: N=3691				

Table 2: An overview of the descriptive statistics of the variables used in the model

acceptable, especially because the houses in this part of the country are somewhat bigger than in the rest of Switzerland. The average house in Switzerland has a floor space of 99m^2 (Expatica, 2015). The mean of the dwellings in this study is 116.33m^2. This difference is partly explained by the fact, that the population density is much lower in the Alps. Another reason is that newly constructed houses in Switzerland are bigger (Swiss Federal Statistical Office, 2011). As it has been chosen to analyse properties which are for sale, it is the case that on average more new dwellings are included in the analyses than if transaction prices would have been analysed.[37] Next to the representativeness of the data with respect to house values, the average asking price and its rather big standard deviation provide evidence for the conception that Switzerland is an expensive country and that luxury villages indeed exist.

[37] This fact also contributes to the fact that the average price in the dataset is higher than the average value of a property in Switzerland.

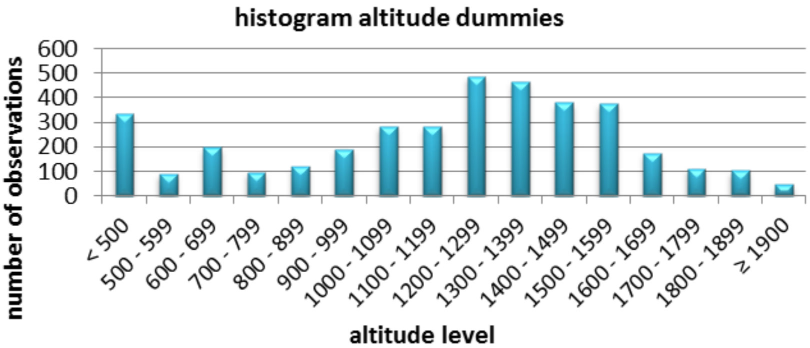

Figure 7: An overview of the distribution of the altitude dummies used in the model

With respect to the other housing characteristics, it is notable that the properties in the model are in about 60% of the cases an apartment. This is because many ski resorts have a large offer of apartment complexes in order to fulfil the demand from foreign people. Those tourists, who buy a house in Switzerland, appreciate the luxury which is related of having an apartment. They like it for example that the route towards the front door is kept snow free and that they do not have to start removing the snow shortly after arrival. As those people often spend only a few days, or weeks, in their house they want to enjoy their holiday as much as possible. Therefore, they prefer to not have to put too much effort in peripheral issues during their holiday.

The snow accessibility variables show also representative descriptive statistics for the winter sport industry, in the country. An average ski resort has almost 40 ski slopes. The red and blue ones are quite equally divided between the different areas. The only difference between them is that blue slopes are always available in a ski resort, while for the red ones this does not has to be the case. This is because the very small areas which only have one ski slope are always having a blue one. Those ski resorts could be seen as practice areas. Overall, the black slopes are far less apparent than the blue and red ones.

The ticket price for the ski regions is between 24 and 79 Swiss francs, with an average of CHF 55.69. There are not that many properties linked with having access to a glacier at which it is possible to ski. This is also logical because in Switzerland it is only possible at five regions to practice winter sports during the whole year. Night skiing is possible at much more regions. In almost half of the resorts people could access the snow also during the evening in the winter season, which is all in line with the average characteristics of Swiss ski areas.

The mean altitude of the properties in the analysis is almost 1183 meters and the standard deviation is close to 400 meters. Related to the altitude, it appears that around 65% of the observations in the sample have direct access to snow in the village. In figure 7, the histogram of the division of altitude is provided. Ignoring the first category, a normal distributed pattern is observable. This is also logical because most ski resorts in the country are located between 1000 and 1600 meters. The category below 500 meters is that high because those properties are located at the bigger villages in the valley. Sometimes a direct cabin goes from those places to the ski area. This is observable in table 3; below 500 meters around one third of the observations have access to a ski cabin in the village. The percentages at somewhat higher altitudes are lower. From 1000 meters onwards at least around two third of the observations have a ski cabin in the village, or it is possible to ski towards the village. This indicates that from those altitude levels onwards, ski resorts are no exception any longer. From 1300 meters onwards more than 75% of observations have direct access to the snow in the own village; therefore at this altitude level ski resorts are becoming the standard; not many villages at higher altitudes are not characterized as ski resort. The same pattern is observed with respect to the distance towards the snow, as table 3 indicates. According to table 2, on average 3.692 kilometers have to be passed before the snow

Average conncetion to snow at different altitude dummies		
Altitude	Skiing until or ski cabin in village (%)	Average distance to ski cabin (km)
< 500	33.53%	9.895
500-599	10.11%	12.322
600-699	13.40%	8.464
700-799	32.63%	8.385
800-899	29.31%	6.190
900-999	51.61%	4.232
1000-1099	65.48%	2.751
1100-1199	65.58%	3.014
1200-1299	70.81%	1.976
1300-1399	76.96%	1.771
1400-1499	79.31%	1.993
1500-1599	88.00%	1.579
1600-1699	87.65%	1.462
1700-1799	86.36%	1.713
1800-1899	89.27%	1.872
≥ 1900	91.31%	1.578

Table 3: Connection to snow for all the altitude categories

could be accessed, which again implies that most ski resorts are situated above 1000 meters. At that altitude level the average distance towards the snow is lower than for the whole sample.

The standard deviation of the distance variable in this study is rather high. The reason for this is that many properties are located within the village with a ski cabin or close to a slope. Therefore they are sometimes closely located to the accessible snow. Many observations are situated at a distance between 0.01 and 0.5 kilometers. Besides there is also a wide dispersion of villages which are further away from the snow. Some are located at more than 20 kilometers of it.

In this study properties of 292 villages are analysed spread over 204 municipalities and 88 ski areas.[38] A geographical representation, of some important variables used in this study, is shown in figures 8-13. [39] In the first three maps, the villages are discussed. In figure 8, all 292 villages, inserted in the dataset are visualized. It is clearly observable that the north of Switzerland is not reliable enough to have ski resorts. From the Jura region only a few villages have been implemented in the study and the properties in the Alps are mostly used in the analysis. It is clearly visible that this part of the country has the highest elevation differences.[40] From the dots in the Alps it is also visible, that both villages from the valleys and from the mountains are inserted in the analysis. The valleys are the parts in between the white areas in the south of the country. The ski resorts are located somewhat higher, closely to those white areas. At that part of the map, where also no dots are observed, the ski slopes are situated.

Figure 9 further highlights the division between ski resorts and the other type of villages. Towns which have no direct access to snow are characterized by a red bullet. The map shows that many of the villages inserted in the sample, are not seen as ski resort. Furthermore, it is observable that the Alps are not that big as figure 8 might have indicated. The dots which are located at the north part of the picture are almost all red. Figure 10 gives an indication of the altitude of the villages inserted in the model. It is clearly visible that the south of the Alps has on average the highest located villages. One reason for this is that there are no valleys in this part of

[38] An overview of the 88 ski areas is provided in table 3 of the appendix together with the minimum altitudes of those ski areas.

[39] Overall, the data is also geographically representative. The 88 ski resorts which are included are evenly distributed over the total 211 ski resorts in the country. This is observable when analysing the dots in figures 8-13 are compared to figure 6 of the appendix. The way the ski areas are chosen also ensures that the ski area characteristics are representative, as the descriptive statistics also show.

[40] If the lay-out of figures 8-13 is compared to figure 1, it is clearly visualized that which parts in the Alps are seen as the valleys, at which places the ski resorts are situated and what the villages in between are in this sample.

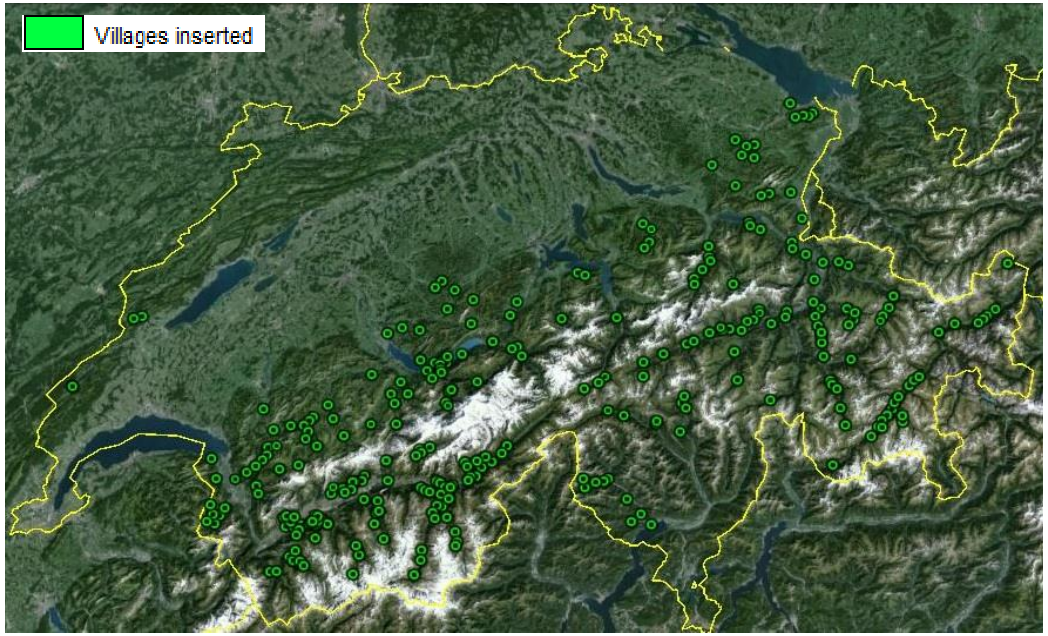

Figure 8: Graphical overview of the location of the inserted villages in the model

