ECONOMIC EFFECTS OF INCREASED RESEARCH ACTIVITIES IN GROßSCHÖNAU ON THE REGION OF LOWER AUSTRIA

An Input-Output Analysis

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Declaration of Honor

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Since this is the only section of this work where I can express myself in a less formal and non-academic way, I will not use the phrases that pop up on the top of the search engine when asking for acknowledgement examples, but I will use my honest words:

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Abstract

This thesis examines the economic effects that increased research activities at the Sonnenplatz Großschönau have on the region of Lower Austria. For that reason, a regional input-output analysis was conducted. The results illustrate direct, indirect, and total effects as well as multipliers for the planned investments. Total output, gross value added, income (compensation of employees) and the number of full-time employees all show an increase as does the gross domestic product. While the positive impact of the investment seems clear, the opportunity costs that come with it must not be neglected. To enhance the outcome of the investment it is suggested that more money is being targeted towards marketing. This should increase the total output due to the utilization of higher multipliers.

Keywords: regional development, research and development, economic growth, input-output analysis, multipliers

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1 Introduction

Taxpayer money that is being used for public funding or for subsidizing should be spent in a way that increases prosperity and the living standard of the public at large. Political agents are in charge of making budget decisions, which define size and targets of certain funding. These decisions should be made based on the results attained from profound analytical frameworks, which gives this thesis its purpose. Decision-makers of Lower Austria are considering to fund a project in Großschönau (municipal of Lower Austria), namely the Sonnenplatz Großschönau. This is an existing place that accommodates various facilities with a focus on energy-efficient and sustainable construction and reconstruction. It contains a research and competence center, an exhibition area as well as buildings with particularly low energy consumption. The objective of this work is to prepare results that offer the chance to take a reasonable investment decision. This is being done by answering the following research question:

What economic effects do increasing research activities of the Sonnenplatz Großschönau have on the region of Lower Austria?

The research conducted to answer this question focuses on regional development theories examining the relationship of research and development and economic growth. The factor space plays a significant role in the distribution of innovation and the formation of an economy (Dawkins, 2003). While it is clear that increased research activities lead to new technologies, a causal relationship between innovation and economic growth cannot simply be assumed (Sylwester, 2001). Since the Sonnenplatz Großschönau is located in a peripheral area, this does have an effect on knowledge spillovers, which also effect the economy as a whole. Economic clusters surrounding research centers make the distribution of knowledge a lot easier and faster. This is true for knowledge coming from the research center and for knowledge coming from the surrounding companies and institutions (Griliches, 1991).

The analytical framework used to measure the economic effects is a regional input-output (I-O) analysis. The fundamental purpose of this tool is to illustrate the interdependencies of industries within an economy. The regional I-O table used for Lower Austria includes 17 industries and the table was shocked (simulation of investments) four times in total. One time for the investment/building phase, then for the running phase, for visitors and finally one shock including all investments creating the overall effects. The results display a growth in total output, in gross value added, in income (compensation of employees) as well as in the number of full-time employees and in the gross domestic product. While these findings show only positive impacts, one must not forget about the opportunity costs of such investments (Sylwester, 2001).

The remainder of this thesis is divided into four chapters: Chapter 2 contrasts various concepts and theories of regional development and illustrates the measurement tool input-output analysis in detail. The case study is outlined in chapter 3, in which the Sonnenplatz Großschönau is being explained and the I-O analysis is conducted. The results are also defined in this chapter including direct, indirect, and total effects as well as multipliers. Chapter 4 offers political implications and investment recommendations followed by the conclusion in chapter 5.

2 Theoretical Approaches of Regional Development

2.1 Key Concepts and Theories

Regional development has been in the scope of scholars for decades, leading to a large pool of literature examining various concepts and theories. While in the early stages of research in regional development mostly economists were interested in the scientific results, the audience has become a lot bigger over the years. Today, researchers from the fields of political science, sociology and other social sciences are fascinated by regional development and therefore are eager to investigate this topic further. The reason for this increase in interest can be explained by the recognition that innovation and economic growth are driven by spatial processes. Put into simple words, space does matter (Dawkins, 2003).

This chapter aims to provide key concepts and theories of regional development which sets the scene for this thesis and is essential to understand the upcoming analytical framework.

First it is important to define what a region is and surprisingly there is very little agreement within the literature when it comes to defining the term region. One of the earlier approaches is Christaller's central place theory which states that a region is made from several cities of different ranks, namely 7 different ranks, meaning there is a strict hierarchy. While there is only one very large city, the number of cities increases as the size of the cities decreases. The ranking depends on the number of goods a city is producing. Each city of a certain rank produces all the goods that the city of the lower rank produces and more. Thus, the higher ranked cities export goods to the lower ranked cities and the lower ranked cities import goods from the higher ranked ones. Cities of the same rank do not exchange goods with one another. This leads to the conclusion that higher ranked cities have a larger market area than lower ranked cities (King, 2020).

Another definition of region would be the one of a geographical area that is forming an entity. It is very helpful to aggregate into regions because there are fewer distinct numbers that need to be examined when comparing or calculating certain data. It becomes clear that this is of vital interest for administrative work when public servants or governmental institutions need to plan and implement policies. For the purpose of public policies, it obviously makes the most sense to use the boundaries of administrative judiciary to divide into regions (Hoover & Frank, 1999). This type of regional grouping will also be used for the analysis within this thesis, since the state of Lower Austria will be examined.

Hoover et al. (1999) also describe that regions are usually following a specific common interest and that there are two types of regions that can be distinguished depending on their internal structure, homogenous and functional regions, which will be outlined in the following:

The characteristic of a homogenous region is that it is internally uniform. To explain this uniformity Hoover at al. use the winter wheat belt of the US where the same type of crop is being grown in all parts of the region. However, since it suits this thesis better the reader should think about the Weinviertel in Lower Austria, which is a homogenous agricultural region of wine. Since the same good is grown basically under the same conditions over the entire region, external factors that influence the harvest and production of wine will be the same for all farmers across this region. For example, if there is a season of drought where rain is missing, this will negatively affect all vineyards within the Weinviertel in a similar way.

Functional regions on the other hand are economically interdependent meaning that areas within the region interact more with one another than they do with areas that are located outside of the region. When it comes to functional regions, the nodal region is specifically popular among scholars. A nodal region is characterized by a single focal point or entity that dominates all others. Hoover et al. mention that a city and the surrounding areas of trade are in fact an example of a nodal region (Hoover & Frank, 1999). This indicates that Christaller's central place theory introduced in 1933 was already outlining the structure of a nodal region.

For the purpose of consistency throughout this thesis, the following definition for the term region was created: A geographical area that is consisting of spatially interrelated smaller geographical areas that are bound by a shared interest, may that be the interest of the entities within that region or the interest of the examiner of that region.

Understanding the characteristics of regions is so crucial because nations obviously want to increase their economic performance over time. Governments try to implement policies that are most likely to lead to these economic improvements and they can only do so if they are aware of how the economy functions. An entire economy is a very complex system consisting of many variables that are interrelated with one another. That makes predicting the outcomes that certain policies have on the economy very difficult. However, the theories and concepts that are being continuously developed by researchers make this task easier, which should eventually lead to policy implementations that are more successful. Since the purpose of this thesis is to provide information to public servants, which should help with political decision-making, elaborating the upcoming theories and concepts is crucial to guarantee meaningful understanding of the final results, thus, creating the most value possible.

2.1.1 Interregional Convergence Hypothesis

The interregional convergence hypothesis states that as time passes, regions tend to become convergent, meaning that the differences of labor and other factor prices decrease across regions (Dawkins, 2003). One way to explain this factor price convergence is the Heckscher-Ohlin-Samuelson (HOS) theorem, which is a fusion of two separate theorems that go hand in hand with one another, the Heckscher-Ohlin (HO) theorem and the factor-prize equalization theorem. While Heckscher set the base for the HO-theorem it was Ohlin who made it popular expanding Heckscher's ideas. Together with Samuelson's factor-prize equalization it became the well-known HOS-theorem, which relies on the following assumptions:

1. There are two regions (region 1 and region 2), two commodities (commodity A and commodity B), and two production factors (labor and capital).
2. Region 1 and region 2 have both the same production functions and use the same technology.

3. For both regions, commodity A is labor-intensive while commodity B is capital-intensive.
4. Commodities A and B (in both regions) are being produced under constant returns to scale.
5. Both regions are producing some of commodity A and some of commodity B, meaning that there is no perfect specialization.
6. Taste is the same across the regions.
7. In both regions there is perfect competition in commodity and factor markets.
8. Factor mobility is perfect within the regions but there is no interregional factor mobility.
9. There are no transportation costs, no tariffs, and no other restraints to interregional trade.
10. Both regions fully employ all resources for the production of both commodities A and B.
11. Interregional trade between region 1 and region 2 is perfectly balanced meaning that the value of regional exports and imports are equal.

Now that the assumptions have been established the Heckscher-Ohlin Theorem can be stated as follows: The commodity for which production is in intensive need of the region's relatively cheap and abundant factor will be exported by that region, while it imports the commodity for which production is in intensive need of the region's relatively expensive and scarce factor. Assuming that region 1 is relatively capital-rich compared to region 2 and commodity A is relatively capital-intensive compared to commodity B, it becomes clear that region 1 will export commodity A to region 2 while it will import commodity B from region 2 (Since region 2 is the relatively labor-rich region it becomes relatively cheaper to produce commodity B, which is the relatively labor-intensive commodity). According to the HOS model, it is this factor abundance of regions that causes comparative advantage, thus, leading to specialization and interregional trade.

With the same assumptions the factor-prize equalization theorem can be stated as follows: Since interregional trade leads to the equalization of relative and absolute factor prices (assuming homogeneous factors) across regions, it functions as a substitute for interregional mobility of factors. This means that the prices for labor will become the same for all trading regions. Similarly, the prices of capital will also be the same among the trading regions. This suggests that region 1 and region 2 will eventually have the same wage rate (*w*) for labor and the same interest rate (*r*) for capital. In the following, the path towards equalization of factor prizes will be outlined: When regions start to specialize, there is going to be a shift in demand. When region 1 (capital-rich) specializes in the production of commodity A (capital-intensive) and therefore reduces the production of commodity B, the relative demand for capital increases, thus, causing *r* to increase as well. On the other hand, the relative demand for labor decreases, which lowers *w* in region 1. For region 2, the exact opposite is true: A specialization in commodity B (labor-intensive) leads to an increase in demand for labor, accelerating *w*, and a decrease in demand for capital, lowering *r*. What happens is that interregional trade reduces the pretrade differences of factor prices across regions. Trade will continue to expand as long as the relative factor prices and therefore also the relative commodity prices differ up until the point where there is complete equalization of factor and commodity prices across region 1 and region 2 (Salvatore, 2013).

This theory sheds light on the reasons for specialization, the effects comparative advantage might have and why regions trade with one another. These theoretical principals should make it easier to understand how and why certain flows of goods influence the economy. This is especially important since the input-output analysis conducted in this thesis illustrates such interregional flows.

2.1.2 Location Theory

Location theorists try to explain the process and indicators of a firm to choose the right location, which is the location that is most profitable. One of the main contributors to location theory is Alfred Weber who put great emphasis on transportation costs in the context of firms selecting the right location for production. In his book from 1909 with the title “Über den Standort der Industrie” (Theory of the Location of

Industries) he outlines three general factors: transportation costs, labor costs and forces of agglomeration. According to Weber production will be facilitated where transportation costs of raw material and the finished good are lowest assuming that all other costs are constant. The product's characteristics will determine whether processing will occur at the consumption center, the location of raw materials or at an intermediate point. Products experiencing a high loss of weight, when raw material is being processed to finished goods, will locate close to the source of raw material. On the other hand, products that show only a slight loss of weight during production, will locate near consumption centers. If there is more than one raw material in use, the production sight will be placed where total transportation costs are lowest (depending on the ton-mile costs).

Weber introduced a labor coefficient to state the differentials of labor cost by using a ratio that includes labor costs per ton and the total weight of goods transported. If the labor coefficient is high enough it could become more profitable for a company to produce at a location where transportation costs are larger. Weber's emphasis on the importance of labor costs was a significant contribution to location theory development. The forces of agglomeration describe the advantages of being close to auxiliary industries, economies of size or better marketing outlets. Eventually, agglomerating forces can make labor and transportation costs relatively insignificant by becoming the determining factor. The interesting part about Weber's location theory is that he only focuses on these general and natural factors because he thinks that they affect all industrial locations no matter which economic type they are. On the contrary, he refuses to include taxes, interest, or insurance in his theory, because these factors only influence a limited number of locations (Richards, 1962).

Jovanovic (2003) raises the concern that the needs of a firm are likely to change over time, which might make the initial "perfect" location less profitable. Reasons for this could be the change and development of technology, the industry as a whole or consumer needs. Put simply, no location of a production sight will always remain the best location (Jovanovic, 2003).

Moses (1958) criticizes the lack of development in location theory because since Weber's model scholars continuously used linear production functions when conducting location theory. With his paper Moses wanted to change this by putting emphasis on factor substitution. In his model, there are two inputs (raw materials) and one final product, which can be produced using any combination of the two inputs. Raw material prices and transportation costs vary. The optimum location of a firm is at the point where total expenditure is minimal, which is the case when the combined factors induce the marginal productivity ratio and the delivered price ratio to be equal. The main conclusion he derives is that profit maximization requires adequate adjustments of three variables: Input-output combination, location, price. Moses claims that Weber does not allow for geographic variation in qualities or prices of the inputs across different sources, which leads to two conclusions:

1. Production costs do not differ between various locations, thus

2. The optimum location is where transportation costs are lowest.

These two conclusions lead to the emergence of a linear production function, which Moses wanted to avoid by allowing for substitution. This, in contrary to Weber's model, permits multiple optimal locations (Moses, 1958).

In the weber model agglomerations were already mentioned and the upcoming outline of the cluster theory will describe the reasons why such agglomerations develop and what advantages they bring.

