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Business-models of gravel, cement and concrete producers in Switzerland and their relevance for resource management and economic development on regional a scale

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Abstract. Traditionally, gravel, cement and concrete producers focus on their role as material or resource suppliers. The higher the material turnover, the higher the economic success. Hence, the business-model conflicts with the societal goal of increased resource efficiency. Driven by stricter regulations, companies started to extend their business models with additional services in waste management and logistics.

In the research project “Co-Evolution of Business Strategies in material and construction industries and public policies” the most relevant business-models of gravel, cement and concrete producers in Switzerland are identified based on case studies of ten different companies. The analysis reveals how these business-models differ with regards to value added, resource consumption and CO₂-emissions. To analyse the relevance of the different business-models on regional scale, an assessment model is developed based on Material Flow Analysis. It is used to analyse the value chain of construction minerals in an alpine region and its effect on value added, resource consumption, waste generation and CO₂-emissions. A comparison between the results of both analyses – companies scale versus regional scale – reveals how alternative business-models could affect resource management and economic development on a regional scale and which types of business-models accelerate or hinder the transition towards a sustainable built environment. The study will show, that it is essential to identify alternative business models in the building materials industry and understand their impacts on the use of primary and secondary resources.

In this paper, we identify two business models, which, at first glance, seems identical as they produce and sell concrete and gravel, but show that the success of a business model highly depends on the source for raw-materials (gravel pit, river extraction or processing excavated materials with high gravel content), the possibility to landfill excavated material and the resulting effects on resource consumption.



1. Introduction

Traditional business models in the construction industry link economic success to material turnover. This promotes an inefficient use of natural resources and contradicts macroeconomic objectives, such as circular material flows and reduced material consumption. Decreasing construction activity and increasing competition among construction material companies provide a complex and challenging environment to these business models. Business model adjustments have been observed along the entire value chain, challenging a rather static industry. For example, building contractors become service agents in materials management of construction sites, and their turnover and profit will become more independent of the consumption of natural raw materials (decoupling of economic growth and resource consumption). This transition to a circular economy can be seen already on entrepreneurial level and regional scale in Switzerland, as an increasing number of companies focus on the preparation and use of secondary building materials. A dominant driver of this transition is the geographical and social limitation of access to natural resources, leading to fierce land competition among companies.

Yet, it is difficult to clearly differentiate between alternative business models in the Swiss building material industry. Today, a diversity of companies varying in size and degree of vertical integration can be found. Few large players with vertical integration dominate the market for concrete, ranging from the production of cement as well as concrete and aggregates. A number of innovative niche players are very strong on regional markets in urban areas with growing market shares. In recent years, some construction companies started providing material management as service on large construction sites including construction waste management, on-site recycling as well as concrete production.

- Can the success of alternative business models be explained by boundary conditions in the specific markets, in the regional supply of natural resources or incentives from public administration?
- If a business model is considered favorable in the transition towards a circular economy, can it be transferred from one region to another without losing its economic benefits?
- How does such a transition towards alternative business models affect regional resource consumption, emissions and value added on regional scale?

In the research project “Co-Evolution of Business Strategies in material and construction industries and public policies” we try to answer these questions by identifying the most relevant business-models of gravel, cement and concrete producers in Switzerland based on case studies of ten different companies. We analyze how these business-models differ with regards to value added, resource consumption and CO₂-emissions. In a second part of the research project we analyze how business model innovations can be encouraged by public policies to stimulate a transition towards a circular economy.

In this paper we present first results of our research focusing on two business models that we could identify and describe so far. The relevance these business-models on regional scale is assessed for a case study region.

2. State of research

2.1. Business-Models and transition management

In our research, we focus on the concept of co-evolutionary transition dynamics, which can be described as the developments within subsystems, influencing the development of a larger system. For example, co-evolution between science and technology, between culture and technology and between technology and society [1], or between institutions and technology [2], or between organisations and institutions [3] haven been researched. A number of studies presented empirical evidence for interdependencies between different societal subsystems, e.g. environmental regulation and the firms’ competitive performance ([4],[5]), environmental taxation and resource management [6] or alternative business

models (e.g. niche players) and mass market players [7]. For the case of construction materials, [8] and [9] showed the importance of planners and engineers as mediators between builders and construction industries for a transition towards resource efficiency. The importance of competing business-models in a changing regulatory environment, however, has not yet been analysed for construction material industries. We try to fill this gap in our research. In our analysis, we consider a business model as the articulation of a company's strategy [10]. Literature suggests that value proposition (product/service, customer segments and relationships); value creation & delivery system (key activities, resources, technologies, etc.); and value capture (cost structure and revenue streams)" form key components of business models [11]. Research on sustainable business models expand this traditional framework by including social and ecological value creation for an extended range of stakeholders [7].

