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Hotel reservation cancellations: analysis and prediction using machine learning algorithms

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Abstract

In this paper, we analyzed data in tourism to predict whether a guest would cancel a hotel reservation using machine learning algorithms. The problem of canceling a hotel reservation is a problem faced by hotels worldwide. In case the guest does not show up and the hotel has kept a guest room, this is a loss for the hotel. Each case of booking cancellation is personal and requires a special approach and, of course, the good will of both sides. Recent advances in data collection and storage technology have led to vast repositories of data that are extremely difficult for humans to analyze. Machine learning algorithms have the ability to predict test data based on learning from training data. Using machine learning algorithms implemented in the Python programming language, we analyzed a set of hotel reservation data and made predictions. As shown in theoretical studies and confirmed in empirical comparative studies, there is no single best algorithm to be used for all data sets. This means that each algorithm has its own area of superiority and specializes in solving some classes of learning problems. In this paper, we used and compared the performance of the following algorithms: logistic regression, k-neighbor, decision tree, bagging, AdaBoost and random forest classifier. Such research can help hotel employees anticipate the possibility of canceling hotel reservations by taking into account detailed reservation data.

Keywords: booking cancellations, classifier, hotel reservation, machine learning.

1. Introduction

Hotels are almost daily confronted with cancellations of booking. Some hotels offer guests the option of a partial or full refund of the paid stay, but most hotels still keep money from canceled reservations. Guests cancel reservations for various reasons such as very intimate, death, flight cancellation or sudden accidents. Each case of booking cancellation is personal and requires a special approach and, of course, the good will of both sides. One way to overcome such situations and to help everyone is the possibility for the guest to use the accommodation at another time, and the hotel will charge the reservation.

The researchers used different machine learning algorithms in their research to analyze hotel reservation data. Agustín Sánchez-Medina, Eleazar C-Sánchez used machine learning and big data for efficient forecasting of hotel booking cancellations (Sánchez-Medina and C-Sánchez 2020). Ansari Ahlam, Shaikh Ashad, Mapkar Salim, Khan Maaz have considered cancellation prediction for flight data using machine learning (Ahlam, Ashad, Salim, and Maaz 2019). Nuno Antonio, Ana de Almeida, Luis Nunes in their work discuss predicting hotel booking cancellations to decrease uncertainty and increase revenue (Antonio, de Almeida, and Nunes 2017). In their work William Caicedo-Torres and Fabian Payares researched a machine learning model for occupancy rates and demand forecasting in the hospitality industry (Caicedo-Torres and Payares 2016). Ku Chih Hao, Chang Yung-Chun, Wang Yichuan, Chen Chien-Hung and Hsiao Shih-Hui analyzed artificial intelligence and visual analytics: a deep-learning approach to analyze hotel reviews & responses (Chih Hao, Yung-Chun, Yichuan, Chien-Hung, and Shih-Hui 2019). In their work Nuno Antonio, Ana de Almeida and Luis Nunes predicted hotel bookings cancellation with a machine learning classification model (Antonio, de Almeida, and Nunes 2017). Mohammad Al-Smadi, Omar Qawasmeh, Mahmoud Al-Ayyoub, Yaser Jararweh, Brij Gupta discussed deep recurrent neural network vs. support vector machine for aspect-based sentiment analysis of Arabic hotels' reviews (Al-Smadi, Qawasmeh, Al-Ayyoub, Jararweh, and Gupta 2018).

In our study, we used a publicly published data set to analyze hotel reservation data and considered the use of different machine learning algorithms in prediction booking cancellations (Antonio, Almeida, and Nunes 2019). The goal of this research is to present different approaches for analyzing the data in tourism to predict booking cancellation. We organized the work as follows: Section 2 describes the theoretical review of machine learning algorithms. Section 3 presents the booking data set. In section 4 we present our experimental research. The last section offers concluding remarks and possible directions for added research.

2. Machine learning algorithms

There is a growing interest in research in the areas of machine learning and knowledge discovery. Recent advances in data collection and storage technology have led to vast repositories of data that are extremely difficult for humans to analyze. This is why many data extraction techniques are being developed to support the extraction of different representations of knowledge from such large databases (Novakovic 2013). The discovery of knowledge, one of the main tasks under consideration is supervised classification, where the learning process provides a number of examples of training target class. Each sample corresponds to a single object to be classified and is described by a certain number of attributes. Learning objective is to discover a rule or a function which maps such samples into appropriate classes.

An algorithm consisting of a representation of knowledge (learned from a set of training) and a strategy for its use forms a classifier, which can be used to predict classes of new samples to come. Classification accuracy is a typical measure used to evaluate classifier performance. Over the years, several algorithms have been proposed to collect different representations of knowledge and different classifiers (Klosgen and Zytchow 2002; Stefanowski 2001; Kunheva 2014). For many classification problems, these algorithms are very efficient, but do not always lead to satisfactory classification accuracy in more complex and difficult cases.

Classification allows us to categorize our data into a desired and separate number of classes to which we can assign a label to each class. The classification can be applied in the following areas: document classification, handwriting recognition, speech recognition, biometric identification, etc. Classifiers can be divided into:

- binary classifiers: classifications with only two different classes or with two possible results,
- multi-class classifiers: a classification with more than two different classes.

As shown in theoretical studies and confirmed in empirical comparative studies, there is no single best algorithm to be used for all data sets. This means that each algorithm has its own area of superiority and specializes in solving some classes of learning problems.