2.1.3 Cluster Theory

This theory focuses on the importance of cooperation among industries and firms within a region. It describes the reasons and advantages of developing a network of interrelated businesses such as sharing knowledge, expertise, and resources. Asheim and Gertler (2009) put emphasis on the geography of innovation by examining regional innovation systems. Doing so, they define two paradoxical characteristics of the modern global economy: First, there is no uniform or random distribution of innovative activity across space. In fact, geographical clusters intensify when economic activity is more knowledge intensive. Asheim et al. give the examples of biotechnology and financial services which are industries that are continuously more tightly clustered in only a few major centers. This is true, even though many other places tried to generate activity in those sectors but failed. Second, the trend towards industrial clustering has become more distinct over time and not less. The main argument of the two authors is that innovation cannot be properly understood if the central role of concentration and spatial proximity in this process is being ignored. Another argument laid out by Asheim and Gertler is that tacit knowledge is being produced during the act of transmission, namely during the interaction between users and producers. While users transmit specific practical problems to the producers, it is the producers who will come up with new and innovative solutions/technologies for these problems. When users start to implement these new technologies in their daily life, they will find new problems arising, thus, transmitting them to the producers. A cycle of joint knowledge and innovation production is the outcome benefitting both producers and users, which would not exist if the two groups would be isolated. This again shows the importance of clusters since valuable knowledge transmission depends on spatial proximity.

The authors explain regional innovation systems (RIS) as institutional infrastructure helping innovation to drive forward within a region's production structure. They outline two definitions for innovation systems, a narrow and a broader one. While the broader one is an interactive, bottom-up innovation model as described in the former paragraph the narrow definition would be the one of a top-down, linear model where R&D of private and public research institutions as well as of universities are primarily responsible for driving innovation. Governing these economic processes of innovation production between regional networks of local clusters, innovators and research institutions has become increasingly important. The RIS type heavily implemented in Austria is the regionally networked innovation system. The characteristics of this form of RIS is that organizations and firms are part of a specific region with localized, interactive learning. Moreover, political interventions strengthen the institutional infrastructure and therefore create a rather planned system. This RIS type is often referred to as the ideal type: regional firm clusters supported by institutional infrastructure (Asheim & Gertler, 2009).

Delgado et al (2010) examine the relationship between clusters and entrepreneurship on the region-industry level and come to the conclusion that clusters have a significant positive impact on entrepreneurial activity. In regions marked with clusters, industries show higher growth rates in new business establishments and employment in start-ups. Existing firms also constitute more new establishments, thus, the decision about location of multi-establishment firms is being influenced by strong clusters. These regional agglomerations improve the diversity of entrepreneurial activity, decrease the costs of forming new businesses and contribute to the survival of start-ups (Delgado, Porter, & Stern, 2010).

These insights are particularly valuable for political agents since the theory here shows how important clusters can be for a rising growth rate and that political interventions have the power to influence the economic structure. As mentioned by Asheim and Gertler, Austria has already implemented the ideal regional innovation system that should support the creation of innovation. This thesis can be seen as an example of this RIS type because it is commissioned by Austrian politicians who are interested in the economic effects certain investments have on the region. This also illustrates the planned characteristic of the Austrian regional development efforts.

2.1.4 New Economic Geography

The issue that the new economic geography is trying to tackle is the understanding of how and why the various forms of economic agglomeration emerge in geographical space. To do so, the goal is to design a model, which enables storytelling in the way that one can explain the economic role of a city like New York within the complex situation of the entire economy. Key to this ambition is the analysis of centripetal factors, which pull together economic activity, and centrifugal forces driving it apart. Therefore, it is about the understanding of the tension of these two forces pushing and pulling simultaneously. The following paragraphs refer heavily to Fujita’s and Krugman’s paper “The new economic geography: Past, present and the future” from the year 2004, which gives great insights into this topic in an interview-style form with two scholar’s that strongly devoted great parts of their research activities in this field.

What made the development of the new economic geography such a difficult task are the following circumstances: Perfect competition cannot be assumed because of increasing returns. It is knowingly hard to integrate imperfect competition in a system of general-equilibrium system. Moreover, it is necessary to embed the income production and resources used by the transportation industry. Transportation costs are crucial and therefore location matters. Finally, the movement of consumers and productive factors between locations is essential for agglomeration. To overcome these hurdles, Krugman explains the importance of making convenient but silly assumptions and using intellectual tricks, which he condenses into one slogan “Dixit-Stiglitz, icebergs, evolution and the computer”.

Dixit-Stigliz: Avinash Dixit and Joseph Stiglitz created a new and compelling formulation of monopolist competition in which it is recognized that increasing returns are the cause for monopoly power, without sacrificing too much of the concept of supply and demand.

Icebergs: This term leads back to a transportation model created by Paul Samuelson in 1952, in which transportation costs are implemented cleverly. In his model, there is no transportation service industry using labor and capital to move goods from point A to point B. Rather the goods can be moved freely, however, a portion of the transported goods will “melt” during transit.

Evolution: Here Krugman talks about how geographical structures evolve and how one possible path out of many is being “selected”. In the new economic theory this means that the hypothetical players of an economy are not given the power to make location decisions based on forecasting the future. Therefore, self-fulfilling prophecies are precluded, and the decisions are made according to the current conditions. This means that the economic geography evolves based on history and accident, rather than on expectations of the future.

Computer: This word simply refers to the possibilities that modern theorists have when using high technology not only to calculate numerical examples but to gain thought-provoking impulses for the underlying models.

In their paper, Fujita and Krugman discuss three distinct models that all correspond to the spatial economy: Core and periphery, evolving an urban system, industrial concentration and trade (Fujita & Krugman, 2004). These models will be given further explanation:

2.1.4.1 Core and Periphery

This model displays the introduction framework of new economic theory by demonstrating the interactions between factor mobility, transport costs and increasing returns on firm level. The following assumptions must be made:

- Two regions, two sectors (sector 1 producing agricultural products, sector 2 producing manufacturing products), two forms of labor (farmers, workers).
- Manufacturing sector produces various products that are horizontally different. Each product variety is manufactured by a distinct firm using economies of scale, with workers being the only input.
- Agricultural sector only produces one type of good (homogenous) with constant returns to scale and famers being the only input.
- Workers can move freely between regions. Farmers are immobile, however, they are equally distributed among the two regions.
- Agricultural goods can be traded without transportation costs. Manufactured products are exposed to transportation costs using the iceberg method.

Now, since the farmers are immobile and they consume both, agricultural and manufactured goods, they function as a centrifugal force. On the other hand, the centripetal force needs a more sophisticated explanation because of its structure of circular causation: When more companies settle in a region, there will be a larger variety of products available. This means that the workers in that region, who are also consumers, can choose between more differentiating products than the workers of the other region. With other things remaining the same, this benefit of a higher real income attracts other workers to migrate. The increase in workers (consumers) leads to a larger market, which gives incentives to economies of scale to produce all different products in that region. This is due to the simple fact that transportation costs make it much more profitable to produce goods where the larger market is and transport those goods to the other region. Eventually there is an even larger variety of products available in one region. In other words, the circular causation of forward and backward linkages is the driver of the centripetal force. The former being the incentive for workers to concentrate near the production of consumer goods and the latter being the motivation for producers to locate at the larger market.

Now if the centripetal force is so strong that it pulls harder (forward and backward linkages) than the centrifugal force can push (immobile farmers), than the economy will eventually display a core-periphery pattern where one region contains all of manufacturing. There are three reasons that accelerate the chance of forming a core-periphery pattern:

1. Transport costs of manufacturing goods are low enough
2. There are sufficiently differentiated varieties
3. Manufacturing expenditure is high enough

Of course, agglomeration must not occur, however, only a tiny change in one of the critical parameters can result in a turnaround of the economy. It can quickly change from two regions that are equal and symmetric to one region becoming the industrial core while the other region turns into a de-industrialized periphery. It is important to stress that the evolution of economic geographical structure is more complex than some might assume. For example, under a certain range of conditions, it is possible to have a self-sustaining region with a concentration of industry, but it would also be possible to have two equal regions that would be just as stable. To picture the situation, Fajita and Krugman let the reader imagine the financial geography of Europe: It is clear that Europe would sustain with a financial capital like seen in the USA with New York, if one had been established. However, this scenario does not have to evolve under the current circumstances (Fujita & Krugman, 2004).

2.1.4.2 Evolving an Urban System

Different to the core-periphery theory the urban system evolution theory requires the following assumptions:

- Land is being distributed uniformly along a real line which describes the location space.
- All workers are identical and can choose freely where they want to work and what their occupation is.
- The production of the agricultural product uses land and labor.
- Transport costs are positive for industrial and agricultural goods.
- Only agricultural land displays as immobile factor (centrifugal force).

The approach initially displays von Thünen's "isolated state": a city (concentration of manufacturing) is surrounded by agricultural hinterland. Next, the population of the entire economy is being increased gradually. When the outbounds of the hinterland are significantly far away from the center, it becomes profitable for some manufacturers to move, creating a new city. Increasing the population more will increase the number of cities emerging. It is vital that the location attractiveness for manufacturers can be illustrated by a "market potential" index. This market potential will determine where economic activity takes place. The shift of the location of economic activity on the other hand will draw a map of market potential, meaning there is a form of co-evolution in terms of the process of economic change. The city-evolution approach suggests that even though multiple equilibria are possible, there are certain regularities within the spatial structure. When the number of cities reaches a significant amount, the distance between cities as well as their size will settle at nearly to a constant level. It is the relative strength of the centrifugal and centripetal forces determining this level, giving Lösch's central place theory[1] some justification. When there are various industries differing in terms of transport costs and economies of scale, the economy will more likely evolve under a hierarchical structure à la Christaller. This shows how older theories can still be linked when conducting modern economic approaches.

This type of evolutionary modelling displays the connection between natural and economic geography. Besides the striking arbitrariness in real economic geography

[1] For the reader interested in Lösch's work refer to his book published in 1940 "Die Räumliche Ordnung der Wirtschaft" – English name: "The Spatial Organization of the Economy" (Lösch, 1940).

(one Stanford official being responsible for the creation of Silicon Valley), rivers and ports are still significant when it comes to location factors with “catalytic” roles around which cities are more likely to emerge. However, once a center is established, it grows in a self-sustaining way where the advantages of the agglomeration itself exceed the initial advantages of the location. It is this self-organizing characteristic that gives natural geography such great importance within spatial economics (Fujita & Krugman, 2004).

2.1.4.3 Industrial Concentration and Trade

In the core-periphery and the urban system models factor mobility played a major role in the development of agglomeration. However, production concentration deals with more than simply resources, meaning that an agglomeration must not have producers from every industry. There are plenty cities specializing in certain industries such as Hollywood with the film industry for example. How the new economic geography deals with these circumstances is to slightly modify the core-periphery approach. This is being done by shifting the emphasis from resource agglomeration to geographical concentrations of specific industries, which is essential because in Fajita’s and Krugman’s model labor is an immobile factor. It is important to consider vertical production where the inputs of at least one downstream sector are being produced by at least one upstream sector, while both producers (upstream and downstream) face rising returns and transportation costs. This inevitably creates forward and backward linkages leading to a concentration of production (upstream and downstream) in one location. While the producers of intermediate goods want to locate where the market is largest, the producers of final goods want to be close to their suppliers. Trade patterns and economic change might be affected by these industrial concentrations since they can function as external economies in trade (Fujita & Krugman, 2004).

The new economic geography is one of the latest theories. It was developed in times of the computer, thus, giving it a whole new set of possibilities, leading to new assumptions and hypotheses. However, this theory is not an entire new construct but rather an updated version of previous economic theories that were modified and adapted. Especially important to understand is the connection between centripetal and centrifugal forces. The objective of public investments towards research facilities is obviously to strengthen the centripetal forces of a region, meaning to pulling economic activity together. In this case it is about making Großschönau a more attractive place to enhance economic productivity in the municipality itself as well as in the surrounding region of lower Austria. Detailed information about the characteristics of Großschönau, the investment size and how it might affect the centripetal forces of the region will follow in chapter 3 "Case Study – Sonnenplatz Großschönau" and chapter 4 "Policy Implications".

2.1.5 Endogenous Growth Theory

The endogenous growth theory puts emphasis on the endogenous or internal forces of an economy leading to economic growth. According to the supporters of this theory it is those endogenous factors that are primarily responsible for economic growth and not external forces. Ramsey (1928) wrote a seminal paper about the mathematical theory of saving, which is arguably the root of endogenous growth theory. He himself declared his findings as the optimal growth theory, which answers the question of how much of a nation's income should be saved in order to reach optimal growth. To do so, Ramsey created distinct utility functions under the assumptions of a never changing population, where goods and labor are fixed standards (they do not vary) and savings are not being consumed by subsequent generations. When striving for optimal growth the goal is to reach bliss, which is the maximum obtainable rate of utility. Using saving as an endogenous determinant Ramsey's optimal growth theory set the ground for the endogenous growth theory (Ramsey, 1928).

There are two scholars who picked up substantially on Ramsey's work, Cass and Koopmans, leading to today's well-known Ramsey-Cass-Koopmans (RCK) model[2]. While Ramsey worked with the rule of bliss, Cass and Koopman adapted their formulas using the golden rule of accumulation introduced by Phelps (1961). This rule states that the fixed investment ratio equals the profit income ratio, and the best

[2] Even though Cass and Koopmans never mentioned that their work contributing to the RCK model was something other than independent and simultaneous, there is a discussion of priority. For the reader interested in this debate refer to Spear and Young's paper "Optimum Savings and Optimal Growth: the Cass-Malinvaud-Koopmans Nexus" (Spear & Young, 2014).

results of social welfare are reached when applying the golden rule within a dynamic equilibrium - capital-output ratio remains steady-state over time since capital and output increase exponentially at an identical rate (Phelps, 1961). Both authors also include the factor of a growing population in their papers, which Ramsey simply ignored with his assumptions. Analyzing the optimal growth including a growing population comes with the necessity of discounting future welfare. In his findings, however, Cass draws attention to the difficulty of weighting future generations properly, especially when the population increases (Cass, 1965). Koopmans raises the issue of technical progress, which can be endogenously affected by the amount of income distributed. This, as does population growth, increases the hurdle of calculating optimal economic growth (Koopman, 1963).

Around the same time Arrow's (1961) paper with the title "Economic Implications of Learning by Doing" was published, in which he addresses the importance of experience when it comes to economic growth. According to Arrow, there is one distinct generalization of the process of learning that most scholars agree upon: Learning is a result of experience, which only occurs when one tries to solve a problem, thus, it only takes place through activity. The second generalization that is unambiguous is that the repetition of trying to solve the same problem inevitably leads to great diminishing returns. What that means is that the stimulus situations must evolve as well to continuously improve performance and it is not sufficient to merely solve the same problem repeatedly. One of Arrow's examples is the description of the learning curve of a Swedish iron manufacturer. Over a decade the company did not receive any new investment, however, the productivity still increased by approximately 2% p.a. on average. Since there was no considerable change in the methods of production, the steady improvement of performance must be the outcome of learning from experience. In his paper, Arrow supports the hypothesis that experience is the main driver of technical change. According to him, it is the production activity itself that creates problems for which suitable solutions are found over time, thus, increasing the improvement of change (Arrow, 1961).