2.2. Assessment of resource consumption, environmental impacts and value added

For the assessment of transition management in the built environment, defined as business environments for construction industries, material flow models are frequently used (an overview is given in [12]). These studies mainly focus on stock-flow-models of defined regions (e.g. Switzerland) [13]–[17], but also comparisons between nations or regions (e.g. EU 25) are available ([18], [19]). Yet, these models describe the underlying cause-effect only with coefficients related to the technical efficiency of processes involved (e.g. recovery rates). The main drivers of development are exogenous parameters such as rates of construction, demolition, or assumed correlations with socioeconomic parameters such as population number or GDP (e.g. [17]).

As a component of the analysis of material flows, Input-Output-Analyses (IOA), in form of Input-Output-Tables (IOT) can be used in combination with environmental and economic performance indicators to form economic and environmental extended Input-Output-Tables (an overview is given in [20]). IOT, as a tool for analyzing interindustrial interdependence, have become the standard since the 1930's. At this time Wassily Leontief developed the first detailed IOT for the United States [21]. In the following decades the IO-Analyses have constantly developed. An overview of the developments of IO-Analyses gives [22]–[24]. Today IOT are used by most governments to carry out analyses of the respective national economy [25], [26].

This paper will introduce an assessment model for environmental and economic impacts in form of environmentally and monetary extended input-output-tables based on Material-Flow-Analysis (MFA). This method was first presented in [27] and is applied on scale of companies as well as regions.

3. Methods and Data

In our study, we identify and describe alternative business models combining methods from business administration as well as environmental and process engineering. In addition, we analyse a regional resource management system for construction minerals. In this section we present the methods used to collect relevant data.

3.1. Definition of criteria for classification and indicators

The analysis of business models is based on the definition of business models presented in [11] and complemented with aspects of research on sustainable business models [7]. For each company the following aspects are analysed:

Value proposition: It describes how the organization attempts to create the willingness-to-pay of its target group to pay for the offered product or services [11]. Furthermore, it describes the intended target audience, enabling evaluation whether the proposed value, relative to the company's competitors, is creating competitive advantage.

Value creation: Describing the operationalization of the company's strategy and internal value chain clarifies how the companies uses their resources and capabilities to create value for its stakeholders.

Building on aspects from research on sustainable business models, the attempt to satisfy a wider range of stakeholders, influencing consumption itself becomes a crucial aspect of corporate responsibility.

Value capture: Value capture completes the picture by examining how the company captures economic value from the consumer and the modes of transaction. Richardson (2008) highlights that economic value is especially dominant in traditional entrepreneurial literature, distinguishing between the economic and revenue model. In essence, the captured value from incorporating sustainability describes the “business case for sustainability”, combining profits with positive impacts.

In addition, we analyse how each business model effects regional resource management systems, economies and the natural environment. To this aim, we define a number of indicators (see table 1). To compare different business models, we use each companies output (in tons) per year as functional unit, differentiating between two major product categories: concrete and aggregates.

table 1: indicators for the assessment

Indicator	Unit	Description
Amount of virgin gravel/sand extracted	ton per year	Most companies extract virgin gravel/sand from surface water or mine in gravel quarries. The rate of substituting virgin material with secondary resources can vary from company to company.
Amount of excavated material deposited		Excavated material is mostly used to refill empty gravel pits. In certain areas in Switzerland, however, the gravel content in excavated material is high enough to use this material as substitute for virgin gravel. In this case, natural resources can be preserved.
Amount of recycling materials used for producing construction materials		Crushed concrete and mixed construction waste can be used to substitute virgin gravel in the production of aggregates and concrete. A high content of these secondary resources the overall material input can indicate a transition towards a circular economy.
Value added	CHF per year	This value is used to indicate effects on the regional economy. It represents factor income generated by labour and capital on regional scale. For each company, this factor income is analysed for each process in the production chain (including internal transports) by subtracting material costs from material turnover, both estimated by multiplying material flows with material prices. Costs of electricity are only considered in cement production.
Global Warming Potential (GWP)	Kg CO ₂ eq. per year	This value is used as indicator for environmental impacts. It is estimated for all processes in the production chain of each company including greenhouse emissions generated in the supply chain (e.g. for electricity production)