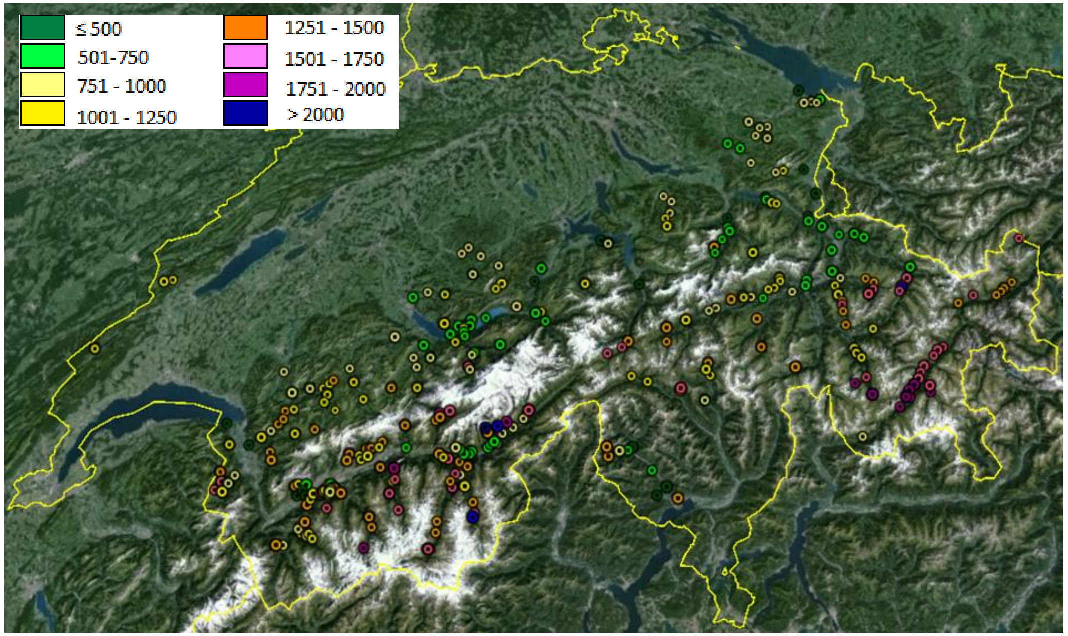

Figure 10: Overview of the altitude at which the inserted villages are situated

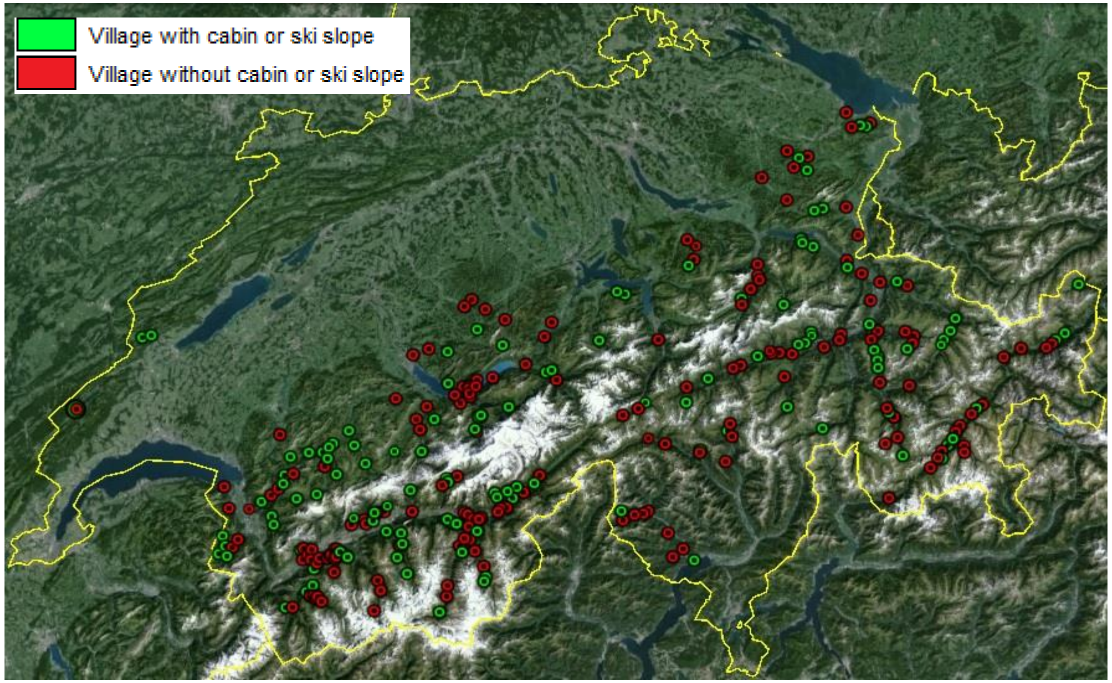

Figure 9: Overview of the villages which directly having access to snow in their own town and those which do not have this

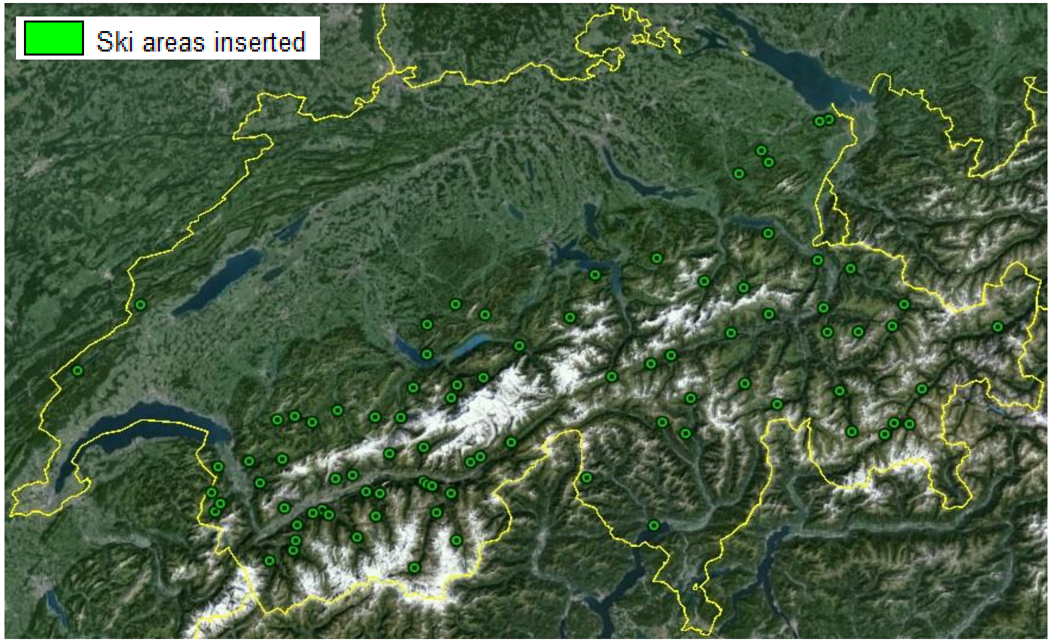

Figure 11: Graphical overview of the ski areas inserted

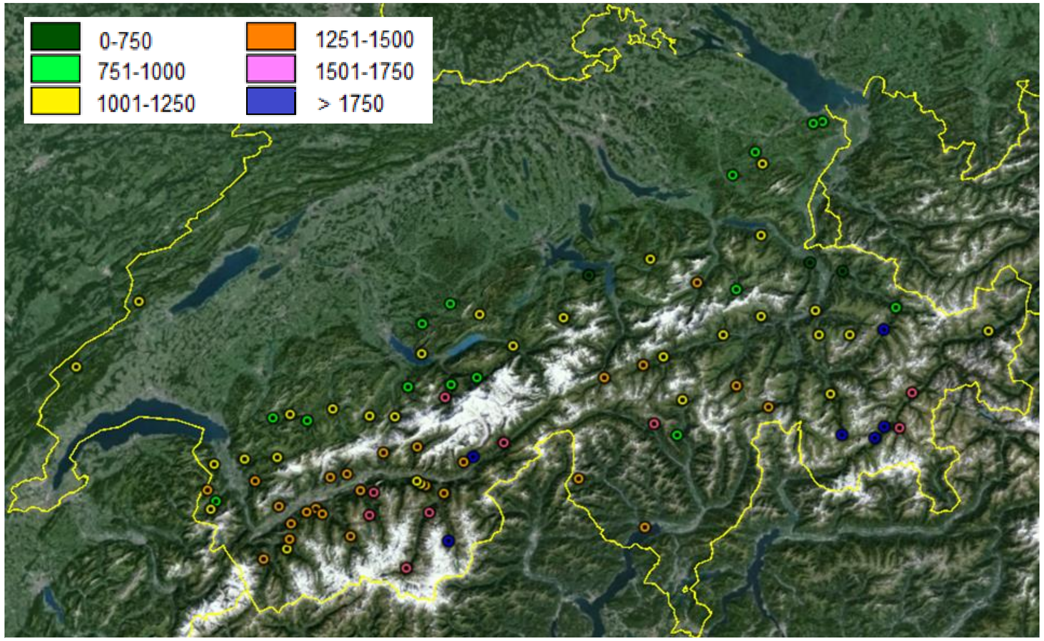

Figure 13: Overview of the minimum altitudes of the ski areas

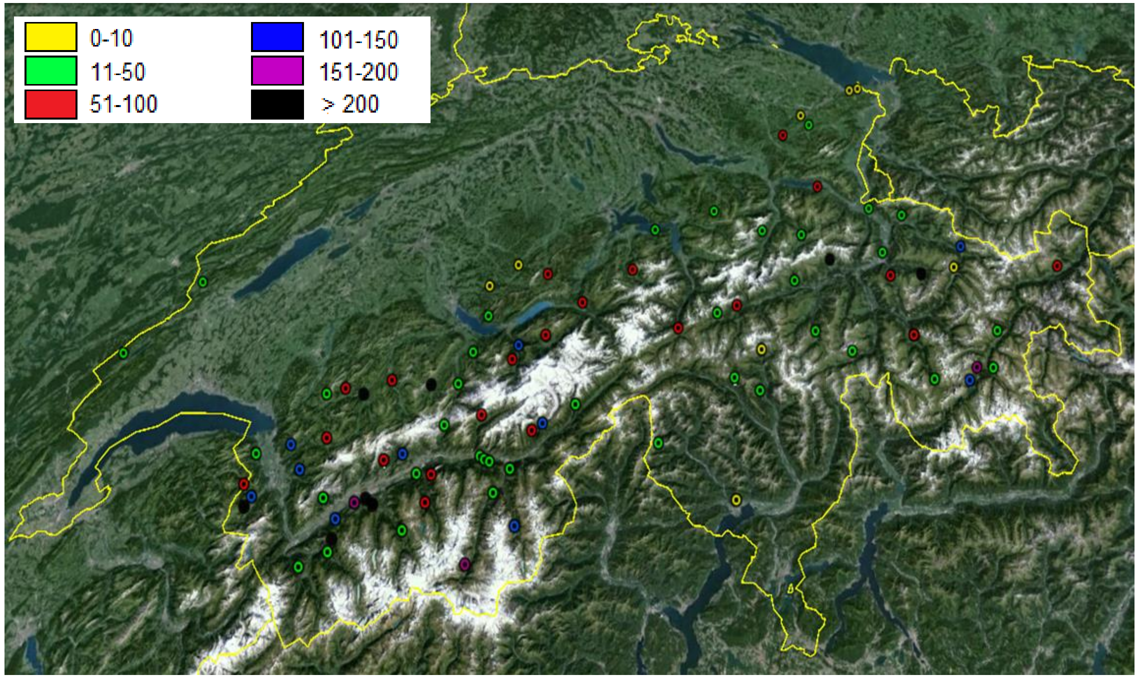

Figure 12: Overview of the size of the ski areas (in kilometers)

Switzerland. Another reason is that the mountains are also higher over here than in the north. From this figure it is also observable that some villages are located at quite a low altitude. Often people from those villages have to travel towards a ski resort by car. Very few of those villages, do however, have direct access to the ski area because there is also a cabin available in the valley where they live. This is for example the case for Locarno.

Figures 11-13, give a graphical representation of the ski area characteristics. Figure 11 shows an overview of which ski areas are taken into account in this study. 86 are located in the Alps and two in the Jura. The dispersion among those regions seems rather fine. The Jura does not have many ski resorts in the end. The mix between the north side and the south part of the Alps is also fine. The same is true considering the east and west. Figure 12 provides an overview of the size of the ski areas. There is not a clear general pattern observable while looking at the figure. Small areas are bordered by large ones, for example. The only pattern visible is that at the borders of the Alps the smallest ski areas are located. This is also intuitively logical because over there the elevation starts to increase gradually, but the high mountains are not immediately apparent. Therefore, only small ski areas are located over there, with only one or two blue slopes. Figure 13 provides an overview of the minimum altitude of the ski areas which are taken into account in the analysis. This figure shows a clear pattern. Areas which are located close to each other tend to be assigned to the same category with respect to the minimum altitude of the resort. Another observation is that the highest resorts are located at the south part of the Alps.