Romer (1986) supports the theory of learning by doing and creates a competitive equilibrium model where technological change is endogenous and knowledge is the primary driver of long-run growth. Knowledge is being gained by diminishing returns of research technology, meaning that increasing the inputs of research by 100% will lead to less than double the amount of knowledge produced. Another finding is that investments in knowledge positively impact the production potential of external companies since knowledge cannot be easily contained and therefore knowledge spillovers are inevitable. Probably the most significant result of Romer’s paper is that knowledge can have increasing marginal productivity. He states that there is no limit to knowledge growth, which is unlike the models where capital has a diminishing marginal product (Romer, 1986).

The above-mentioned authors of the endogenous growth theory have one thing in common: they do not take the spatial factor in consideration when examining the progress of economic growth. This changes with Nijkamp and Poot (1998), who emphasize on spatial interdependence and how it influences economic growth in a regional system. In their model endogenous technological change leads to steady-state growth in the long run considering a closed economy. When examining the effect of spatial interdependence, the results heavily depend on certain specifications leading to various possible outcomes: spatial convergence, unstable growth or a steady state with different growth rates varying among space. Nijkamp and Poot include factor mobility and diffusion in their analysis of long-run growth trends in open economies.

Concerning factor mobility, the different characteristics of the models will determine the influence of production factor reallocation and whether the factor movement will lead to interregional convergence or divergence. Important here is the cause of differentials in spatial factor prices. If it is due to diverse factor endowments, convergence will be the result. If it is due to diverse preferences (tastes) or differences in technological standard, divergence will be the result. The two authors explain the potential effects that immigration policies might have on the long-run growth rate. A relaxation of immigration regulations causes the growth rate to decrease assuming that the amount of capital the immigrants bring with them remains steady. If, on the other hand, the government implements policies that target high-skilled workers, this will lead to an increase of the long-run growth rate. In addition, there is a positive impact to productivity that comes with immigrants who develop new ideas, which leads to further investments, thus, enhancing technologies eventually leading to an increase in per capita incomes (study is based on North America and Australasia).

In the model of Nijkamp and Poot diffusion coupled with factor mobility leads to a convergence of capital intensities and therefore has an equilibrating effect. The benefits of diffusion identified under a steady state are an increasing capital return rate and faster growing income per capita. However, diffusion can lead to a certain phenomenon: since adopting imported technology requires resources, companies must compare the cost of adoption with the cost of internal research and development activities. The formation of a leader-follower situation is likely where one region invests all its budget and resources into the R&D sector while the other region invests all in the adoption process of importing technologies (Nijkamp & Poot, 1998).

Grossman and Helpman (1994) write about endogenous innovation in the field of economic growth theory. According to various studies the utilization of scientific ideas requires significant investment and allocation of resources. These results apply to innovations in industries such as machinery, metallurgy, synthetic chemicals, and semiconductors. It is firms that invest into new technology when they detect an opportunity to enhance their profits. In fact, the private industry is responsible for financing substantial parts of scientific research executed within OECD countries. Under these circumstances, the direction and pace of technological progress is heavily influenced by the economic, legal, and institutional environment determining the investment profitability.

Even though there are many papers analyzing the endogenous effect of technology change, there was yet no empirical evidence that technology is the driver of growth in modern times. However, the authors stress the reader to imagine how growth would have evolved over the last century without commercially driven inventions like the advancement of electricity generating technology, the new refinement process of iron from Bessemer, the use of radio waves for sound transmission or product development of cars, airplanes, and computers. In their final remarks, Grossman and Helpman explain that new technology development is the best chance for humanity to overcome “limits to growth” (scarce resources). As long as there is discovery of more efficient or effective production, while retaining those resources that are scarce and cannot be reproduced, the living standards can continue to improve for centuries. While the determining factors of technological progress are still not fully clear, it seems like the growth theory is moving the right way by acknowledging imperfect competition and international interdependence in the models, which are aspects of reality (Grossman & Helpman, 1994).

Even though research and development is often used within the endogenous growth theory, further explanations on this specific type of growth theory will follow in the upcoming paragraphs under a new chapter. This structure was chosen because of the high relevance of this topic for this thesis.

2.1.6 Economic Effects of Research and Development

Griliches (1991) searched for evidence of R&D spillovers and comes to the conclusion that they are not only prevalent but also very important in terms of economic growth. A firm’s productivity level depends on both own research efforts and the general knowledge pool that is available to it. Griliches explains the difficulty of examining where specifically knowledge is derived from since there could be intra- or interindustry diffusion. However, it is clear that the productivity of own research activities is influenced by the amount and sizes of pools the firm can extract from. The author describes true spillovers to occur when researchers from industry *i* use research results developed by industry *j* to improve their status quo. This is different from mere productivity transfers such as the ones after the invention of computers. Other industries started to implement computers in their business operations and depending on each firm’s investments and process structures the productivity benefits differentiated substantially. Griliches argues that R&D spillovers are most beneficial if the research is contained from firms being in the same classification of SIC[3] (Standard Industrial Classification). The more firms are apart within the SIC the fewer advantages can be gained from spillovers. When it comes to externalities like public expenditures, the author doubts the accuracy in measuring such contributions

[3] SIC is a classification scheme that classifies between industries in the USA. In 1997 it was replaced by the North American Industry Classification System (NAICS) that was co-created by the USA, Canada, and Mexico.

in an adequate fashion, however, he does believe in the active role that public capital plays in the functioning of the economy (Griliches, 1991).

Sylwester (2001) examines the relationship between R&D and economic growth in terms of per capita output at national level. He outlines the common perceptions of proponents who believe in the positive impact that investments in research and development supposedly have on economic growth. According to them, R&D is responsible for technological breakthroughs increasing the economic growth rate, thus, enhancing prosperity. Countries using the advantage of rising productivity will have workers with higher real wages and therefore also a higher standard of living. That is why governments should actively support R&D activities. Even though a positive relationship between the amount of resources allocated in the R&D sector and the income level truly exists across countries, it is important to stress that this does not indicate any causal direction. Perhaps it is the economic prosperity of a country that leads to higher investments in R&D because firms want to increase their efforts to gain market share.

Furthermore, Sylwester stresses that the opportunity costs of R&D investments are regularly ignored, and it is important to understand that these investments could have been used for different – perhaps more beneficial – purposes to enhance economic growth. Therefore, it should not be inherently assumed that R&D has a causal effect on economic growth. In his paper Sylwester investigated 20 OECD countries which brought him to the conclusion that there is no strong correlation between the two factors. However, when only taking the G-7 countries into account a positive relationship between expenditures in R&D and economic growth can be found. This may be due to the previously explained disparity of technological progress across countries. A possible reason for the lack of more meaningful findings is the increase of the service sector in economic output. In these countries it accounts for more than 50% today. It is still unclear how important the role of R&D and innovation is in terms of services compared to the manufacturing industry. Since the size of the service sector can vary largely between countries, the relevance of R&D expenditures for economic growth might do so as well. Finally, Sylvester argues that different types of R&D expenditures will most likely have different effects on economic growth, but more research is needed to investigate his assumption (Sylwester, 2001).

Bilbao-Osorio and Rodríguez-Pose (2004) put emphasis on the EU when analyzing different sectors of R&D (private, public, higher education) and what effects they have on innovation. They further examine the relationship between innovation and economic growth and if those relationships vary across regions of periphery and non-periphery. For their research the authors use the number of applications for patents as a proxy for innovation. In general, it can be said that R&D activities have a positive impact on the creation of innovation even though the various sectors of R&D are not equally innovative. Those research activities that are executed by the private sector show higher return rates than research performed by the other two sectors. These results are not surprising since the private sector is more commercially oriented and the measure criteria used are patents, which also have a profound commercial orientation. Since research in the public and higher education sector are more basic and less applied, the effect it has on new patent applications is weaker.

When comparing the data of peripheral and non-peripheral regions the results vary. In non-peripheral regions the main driver of innovation is privately funded research, which also plays a strong role in non-peripheral regions. However, in the non-peripheral regions also the research done by higher educational institutions yields positive returns. The two scholars explain that this difference might be the result of the diversity in university research carried out among various regions. In peripheral regions universities are more likely to adopt their research to a more applied role to compensate the private research deficit. Public R&D does not significantly contribute to innovation, which could be explained by its basic nature and the missing direct link to patent applications, which was used to measure innovation. In terms of peripheral regions, public research might be lacking a critical mass to trigger innovation. Another finding of the two authors is that the effect R&D has on innovation depends on socio-economic factors of a region like the availability of skills, initial wealth, and the existence of high-technology sectors. The negative outcome of poor innovative performance is created by regions having a large population of low-educated people. While there is a clear relationship between R&D expenditures and innovation the connection between innovation and economic growth is far less distinct. While in peripheral regions increasing innovation can be a motor of economic growth, the same is not true for non-peripheral regions, where the two factors show no significant relationship (Bilbao-Osorio & Rodríguez-Pose, 2004).

Segerstrom (2000) devoted his work to the long-run growth effects of R&D subsidies by examining two dimensions of innovation: vertical and horizontal. The former being the improvement of existing products (quality, features, materials, etc.) and the latter being the creation of completely new products giving rise to new industries. Firms that are able to innovate to become leaders of the industry will earn monopoly profits for their increased R&D efforts. However, these rewards are only temporarily. In his model, Segerstrom describes a balanced-growth equilibrium which includes a constant portion of labor force engaging in R&D activities. The assumed positive population growth leads to an increase in expected discounted profits over time. This is true for profits generated by vertical and horizontal innovations. The force that is counterbalancing this trend is increasing complexity, which means that as new technology is being created, the costs of resources for even further advancements will also increase. The rewards gained by innovations lead firms to push investments in R&D by hiring new researchers, but the decreasing productivity of those researchers balance the effects leading to constant rates of vertical and horizontal innovation. The results of this model stand against the R&D-driven endogenous growth theory.

Segerstrom comes to a new conclusion in his article, which is that R&D subsidies will never lead to permanently increasing vertical and horizontal innovation rates. Here is why: Starting with the above-mentioned balanced-growth equilibrium and a constantly increasing rate of R&D subsidies, firms will immediately react by raising their vertical and horizontal R&D spendings. The increase in R&D expenditures leads to an increase in technological complexity, demanding researchers to deal with more complicated issues. The steady decline of research productivity negatively impacts vertical and horizontal innovation growth causing both rates to fall gradually. Since the population-growth rate ultimately constrains these rates and the increase in R&D subsidies has no changing effect on the population-growth rate, the vertical and horizontal innovation rates will continuously decline until they reach the level of the initial balanced-growth equilibrium (before the increase in R&D subsidies). In the long-run, changes in the vertical innovation rate trigger a corresponding change of the horizontal innovation rate in the opposite direction, explaining Segerstrom's new insight.

Another vital argument is that only one of the two innovation forms (vertical and horizontal) will be the strong engine, meaning that research activities promoted in this form will lead to long-run economic growth. This is crucial, because if subsidies promote investments in R&D of the weaker engine, the result will be a decreasing long-run economic growth rate. It is the pace of the increase in R&D difficulty that defines the stronger engine: If it increases rapidly, horizontal innovation will be the stronger engine of growth, if it increases slowly, it will be vertical innovation. A final note from Segerstrom is that subsidies in R&D always lead to short-term increases of the economic growth rate no matter if the long-run effects are positive or negative. The time at which the economy starts to experience the negative effects of constantly increasing R&D subsidies depends on the speed of convergence towards the balanced-growth path (Segerstrom, 2000).

In a short article, Pessoa (2010) examines the contributions of research and development on productivity growth. His results show that the relationship between the two can differ heavily from one country to another. This means that country specific factors play an important role in elaborating an R&D-growth link. It is suggested that governments do not rely on simply increasing R&D outlays since this is inefficient in terms of increasing the economic growth rate. Country specific measures must be considered to enhance the benefits of R&D expenditures (Pessoa, 2010).

Gumus and Celikay (2015) investigate the relationship between research and development activities and economic growth by analyzing 52 countries with different degrees of development. They wanted to know about the short- and long-run impacts of R&D and if the development stage of a country plays a significant role. What the scholars found is that all countries benefit from R&D activities in the long-run meaning that the long-run growth rate increases when R&D expenditures are being increased. However, the countries that show a lack of development experience a weaker positive impact of R&D on their economic growth in the short run than developed countries. Gumus and Celikay therefore suggest that developing countries should allocate more resources in R&D to speed up economic growth and performance (Gumus & Celikay, 2015).

2.2 Remarks on Theoretical Approaches

The previously analyzed theories should give an insight into regional development and illustrate what factors play a role in the structure process of an economy. It must be mentioned that most of the authors make use of the term region without explaining what this term actually means to them. Since there is not one universal description, the issue of misunderstandings might arise. However, the negative effect of these potential misinterpretations is only minor because most scholars seem to silently agree on a similar meaning of the term. The various theories are based on different assumptions, which is obvious but crucial to understand how and why distinct results emerge. Implementing assumptions into a theory is important because one cannot bring reality into a theory. First, there is not one reality (all countries and regions are different) and second, scholars need to simplify to come to conclusions. Of course, the more assumptions are being used the further away from reality the results will be. However, this does not dimmish the importance and significance of the results since they give people the ability to comprehend certain structures and systems, which they otherwise would not be able to.

It is interesting to see how the theories take different angles of regional development into account and even though they differ in many ways they still build on one another. For example, the new economic geography uses ideas from previous theories like the central place theory or the iceberg model and by changing parts of the assumptions new models arise. While a large part of the literature review only focused on theories themselves, empirical studies cannot be neglected since they are just as important as the theory. Therefore, papers analyzing the effects that R&D activities have on economic growth where analyzed. While most scholars agree that a positive relationship between R&D expenditures and economic growth exists, Sylwester stresses that one cannot just assume a causal relationship because it is not proven. Especially interesting for this thesis are the results of Bilbao-Osorio and

Rodríguez-Pose who state that public R&D does not significantly contribute to the creation of innovation.