3.2. Collection of data

A case study with ten companies is used to determine the relevant business models. Each company covers a specific step in the value chain of construction minerals, ranging from extraction of primary materials, over processing virgin/recycling aggregates, producing concrete, producing cement, constructing building and infrastructures and providing services in logistics, demolition, to sorting of construction wastes and waste management. Most companies' activities in this study focus on concrete production with a variation in the degree of vertical integration as well as major resource input (primary versus secondary).

table 2: collection of data

Workshop no.	Aim of the workshop	Data collected	Methods	Reference
1	Understand fundamental business model logic	Socially and environmentally extended business models perspective	Flourishing business models canvas	[28]
2	Identify physical flows economic indicators associated with key resources, value proposition and value capture.	Material flows and respective prices and costs	Material flow analysis	[20], [29]

With each company, two workshops are carried out (see table 2). In the first workshop, the companies' business model is analysed using the business canvas introduced in [30]. Thereby, the data collection exceeds purely economic aspects and includes social and environmental dimensions. In the second workshop, material flows and production costs are analyzed using MFA on company level. The results of each workshop are discussed with the companies' representatives and validated with company internal data on material flows and costs. CO₂-emissions are assessed with data from the ecoinvent database using the indicator GWP (global warming potential) to cover all emissions relevant for climate change.

The analysis on regional scale is intended to provide a reference system for evaluating the effect of alternative business models. Yet, identifying a region for that purpose posed a major challenge. [13] showed that consumption of construction minerals varies significantly from canton to canton due to imports and exports across the Swiss border as well as between cantons. To eliminate such effects, we chose an alpine region which is self-supplied with gravel and sand as well as landfill capacity. It is densely populated with around 82'000 inhabitants and its settlement growth rate is near the Swiss average. In this region, we can identify companies with different business models. In order to ensure confidentiality of all company data, we decided not give any additional information on the region itself but to use it as a representative "model region" named ALPVAL (for "alpine valley").

The material flows in this region were assessed by interviews with representatives of all mayor companies located in the area. In addition, data was gathered from reports of the cantonal waste management authorities as well as statistics of gravel extraction from ground as well as rivers. Data on communal data was collected to additionally assess fees on gravel extraction.

3.3. Assessment of business models

The assessment of each company is based on a Material-Flow-Analysis (MFA) with data collected in workshops as described in section 3.2. Each company MFA was transferred to an Input-Output-Table (IOT) describing input, output and internal flows. IOTs were used to combine MFA data with additional information on prices of products, services and production factors and estimate factor income (value added) for each process in the production chain as represented in figure 1. For each process CO₂ eq. were estimated to assess GWP according IPCC 2013 based on data from the database ecoinvent (version 3.4) using standard datasets of gravel, concrete and construction waste in Switzerland.

4. Results

Following workshops with different companies, distinguishable features of each business model emerged. Building on features that are present in both business models, the unique attributes are summarized in table 3. To differentiate between these two idealized companies, the value proposition, value creation and value capture are further discussed. As mentioned earlier, competition for land has increased the value of accessible land for extraction and disposal purposes. The relevance of these boundary condition will further be highlighted in the remainder of the discussion.

table 3: insights and differences between the two business models

	Similar features	Distinction company A “Extraction”	Distinction company B “Recycling”
Value proposition	<ul style="list-style-type: none"> • Provision of gravel & concrete according to norms to construction companies. • Intake of disposable and excavation material 	<ul style="list-style-type: none"> • Desired equilibrium between intake of disposable material and output of gravel 	<ul style="list-style-type: none"> • Material management on construction site as service. • Vertical integration → Construction services • Development of Niche products for (1) specific application and (2) reduced primary raw material input
Value creation	<ul style="list-style-type: none"> • Disposal volume is profitable and scarce • Machinery and infrastructure 	<ul style="list-style-type: none"> • Gravel extraction creates volume for disposal of material. 	<ul style="list-style-type: none"> • Gravel extraction does not create volume for disposal. • Increase available volume for intake of disposal material with treatments • Cooperation’s with engineers aim at adjusting norms in favour of recycled products
Value capture	<ul style="list-style-type: none"> • Sales of loose gravel/ concrete (CHF/m³) • Accept disposal and excavation material (CH/m³) • Tie incoming and outgoing deliveries 	<ul style="list-style-type: none"> • Community management is crucial for access to key resources (land/gravel quarries) 	<ul style="list-style-type: none"> • High quality products to increase uptake of recycling products.