4. Results

In this section of the study the regression results are provided, so that the hypotheses about snow accessibility can be tested. Table 4 shows the coefficients of the main explanatory variables, together with their standard errors. Besides, the key features of the model are observable; the number of observations, the R^2, and the mean VIF of the model.

The R^2 of all models are rather high, which implies that the variation of the outcomes is explained well. In model 1[41], which is the base model, it is already 0.723. Adding snow variables leads to a meaningful increase of this number, which already indicates that snow has an effect on house prices. The best fitted model has an R^2 of 0.819.

The base model shows intuitive results. The important variables are all significant, at least at the 10% level, and their signs are also intuitively logical. Only the negative sign of the dummy variable new is not in line with the theory. It would imply that a house which is recently constructed has an extra negative effect on the house price. This means that this effect comes above the influence of age. However if the snow variables are added, the sign switches. This also proves that the snow variables are important in determining house prices. The other variables do not switch of sign, or significance, in the next models. They also keep in line with the existing theory.

When the snow variables are added in model 2, it appears that all coefficients are significant at the 10% level. For the variables which measure the snow accessibility, it appears that they are even significant at the 1% level and most of them show intuitive results. The altitude of the village increases the asking price of a property by 2.5% per 100 meters of elevation increase. The distance towards snow is, in this model, measured by the

[41] The assumptions which are necessary to have a good model are all satisfied except for the one of having a constant conditional error variance. Therefore the model is estimated with robust standard errors. The graphical checks of the assumptions are provided in figures 9-12 and table 7 in the appendix. An overview of the assumptions is also provided in the appendix. This is observable in table 8

Regression model results				
Variables		**Model 1**	**Model 2**	**Model 3**
C		4.169 (0.216)***	4.838 (0.230)***	5.402 (0.246)***
LN(FLR)	m^2	0.912 (0.038)***	0.878 (0.032)***	0.870 (0.033)***
RMS		0.019 (0.011)*	0.020 (0.010)**	0.025 (0.009)***
APP		0.279 (0.050)***	0.329 (0.041)***	0.325 (0.042)***
CHA		0.174 (0.060)***	0.307 (0.049)***	0.321 (0.050)***
DUP		0.443 (0.066)***	0.511 (0.054)***	0.495 (0.055)***
LOT*APP	m^2	0.001 (0.001)*	0.001 (0.001)*	0.001 (0.000)***
LOT*STU	m^2	0.027 (0.006)***	0.026 (0.005)***	0.024 (0.006)***
LOT*DUP	m^2	0.000 (0.000)	0.001 (0.000)**	0.001 (0.000)**
LOT*CHA	m^2	0.000 (0.000)**	0.000 (0.000)**	0.000 (0.000)**
AGE		-0.006 (0.001)***	-0.006 (0.001)***	-0.006 (0.001)***
AGE_SQ		0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***
NEW		-0.079 (0.020)***	0.040 (0.018)**	0.057 (0.018)***
SWIM		0.178 (0.037)***	0.200 (0.031)***	0.203 (0.032)***
WATER		0.177 (0.031)***	0.345 (0.028)***	0.287 (0.031)***
SUP		0.018 (0.005)***	0.012 (0.005)**	0.010 (0.005)**
LN(POP_M)		0.048 (0.009)***	0.049 (0.009)***	0.035 (0.009)***
LN(CL_P)		0.330 (0.014)***	0.208 (0.012)***	0.182 (0.012)***
LUX			0.388 (0.023)***	0.348 (0.030)***
BEST			0.135 (0.015)***	0.223 (0.021)***
ALT	100 m		0.025 (0.002)***	
ALT 500-599	m			-0.021 (0.037)
ALT 600-699	m			-0.133 (0.028)***
ALT 700-799	m			-0.146 (0.037)***
ALT 800-899	m			-0.123 (0.034)***
ALT 900-999	m			0.031 (0.035)
ALT 1000-1099	m			-0.010 (0.037)
ALT 1100-1199	m			-0.044 (0.033)
ALT 1200-1299	m			-0.023 (0.030)
ALT 1300-1399	m			0,040 (0.029)
ALT 1400-1499	m			0.074 (0.031)**
ALT 1500-1599	m			0.052 (0.026)**
ALT 1600-1699	m			0.090 (0.038)**
ALT 1700-1799	m			0.143 (0.047)***
ALT 1800-1899	m			0.368 (0.055)***
ALT ≥ 1900	m			0.147 (0.063)**
SKI_CAB			0.107 (0.015)***	
SLP			0.001 (0.000)***	
S_BLUE				0.005 (0.001)***
S_RED				-0.005 (0.001)***
S_BLACK				0.003 (0.001)**
GLA			-0.063 (0.021)***	-0.014 (0.022)
LN(T_PR)	CHF		0.112 (0.035)***	0.197 (0.040)***
NIGHT			0.060 (0.015)***	0.052 (0.016)***
DIS	km			-0.017 (0.002)***
BEST * DIS				-0.012 (0,003)***
R^2		0.723	0.806	0.819
Mean VIF		3.62	3.70	3.43
N		3691	3691	3691

Note: * = Significant at 10% ** = Significant at 5% *** = Significant at 1%

Base level dummies: **TYPE**: studio, **NEW**: property is not constructed in 2014 or 2015, **SWIM**: property does not have a swimmingpool, **WATER**: property close to water, **LUX**: village at which property is located is not luxury, **BEST**: ski resort belonging to property is not known as the best in a certain category, **ALT**: ≤499 meter, **SKI_CAB**: it is not possible to ski untill the village and there is no cabin available in the village, **GLA**: there is no glacier in the ski resort which belongs to the property, **NIGHT**: it is not possible to ski in the evening in the ski area.

Table 4: The spatial model outcomes

dummy variable which controls for having direct access to snow within the village the property is located at, or not. The results show that if this is the case a property is worth 10.7% more than if the property would have no direct access. The number of slopes in the ski area is also positively affecting the house prices. Having access to one more slope increases the house price by 0.1%. If the ski area provides the opportunity to ski in the evening it increases the asking price of a house with 6.0%. All those results indicate that accessible snow is indeed affecting property values positively. The unexpected results are observed at the coefficients measuring the price to access a ski area and the one which controls for having access to a glacier or not. The outcomes of this spatial model indicate that a higher ticket price increases the value of a property. Although it is not in line with the theory of snow accessibility, this result is still logical because of two reasons. First, the most important reason is, that the ticket price also includes some unobserved characteristics of the ski area, as previous research has proven. Apparently, the willingness to pay for such characteristics is not only observable in the ticket price but also in the value of a property in that ski resort. Second, higher ticket prices pull away the people which are not willing to pay somewhat more for their ticket price. The richer people stay and therefore those resorts get more exclusive. An increase of 1% is too small to observe this behaviour, but increases by 10% are not, ceteris paribus. Both explanations have the power to influence house prices in the end. Because of these reasons the sign and magnitude of the coefficient is accepted. With respect to the glacier estimator it appears that houses are worth 6.3% less than if they would have been located in a village which is not connected to a resort with a glacier. This implies that people are not willing to pay more for the opportunity to ski in summer too. People are satisfied with only skiing during the winter season. So houses are not worth more if the winter sport season is enlarged to a whole year. Measuring the effect closer by investigating the number of weeks a ski resort is open was not possible, due to technical reasons. Therefore, this component of snow accessibility remains unclear, although this model implies that it does not affect property values.

Overall, model 2 shows that accessible snow indeed affects house prices. Model 3 is constructed, with categorized dummies based on the altitude of the village, a distinction is made based on the difficulty level of the slopes in the ski area and the distance towards the snow is measured exactly, to find if this evidence is also apparent when the concept of snow accessibility is measured more thoroughly. In general, the model has improved compared to the previous one; the R^2 improved and the mean VIF declined. Only some altitude dummies and the glacier coefficient are not significant. The control variables are providing intuitive results and are all significant at the 5% significance level. The variable which makes the model a spatial one, for example predicts that the value of the dwelling increases by 0.182%, if the neighbouring property in the sample has a 1% increase in its value. With respect to the altitude dummies there is clear pattern visible, although some dummies are insignificant. The movements are also visualized in figure 14. Moving up to a somewhat higher altitude, compared to the base level, is not beneficial for the asking price. However, the general pattern is that at higher elevation levels the price of a property increases. The pattern visible in figure 14 is also in line with the theory about the characteristics of villages in the valley, in the mountains and in the areas in between. It appears that the availability of services does indeed matter and therefore the prices are higher in the valleys. Snow is however making up for the loss of some services. In the areas in between, where snow is not guaranteed and services are not sufficiently available, property values are lower.

The division of the difficulty levels of the slopes in a ski area also improves the model. Having more blue and black slopes in the ski area improves the value of the house. An extra

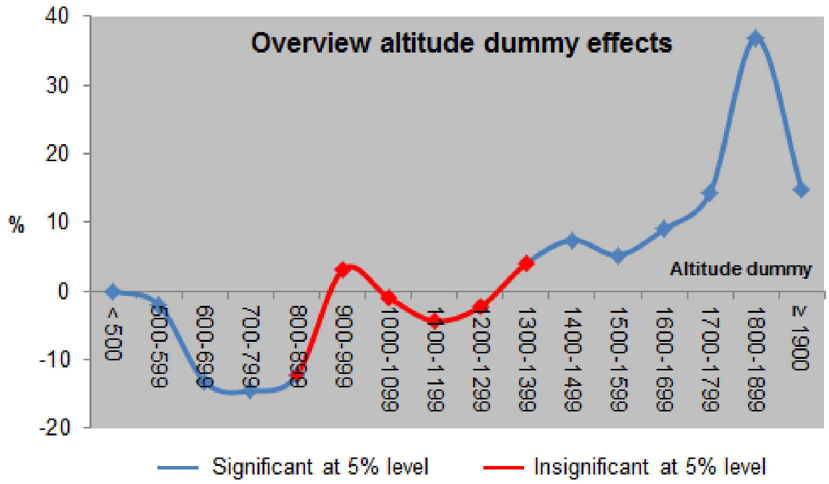

Figure 14: Overview of the effects of altitude dummies on house prices

red slope leads to a 0.5% decrease of the price which is asked for the property, ceteris paribus. This seems contradictory but it is not. The information about the three different types of skiers provides the solution. Beginners and elderly people prefer blue slopes, the experienced ones like to ski on the black slopes and the all-round skiers are indifferent. Those intermediate skiers just want to ski, independent of the difficulty level. As long as they have a several different slopes in the area, they are satisfied. This implies that none of the groups explicitly receive satisfaction from skiing at red slopes. Having none of them is also not valuable, but many resorts do have lots of red slopes.

The magnitude of the luxury and best ski resort dummies might look smaller as expected. A property within a village with an exclusive status has a 34.8% higher value than if it would have been located in another town. However, those luxury villages do also have, on average, more ski slopes, higher ticket prices, the possibility to ski at night and they are located at higher altitude levels. The same is true for the best ski resorts, for which the price effect is 22.3%. So the price differences are in the end, on average, bigger than what those specific dummy variables predict. Furthermore, it is also true that some villages are both known as exclusive and have been declared as best ski resort in a certain category.