2.3 Measuring Regional Development

The purpose of this section is to describe some of the most used analytical tools for regional development and to explain why the input-output analysis is more suitable than the computable general equilibrium (CGE) model and the social accounting matrix (SAM) model when it comes to the upcoming case study. Due to the importance of the input-output (I-O) analysis for this paper, it will be outlined in much more detail than the other two. To understand why these three tools were considered the reader should once more visualize the objective of this thesis, which is to examine the economic effects of increased research activities in Großschönau on the region of Lower Austria. Therefore, the analysis will be about provoked economic change, meaning that a tool is needed that can evaluate this change. That is the reason for the choice of these specific analytical tools, which all fall under the category of impact analysis.

2.3.1 Comparison of Impact Models

Wyk et al. (2015) compared the three methods (I-O, SAM and CGE) to find out how much their results differ and to help analysists with choosing the right method. They stress that each model has its strengths and weaknesses, and that the choice should fall on the one that considers the most important issues while ignoring the least other elements that might be considered less relevant for the problem. The conducted literature review of their article includes a table with a vast number of authors who wrote about the economic impact of events and the according model they used. Of the ten possible models, the three models examined in this thesis are the most prevalent ones with the I-O model showing the most significant dominance. From the sample of 86 scholars (papers included range from year 1988 to 2011), 6 used the SAM model, 9 the CGE model and a majority of 41 the I-O model. In the following each model will be briefly outlined before explaining the reason for choosing the input output analysis for this thesis and diving into detail with this specific measurement tool.

I-O model: The purpose of an input output analysis is to measure the interdependencies of the various sectors of an economy. This is being done by using linear equations for each of the sectors illustrating the distributions of their products throughout the economy.

SAM model: Despite including economic data, the SAM model also contains social data of an economy. This is why its results can be classified between the various socio-economic backgrounds of institutions instead of merely their economic activities. A social accounting matrix can display statistical information of the income flows of an economy in a logical manner and the SAM model serves two objectives: The first one is to organize information of both the economic as well as the social structure of a country over a certain time period (usually a year). Secondly, being the statistical basis for presenting an economy in a static image and to simulate the effects that policy interventions have on the economy (Wyk, Saayman, Rossouw, & Saayman, 2015)

CGE model: The computable general equilibrium model relies on the data of I-O and/or SAM as its base. The CGE model does include elasticities and in contrast to the theoretical general equilibrium it allows for certain relaxations (e.g., unemployment and imperfect competition). Moreover, in this model price movements are possible, which is contrary to the I-O model. Once a shock is being simulated in a CGE model the results must be compared with the actual economic situation to validate the estimations. The amount of data needed as well as the underlying equations and assumptions make this model a rather time and cost consuming tool. (Scottish Government, 2016)

Table 1 illustrates the characteristics of the three models, which should give an idea about their differences but also their similarities:

Model	Level of effects on a local economy	Shocks that can be analyzed	Results	Strengths	Boundaries
I-O	Direct, indirect and induced effects on output, income and employment	Changes in consumption by product or industry	Local (place specific) output, income, employment, production	Well-understood, standard methodology; standardised construction and presentation	Assumes: no constraints on availability of factors of production; that prices and wages do not vary; that distribution of factor inputs required by outputs does not vary
SAM	Indirect and induced effects on output, income and employment; by disaggregated households, firms and other institutions, products, types of demand and other elements	Changes in consumption by product or industry; changes in policy: tax rates, government spending, price inflation	Regional output, income, employment, production; product prices, wage rates; broken down by type of household, labour and capital source	Disaggregates households, firms and other institutions, products, types of demand and other elements of the economy according to analytical needs and data resources	No standard methodology or presentation; same boundaries as I-O model
CGE	Indirect and induced effects on output, income and employment; prices and wage rates by industry	Changes in consumption by product or industry; changes in policy: tax rates, government spending, price inflation	Regional output, income, employment, production; product prices, wage rates; broken down by type of household, labour and capital source	Allows factor- of production prices to vary; effects of resource constraints covered; all markets clear	No standard methodology or presentation; posited relationship equations, parameters and elasticities seldom made public; heavily dependent on assumptions; requires massive input data that is seldom current; requires validation against the actual economy

Table 1: Comparison of Characteristics of Impact Models (Wyk, Saayman, Rossouw, & Saayman, 2015)

For the upcoming case study the input-output model was chosen to be the most suitable tool because of the following reasons: The I-O model is a well-known and frequently used model with a standardized methodology that can present results in a way that is easily understandable. Furthermore, the results it offers cover all the effects asked for by the commissioners, namely direct, indirect effects and multipliers for the output, gross value added, income and employment. The data needed for this type of analysis is available, which guarantees a valuable and on time delivery of work. The I-O model is the model that fulfills the criteria previously mentioned for choosing the right method – it considers the most important issues while ignoring the least other elements that might be considered less relevant for the problem. The limitation of no price changes within the model is usually not a big issue when the economy is not suffering from high inflation. Due to the covid-19 crisis and the Russian-Ukranian war that is still ongoing, inflation in Austria is still quite high to this date. In April 2023 the inflation rate reached 9,7%, which shows an increase of 8,9% to the previous year (Statista, 2023). Even though inflation in Austria is unusual high and the input-output model does not consider these price changes, this model still offers relevant insights into the economic structures and the flows of goods. Those are the reasons why the input-output analysis was considered to be the most suitable and most valuable tool for the purpose of this theses. The upcoming chapter will describe this model in more detail to prepare the reader for the case study itself that will follow afterwards.

2.3.2 Input-Output-Analysis

The outline and explanation of the input-output analysis will heavily draw from Miller and Blair's book "Input-Output Analysis – Foundations and Extensions" (Third Edition, 2022), which is arguably the most cohesive and accurate collection of information about this analytical framework. Miller and Blair have been working on this topic for over 40 years now, publishing the first edition of their book in 1985 and the updated second edition in 2009 (Miller & Blair, 2022).

It was Wassily Leontief who developed the input-output analysis in the late 1930s for which he eventually received the Nobel Prize of Economic Science in the year 1973. That is why the term Leontief model is also commonly used. Scholars also refer to it as interindustry analysis because the analysis of interdependencies of industries within an economy is the fundamental purpose of this framework. Over the last few decades, the input-output analysis has been one of the most applied tools in economics, which should illustrate the significance of this framework in general and for this thesis in particular.

2.3.2.1 Basic Framework

In the most basic input-output model economic data of one specific region is being observed. It is about the activity of various sectors producing goods (outputs) as well as consuming goods (inputs) from the other industries to produce the own product (output). It is relevant to mention that the terms industry and sector are commonly used interchangeably when it comes to input-output analysis. The number of industries used for the analysis can vary largely depending on how far one breaks down the categories of industries. For example, one could use the industry manufacturing as a whole or one could fragment it down to steel or even steel nails. The foundation of the analysis is built by the flows of products from one sector (producer) to itself and to other industries (consumers). This information is being illustrated on an interindustry transactions table where the rows contain the distribution of an industry's outputs for the economy and the columns contain the inputs needed for an industry to produce its product. This exchange of goods between industries is visualized by the shaded field in table 2. The columns listed under “Final Demand” display the sales of each individual sector to final markets like personal consumption or federal governments. An example would be the sale of electricity to other sectors, which will be used to produce goods (interindustry transaction) and the sale of electricity to residential consumers (final demand). The rows displayed under the category “Value Added” include other, non-industrial production inputs, such as labor, imports, indirect business taxes and depreciation of capital.

For the upcoming explanations of the notation and fundamental relationships in input-output analysis one shall assume that the region or economic area in focus is a country. The necessary data in use, which are interindustry flows, are measured for a specific period of time (usually one year) and in monetary terms[4] (euro value of steel sold to the buildings industry). These transaction flows between pairs of industries – from each industry i to each industry j – are commonly defined as z_{ij}. The demand of industry j for inputs from the other industries for one year is heavily related to the number of goods industry j produces within the same period. To give an example, the demand of the housing industry for the product of the steel industry (output is steel), depends on the number of houses that are being built in that year. The same is true for the demand for microchips by the smartphone industry, which depends on the number of phones being produced.

[4] The intersectoral exchanges of goods can in principle also be recorded in physical terms, however, this comes with a significant measurement problem. when industries sell more than one product. For example, a care manufacturer sells two different types of cars; these two products might have substantially different prices (one very expensive car and a cheaper one) even though the amounts of materials used for producing the products are very similar. That is why most analysts use monetary terms, which can also lead to issues but less significant ones - prices might change unrelated to the change in physical output (Miller & Blair, 2022).

		Industry Producers as Consumers								Final Demand for Goods and Services			
		Agric.	Mining	Const.	Manuf.	Trade	Transp.	Services	Other	Personal Consumption Expenditures	Gross Private Domestic Investment	Government Purchases of Goods & Services	Net Exports of Goods & Services
Industry Producers	Agriculture												
	Mining												
	Construction												
	Manufactoring												
	Trade												
	Transportation												
	Services												
	Other Industries												
Value Added	Employees	Employee Compensation											
	Business Owners and Capital	Profit-type income and capital consumption allowances								Gross Domestic Product			
	Government	Indirect Business Taxes											

Table 2: Input-Output Transactions Table (Miller & Blair, 2022)

Then, each country also has more exogenous purchasers like households, government, and foreign trade, which are more external to the industrial sectors. The demand of these exogenous purchasers is relatively unrelated to the amount of output produced. For example, the government's demand for heavy trucks depends on changes in budget levels, national policy or needs for defense. Since the demand of the external purchasers tends to be mainly for finished products rather than for products used as an input for a production process, it is indicated as final demand (Miller & Blair, 2022)

It will be assumed that the country's economy can be separated into *n* industries. The total output of industry *i* will be denoted by x_i and the total final demand for the product of industry *i* will be denoted by f_i. The way in which industry *i* distributes its output to other industries as well as to final demand through sales can be displayed with the following equation:

$$x_i = z_{i1} + \cdots + z_{ij} + \cdots + z_{in} + f_i = \sum_{j=1}^{n} z_{ij} + f_1$$

The terms z_{ij} indicate interindustry sales from industry *i* to all the industries *j*, including itself (*j* = *i*). As the equation above displays how the output of industry *i* is distributed, it becomes clear that there is an equation like this for each one of the *n* industries representing their sales of output:

$$x_1 = z_{11} + \cdots + z_{ij} + \cdots + z_{in} + f_1$$

$$\vdots$$

$$x_i = z_{i1} + \cdots + z_{ij} + \cdots + z_{in} + f_i$$

$$\vdots$$

$$x_n = z_{n1} + \cdots + z_{nj} + \cdots + z_{nn} + f_n$$

A different way of illustrating this is:

$$\mathbf{x} = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix}, \quad \mathbf{Z} = \begin{bmatrix} z_{11} & \cdots & z_{1n} \\ \vdots & \ddots & \vdots \\ z_{n1} & \cdots & z_{nn} \end{bmatrix}, \quad \mathbf{f} = \begin{bmatrix} f_1 \\ \vdots \\ f_n \end{bmatrix}$$

In this case the bold lower-case letters are being used for column vectors, as illustrated above with **x** and **f** (therefore, **x'** would be the corresponding row vector to **x**). The bold upper-case letters are being used for matrices, as illustrated above with **Z**. Using this type of notation, the information of the equation, which shows the sales distribution of every sector, can be summarized in a more compact way:

$$\mathbf{x} = \mathbf{Zi} + \mathbf{f}$$

In this equation **i** indicates the column vector of 1's, which is often referred to as "summation" vector. This vector is important because when post multiplying it with a matrix, the result will be a column vector that displays the matrix' row sums as its elements. Similarly, when pre multiplying a matrix with **i'** (row vector of 1's), the outcome will be a row vector with the matrix' column sums as its elements.

The following vector illustrates the information of *z*'s in the *j*th column:

$$\begin{bmatrix} z_{1j} \\ \vdots \\ z_{ij} \\ \vdots \\ z_{nj} \end{bmatrix}$$

The elements display the different sales to industry *j*, which in other words represent the magnitude of inputs of industry *j*. It is clear that a producing industry also pays for other things like labor and capital and also uses inventoried items as inputs. These primary inputs of industry *j* are being called value added. Additionally, industry *j* might purchase imported goods, which will be used as input in production. All these inputs are commonly summarized under purchases from the "payments" sector. On the other hand, the "processing" sector includes all interindustry or intermediate inputs and since an industry might use its own output as an input for production, the inputs might as well include intraindustry transactions. Considering that these flows are implemented into a table, with the producers on the left side and the purchasers (which are the same industries as the producers) across the top, it becomes clear that the columns illustrate each industry's inputs while the rows illustrate each industry's outputs. This explains the appropriate name of input-output analysis (Miller & Blair, 2022).

2.3.2.2 Flow Tables and National Accounts

Table 3 illustrates the interindustry transactions between the selling and the buying sectors of an economy. Table 4 displays an expanded flow table with a simplified economy that only has two sectors, which helps to emphasize the elements that are missing in table 3. It now contains a full set of accounts. Under final demand one can now see the components C, I, G, and E which stand for consumer spending, (private) investments, government spending, and exports (sales to foreign countries). These components are often divided into domestic (C+I+G) and foreign (E) final demand.