4.1. Identification of idealized business models

To showcase preliminary results from this ongoing research project, two representative business models are identified and discussed: company A “extraction” and company B “recycling”. Extraction, as well as recycling companies, provide raw materials for the built environment and handle the material flows that leave the building stock. Along this value chain, extraction and disposal processes are different, whereas the technical processing of raw materials is rather similar (see figure 1). The access to gravel quarries, being a key resource, appeared to be central to the extraction business model. Both business models strongly depend on the access to land, either for the storage of material before processing, or for mining purposes. The negative externalities for the local communities appear to be significant in both business model, yet the financial compensation for mining purposes has gained more traction in recent years. Thereby, a tendency of extraction companies to focus on community management to ensure long term access has been observed. Recycling companies appear to be focussed on actively influencing market demand, by promoting the uptake of recycled products among engineers and planners. Increased material turnover frees capacity to accept more valuable volume for storage and processing of excavation material.

We find that both business model builds on similar value propositions and value capture, yet fundamentally differ in terms of value creation. As both business model build on similar processes and differ mainly in the access to gravel quarries (see section 4.2), we elevate these process to a regional level to understand the systemic implication (section 4.3).

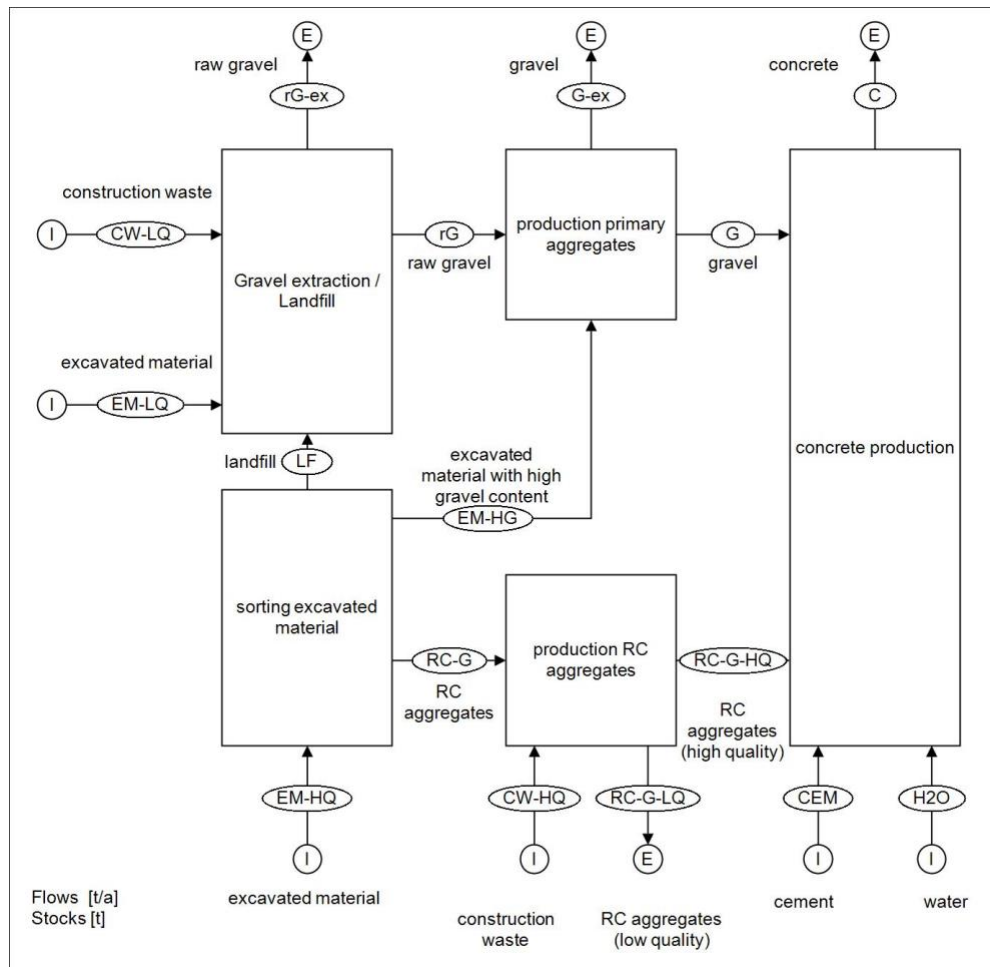


figure 1: Generalized system definition of gravel and concrete producers

4.2. Assessment of business models

Two companies were identified as representatives of the two idealized business models described in section 4.1. The company representing “Extraction” (Company A) owns several gravel pits and sells waste management services for depositing excavated materials (in empty gravel pits) and sorting and processing mineral construction waste. It sells mostly concrete and a comparatively small amount of gravel. The company representing “Recycling” (Company B) produces gravel and aggregates using virgin gravel extracted from rivers, excavated materials with a high gravel content and processing mineral construction waste. It sells concrete as well as gravel. We calculated all values for the indicators listed in table 1, but a comparison of the total numbers is not meaningful as both companies differ in product mix as well as total amount of material turnover.

For a meaningful comparison, value added is used as reference value. For both GWP and primary resource consumption, the performance of Company B “Recycling” exceeds the performance of Company A “Extraction” with 2.21 GWP per CHF (Company B) to 2.66 GWP per CHF (Company A) and 0.01 tons of virgin gravel per CHF (Company B) to 0.02 tons of virgin gravel CHF (Company A). To better understand these differences, we also compared the indicator values per tons of concrete and gravel produced by each company. For one ton of concrete, company A “Extraction” uses 0.49 tons of virgin gravel whereas company B “Recycling” only needs 0.32 tons. This difference is even more distinct for gravel production with 0.77 tons of virgin gravel for one ton of gravel sold (company A “Extraction”) compared to 0.44 tons of virgin gravel for one ton of gravel sold (company B “Recycling”).