The coefficients for having access to a glacier in summer, the possibility to ski during the evening and for the ticket price are in line with the outcomes in model 2. A, one percent increase in the ticket price increases the asking price by 0.19%. Having a glacier is insignificant in model 3. The possibility to ski in the evening by artificial light improves the value of the house by 5.2%. This is because people are having access to the snow for a longer time. They can enjoy the snow for a longer period during the day which makes them less dependent on time concerns. In the end people are willing to pay for this. They want to be independent during their leisure time and want to practice the sport whenever they want. This gives also the opportunity for Swiss residents who work during the week to enjoy skiing after they have finished their job. Altogether, this provides evidence for the fact that having access to snow for a longer time does improve the value of a property. The effect is however only observable in winter because the glacier coefficient is not proving this for the summer.

The distance towards a ski cabin does also affect house prices, if it is measured specifically. It is although likely that this effect is not the same for all ski areas; therefore a distinction has been made between areas which are known as the best and those who are not. Therefore, the total distance effect for those ski resorts with a good reputation is gathered by looking at the coefficients measuring distance, best reputations and the interaction term. For other ski resorts the outcomes indicate that per kilometre the price of a property declines by 1.7%. This is in line with the expectations from the snow accessibility theory. Overall, the results for best ski resorts are also intuitive. At the mean distance of a property towards accessible snow, the property value is higher than if it would not be connected to a best ski resort.[42] At that distance the price effect is 17.87%. Closer towards the accessible snow those price differences are bigger and further away smaller.

To check that there is indeed such a price difference between ski resorts which have the best reputation and those who do not, equation (1) has been rewritten.[43] The mean distance in the model has been taken as a cut-off point to check if there is indeed a significant price difference at this point. After implementing the null hypothesis in the equation the model has been estimated. Looking at the coefficient ''BEST'' provides the evidence that there is indeed a significant price difference at the 1% significance level. Therefore it is concluded that at other ski resorts an extra kilometre further away of the snow will decrease the property value by 1.7%. At the best ski resorts this decline in prices is bigger but overall being connected to such an area still improves the price of the property at distances at which the travel time towards such a ski resort is still acceptable.

To give a final verdict on the relation between snow accessibility and house values an F-test has been constructed. It tests the null hypothesis that all snow coefficients together are equal to 0, against the alternative hypothesis that this is not the case.[44] The result shows that the null can be rejected at the 1% significance level. This implies that overall snow accessibility indeed has an effect on house prices.

A last check to determine the credibility of the model is to look at the variable age. This variable consists of the regular coefficient and the squared one[45]. Therefore, at a certain point, the overall effect of the variable is changing from positive to negative or vice versa. This should happen at an intuitively logical point to let the model be credible. It appears that if a house has been built around two centuries ago the age effect will start to increase, again.[46] This implies that from this age onwards people are going to see it as a scarce good because it is such an old building. They kind of treat those residential properties as a monument. Altogether, both outcomes are intuitively logical which implies that the model is also credible with respect to those outcomes. The model is fulfilling the requirements of a multiple regression model and its coefficients are also plausible. Therefore it is concluded that the snow has a positive effect on the property values in the Swiss mountains.

5. Implications of global warming

The evidence that accessible snow has a positive effect on housing values is delivered. In this section it is therefore possible to link the climate change predictions with the results of model 3 to investigate the future of the Swiss housing market in mountain areas. The snow accessibility characteristics and outcomes of that model are used together with the newly estimated reliable snow lines of table 1, to provide a future outlook.

When the estimated future snow lines in 2085 are linked with the minimum altitude of the ski resorts[47], it is possible to give a graphical representation of the implications of global warming. Figure 15 and 16 show the results for the scenario with and without the use of

[42] The proof for this could be found in equation 1 of the appendix.
[43] This rewritten version could be found in the appendix by looking at equation 1-4
[44] The hypothesis is written down in appendix. Also the outcome is provided.
[45] The scatterplot which provides the graphical explanation to do so, is represented in the appendix as figure 8.
[46] The calculation could be found in equation 5 in the appendix. The coefficients used are the non-rounded values of model 3.
[47] Those minimum altitudes are visible in the appendix in table 3, together with the 88 included ski areas.

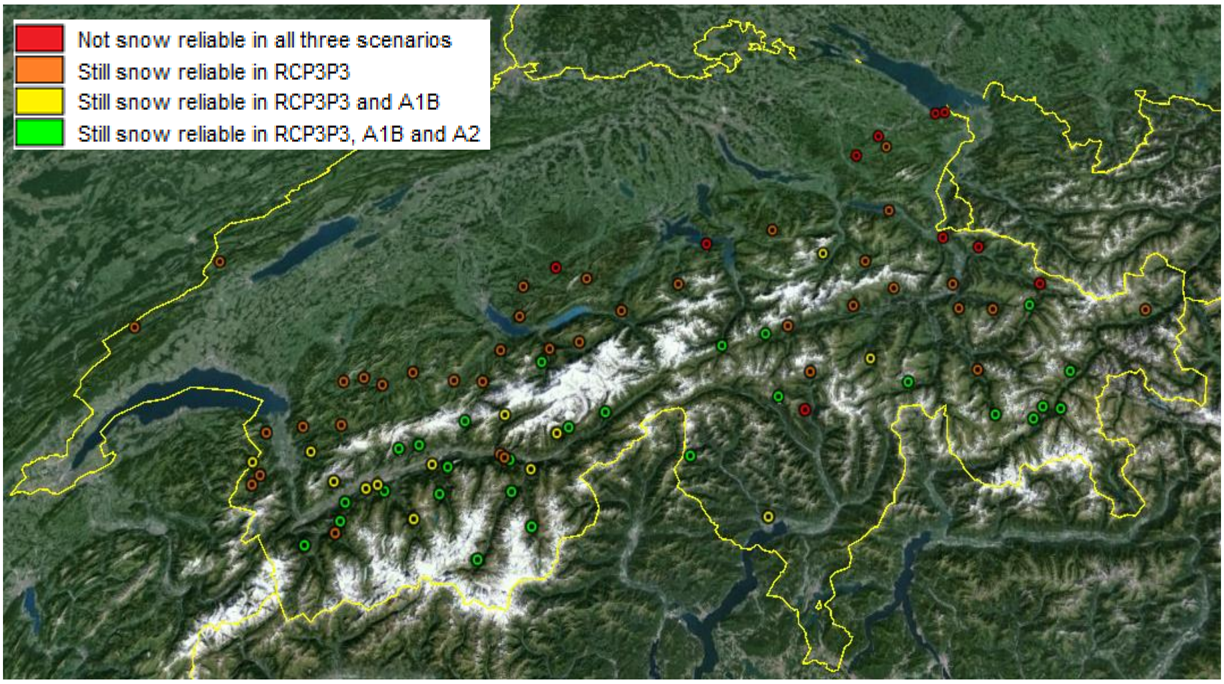

Figure 15: Overview of the implications of global warming at the end of this century, with natural snow fall considered

artificial snow. In the case without using it, which is observable in figure 15, many ski resorts will disappear. The areas represented by the red bullets will not survive independent of which scenario occurs. The orange ones stay snow reliable if the most positive scenario becomes the truth. This implies that the emission of greenhouse gases should decline from 2020 onwards. This is not very likely and therefore global warming will also be a threat for those ski resorts. Adding up the orange and red bullets it would imply that it is likely that 46 of the 88 ski resorts used in the analysis will not be indicated as snow reliable any longer. If the worst case scenario will occur this amount will increase even further, indicating that almost 75% of the ski resorts will disappear. It should however be noted that this analysis is based on the minimum altitude of the ski area and not on the altitude of the resorts. In many cases these altitudes are however the same, or very closely related. No matter which scenario occurs, the general picture is clear; only those areas which are located in the southwest and southeast of the country are likely to survive. The more drastic the temperature changes are, the more the skiing industry will be concentrated in the south of the country. The north side of the Alps will have difficulties to remain snow reliable in the future. This implies that the snow industry will be more concentrated and that there will be less supply of ski resorts in Switzerland. Tourists who want to keep skiing have no other choice than visiting those villages. The rule of supply and demand states that when supply is decreasing the prices will go up. As there is a theoretical shift of the supply curve to the left and a movement on the demand curve, accessible snow is getting more expensive. Not only ticket prices for cabins will go up but also the property values and rents in those areas where it is still possible to perform winter sports. The people who quit skiing and snowboarding are the people who do not have the willingness to pay that amount of money.

All this will have a huge impact on the regions which will not be snow reliable in the future anymore. Of course during some winters it will still be possible to ski at those regions but not for that many days. It does also not imply that 100 days of snow cover will never be reached again, but not for seven out of ten winters. Foreign tourists will not take the risk to book a holiday without snow and therefore only some local people will make use of those ski areas. Therefore the regional economy will change; the construction sector will be hurt.

Fewer houses will be built in those areas. Tax incomes earned by the cantons will also be lower, because the value of the residential properties will decline. Evidence for this is provided in all snow accessibility models. Houses at those lower altitudes will get worth less because of the rise of the snow line. Accessible snow will be further away. Having a cabin or access to the snow in those villages probably will not have the same effect any longer. Snow reliable places will be further away. That is the reason why the values of the properties will decrease by quite a drastic amount.

Luckily for many villages the innovation of artificial snow could provide a solution. Figure 16 gives an overview of the survival possibilities of the included ski areas with artificial snow for the different scenarios. The same pattern is observable. Resorts located at the north side of the Alps will have the most difficulties concerning the reliability of their ski area. The implications are however far less drastic than before. Two areas will not stay reliable in 2085 independently which scenario occurs. The temperature will rise by such an amount that those resorts will not be considered as reliable in the future. Only eight extra resorts will not be considered as snow reliable anymore if scenario A1B occurs. At the most extreme scenario still 51 resorts are considered as snow reliable. This implies that the property market will only change marginally. This is especially true because the minimum altitude of the two red bullets is already under the current reliable snow line. Therefore, if RCP3P3 occurs maybe nothing is even likely to happen at all, before the end of this century.

Considering the moderate scenario, changes will also not be that big. The only note which should be made is that not all ski resorts already have the equipment to make artificial snow. Therefore at some resorts the ticket prices will somewhat increase because the investment will be partly paid back by the customers. This price increase will not be that big, otherwise many people will stay away. So this might still be a problem for very small areas. Overall, there will be somewhat less supply of ski areas. Those which disappear are already questionable concerning snow reliability, or the ski areas are rather small. This indicates that they will not be affected that much because tourists do prefer other ski resorts.

Because of these small changes, not much is expected to happen with the pattern observed for the altitude dummies in model 3. The relatively minor change of the reliable snow line will not cause that many ski resorts will disappear. The bigger ones are all likely to stay anyway. Therefore the general characteristics in Swiss mountain areas will stay the same. In the valley a broad range of services is provided and high in the mountains there are some main services available and accessible snow. Therefore at those levels of altitudes the house values are higher than in the valley. In between, the lowest property prices are observed. This is because accessible snow is not close and the amount of services available is negligible.