		Buying Sector				
		1	…	*j*	…	*n*
Selling Sector	1	z_{11}	…	z_{1j}	…	z_{1n}
	⋮	⋮		⋮		⋮
	i	z_{i1}	…	z_{ij}	…	z_{in}
	⋮	⋮		⋮		⋮
	n	z_{n1}	…	z_{nj}	…	z_{nn}

Table 3: Interindustry Flows of Goods in Input-Output Table (Miller & Blair, 2022)

		Processing Sectors		Final Demand				Total Output (x)
		1	2					
Processing	1	z_{11}	z_{21}	c_1	i_1	g_1	e_1	x_1
Sectors	2	z_{21}	z_{22}	c_2	i_2	g_2	e_2	x_2
Payment	Labor	l_1	l_2	l_C	l_I	l_G	l_E	L
Sectors	Other Value Added	n_1	n_2	n_C	n_I	n_G	n_E	N
	Imports	m_1	m_2	m_C	m_I	m_G	m_E	M
Total Outlays (**x'**)		x_1	x_2	C	I	G	E	X

Table 4: Expanded Flow Table - Simplified Economy with Two Sectors (Miller & Blair, 2022)

Therefore, the following two equations represent the final demand of industry 1 and industry 2, respectively:

$$f_1 = c_1 + i_1 + g_1 + e_1$$

$$f_2 = c_2 + i_2 + g_2 + e_2$$

The payment sectors include the components *l* (labor), *n* (other value-added payments) and *m* (imports). While labor clearly stands for the compensation for employees, the items included in *n* might be less obvious, thus, a few examples will be listed: government services (are being paid in form of taxes), land (includes rental payments), and capital (comprises interest payments). The total value-added payments can now be illustrated like this:

$$v_1 = l_1 + n_1$$

$$v_2 = l_2 + n_2$$

Since most of the sectors, probably all of them, use imported goods to produce their final outputs, they are recorded by *m*. This leads to the following equations to show the total expenditures of sector 1 and 2 within the payment sector:

$$l_1 + n_1 + m_1 = v_1 + m_1$$

$$l_2 + n_2 + m_2 = v_2 + m_2$$

The elements displayed in the junction of the final demand rows and the value-added columns include payments of final consumers for labor and for other value added. The payments for labor services could be, for example, transactions to government workers (l_G) and for other value added tax payments from households (n_C). In the intersection of the final demand columns and import rows one can find m_G and m_E, with the former representing imported goods by the government and the latter imported goods that are being exported again. The sum of the total output column is the gross output of the economy, in this case X:

$$X = x_1 + x_2 + L + N + M$$

Taking the sum of the total outlays row leads to the same result:

$$X = x_1 + x_2 + C + I + G + E$$

States analyzing these numbers have usually great interest in the value of the total final product. For example, the national income and product accountants want to know about the goods available for consumptions and the size of exports. Therefore, the following two equations are of importance, which are created by subtracting x_1 and x_2 from the two sides and equating for X:

$$L + M + N = C + I + G + E$$

$$L + N = C + I + G + (E - M)$$

One can see that both equations include the same values, however, in the second equation imports are being subtracted from the exports. Now, the left side of the equation represents the gross national income of the economy, while the right side represents total expenditure on consumption, total investment, and government spending as well as the overall value of net exports. The sum of each of the sides (gross income on the left, total final demand on the right), is the gross domestic product (GDP) of a nation (Miller & Blair, 2022).

2.3.2.3 Leontief Inverse

The Leontief inverse is crucial for the input-output analysis and how it can be established will be explained now: First, the technical coefficient matrix is needed, which contains the input-output ratios of the various industries. In other words, it tells us the input requirements per unit of output for each sector. In this thesis the technical coefficient matrix will be labeled with the letter A. The second essential matrix for calculating the Leontief inverse is the identity matrix – matrix I. This is a matrix containing 1s across the diagonal from top left to bottom right, while all the other numbers equal zero. It must be corresponding to matrix A, meaning that both matrices have the same number of rows and columns. Here is an easy example for a random 2 x 2 matrix:

$$A = \begin{bmatrix} 12 & 4 \\ 6 & 8 \end{bmatrix};\ I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}.$$

With these two matrices (A & I) it is possible to create the Leontief inverse by inversing the result of subtracting matrix I by matrix A. When designating the inverse with the letter M then this means that:

$$M = (I - A)^{-1}$$

The Leontief inverse functions as a transformation mechanism, which translates expected output to the inputs required to satisfy this extra demand (Miller & Blair, 2022)

The purpose of this thesis is to execute an input-output analysis for the region of Lower Austria, however, the necessary data is usually only accessible from national accounts. That means that the numbers for the region under investigation must be somehow estimated. How this can be done will be explained in the following section.

2.3.2.4 Regional Input-Output Analysis

The data of a national input-output table uses averages of data from the various producers that are located in certain regions. To illustrate the reason behind this the reader should consider the example of universities. A university that has its focus on technical learnings and on lab work will obviously be a customer of lab supplies and tools that are needed for those purposes. On the other hand, a university that has a more theoretical approach might not need lab utilities at all. Therefore, the industries affected by the two universities vary markedly. That is the reason for creating averages for all the universities and also for every other industry. From this example, the reader can take away a second learning: The production structure of a specific region might be very similar to the one recorded in the national table or it might differ substantially. Once again, the reason is that no company or entity is identical to the other and clusters of one region are likely to be different to clusters of other regions. These regional variations of the production input mix led to the creation of region-specific coefficient tables. In general, the smaller the economic area is, the more it depends on outside trade - more of the inputs needed for production will be imported from other regions. Similarly, the exports of the small area also play a larger role in terms of trade.

One type of estimation are regional coefficients that are calculated by using regional supply percentages. These percentages are being retrieved by considering total regional output of every industry, exports of each industry's product from the region and imports into the region. This type of data is usually available on a regional level and with it, one can calculate the proportion of good's *i* total availability in region *r* which is produced in that region *r*. This type of estimation is also applied for the input-output table that was used for this thesis. The previously mentioned product-mix problem of the input-output analysis (firms of the same industry produce different types/variations of products) can be avoided by conducting surveys with the firms of the respective region. When conducting these kinds of surveys one can ask two different types of basic questions (the questions are directed towards firms of sector *j* in a specific region):

1. For producing your output, how much of the good from sector *i* did you buy over the last year? (e.g., how much lab material did universities in Lower Austria buy last year?)

2. For producing your output, how much of the good from sector I did you buy over the last year from firms that are located in that region? (e.g., how much lab material did universities in Lower Austria buy from producers in Lower Austria?)

Using the former results in true regional technical coefficients that reflect the regional production practices better than the national ones. However, it does not give insights into the proportions of inputs coming from the region and inputs being imported. Using the latter leads to regional input coefficients that are different to the regional technical coefficients in the way that they do not always precisely picture the technology of firms of a region but rather how these firms use the local inputs[5] (Miller & Blair, 2022).

[5] There are also more sophisticated ways of surveying that will not be explained in this text since it does not add any extra value to fulfilling the purpose of this thesis. However, the reader interested in those methods can refer to Miller and Blair's book "Input-Output Analysis – Foundations and Extensions" - Third Edition – chapter 3.2.2. "Regional Coefficients (Miller & Blair, 2022).

3 Case Study – Sonnenplatz Großschönau

The focus of this chapter lies in the execution and description of the input-output analysis to find out what impacts an investment into the Sonnenplatz Großschönau has on the federal state of Lower Austria. Therefore, a brief explanation about the political structure will be provided before picturing what the Sonnenplatz Großschönau actually is. Then, the in-depth input-output analysis will be illustrated.

3.1 Descriptive Overview

3.1.1 Austria – Political Structure

The reader familiar with the political structures of Austria and its boundaries of administrative judiciary can skip this section and continue with 3.1.2 “Lower Austria and Großschönau – A Comparison”. For the reader unfamiliar with Austrian politics, this section is supposed to give a brief overview to establish common ground for understanding the upcoming analytical framework.

Austria is a democratic-republic state with a federalist structure. What this means is that the law is determined by the people. In the case of Austria, the people vote representatives who run the state parliament situated in Vienna, the capital of Austria. The highest ranked representative is the president of Austria, who is Alexander Van der Bellen serving his second term of presidency, which is the maximum number of terms before a new president must be elected for office. The three most important characteristics of a representative democracy are freedom of speech, the presence of opposition and checks and balances (BM für Inneres, 2023). Checks and balances mean that the power of the state is divided into three distinct branches: the legislative (makes laws), executive (enforces laws) and judicial (evaluates laws). This system was implemented to diminish the power of one individual or a small group of people (BM für Inneres & BM für Justiz, 2023). Federalism comes into play because Austria is divided into 9 different federal states: Vienna (capital), Lower Austria, Upper Austria, Burgenland, Styria, Carinthia, Salzburg, Tyrol, and Vorarlberg. Each federal state has its own government called “Landtag” and there is a clear division of competences between the state government and the federal governments. Moreover, every federal state consists of smaller municipals that function as administrative bodies that do not have the power to pass new laws, however, they can function more independently (unsereVerfassung, 2016).

3.1.2 Lower Austria and Großschönau – A Comparison

Lower Austria consists of 573 municipals (Österreichischer Gemeindebund, 2023). The following table is supposed to give an overview of the landscape of lower Austria compared to the landscape of Großschönau, which is the municipal that will be analyzed in this thesis.

	Area	Buildings	Apartments	Residents	Worksites	Agr. & For. Sites[6]
Lower Austria (LA)	1.917.777,62 ha	553.604	738.235	1.545.804	68.530	78.547
Groß-schönau (GS)	702,04 ha	427	512	1.264	44	215
Ratio (GS/LA)	0,00037	0,00077	0,00069	0,00082	0,00064	0,00274

Table 5: Landscape Comparison between Lower Austria and Großschönau (Statistik Austria, 2005)

Table 5 displays the size of Großschönau and it becomes clear that it is a rather small municipal. However, it plays the central role of this work, and it will be interesting to see what impact an investment into a small Austrian municipal has on a large region like the federal state of Lower Austria. The municipal is situated in the North West of Lower Austria in the so called Waldviertel, which is characterized by natural landsapes – woods, ponds, rock formations and moors (Waldviertel Tourismus, 2023).

[6] Agriculture and Forestry Sites

3.1.3 Sonnenplatz Großschönau

The Sonnenplatz Großschönau is a place (built like a tiny village in 2011) accommodating various facilities that have a focus on energy-efficient and sustainable construction and reconstruction. Its legal status is a Gesellschaft mit beschränkter Haftung (GmbH), which is the Austrian equivalent to a limited company (Ltd.) in the UK or a limited liability company (LLC) in the US. Its main highlights are the research and competence center of energy and construction, the “Sonnenwelt” (engl. world of the sun) and the “Passivdorf” (engl. passive village). These three parts of the Sonnenplatz are also the places that will be “shocked” (simulation of extra investments) to see what impact these investments might have on the surrounding economic area. In the following they will be briefly explained:

Research and competence center of energy and construction: The research center is definitely the centerpiece of the small village, and it is a place where visitors can explore the latest innovations of energy-efficient construction and housing. It contains modern seminar rooms for educational training purposes, office spaces for research projects as well as the “Sonnenwelt”. While most conducted and ongoing research projects deal with problems within Austria, there were and are also several international projects that Sonnenplatz Großschönau was or is part of. “Hypergryd” is an example of a current international project that is sponsored by the European Commission. It aims to accelerate the transition towards a sustainable future of district heating and Cooling (DHC). This can be achieved by integrating thermal and electric grids with user-centered, renewable, and digitally operated solutions. An example of a current national research project would be “SmallWind4Cities”. The objective of this project is to increase awareness for small wind turbines, which are a reliable and sustainable option for the production of energy. However, this technology is still not commonly used throughout Austria, because of its complex site assessments and a lack of consistent guidelines when it comes to the permission process. The projects are being executed with various national and international partners and help the Sonnenplatz Großschönau to become an increasingly significant research and knowledge platform.

Sonnenwelt: This is an interactive exhibition area that exposes the housing history of the past 10.000 years. It is especially attractive for school tours since the students can learn by participating in various games and activities on an area of 20.000 square meters. It is common to do a day trip to visit the Sonnenwelt.

Passivdorf: The term passive house is being used to describe buildings that do not use more than 15 kWh per square meter and year, which is being achieved by intelligent planning methods. The passive houses don't look different from the outside than other conventional buildings, however they have a very small energy consumption. The term passive house is therefore not a specific construction method but rather an energy standard. The "Passivdorf" was established before the research and competence center and the idea was to give interested people the chance to experience how it is to live in such a passive house. Individuals, couples, and families were able to stay in the various apartments for two to seven days. By sharing this experience with as many people as possible the Sonnenplatz Großschönau hoped to increase awareness and interest in this energy-sufficient way of living.

Research facilities like the one of the Sonnenplatz Großschönau are drivers of innovation and Bilbao-Osorio and Rodríguez-Pose (2004) explained that there is a clear positive relationship between R&D expenditures and innovation. This leads to the conclusion that an increase in the research activities of the Sonnenplatz Großschönau will eventually lead to an increase of innovation (Bilbao-Osorio & Rodríguez-Pose, 2004). However, knowledge spillovers play a crucial role for the distribution of innovation across space and depending on the cluster of companies and institutions surrounding the research facility, the impact of the knowledge spillovers can be stronger or weaker. Since the Sonnenplatz Großschönau is situated in a peripheral area, it is likely that the knowledge spillovers are less dominant than they would be in a non-peripheral area. This is true for innovation coming from the research facility of the Sonnenplatz Großschönau but also going towards it, spilled by other companies or institutions (Griliches, 1991).

The reader should now have sufficient knowledge about the Sonnenplatz Großschönau to understand the explanations of the upcoming input-output analysis.

The purpose of the analysis is to examine what impacts potential investments targeted at the Sonnenplatz Großschönau have on the region of Lower Austria.

3.2 Input-Output Analysis – Execution

As mentioned previously the input-output table used for this thesis is a regional table from the federal state of Lower Austria and was conducted using a simple location quotient[7]. The table includes 17 sectors that are labeled with letters from A to U. Sectors M and N were merged as were the sectors R to U, which can be seen in figure 1. The calculations for the analysis were executed using the program Microsoft Excel. In a first step, the technical coefficients matrix - matrix A - was created, which contains the input-output ratios of the various industries. Coefficients that are equal to zero indicate that no input of this certain industry was needed to create the output of another sector. This is the case for the mining industry, for example, when taking agriculture and forestry as an input to calculate the coefficient. After matrix A has been established, the corresponding identity matrix (I) needed to be created. As described in chapter 2.3.2.3 this matrix contains 1s across the diagonal from top left to bottom right, while all the other numbers equal zero. Since matrix A consists of 17 rows and 17 columns, the same must be true for the identity matrix making it a 17x17 matrix. Inversing the result of subtracting matrix I by matrix A, the new matrix M (Leontief Inverse) was created: $M = (I - A)^{-1}$.

Before explaining the calculations of the economic effects of additional investments, an overview of the forward and backward linkages of the economy will be given. This helps to understand how the different sectors are connected to one another and what impact they have on each other. Linkages are relationships within the supply chain of products and services with the terms forward and backward indicating the direction of those relationships. While forward linkages indicate the direction towards the end consumer, backward linkages refer to the direction away from the end consumer towards raw materials. The force of these linkages can vary between industries and how they vary in the case of Lower Austria can be seen in figure 1.