To compare value added of processes in both companies, it is interesting to look at the contribution of the different processes as well as the different products. As shown in table 4, the sums of value added generated by the different products vary only slightly between the two companies. Company B "Recycling" has a higher value added for concrete and recycling aggregates than company A "Extraction" whereas company A performs better in the production of primary aggregates. In the results of the value added of the production of one ton of primary aggregate, it can be seen that the value added shifts from the gravel pits and landfill in the case of company A "Extraction" to production of primary aggregates (gravel) in the case of company B "Recycling". This is due to the fact, that company B processes excavated material with high gravel content to produce primary aggregate and increases the value added significantly.

table 4: value added of the two companies

	<i>Change in Value added per ton of concrete</i>		<i>Change in Value added per ton of primary aggregate</i>		<i>Change in Value added per ton of recycling aggregate</i>	
	<i>[CHF]</i> company A	company B	company A	company B	company A	company B
<i>landfill</i>	3.38	-	5.67	-	-1.30	-
<i>gravel pits</i>	7.34	4.83	11.50	6.54	-	-
<i>production primary aggregates</i>	1.58	7.10	2.47	12.19	-	-
<i>production recycling aggregates</i>	2.81	2.60	-	-	15.49	14.63
<i>concrete production</i>	19.50	21.60	-	-	-	-
	34.61	36.13	19.64	18.73	14.18	14.63

The global warming potential according IPCC 2013 can be seen in table 5. By assuming, that both companies produce concrete with the same mix design (355 kg cement CEM II A-LL, 1855 kg aggregates and a water-cement-value of 0.53) and normalizing the material flows, company B "Recycling" has a slightly lower GWP than company A. This can be explained by the lower GWP of the production of recycled aggregates in contrast to the production to primary aggregates. It has to be noted, that the transport outside of the company, e.g. transport from construction site to the company, is not considered. It can also be seen, that the GWP is mainly influenced by concrete production due to the input of cement. Furthermore, it is interesting to see, that concrete production has a much higher impact per ton on GWP than on value added.

table 5: GWP of the two companies

	<i>Change in GWP per ton of concrete</i>	
	<i>[kg CO₂-Eq]</i> company A	company B
<i>landfill</i>	-	-
<i>gravel pits</i>	-	-
<i>production primary aggregates</i>	3.13	2.82
<i>production recycling aggregates</i>	0.69	0.66
<i>concrete production</i>	99.22	99.22
	103.04	102.71

4.3. Influence of alternative business models of regional scale

The results of regional MFA for construction minerals is shown in figure 2. It includes the following processes:

Gravel pits/landfills: In ALPVAL gravel is extracted from rivers as well as traditional gravel pits, that are also used as landfills to deposit excavated material from construction sites. In 2018, the amount of gravel extracted exceeds the amount of excavated material deposited.