Next to the change of reliable snow lines, glaciers will also be affected. It is predicted that skiing in summer will be impossible, at the end of this century. The outcomes of this study do however not provide evidence that there is a significant difference between having access to a glacier or not. Therefore global warming will not change property values significantly, in the five areas which have access to a glacier. [48]

Luckily for the Swiss ski resorts artificial snow is not considered as a reason to not ski anymore by many consumers. This does not imply that they are completely indifferent but they feel that the possibility to ski is more important than the conditions of the snow. Therefore, artificial snow will be the rescue of the snow industry in Switzerland. There is no

[48] These five ski areas are: Engelberg Titlis, Les Diablerets - Glacier 3000, Nendaz / 4 Vallées, Saas-Fee and Zermatt

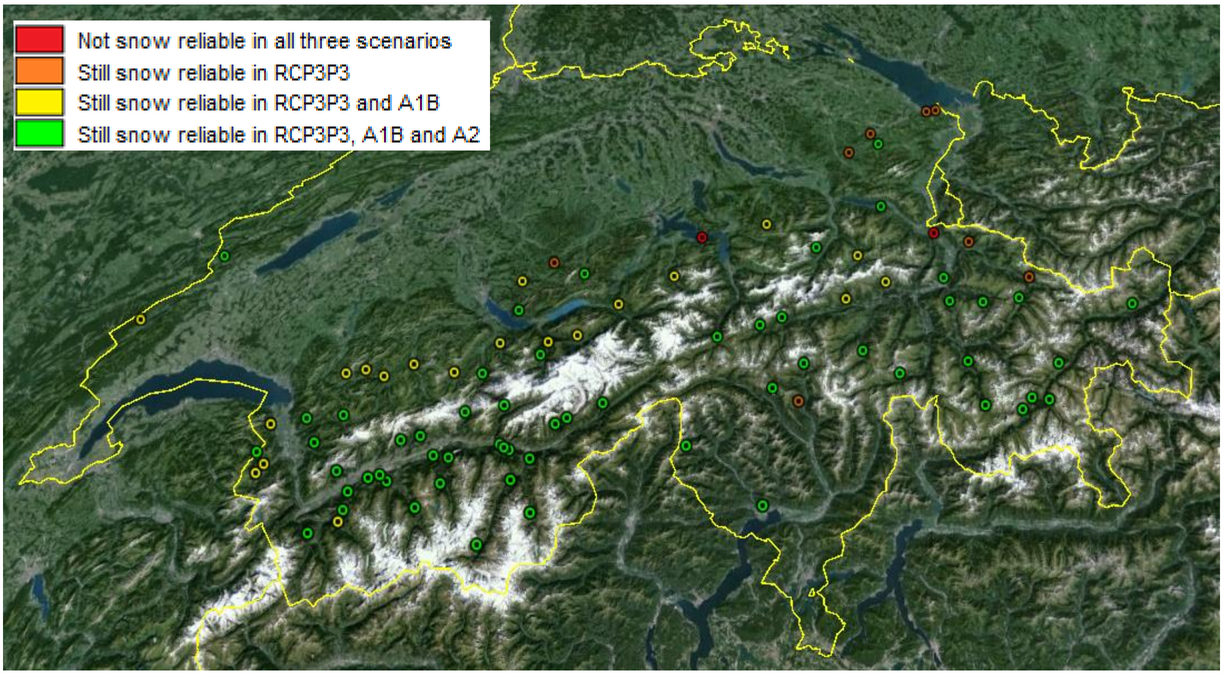

Figure 16: Overview of the implications of global warming at the end of this century, with artificial snow considered

clear evidence that things are changing drastically so that the whole local mountain economies are affected. Therefore the property markets will also behave rather the same, ceteris paribus. The country and tourism sector should however keep investments and innovations at a high level to not lose their comparative advantage. Competition with other regions and countries is still likely to increase because of the implications of global warming. Furthermore, it needs to be made sure that the high investment costs will be earned back.

6. Discussion and conclusion

6.1 Recommendations

Although the outcomes of this study are clear, there is enough space to enlarge the scientific knowledge about this subject. It could for example be a good idea to include the option to link more than one ski resort to a property. People are not obliged to go to one ski resort and often people are also switching. This is especially the case when they do not have a ski cabin in their own village. Taking the possibility to ski at more than one resort into account, will give a better indication of what will happen to a village when their ski resort is not treated as snow reliable any longer. The problem of this method is that all ski resorts in the country, or in a part of it, should be included in the model. For performing such an analysis, also enough data per area should be available.

The current study has two drawbacks. First, there are some indications which provide evidence that there are regional differences in the effects of global warming. The scenario figures also show this. It is however assumed in this study that temperature rises will be the same all over the country. This could not have been done differently because the exact differences and changes are not known explicitly for a village or district. It might however be nice to gather such data and insert those predictions in the model. The second drawback is that the permits are not analysed in this study. It is very likely that this will have an effect on house prices and therefore it is recommended to analyse the relation between accessible snow and residential property values again, while this is also taken into account.

The spatial model in this thesis is static, which implies that no observations over time are included. As there is no relation observable over time between global warming and house prices it is not clear if the market is adjusting to this threat. If this is the case it could be determined if the market is influenced by, for example, speculative behaviour based on climate change. This will give an indication if people are worrying about their property value due to the threat of the greenhouse effect. Therefore, it is also an option to perform a rather equal study, but with data of several years.

The final outcome of the study is that not many properties will be affected due to climate change. It is however still recommendable to implement the perceptions about artificial snow in the analysis. In the end, this snow type will be the rescue of the winter sport tourism in the country. If places with natural snow are preferred by people, price differences between properties will also occur based on this observation. This could be an important implication of climate change. To do such an analysis, first it has to be investigated which resorts are using artificial snow and which are not. Furthermore, it is also important to link it to the percentage of slopes in the area which could be covered by artificial snow. Not all slopes in the ski area have access to the equipment. All this will probably have an effect on the willingness to pay for natural or artificial snow.

6.2. Conclusion

In this study, it is explored if snow has a positive relation on property values or not. Furthermore, the implications of global warming are added to the analysis. Previous literature has never researched those issues, with the help of a spatial or hedonic model for Swiss mountain areas. It has especially been neglected what the price effects of snow are on house prices; the relation between snow and other affairs have been analysed. The effect of global warming has sometimes also been addressed in those studies and there are also articles which only investigate the impact of the greenhouse effect on mountain areas. This subject has also never been directly applied to the Swiss property market.

In the end, this thesis is relevant because of several reasons. One of them is that property values are linked to tax incomes for the cantons. Besides it is also important to know the effect because of investment purposes. If climate change will considerably change the property values in mountain areas investors need to get knowledge of this. Otherwise they will make unnecessary financial losses by putting money in the wrong projects. Furthermore, they will not observe the opportunities to make extra money. Next to this the information is also important for current house owners which are obliged to certain financial obligation with respect to their own house.

By using a unique dataset, it has been shown that snow accessibility is affecting property prices positively. With the help of climate change scenarios future reliable snow lines have been established. It is concluded that if ski resorts are not relying on artificial snow, many of them will disappear before the end of this century. If artificial snow is being used, the snow line will be lowered and therefore there seems to be no problem in the future for the majority of the winter sport resorts.

Climate change is the biggest threat for the small resorts at the north side of the Alps and those located in the Jura. Altitudes of the ski areas are relatively low over there compared to the places in the south. As those areas are also rather small it is questionable if they should invest a huge amount of money in the equipment of artificial snow. Foreign tourists already do not visit those areas that often. So changes will not be that big over there, even if the worst global warming scenario occurs. The snow tourists especially focus on the big areas in the middle and the south of the Alps. Those places are likely to survive the increasing temperatures of this century by using artificial snow. Therefore the property prices will not be affected that much in Swiss mountain areas in the future. Another change, caused by global warming, will be that skiing in summer will be impossible at the end of this century. Glaciers will almost completely disappear. This implies that five ski resorts cannot differentiate themselves any longer from the others concerning the length of the ski season. The outcomes of the model do not show that this will significantly affect house prices. So this will not influence the property market that much.

Altogether, it is clear that the property market will not be changed drastically because of the global warming, which affects the snow tourism sector. Minor changes will occur, but price differences will not become huge in the future, compared to current values in Swiss mountain resorts.

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Appendix

Extra figures

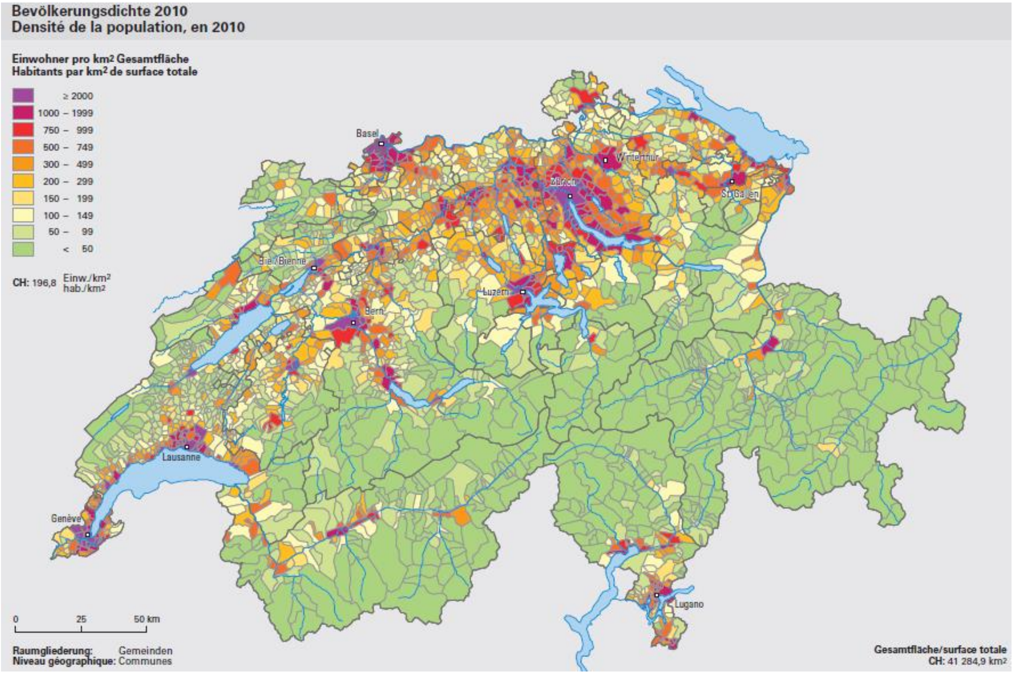

Figure 1: Overview of the population density in Switzerland

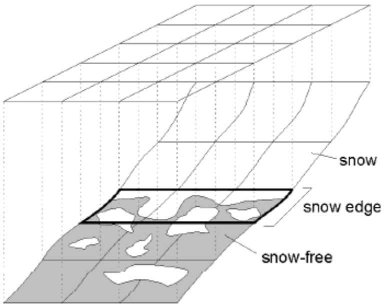

Figure 2: Explanation of the snow line concept

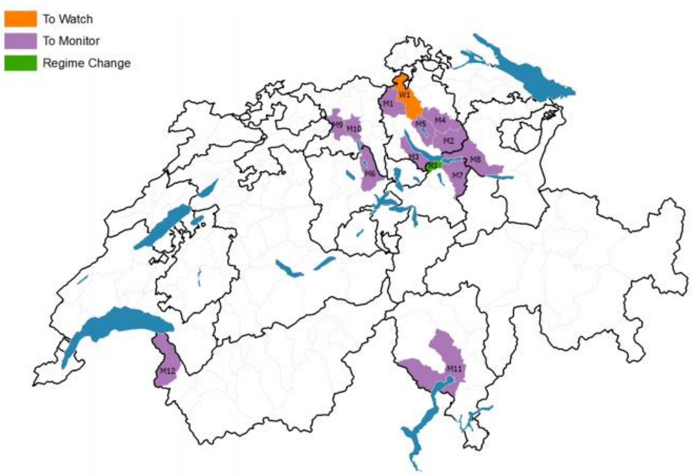

Figure 3: Overview of the possible bubble markets in the country

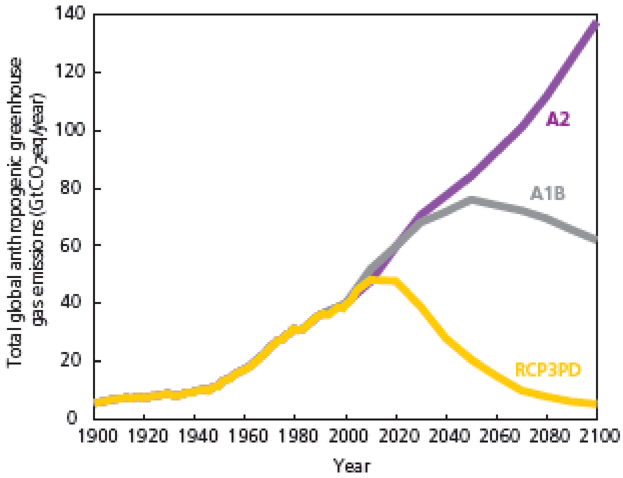

Figure 4: Overview of the underlying CO2 emissions for the different climate scenarios