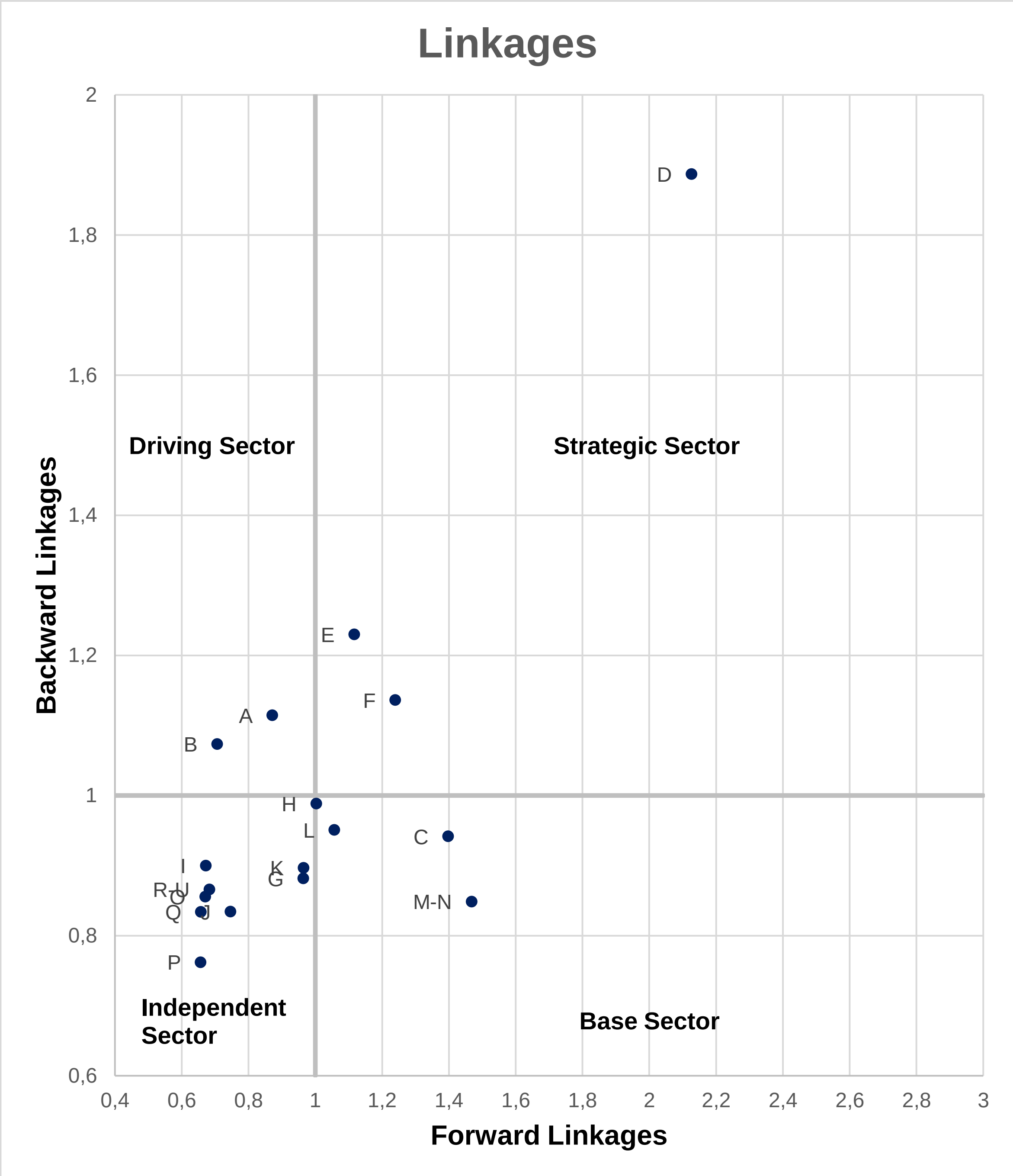
[7] I would like to express my gratitude to the Institute for International Trade and Sustainable Economy at the IMC Krems that agreed to let me use this regional input-output table for my calculations. (Regional Input-Output Table of Lower Austria - 2019, 2023)

In order to establish this table, the sums of the rows and columns of matrix M where calculated and then the average of the sums was computed. The results of dividing each of the sums by the average of the sums illustrates how strong or weak the forward and backward linkages of an industry are. If the number is below 1 it indicates a weaker linkage, if it is above 1 the opposite is true. With this information the industries can be divided into four groups: driving sectors, strategic sectors, independent sectors and base sectors:

Driving sectors: Low forward linkages and high backward linkages. This means that the products of these industries get used below average by other industries, however, to produce their goods, a large number of inputs is needed. Examples for driving sectors of the economy in Lower Austria, as can be seen in figure 1, are agriculture and forestry (A) as well as mining (B).

Strategic sectors: High forward linkages and high backward linkages. The products of these sectors are being used a lot by other industries, while they themselves are in need of many inputs from various sectors. Examples for this category are water supply and waste management (E) and construction (F), which are still in the bottom left corner of the strategic sector in the graph. Then there is energy supply (D), which is an outlier on the top right of the graph. This is easy to understand since there is no industry that does not need energy to produce their goods. On the other hand, it is also very input-consuming to produce energy.

Independent sectors: Low forward linkages and low backward linkages. The independent sectors use fewer inputs compared to other sectors to produce their goods and their products are also used less than average by the other industries. Most of the sectors of Lower Austria are independent sectors: trade (G), accommodation and gastronomy (I), information and communication (J), finance and insurance (K), public administration (O), education (P), health and social services (Q) and art, entertainment and other services (R-U).



A	Agriculture and Forestry	J	Information and telecommunications services
B	Mining and Quarrying	K	Finance and Insurance services
C	Manufacturing	L	Real estate services
D	Electricity, gas, steam and air-conditioning	M-N	Legal, accounting, architectural, research services
E	Water, sewerage, waste	O	Public administration and defense services
F	Construction	P	Education services
G	Wholesale and retail trade	Q	Human health and social services
H	Transportation	R-U	Creative, arts and entertainment services, sports
I	Accommodation and food services		

Figure 1: Forward and Backward Linkages of Industries in Lower Austria

Base sectors: High forward linkages and low backward linkages. These sectors produce goods that are being used a lot by other industries, while they need less inputs to produce their own goods. Examples are manufacturing of goods (C), transportation (H), property and housing (L) and self-employed, scientific, technical services and other economic services (M-N). The forward and backward linkages of the transportation industry are both very close to 1, meaning that it finds itself at the verge of all four categories.

The reader should now have an idea about how the different sectors of an economy are connected to one another and understand that an investment in one sector has an influence on various other sectors depending on the forward and backward linkages of that specific sector. Since figure 1 illustrates the linkages of the industries within Lower Austria it really gives valuable insights for the upcoming calculations.

The following section will outline the simulation of economic shocks, meaning that the impacts of investments in certain industries will be examined. The outcome of the analysis will be direct and indirect effects as well as multipliers for output, gross value added (GVA), income (compensation of employees) and employment. The change in GDP will also be illustrated. To make the analysis as significant as possible it was important to make the right estimations for the shocks. Therefore, data about the planned investments was provided by the commissioners. It is important to point out that the economy was being shocked four times for the analysis:

1st Shock: Investment/Building phase of the Sonnenplatz Großschönau. Here the initial investments for building new facilities and implementing new equipment were simulated.

2nd Shock: Running phase of the Sonnenplatz Großschönau. Since there are yearly costs (e.g., operating costs, marketing costs, labor costs), the impact of these expenses on the economy were analyzed.

3rd Shock: The new investments will attract new visitors, who will also spend money outside of the facilities of the Sonnenplatz (e.g., having lunch in an outside restaurant, spending a night in a hotel). These money transactions were simulated with the 3rd shock.

4th Shock: The total effects were simulated by putting the three previous shocks all together into one shock. This simply illustrate the overall effects of all the changes at once.

Expenditures	Total	Research	Education	Passivdorf	Gastro-nomy
Investment	**6.362.000**	**2.280.000**	**978.000**	**2.480.000**	**624.000**
One-time object/infrastructure	3.260.000	1.200.000	600.000	1.100.000	360.000
One-time equipment	2.750.000	960.000	360.000	1.200.000	240.000
Ongoing p.a.	342.000	120.000	18.000	180.000	24.000
Operating costs p.a.	**465.000**	**240.000**	**95.000**	**40.000**	**90.000**
Labor costs p.a.	**815.000**	**360.000**	**170.000**	**135.000**	**150.000**
Employees p.a.	505.000	210.000	70.000	135.000	90.000
Additional Purchases p.a.	310.000	150.000	100.000	0	60.000
Marketing p.a.	**30.000**	**12.000**	**10.000**	**3.000**	**5.000**
Financing costs p.a. (Bank loans)	**290.667**	**104.000**	**44.000**	**106.667**	**36.000**

Table 6: Planned Expenditures - Shock Allocation

Construction	3.260.000
Wholesale and retail trade	2.750.000

Table 7: Allocation for 1st Shock - Building/Investment Phase

Legal, accounting, architectural, research services	836.000
Education services	337.000
Creative, arts and entertainment services, sports	464.667
Accommodation and food services	305.000

Table 8: Allocation for 2nd Shock - Running Phase

To understand how the numbers for the 1st and 2nd shock were accumulated tables 7-9 illustrate the planned investments and how they are being distributed towards the various industries. The colors of the tables indicate the corresponding sectors, meaning that the numbers within cells of the same color were added up to reach the investment sizes for the simulation of the economic shock.

3.2.1 1st Shock - Investment/Building Phase

As can be seen in table 11 and 12 the simulated shock targets the industries construction and wholesale and retail trade with the former reaching a planned investment of €3,26 million and the latter an investment of €2,75 million. The following bar chart illustrates how these investments would impact the 17 sectors of the economy:

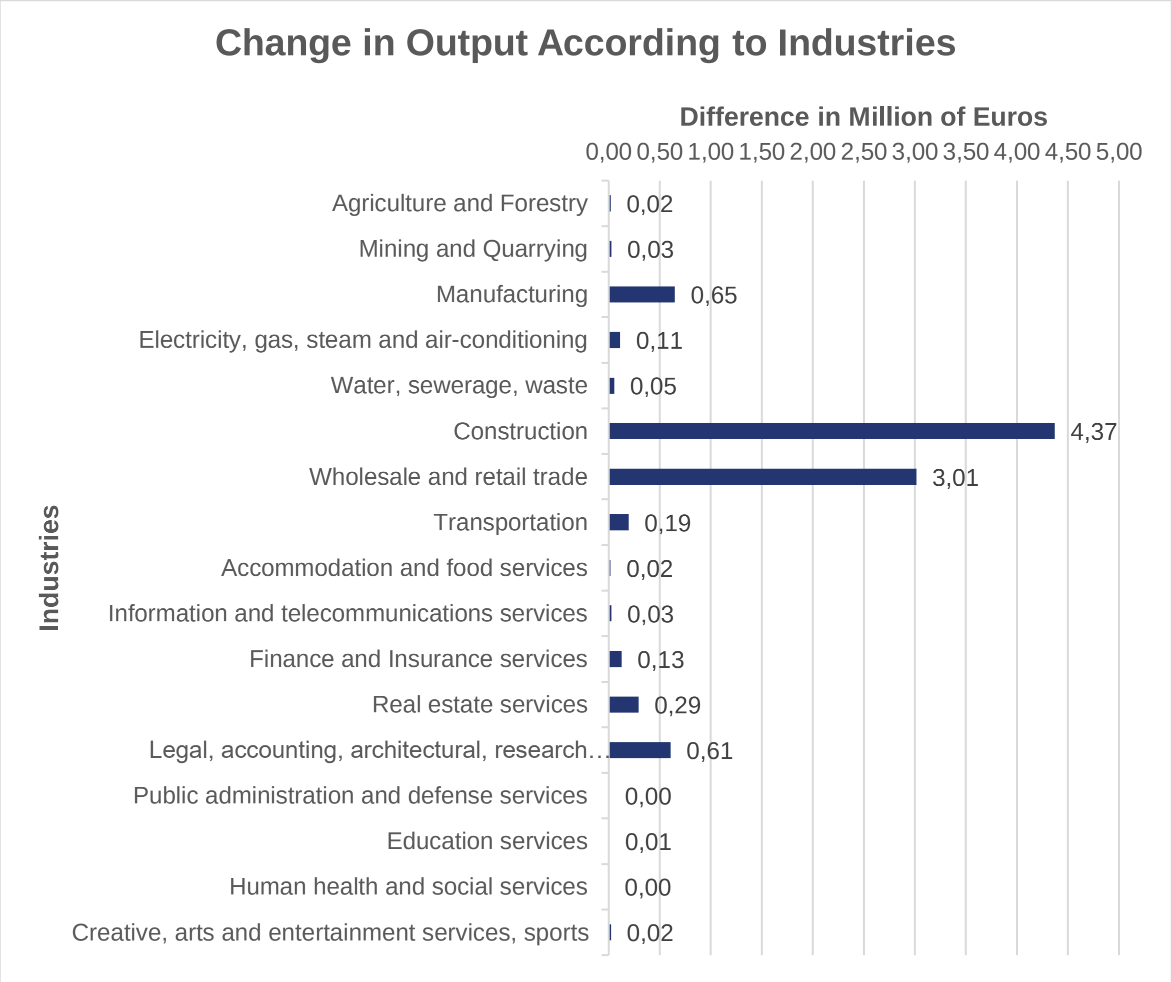


Figure 2: Change in Output of Industries - 1st Shock – Building/Investment Phase

Construction and wholesale and retail trade obviously show the largest numbers, however, the reader might wonder why the numbers do not match the actual investment size. This is due to the indirect effects such investments have on an economy. While, for example, an investment in the construction sector influences the productivity of the manufacturing sector, it is this additional output of the manufacturing sector that also has an impact on the construction sector. Thus, the numbers in the table are higher than the initial investments. Without considering the two sectors that were shocked, the manufacturing industry shows the largest impact with €650.000 of additional output. Slightly lower is the number of legal, accounting, architectural, research services reaching €610.000. With €290.000 the real estate service sector is the last industry showing an impact of above €200.000. Figure 2 already gives some insights on how the input-output analysis works and what results one can gain from it. Probably even more significant results are the direct, indirect and total effects of the output, gross value added (GVA), income and employment, and their corresponding multipliers:

	Direct	**Indirect**	**Total**	**Multiplier**
Output	6,01	3,53	9,54	1,58731
GVA	2,79	1,58	4,37	0,72758
Income	1,96	1,38	3,34	0,55609
Employment	28,10	11,84	39,94	6,64571

Table 9: Effects and Multipliers[8] - 1st Shock - Building/Investment Phase

Table 10 illustrates three types of effects: direct, indirect and total effects. The direct effects are the effects that occur directly at the industries for meeting the new demand (e.g., a new house is being built, therefore the amount of steel and construction equipment will increase). The suppliers of the inputs need new inputs themselves to deal with the rising demand, which explains the presence of indirect effects. The total effects are the sum of the direct and indirect effects. The multipliers state by how much the total effects increase when increasing the output by a million euros. In this case, increasing the output by one million euros will lead to total output effects of above €1,55 million. It works the same way with gross value added and

[8] The numbers at the intersection of output, GVA, income (left side) and direct, indirect and total effects (top) are given in millions of euros. The numbers at the intersection of employment (left) and direct, indirect and total effects (top) are given as full-time equivalents.

income (compensation of employees). Therefore, an increase in output by million euros leads to an increase of GVA by just above €0,7 million and an increase of income by more than €0,55 million respectively. For employment the numbers must be read a little bit differently: they are stated in full-time equivalents (FTE) meaning that the multiplier shows how many more FTE-employees will be employed to reach an increase in output by a million euros. One must not forget that the investments simulated are targeted towards the Sonnenplatz Großschönau and the effects are for the entire region of Lower Austria. The last significant result that can be retrieved from the input-output analysis is the effect on the gross domestic product (GDP). The following table displays how the GDP was calculated and shows the change in percent after the shock:

	Before	After	Change in %
Output	119 233,77	119 243,31	0,00800%
Intermediate Consumption	62 921,23	62 926,39	0,00821%
Value Added	56 312,54	56316,9135	0,00777%
Taxes less subsidies on products	1 436,33	1 436,33	0,00000%
Gross domestic product at market prices	57 748,87	57 753,24	0,00757%

Table 10: Change in GDP - 1st Shock - Building/Investment Phase

Table 11 shows that a little investment of 6,01 million euros in a small village like the Sonnenplatz Großschönau, has a positive impact on the GDP of Lower Austria.

3.2.2 2nd Shock - Running Phase

The running phase analyses the impact of the yearly running costs of the facilities and includes ongoing investments, operating costs, labor costs, marketing costs and financing costs. The corresponding industries were shocked accordingly, as was shown in table 7 and 9. Figure 3 illustrates again the impact of the investments on the 17 sectors and it is easy to see, which four sectors were shocked. However, this time all the other sectors show additional output of less than €80.000 euros. With €70.000 euros manufacturing and real estate services show the highest increase (excluding the industries that were shocked), followed by electricity, gas, steam and air conditioning with €60.000 and then construction and wholesale and retail services each with €50.000. As it was the case during the 1st shock, the sectors public administration and human health and social services show no additional demand.

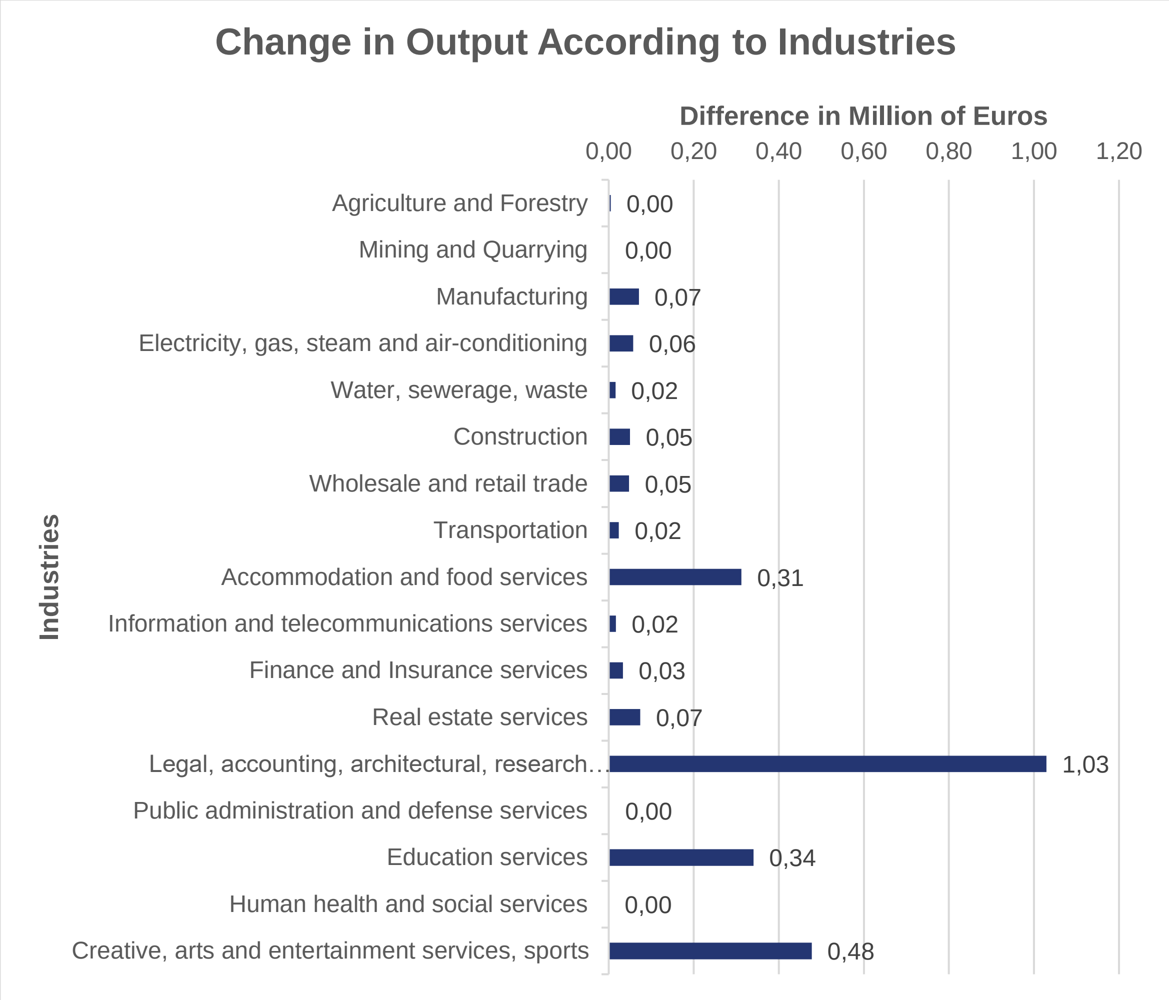


Figure 3: Change in Output of Industries - 2nd Shock - Running Phase

	Direct	Indirect	Total	Multiplier
Output	1,94	0,62	2,56	1,31668
GVA	1,27	0,30	1,58	0,81234
Income	1,92	0,36	2,28	1,17305
Employment	8,17	1,92	10,09	5,19584

Table 11: Effects and Multipliers - 2nd Shock - Running Phase

The numbers in table 12 can be read in the same way as was done in table 10. Since the investment sizes of the 2nd shock were a lot smaller than for the 1st shock (investments for the 2nd shock are less than a third of the ones from the 1st shock) it becomes obvious that all the total effects are smaller as well. What is interesting to examine are the multipliers. While the multipliers for output and employment are slightly smaller than the ones from the 1st shock, the multipliers for GVA and income actually increased in comparison. The multiplier for GVA slightly increased by almost 0,1 but the multiplier for income shows significant growth. It is almost double the amount from the 1st shock, which is surprising because it is unusual for an income multiplier to exceed 1. These results illustrate how much the outcomes can change depending on the way the economy is being shocked. This is vital information that is truly meaningful for policymakers and those who have to decide how certain funds are being used and where the money should be invested. The 2nd shock also shows an increase in GDP but due to the smaller investment size it makes sense that the growth is smaller than in the case of the 1st shock:

	Before	After	Change in %
Output	119 233,77	119 236,32	0,00215%
Intermediate Consumption	62 921,23	62 922,21	0,00156%
Value Added	56 312,54	56314,1188	0,00280%
Taxes less subsidies on products	1 436,33	1 436,33	0,00000%
Gross domestic product at market prices	57 748,87	57 750,45	0,00273%

Table 12: Change in GDP - 2nd Shock - Running Phase

3.2.3 3rd Shock - Visitors

To make the right estimations for the 3rd shock it was necessary to find out how much visitors spend on average per day when they do a day trip and when they stay overnight. In their paper Egger et al. work with a day trip indicator that shows an average spending per day and person of €25,53. To establish this number tourists who made trips to destinations within Lower Austria were interviewed making these results especially suitable for this thesis. However, since many different destinations were examined to calculate the average, costs are included for services that Großschönau does not offer (e.g., cable car). Therefore, these numbers were excluded. Furthermore, the number for food and drinks was adjusted, since some visitors will eat and drink at facilities of the Sonnenplatz Großschönau, which cannot be included because this would lead to double counting (These expenditures are already included in the shock). This is the same reason why the expenditures for entry fees were also excluded. The last adjustment was to correct the numbers to the value of 2019, so that they correspond to the numbers of the input-output table.

The numbers used by Egger et al. are from 2005 and therefore the modification is a necessary step. The above-mentioned adjustments lead to the following expenditure table (Egger, Hörl, & Jooss, 2006):

Category	Expenditures in €
Food and Drinks	11,65
Transportation	7,31
Typ. Excursion Products	2,33
Products	0,39
Others	1,35
Total	23,03

Table 13: Day Trip Index - Expenditures Per Day and Person

Now that the expenditures for day-tourists have been established it is necessary to establish another table that includes the expenditures for overnight stays. For this purpose, the average spendings per night according to accommodation in Großschönau was simply added:

Category	Expenditures in €
Food and Drinks	11,65
Transportation	7,31
Typ. Excursion Products	2,33
Products	0,39
Others	1,35
Accomodation	80
Total	103,03

Table 14: Overnight Stays - Expenditures Per Day (Including Night) and Person

With these numbers and the data provided by the commissioners (estimation of visitor number per year of 13.500 in total including 9.684 day-tourist and 3.816 visitors spending a night) the allocation of the expenditures to the according sectors could be conducted:

Accommodation and food services	462.555
Transportation	98.685
Wholesale and retail trade	36.720

Table 15: Allocation for 3rd Shock - Visitors

The total volume of the 3rd shock is less than a third of the volume of the 2nd shock, which obviously leads to significantly smaller impacts on the other industries. As can be seen in figure 4 the manufacturing industry shows the largest effects (excluding the sectors that were shocked) with €60.000. Real estate services and legal, accounting, architectural, research services both reach an increased output of €30.000. The other industries are less significant with effects of less than €30.000 and seven industries showing no impact at all when looking at two decimal places.

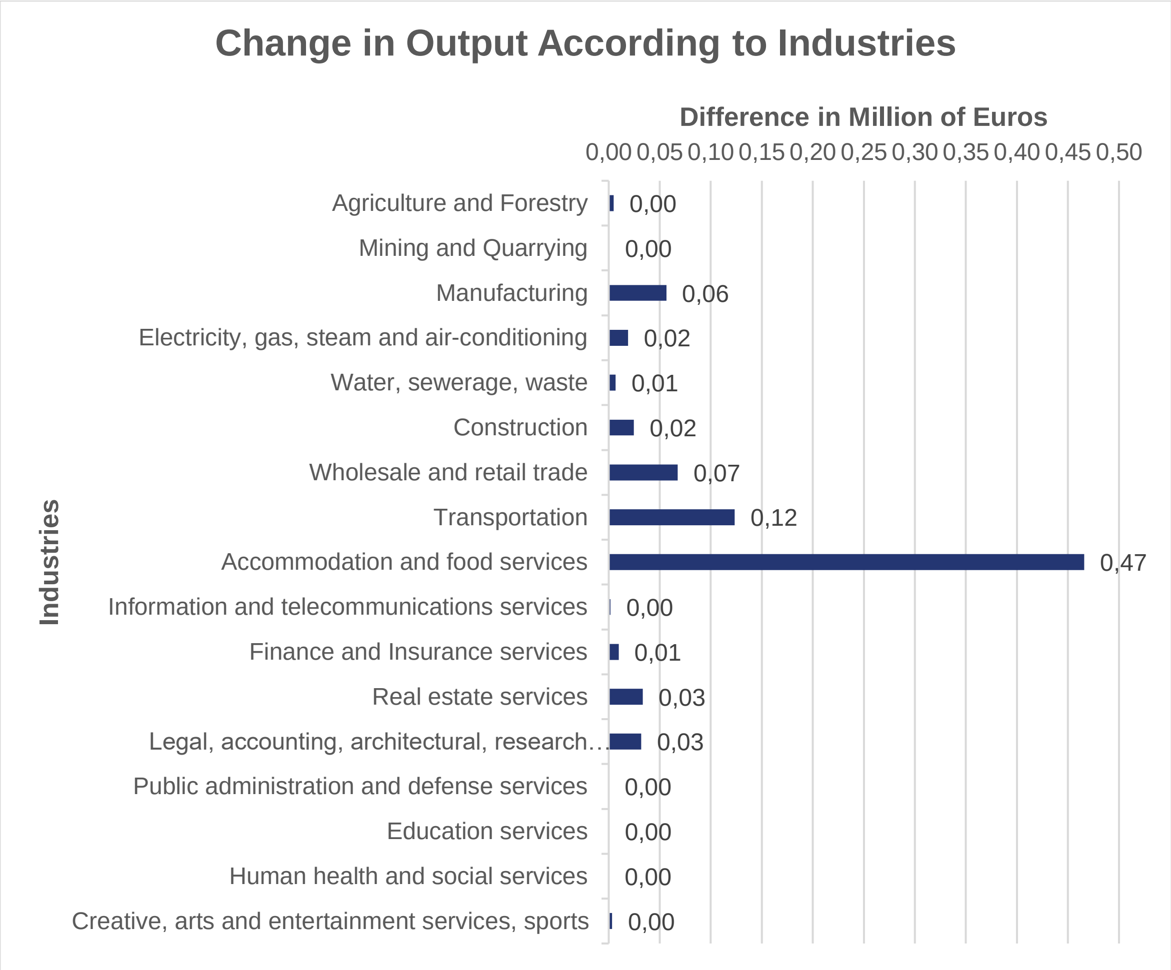


Figure 4: Change in Output of Industries - 3rd Shock - Visitors

	Direct	Indirect	Total	Multiplier
Output	0,60	0,25	0,85	1,42191
GVA	0,36	0,12	0,48	0,79518
Income	0,36	0,09	0,45	0,75152
Employment	3,17	0,80	3,96	6,63086