Production primary aggregates: Primary aggregates are produced with either virgin gravel/sand from gravel pits and rivers or excavated material with a high content of gravel. This is a typical situation for an alpine valley where glaciers deposited virgin gravel on the entire valley bottom during ice age. The majority of aggregates is used to produce concrete.

Production RC aggregates: RC aggregates are produced with mineral construction waste. High quality aggregates (mostly from crushed concrete) are used to produce concrete; low quality aggregates are used for road construction and similar purposes.

Concrete production: Only 14% of all concrete in the region is produced with RC aggregates. All concrete is used in regional construction.

Building stock: The building stock is still growing as the amount of construction minerals used exceeds the amount of construction waste. Yet, there is a significant amount of excavated material generated in construction. Only a minor share of construction waste is landfilled.

Sorting excavated material: This process is defined to simplify material balancing. In reality, sorting takes place on the construction sites and is determined by the capacity of companies to use excavated materials with high gravel content to produce primary aggregates.

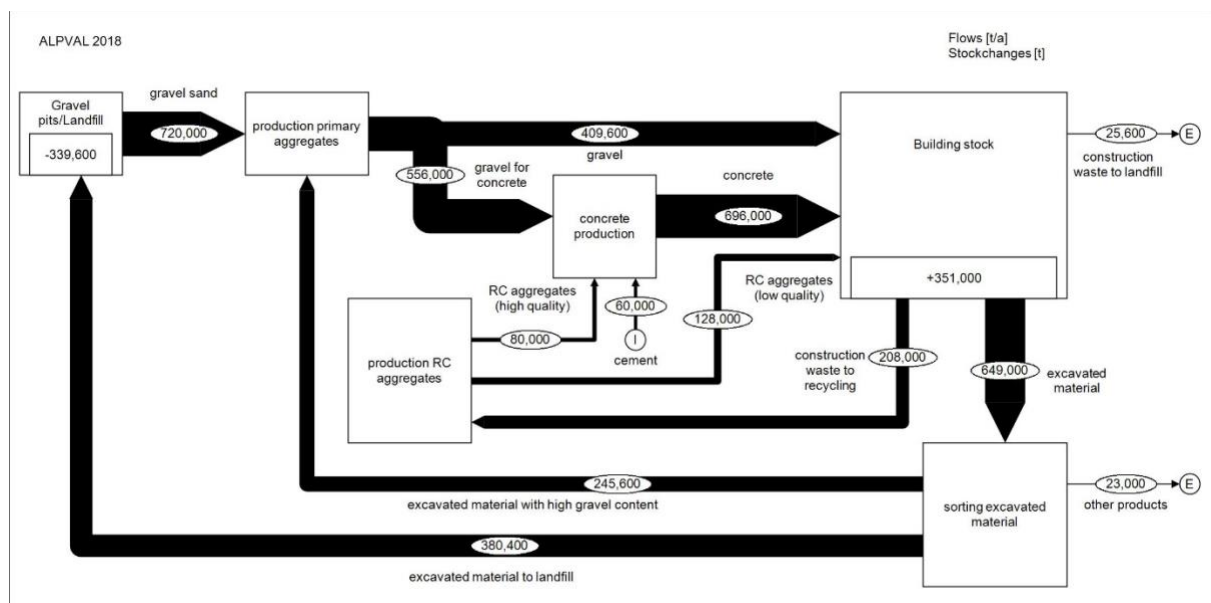


figure 2: material flows of the region ALPVAL

To assess the impact of alternative business models on regional scale, we analyse two alternative scenarios and compare it to the status quo presented in figure 2:

Scenario A: All concrete and gravel produced in ALPVAL is produced by company A “Extraction”

Scenario B: All concrete and gravel produced in ALPVAL is produced by company B “Recycling”