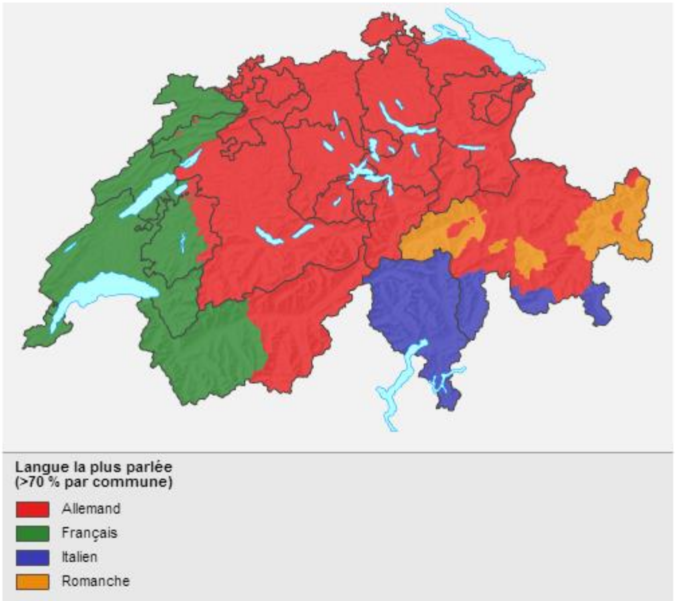

Figure 5: Overview of the languages spoken over the country

Figure 6: Overview of the locations of the ski areas in the country

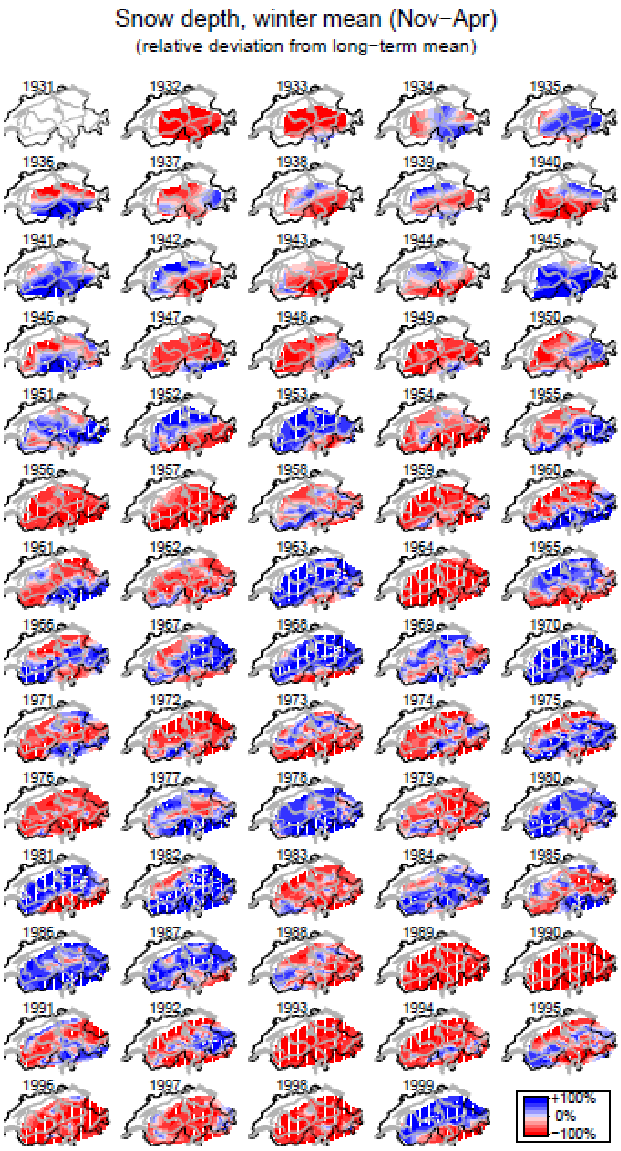

Figure 7: A yearly overview of the snow depths compared to the long run mean.

Dataset information and related issues

Variable	Source
Asking price	Online advertisements
M2	Online advertisements
Lotsize	Online advertisements
Size balcony/terrace	Online advertisements
Size garden	Online advertisements
Rooms	Online advertisements
Type	Online advertisements
Floor	Online advertisements
Number of floors	Online advertisements
Construction year	Online advertisements
Age	Online advertisements
New property	Online advertisements
Swimmingpool	Online advertisements
Zipp code	Online advertisements
Village	Online advertisements
Price closest property	Google Earth
Bordered to water	Google Earth
Number of supermarkets village	Google Maps
Municipality	Online advertisements
Population municipality	Swiss Federal Statistical Office
District	Swiss Federal Statistical Office
Population district	Swiss Federal Statistical Office
Province	Online advertisements
Province abr.	Online advertisements
Population province	Swiss Federal Statistical Office
Language	Swiss Federal Statistical Office
Ski area	Bergfex & Google Earth
Altitude	Google Earth
Distance to nearest cabin (km)	Route planner
Whitin village with ski cabin	Bergfex & Google Earth
ski until village	Bergfex
Cabins ski area	Bergfex
Min. altitude ski area	Bergfex
Max. altitude ski area	Bergfex
Height difference ski area	Bergfex
Number of blue pistes	Bergfex
Blue pistes km	Bergfex
Number of red pistes	Bergfex
Red pistes km	Bergfex
Number of black pistes	Bergfex
Black pistes km	Bergfex
Total number of ski pistes	Bergfex
Ski area size (km)	Bergfex
Glacier	Bergfex
Skiable weeks	Bergfex
One day ticket price adult (CHF)	Bergfex
Night skiing	Bergfex
Luxury reputation	Online articles combined (two sources)
Best snow	Online article (The Telegraph)
Best for experts	Online article (The Telegraph)
Best for intermediates	Online article (The Telegraph)
Best for beginners	Online article (The Telegraph)
Best for charm	Online article (The Telegraph)
Best for partying	Online article (The Telegraph)
Best for families	Online article (The Telegraph)
Best for snowboarders	Online article (The Telegraph)
Best for value	Online article (The Telegraph)
Best for weekends	Online article (The Telegraph)
Best ski resort reputation	Online article (The Telegraph)
Former host Olympic Games	IOC website & Bergfex

Table 1: Overview of the sources used to gather the data

Variables description		
Abreviation	*Description*	
C	Constant	
LN(ASK)	Asking price of property	CHF
LN(FLR)	ln(floor space)	m^2
RMS	Rooms	
TYPE	Property type	
APP	Appartment	
CHA	Chalet	
STU	Studio	
DUP	Duplex	
LOT	Lot size	
LOT*APP	Size balcony / terrace * appartment	m^2
LOT*STU	Size balcony / terrace * studio	m^2
LOT*DUP	Size balcony / terrace * duplex	m^2
LOT*CHA	Size garden * chalet	m^2
AGE	Age	
AGE_SQ	Age^2	
NEW	New	
SWIM	Swimmingpool	
POP_M	Property close to water	
SUP	Number of supermarkets in village	
LN(POP_M)	ln(population municipality)	
LN(CL_P)	ln(price closest property)	CHF
LUX	Luxury reputation village	
BEST	Best ski resort reputation	
ALT	Altitude	100m
ALT 500-599	Altitude 500-599	m
ALT 600-699	Altitude 600-699	m
ALT 700-799	Altitude 700-799	m
ALT 800-899	Altitude 800-899	m
ALT 900-999	Altitude 900-999	m
ALT 1000-1099	Altitude 1000-1099	m
ALT 1100-1199	Altitude 1100-1199	m
ALT 1200-1299	Altitude 1200-1299	m
ALT 1300-1399	Altitude 1300-1399	m
ALT 1400-1499	Altitude 1400-1499	m
ALT 1500-1599	Altitude 1500-1599	m
ALT 1600-1699	Altitude 1600-1699	m
ALT 1700-1799	Altitude 1700-1799	m
ALT 1800-1899	Altitude 1800-1899	m
ALT ≥ 1900	Altitude ≥ 1900	m
SKI_CAB	Skiing until or ski cabin in village	
SLP	Number of slopes in ski area	
S_BLUE	Number of blue slopes in ski area	
S_RED	Number of red slopes in ski area	
S_BLACK	Number of black slopes in ski area	
GLA	Glacier	
LN(T_PR)	ln(cabin ticket price)	CHF
NIGHT	Night skiing	
DIS	distance to nearest ski cabin	km
BEST*DIS	Reputation * Distance to nearest ski cabin	

Table 2: Overview of the abbreviations used and there meaning for the inserted variables