Table 16: Effects and Multipliers - 3rd Shock - Visitors

With 1,42 the output multiplier is slightly higher than the one from the 2nd shock. The multipliers for GVA and income are just short 0,8 and the employment multiplier shows a significant number of over 6,6 in full time equivalents. The visitors are estimated to increase the extra demand by less than €60.000 in total, which makes the impact on the GDP less substantial:

	Before	After	Change in %
Output	119 233,77	119 234,62	0,00071%
Intermediate Consumption	62 921,23	62 921,60	0,00060%
Value Added	56 312,54	56313,0162	0,00084%
Taxes less subsidies on products	1 436,33	1 436,33	0,00000%
Gross domestic product at market prices	57 748,87	57 749,35	0,00082%

Table 17: Change in GDP - 3rd Shock - Visitors

3.2.4 4th Shock - Total Shock

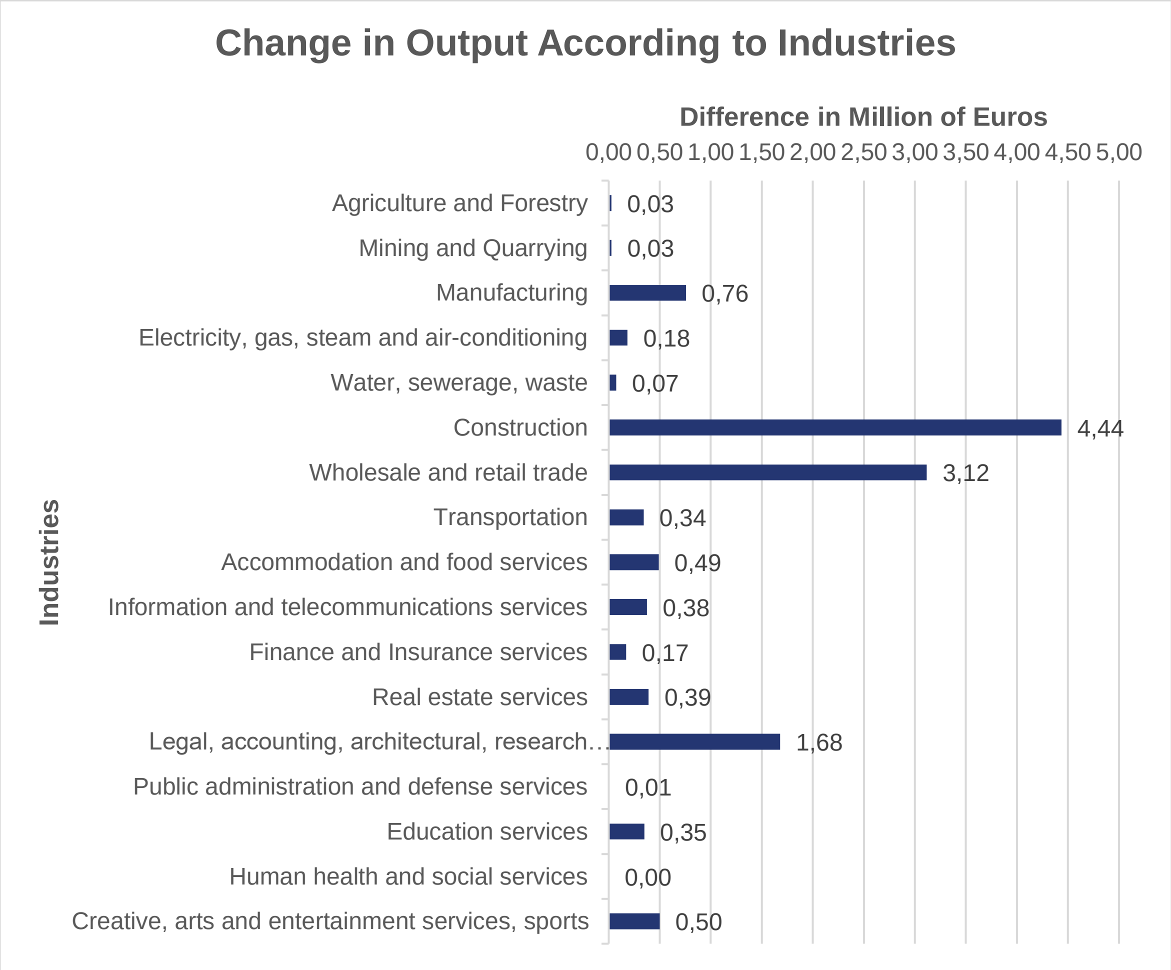


Figure 5: Change in Output of Industries - 4th Shock - Total

After conducting all the shocks separately, it only makes sense to shock the economy all at once to see what effect all the investments have combined. For the total effects eight different industries were shocked at the same time, leading to impacts in every industry but human health and social services. The increase in total investments also raises the sizes of the indirect effects.

	Direct	Indirect	Total	Multiplier
Output	8,56	4,37	12,93	1,51037
GVA	4,38	2,00	6,38	0,74507
Income	4,87	1,89	6,76	0,78984
Employment	38,56	14,46	53,03	6,19602

Table 18: Effects and Multipliers - 4th Shock

Table 19 shows a total extra output of 12,93 million euros with indirect effects reaching 4,37 million euros. GVA and income show numbers not far apart from one another with 6,38 and 6,76 million euros respectively. Now that all the multipliers have been established, they will be compared in one table to explore the differences of the various shocks:

	Multipliers			
	1st Shock	**2nd Shock**	**3rd Shock**	**4th Shock**
	Investment/Building Phase	Running Phase	Visitors	Total
Output	1,58731	1,31668	1,42191	1,51037
GVA	0,72758	0,81234	0,79518	0,74507
Income	0,55609	1,17305	0,75152	0,78984
Employment	6,64571	5,19584	6,63086	6,19602

Table 19: Comparison of Multipliers - All Shocks

Table 20 shows all the multipliers next to one another with the colored cells displaying the highest number of each row. This means that the output and employment multipliers are highest in the investment/building phase and the GVA and income multipliers are highest in the running phase. While the visitor and total shock do not have one of the highest multipliers, they both outperform the running phase with their output and employment multipliers as well as the investment/building phase with their GVA and income multipliers. The reason why those multipliers are so important is because they give insights on the output size when investing into certain sectors. For political agents and the commissioners of this thesis in particular, it is of interest to reach the highest possible output with a given budget. Therefore, it is necessary to understand how investments in one sector differentiate from investments in another sector, to ensure pursuing the investment that shows the highest outcome potential. The purpose of the following chapter is to give recommendations for policy implications that can be made using the results of the conducted input-output analysis. But before that, the economic effects the total investments in Großschönau would have on the region of Lower Austria will be summarized, starting with the change in GDP of the accumulated shocks that is illustrated in the following table:

	Before	After	Change in %
Output	119 233,77	119 246,69	0,01084%
Intermediate Consumption	62 921,23	62 927,78	0,01041%
Value Added	56 312,54	56318,917	0,01132%
Taxes less subsidies on products	1 436,33	1 436,33	0,00000%
Gross domestic product at market prices	57 748,87	57 755,25	0,01104%

Table 20: Change in GDP - 4^{th} Shock - Total

This means that the planned investment of 8,56 million euros in a small research and education facility like Sonnenplatz Großschönau leads to an increase in GDP of Lower Austria of more than a tenth of a percent. This number might seem small, but it must be set into relation with the investment size, which makes the significance clearer.

In order to consider potential investment size changes, the following explanations of the results should be of interest: Per €10 million of investment one can expect a total output of above €15 million, an increase in gross value added by just under €750 thousand. a rise in income (compensation of employees) of close to €800 thousand and six new full-time employees. This simple overview summarizes the economic effects that investments into the Sonnenplatz Großschönau would have on the region of Lower Austria and should help the responsible decision-makers to reasonably discuss the budget size to make the most suitable investment.

4 Policy Implications

Considering that input-output analyses are being used to get valuable insights on how potential investments impact the economy as a whole, it is necessary to illustrate results that give justification to specific investments like the ones used for this thesis. The previous chapter outlined the effects that the various phases have on the economy and also showed the total effects of the planned project. While it is obvious from the results that the investments would lead to a certain level of economic growth, the question arises if the investments used for this project are reasonable. The answer cannot be a simple yes or no because it depends on the specific goal or vision of the political parties involved. If the only objective is to advance the knowledge in the field of sustainable and energy-efficient construction, then it is easy to say that the planned investment is a step into the right direction because it will for sure lead to an enhancement in research activities. However, if this investment is supposed to change the entire structure of the region and make the municipal Großschönau a lot more attractive for people to visit and to work and live there, it makes answering the question more complex.

As mentioned in chapter 2.1.6 “Economic Effects of Research and Development” the existence of a causal relationship between economic growth and research activities cannot simply be assumed. However, it is sure that the new research results will lead to technology inventions and knowledge spillovers are inevitable (Griliches, 1991). The long-term effects these new technologies will have on the regional development of Großschönau and Lower Austria cannot be determined by the results of the conducted input-output analysis. What makes the investment into an existing research facility more relevant is the endogenous growth theory including Arrow’s theory of learning by doing that was explained in chapter 2.1.5 “Endogenous Growth Theory”. This theory puts emphasis on the importance of experience when it comes to economic growth. Since the Sonnenplatz Großschönau is already a fully functioning research facility, expertise was built up and it can be assumed that the learning curve is more advanced than if a new facility was constructed (Arrow, 1961). This is a significant factor when considering the reasonability of the planned investments. It is vital for the commissioners of this thesis to consider the opportunity costs of the investments, which, as Sylwester mentioned, are being regularly ignored. Opportunity costs refer to the possibility of using the investments for different projects that would obviously influence the economy in a different way (Sylwester, 2001).

While the new investments will most likely not increase the centripetal forces of Gr0ßschönau significantly, the investments are still reasonable considering the goal of increasing innovation in sustainable and energy-efficient construction. The reasons are the existing expertise and the positive economic outcomes illustrated in the input-output analysis. In order to get the most out of the investments the investors should consider the multipliers described in the previous chapter. While the running phase shows great income and gross value-added multipliers, the visitors are the ones who lead to higher employment and output multipliers. Considering that the running phase includes costs that are supposed to increase the number of visitors (marketing costs), it might be helpful to invest more for that purpose. A larger input of marketing makes use of the higher GVA and income multipliers, while also attracting more visitors, who show the higher employment and output multipliers. Therefore, it seems like this measure could increase the value of investments. This is because higher multipliers simply lead to higher output for the same input. It does make a difference if a million euros invested lead to an output of 1,3 or 1,5 million euros.

It is not only in the interest of the investors to get the highest potential out of their investment but in the interest of every stakeholder. The reason is simple: The money will be spent anyways, the only question is, how big will the impact of that money be and how much prosperity will it bring to the region. The purpose of the conducted input-output analysis is to show the potential of the planned investments and to give the responsible parties a basis to take reasonable investment decisions. The results illustrated in the previous chapter will not change if another person will conduct the same analysis. However, the interpretation of the results might vary, and the recommended implications might do so as well. Therefore, it is crucial to consider the given recommendations as thought-provoking impulses and to use the results of the input-output analysis to discuss the benefits of the planned investments without ignoring its opportunity costs.

5 Conclusion

The aim of this research was to determine the economic effects that increasing research activities at the Sonnenplatz Großschönau have on the region of Lower Austria. The results of the conducted input-output analysis, in which the planned investments were simulated, show positive effects in total output, gross value added, income (compensation of employees) as well as for full-time employees and the gross domestic product. The industries that are mostly impacted and therefore show the largest change in output are “construction”, “wholesale and retail trade”, “legal, accounting, architectural, research activities” and “manufacturing”. Since this thesis is a commissioned work, it was essential to gain results that would help the responsible decision-makers to get the most potential out of their investments. Therefore, the economy was shocked four times in total, to illustrate the effects of the different phases and situations. In the end, the multipliers of the various shocks were compared with one another, which lead to helpful findings: The income and gross value-added multipliers are highest in the running phase (reflecting yearly operating expenses), while the output and employment multipliers are largest for the visitors (day-tourists and overnight guests visiting the facilities of the Sonnenplatz Großschönau). Since the multipliers determine the size of the output per input it is suggested to invest more money into marketing activities (part of running phase), which should increase the number of visitors, thus, making use of the higher multipliers to maximize the overall output of the investments.

While the input-output analysis could be used to extract direct and indirect effects, it does not give any indicators on effects on long-run economic growth. This is crucial to understand because the positive results described in the previous paragraph must not be used to predict long-run prosperity for Großschönau nor the region of Lower Austria. However, the investments will lead to innovation and the invention of new technologies in the field of energy-efficient and sustainable construction and reconstruction. Since the Sonnenplatz Großschönau is located in a peripheral area the positive effects of knowledge spillovers are less significant than they would be in a non-peripheral area. Nevertheless, Großschönau is an Austrian municipal and

Asheim and Gertler explained that the regional innovation system heavily implemented in Austria is referred to as ideal. This means that the institutional infrastructure helps innovation to drive forward within the regional production structure (Asheim & Gertler, 2009).

The theoretical approaches of regional development explored in this thesis gave insights into various concepts on how and why agglomerations are formed and how the structure of an economy is being influenced. Research and development does play a role in terms of a growing economy but even though there are many scholars describing the positive relationship between R&D activities and economic growth, there is no general rule explaining the effects of increased R&D. The results vary substantially between regions, depending on the differences in the stage of development. Therefore, it is vital not to just blindly invest into research and development because theories show the positive impact this has on economic growth, but to consider each investment project as a separate case in need of specific analysis. This is the reason why this thesis was conducted for the Sonnenplatz Großschönau, to have analytical results to take reasonable investment decisions for a specific project.

Since this research was targeted at a specific project it is not necessary to conduct further research that analyses the effects of the planned investments of the Sonnenplatz Großschönau to take an investment decision. However, it would be interesting to explore the ways of knowledge distribution of peripheral areas and to find out if certain actions can be taken to make the knowledge transfer more efficient. This could help to increase the economic growth rate and the progress of innovation, which is desirable for any economy of any region.

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