Table 6 presents the results of the scenario calculation. It shows that the amount of virgin gravel/sand extracted per year decreases in both scenarios: by 44% in Scenario B “Recycling” and in Scenario A “Extraction”. This implies that the company we chose as representative for the business model “Extraction” uses more secondary resources than the average company in ALPVAL. Yet, it also deposits more excavated materials per year than an average company in ALPVAL because a smaller share of virgin gravel is gained by processing excavated materials. In scenario B “Recycling” no excavated material is deposited because the entire amount is used in gravel production. The amount of recycling materials used in production increases in both scenarios.

table 6: comparison of the companies on a regional level

	status quo	Scenario A	Scenario B
Amount of virgin gravel/sand extracted (tons per year)	720'000.00	656'432.00	402'944.00
Amount of excavated material deposited (tons per year)	380'400.00	485'264.00	0
Amount of recycling materials used for producing construction materials (tons per year)	208'000.00	253'280.00	253'280.00
Value added (CHF per year)		33'948'144.00	34'690'928.00
Global Warming potential (kg CO ₂ eq per year)		71'715'840.00	71'486'160.00

Value added and GWP are calculated for both scenarios but no comparison to the status quo is possible due to lacking data. But if we calculate GWP and Value added per capita for ALPVAL we see the industries relevance on regional scale. The production of gravel and concrete is of minor importance for the regional economy with a share of 1% in the regional GDP per capita. For climate gas emissions, however, concrete production accounts for 19% of the direct emissions (per capita) and 6% of the global emissions (per capita) – both closely related to CO₂ emissions in cement production.

5. Conclusions

For a transition towards a circular economy in the building materials industry it is essential to identify alternative business models and understand their impacts on the use of primary and secondary resources. In this paper, we identified two business models which, at first glance, seems identical as they produce and sell concrete and gravel. By investigating these businesses in detail, we wanted to answer the following questions:

Can the success of alternative business models be explained by boundary conditions in the specific markets, in the regional supply of natural resources or incentives from public administration?

It could be shown, that the success of a business model highly depends on the source for raw-materials (gravel pit, river extraction or processing excavated materials with high gravel content) and the possibility to landfill excavated material. Both have a relevant impact on value added and lead to different strategies to create and capture value. Demand for primary and recycled materials can vary from region to region, as different public policies influence the market (e.g. share of recycled concrete, availability of land/gravel quarries). For the business models described in this paper, the availability of raw material is crucial and both companies developed strategies to cope with this challenge. It is interesting to see, that both strategies are economically beneficial with a comparable amount of value added per unit of output. Compared to the case study region, both business models use more secondary resources than an average gravel and concrete producer. In the further course of the research, we will

have to find a better representative for the business model A “Extraction” to get a clearer distinction between both business strategies.

If a business model is considered favorable in the transition towards a circular economy, can it be transferred from one region to another without losing its economic benefits?

In this study, it is assumed that both companies produce with same costs and sell at comparable prices. In reality costs for gravel pits (e.g. concessions) and landfills differ significantly due to geological, political and economic boundary conditions. Also prices highly depend on demand of building materials and waste management services induced by building activities and economic development on regional scale. Based on our current results, no well-founded answer can be given to question above. In the further course of the research, we will analyze more case study regions that differ in the level of building activity, geological boundary conditions and vicinity of the national border. We expect to find significant difference in costs and prices that will have an impact on the development of business models.

How does such a transition towards alternative business models affect regional resource consumption, emissions and value added on regional scale?

As seen in section 4.3 the effects on resource consumption can be significant. In the cases shown here, resource consumption on a regional scale differs widely. Above all, the amount of excavated material deposited has to be mentioned. But also the amount of virgin gravel used in production strongly depends on the dominant business models in construction industries on regional scale. The effect on the regional economy is negligible. Concrete production has a significant impact on GWP on regional scale if the cement is produced in the region itself (direct emissions). But even if imported from other regions, the impact is not negligible. For our further research, we will analyze how different business models affect the use of cement in concrete production.

In this paper we compared a traditional, linear business model “Extraction” with a circular business model “Recycling”. Building on quantitative data, we demonstrated their impact on a regional scale. It appeared that in terms of value generation, the differences were marginal. These indifferences results from the coupling of value capture and material turnover. A higher material turnover leads to a higher revenue, a logic that is inherently contracting concepts of sustainable business models. Nevertheless, business model so far do not fully decouple this logic, but expand their value proposition with additional services such as waste management. While these have not been fully captured in this paper here, further research will detail how circular economy ideas change business models towards more sustainability, and their impact on regional resource consumption, emissions and value added.

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