	Ski area	Minimum altitude		Ski area	Minimum altitude
1.	Adelboden - Lenk	1053	45.	Jungfrau ski Region - Kleine Scheidegg - Männlichen - Wengen	1000
2.	Aletsch-Arena / Riederalp - Bettmeralp - Fiesch - Eggishorn	1925	46.	Jungfrau Ski Region - Mürren - Schilthorn	1650
3.	Andermatt-Gemsstock-Nätschen	1444	47.	Kiental	1000
4.	Anzère	1500	48.	La Tzoumaz - Mayens de Riddes	1500
5.	Arosa - Lenzerheide	1230	49.	Lauchernalp / Lötschental	1400
6.	Beatenberg - Niederhorn	1200	50.	Les Diablerets	1200
7.	Belalp - Blatten	1322	51.	Leysin - Les Mosses - La Lécherette	1250
8.	Bellwald	1600	52.	Marbach - Marbachegg	884
9.	Bivio	1769	53.	Meiringen - Hasliberg	1066
10.	Bosco Gurin	1480	54.	Morgins / Portes du soleil	1350
11.	Braunwald	1256	55.	Muottas - Muragl	1750
12.	Brigels - Waltensburg - Andiast	1100	56.	Nara / Leontica - Cancorì	875
13.	Bruson	1080	57.	Nendaz / 4 Vallées	1350
14.	Bürchen	1480	58.	Oeschinensee - Kandersteg	1200
15.	Campo Blenio - Ghirone	1200	59.	Ovronnaz	1400
16.	Cardada Cimetta / Locarno	1340	60.	Pizol - Bad Ragaz - Wangs	500
17.	Carì	1600	61.	Saas Grund - Hohsaas	1559
18.	Champéry / Portes du soleil	1050	62.	Saas-Fee	1800
19.	Champex-Lac	1486	63.	Sainte Croix - Les Rasses	1150
20.	Chur - Brambrüesch	1170	64.	Savognin	1200
21.	Churwalden	1229	65.	Schwellbrunn	852
22.	Corvatsch	1870	66.	Scuol - Motta - Naluns	1250
23.	Crans Montana - Aminona	1500	67.	Sedrun Oberalp	1500
24.	Davos - Klosters - Parsenn	810	68.	Sörenberg	1166
25.	Davos - Schatzalp	1860	69.	Splügen / Rheinwald	1457
26.	Disentis	1150	70.	Sportbahnen - Eischoll	1220
27.	Elm	1000	71.	St. Moritz / Corviglia	1773
28.	Emmetten - Beckenried	450	72.	St-Luc / Chandolin	1650
29.	Engelberg - Titlis	1050	73.	Thyon / 4 Vallées	1470
30.	Eriz	1000	74.	Toggenburg	900
31.	Evolène	1380	75.	Torgon / Portes du Soleil	1100
32.	Flims - Laax - Falera	1100	76.	Torrent - Bahnen - Leukerbad	1410
33.	Flumserberg	1220	77.	Unterbäch - Brandalp	1200
34.	Grächen	1619	78.	Urnäsch / Osteregg	1200
35.	Grimentz - Zinal	1600	79.	Val - d'Illiez - Les Crosets - Champoussin / Portes du Soleil	1000
36.	Grub / Kaien	845	80.	Vallée de joux	1010
37.	Grüsch Danusa	630	81.	Vals	1252
38.	Gstaad - Châteaux-d'Oex	958	82.	Verbier / 4 vallées	1500
39.	Gstaad - Mountain rides	1000	83.	Vercorin	1300
40.	Gstaad - Saanen - Rougemont	1050	84.	Veysonnaz / 4 Vallées	1350
41.	Gstaad - Schönried - Saanenmöser - Zweisimmen - St. Stephan	1050	85.	Villars - Gryon	1300
42.	Heiden / Bischofsberg	810	86.	Visperterminen	1340
43.	Hoch-Ybrig	1050	87.	Zermatt	1620
44.	Jungfrau ski Region - Grindelwald - First	1000	88.	Zuoz	1716

Table 3: Overview of the inserted ski areas in the model together with its minimum altitude

Ski reputation	Ski area
Best for snowpowder	Andermatt-Gemsstock-Nätschen
Best for experts	Verbier / 4 vallées
Best for intermediates	Davos - Klosters – Parsenn
Best for beginners	Villars – Gryon
Best for charm	Jungfrau Ski Region / Mürren – Schilthorn
Best for partying	Zermatt
Best for families	Jungfrau ski Region / Kleine Scheidegg - Männlichen - Wengen
Best for snowboarders	Flims - Laax – Falera
Best for value	Val d'Anniviers (two ski areas): ▪ Grimentz – Zinal ▪ St-Luc – Chandolin
Best for weekends	Crans Montana – Aminona

Table 4: Overview of the best ski resorts in the country. Inserted as dummy variable in the model. *Source: The Telegraph*

Calculations and mathematical derivations

Calculations snow line		
• Current snow line: Somewhat less than 750 meters, • Temperature decline 0.6 °C per 100 meter, • Artificial snow possible at 2 °C instead of 0°C.		
Scenario RCP3PD		
2035	**2060**	**2085**
$750 + \left(\frac{100}{0.6}\right) * 1 \approx 900$	$750 + \left(\frac{100}{0.6}\right) * 1.25 \approx 950$	$750 + \left(\frac{100}{0.6}\right) * 1.25 \approx 950$
Scenario RCP3PD Art. S.		
$750 + \left(\frac{100}{0.6}\right) * (1 - 2) \approx 550$	$750 + \left(\frac{100}{0.6}\right) * (1.25 - 2) \approx 600$	$750 + \left(\frac{100}{0.6}\right) * (1.25 - 2) \approx 600$
Scenario A1B		
$750 + \left(\frac{100}{0.6}\right) * 1 \approx 900$	$750 + \left(\frac{100}{0.6}\right) * 2.5 \approx 1150$	$750 + \left(\frac{100}{0.6}\right) * 3 \approx 1250$
Scenario A1B Art. S		
$750 + \left(\frac{100}{0.6}\right) * (1 - 2) \approx 550$	$750 + \left(\frac{100}{0.6}\right) * (2.5 - 2) \approx 800$	$750 + \left(\frac{100}{0.6}\right) * (3 - 2) \approx 900$
Scenario A2		
$750 + \left(\frac{100}{0.6}\right) * 1 \approx 900$	$750 + \left(\frac{100}{0.6}\right) * 2.5 \approx 1150$	$750 + \left(\frac{100}{0.6}\right) * 4 \approx 1400$
Scenario A2 Art. S.		
$750 + \left(\frac{100}{0.6}\right) * (1 - 2) \approx 550$	$750 + \left(\frac{100}{0.6}\right) * (2.5 - 2) \approx 800$	$750 + \left(\frac{100}{0.6}\right) * (4 - 2) \approx 1100$

Table 5: Calculations for the future reliable snow lines

Rewritten version of model 3 to check if there is a difference in distance between best ski resort and those who are not announced to be the best:

Checking if the implications of the interaction term are grounded a little transformation needs to be made to equation 9. The average distance towards accessible snow is 3.692 kilometre in this study. Based on this and the outcomes of model 3 it is possible to look at the precise effect of having a property at the mean distance in a ski resort which is announced to be the best and one which is not. The calculation looks as follows

$$0.223 - (3.692*0.012) \approx 0.1787 \quad (1)$$

This implies that having a property at 3.70 kilometres from a ski resort which is announced to be the best is given the house an extra value of 17.87%, ceteris paribus. Houses which are connected to another ski resort do not have this extra effect on the house value. To test if this effect is significant the following null hypothesis is written down

$$H_0: \beta_3 + 3.692\, \beta_{11} = 0 \quad (2)$$

$$\emptyset = \beta_3 + 3.692\,\beta_{11} = 0$$

$$H_0: \emptyset = 0$$

This could be rewritten as

$$\beta_3 = \emptyset - 3.692\,\beta_{11} \quad (3)$$

Substituting this in the model gives:

$$LN(ASK) = \beta_0 + \ldots\ldots + (\emptyset - 3.692\beta_{11})BEST_i + \ldots\ldots + \beta_{11}BEST_i * DIS_i + \mu_i$$

$$= \beta_0 + \ldots\ldots + \emptyset\, BEST_i + \ldots\ldots + \beta_{11}BEST_i * (DIS_i - 3.692) + \mu_i \quad (4)$$

Testing the null could now easily be done by running this model and looking at the significance of ∅ best ski resort. If it is significant it indicates that houses connected towards a ski area which is known as the best in the country are worth 17.87% more than if they would exactly be the same but connected to another ski area.

The result is that it is indeed significant so that there is indeed a price difference.

The calculations to derive the switching point of age with respect to the house price:

- Age

$$\ln(\widehat{asking\ price}) = -0.0062323\,age + 0.0000143\,age^2 + rest \quad (5)$$

$$\frac{\partial \ln(\widehat{asking\ price})}{\partial age} = -0.0062323 + 0.0000286\,age = 0$$

$$age = 217{,}91 \rightarrow 218$$

The scatterplot at which the pattern is visible could be observed over here:

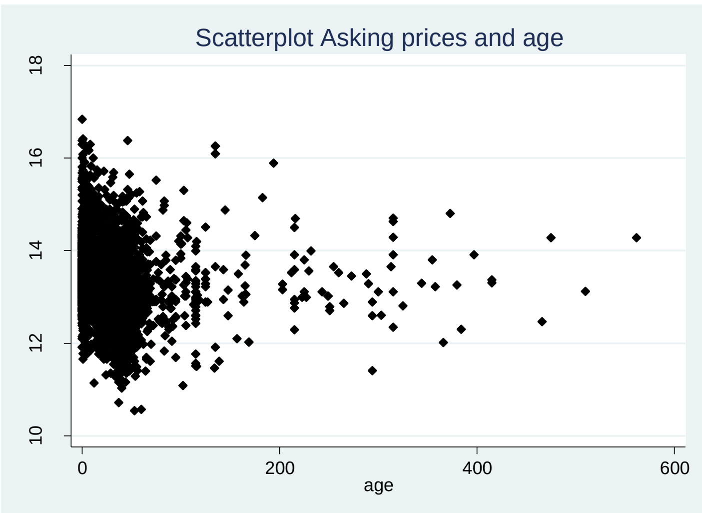

Figure 8: Overview of the relation between age and asking price

An F-test has been performed to check if all snow accessibility variables together are significant:

F-test:
Ho: (1) alt_500_600 = 0, (2) alt_600_700 = 0, (3) alt_700_800 = 0, (4) alt_800_900 = 0 , (5) alt_900_1000 = 0, (6) alt_1000_1100 = 0, (7) alt_1100_1200 = 0, (8) alt_1200_1300 = 0, (9), alt_1300_1400 = 0, (10) alt_1400_1500 = 0, (11) alt_1500_1600 = 0, (12) alt_1600_1700 = 0, (13) alt_1700_1800 = 0, (14) alt_1800_1900 = 0, (15) alt_1900 = 0, (16) S_BLUE = 0, (17) S_RED = 0, (18) S_BLACK = 0, (19) GLAC = 0, (20) NIGHT = 0, (21) DIS = 0, (22) DIS*BEST= 0, (23) BEST = 0 (24) :LN(T_PR), (25) LUX = 0

Outcome:
F(23, 3647) = 45.13
→ Prob > F = 0.0000

Spatial model information

Correlation Matrix																										
	LN(ASK)	LN(FLR)	APP	CHA	STU	DUP	RMS	AGE	NEW	SWIM	WATER	SUP	LN(POP_M)	LN(CL_P)	LUX	BEST	ALT	SKI_CAB	SLP	S_BLUE	S_RED	S_BLACK	GLA	LN(T_PR)	NIGHT	DIS
LN(ASK)	1.0000																									
LN(FLR)	0.7453	1.0000																								
APP	-0.1344	-0.3402	1.0000																							
CHA	0.2795	0.5584	-0.6028	1.0000																						
STU	-0.3986	0.3852	-0.2935	-0.1501	1.0000																					
DUP	0.1293	0.0795	-0.2753	-0.1408	-0.0515	1.0000																				
RMS	0.5886	0.6978	-0.4002	0.6053	-0.4101	0.0535	1.0000																			
AGE	-0.1408	0.0319	-0.1810	0.1987	0.0251	-0.0363	0.1184	1.0000																		
NEW	0.1240	0.0808	0.1080	-0.0728	-0.0780	-0.0108	-0.0143	-0.3355	1.0000																	
SWIM	0.0746	0.0201	-0.0038	-0.0200	0.0186	0.0324	-0.0096	-0.0360	0.0247	1.0000																
WATER	0.1539	0.0480	0.0600	-0.0553	-0.0178	-0.0009	-0.0004	0.0166	0.0046	0.0485	1.0000															
SUP	0.1640	0.0247	0.1039	-0.1195	0.0044	0.0126	-0.0380	-0.1009	0.0291	0.0483	0.0457	1.0000														
LN(POP_M)	0.2313	0.0768	0.0580	-0.0661	-0.0157	0.0251	-0.0023	-0.1194	0.0390	0.0424	0.1115	0.5811	1.0000													
LN(CL_P)	0.5001	0.4921	-0.0018	0.0206	-0.0993	0.0646	0.1320	-0.0545	0.0410	0.0491	0.1456	0.1492	0.2139	1.0000												
LUX	0.3281	0.0488	0.0788	-0.0832	0.0077	-0.0110	-0.0299	-0.0180	-0.0718	0.0183	0.0351	0.1647	0.2097	0.2870	1.0000											
BEST	0.1956	-0.0467	0.0705	-0.1055	0.0327	0.0301	-0.0808	-0.0103	-0.0799	-0.0055	-0.1220	0.1472	0.2623	0.1943	0.2794	1.0000										
ALT	0.0527	-0.1749	0.0409	-0.1167	0.1224	0.0282	-0.1476	0.0350	-0.2191	-0.0287	-0.1999	-0.0876	-0.1764	0.0778	0.2297	0.2529	1.0000									
SKI_CAB	0.1082	-0.1227	0.0799	-0.1216	0.0618	0.0121	-0.1158	-0.0210	-0.0830	0.0264	0.0550	0.1332	-0.0087	0.1326	0.1821	0.0593	0.4177	1.0000								
SLP	0.1601	-0.0263	0.0294	-0.0489	0.0102	0.0268	-0.0264	-0.0149	-0.0677	-0.0111	-0.1358	0.0508	-0.0989	0.2070	0.1873	0.2232	0.2016	0.1884	1.0000							
S_BLUE	0.1459	-0.0208	0.0178	-0.0313	-0.0079	0.0346	-0.0035	-0.0019	-0.0493	-0.0040	-0.0976	0.0286	-0.1050	0.2153	0.0702	0.1173	0.1488	0.1649	0.9558	1.0000						
S_RED	0.0745	-0.0675	0.0196	-0.0475	0.0326	0.0229	-0.0452	-0.0297	-0.0680	-0.0106	-0.1621	0.0136	-0.1406	0.1024	0.0954	0.1815	0.1945	0.1579	0.9293	0.5743	1.0000					
S_BLACK	0.2932	0.0336	0.0648	-0.0704	0.0030	-0.0012	-0.0305	-0.0081	-0.0767	-0.0246	-0.0997	0.1626	0.0673	0.2941	0.5931	0.4673	0.2403	0.2080	0.6875	0.4176	0.3084	1.0000				
GLA	-0.0026	-0.0075	-0.0500	0.0460	0.0122	0.0038	-0.0067	-0.0368	-0.0242	0.0205	-0.0932	0.2186	0.0561	-0.0250	0.0849	-0.0902	0.0952	0.0750	0.0197	-0.0379	0.1036	-0.0236	1.0000			
LN(T_PR)	0.1871	-0.0237	0.0611	-0.0906	0.0782	0.0172	-0.0380	-0.0272	0.0311	0.0970	-0.1452	0.1278	0.0459	0.1101	0.4356	0.3328	0.3421	0.0716	0.0467	0.4512	0.5909	0.4662	0.3159	1.0000		
NIGHT	0.1456	-0.0237	0.0921	-0.1049	-0.0209	0.0351	-0.0422	-0.0260	-0.0564	-0.0225	-0.1050	-0.0574	0.0821	0.1905	0.1756	0.3557	0.0748	0.0154	0.4449	0.4488	0.3732	0.3259	-0.2355	-0.2346	1.0000	
DIS	-0.0757	0.2127	-0.0943	0.1588	-0.0890	-0.0304	0.1673	0.0099	0.1640	-0.0030	0.0668	-0.0106	0.0270	-0.1018	-0.1224	-0.1008	-0.5558	-0.6661	-0.1553	-0.1386	-0.1459	-0.1294	-0.0402	-0.0447	-0.1351	1.0000

Table 6: Correlation matrix

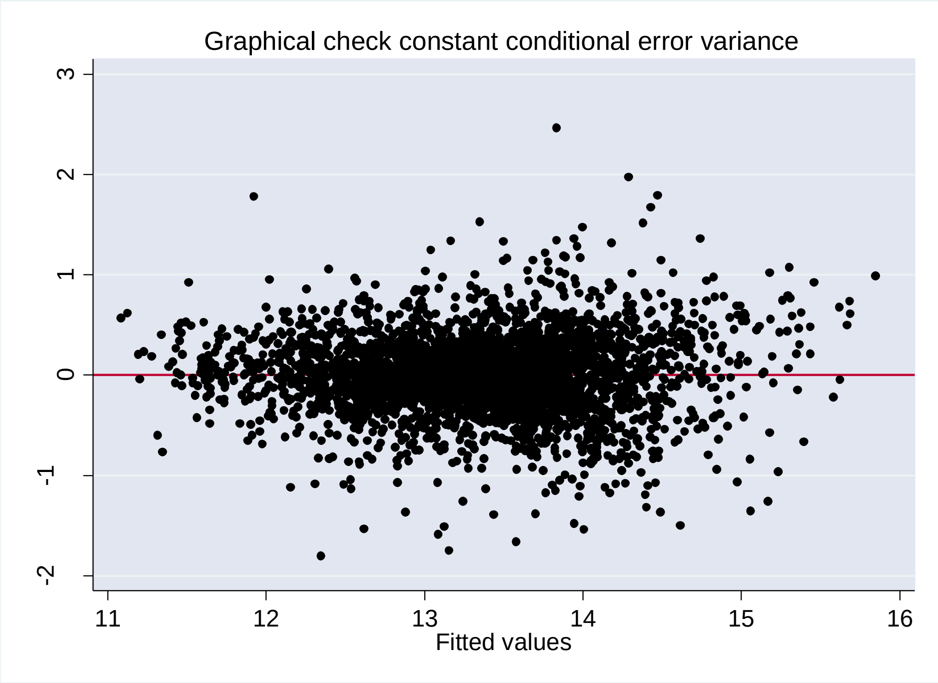

Figure 9: Graphical check on violation of constant conditional error variance

Breusch-Pagan	
Ho: Constant variance	
chi2(1)	177.6
Prob > chi2	0.000

Table 7: Test for violation of constant conditional error variance

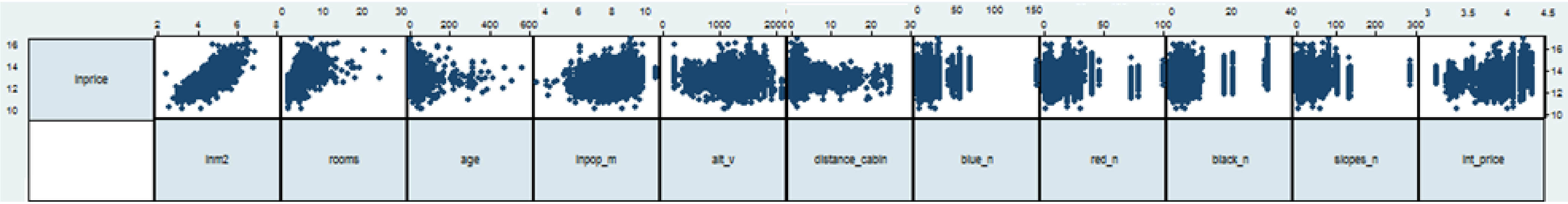

Figure 10: Visible relationships between ln(asking price) and the explanatory variables

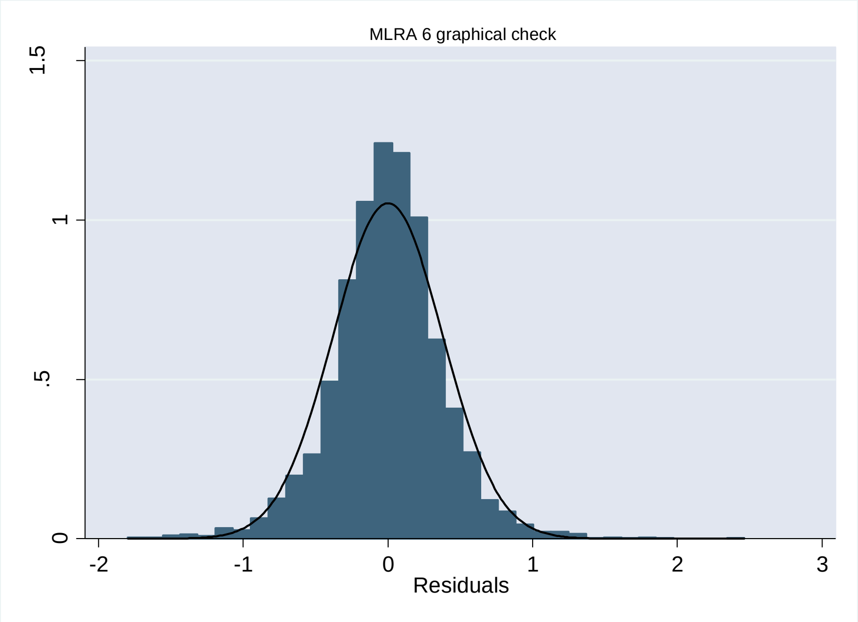

Figure 11: Visible check on normality assumption

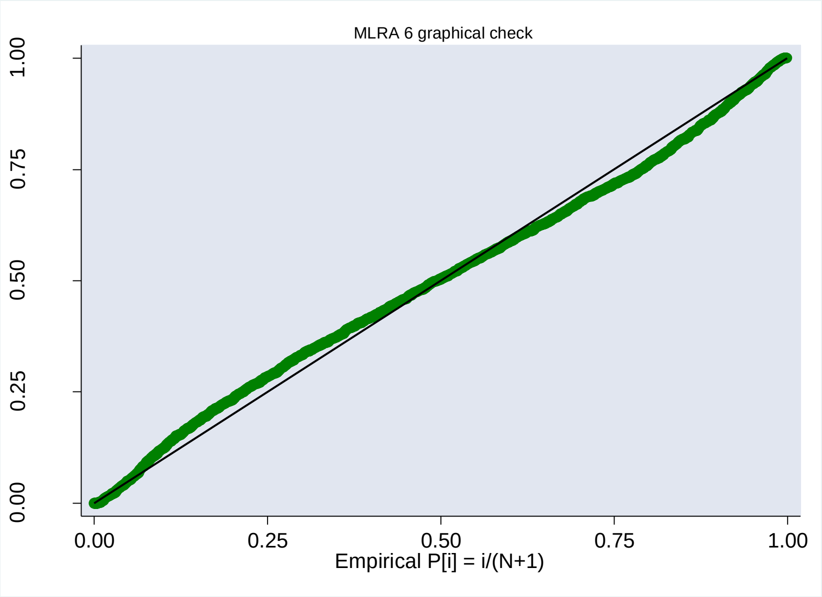

Figure 12: Another visible check for normality assumption

Assumption	Satisfied
1 $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n + \mu$ $(y, x_1, \ldots, x_n \text{ and } \mu \text{ all random})$	Yes
2 $\{(x_{i1}, x_{i2}, \ldots, x_{in}, y_i): i = 1, 2, \ldots, n\}$	Yes
3 *No perfect collineairty*	Yes
4 $E(\mu \mid x_1, x_2, \ldots, x_n) = 0$	Yes
5 $Var(\mu \mid x_1, x_2, \ldots, x_n) = \sigma^2$	No*
6 $\sigma^2: \mu \sim Normal\,(0, \sigma^2)$	Yes
*: constant variance of error term is not satisfied. Solved by using robust standard errors	

Table 8: Overview of the multiple regression assumptions for this model