2.1. Logistic regression

Logistic regression is a classification algorithm used to assign observations to a discrete set of classes. Logistic regression transforms its output using a logistic sigmoid function to return probability values. Logistic regression is a machine learning algorithm used for classification problems, it is a prediction algorithm and is based on the concept of probability.

Advantages of this algorithm is: it is incredibly easy to implement and very efficient to train. It usually starts with a logistic regression model as a benchmark and tries to use more complex algorithms. Disadvantages of this algorithm is: we can't solve non-linear problems with logistic regression since its decision surface is linear.

2.2. K-neighbor classifier

K-neighbor classifier classified the object by a majority vote of the object's neighbors, in the space of input parameters. The object is assigned to the class that is most common among its K (integer determined by man) closest neighbor. The classification is calculated by a simple majority vote of the nearest neighbors of each point.

Advantages of this algorithm is: easy to implement, robust to noisy training data, effective if the training data is large. Disadvantages of this algorithm: it is necessary to determine the value of K and the computational cost is high because it needs the computer distance of each instance to all training samples.

2.3. Decision tree classifier

The decision tree creates a set of rules that can be used to classify the data. The decision tree, as its name suggests, makes a decision with a tree-like model. Divide the sample into two or more homogeneous sets based on the most significant differentiators in your input variables. To select a differentiator (predictor), the algorithm takes into account all the features and performs a binary division on them. It will then select the one with the least cost and repeat recursively, until it successfully divides the data in all leaves (or reaches maximum depth).

Advantages of this algorithm: the decision tree is easy to understand and visualize, requires little data preparation, and can process both numerical and categorical data. Disadvantages of this algorithm: a decision tree can create complex trees that do not generalize well, and decision trees can be unstable because small variations in the data can result in the generation of a completely different tree.

2.4. Bagging classifier

Ensemble machine learning can generally be categorized into bagging and boosting. The bagging technique is useful for both regression and statistical classification. This classifier is used with decision trees, where it significantly raises the stability of models in the reduction of variance and improving accuracy, which eliminates the challenge of overfitting. Bagging in ensemble machine learning takes several weak models, aggregating the predictions to select the best prediction. Weak models specialize in distinct sections of the feature space, which enables bagging leverage predictions to come from every model to reach the utmost purpose. Random forest is one of the most popular bagging algorithms.

Advantages of this algorithm is: offers the advantage of allowing many weak learners to combine efforts to outdo a single strong learner. Bagging also helps in the reduction of variance, hence eliminating the overfitting of models in the procedure. Disadvantages of this algorithm is: it introduces a loss of interpretability of a model. The resultant model can experience lots of bias when the proper procedure is ignored. Despite bagging being highly accurate, it can be computationally expensive and this may discourage its use in certain instances.

2.5. AdaBoost classifier

Boosting is algorithm that attempts to create a strong classifier from many weak classifiers. This is accomplished by trying to make a model from the training data and then creating a second model to try to correct the error from the first model. Add a model until you perfectly anticipate the training set or add the largest number of models. AdaBoost is the first truly successful improvement algorithm developed for binary classification. AdaBoost is the best starting point for understanding help. The modern boost method is based on AdaBoost, the most famous is the random gradient enhancement machine.

Advantages of this algorithm is: very good use of weak classifiers for cascading, different classification algorithms can be used as weak classifiers, AdaBoost has a high degree of precision. Disadvantages of this algorithm is: the number of AdaBoost iterations is also a poorly set number of weak classifiers, which can be determined using cross-validation, data imbalance leads to a decrease in classification accuracy, training is time consuming.

2.6. Random forest classifier

A random forest is an ensemble model that grows multiple trees and classifies objects based on the “votes” of all the trees. The object is assigned to the class that has the most votes from all the trees. This could reduce the problem of high bias (overfitting). It could process a large set of data with a large dimension and it useful for data research. With this algorithm, missing data can be processed while maintaining accuracy. This algorithm could be a black box, and users have little control over what the model does. Advantages of this algorithm is: reduction in over-fitting and random forest classifier is more accurate than decision trees in most cases. Disadvantages of this algorithm is: slow real-time prediction, difficult to implement, and complex algorithm.

3. Booking demand data set

For our research we used “Hotel booking demand” data set, which is published on Kaggle [<https://www.kaggle.com/jessemostipak/hotel-booking-demand/data#>]. Kaggle is online community of data scientists and machine learning practitioners, with a huge repository of data sets. Hotel booking demand data set has information about the reservation for a city hotel and a resort hotel. All personally identifying information has been removed from this data set. Hotel booking demand data set was downloaded and cleaned by Thomas Mock and Antoine Bichat for #TidyTuesday during the week of February 11th, 2020. Hotel booking demand data set consists of 32 attributes, such as hotel, arrival date, stays in week nights, number of adults, children, baby, whether meals are included, country, market segment, distribution channel, whether the guest has already stayed at the hotel, whether the guest canceled previous reservations, number of previous guest reservations not canceled, type of room booked, changes in reservation, type of deposit, agent, whether parking space is required, total number of special requests, date of reservation, whether reservation is canceled and more (Antonio, de Almeida, and Nunes 2017).

Hotel occupancy data is based on real Portuguese market research data. Because as relevant data that can be used to study hotel market research. Therefore, these data actually have a very high research value. By analyzing these data in detail, we can more comprehensively understand the relationship between different parameters, such as hotel market conditions, occupancy conditions and seasonal changes. Using this data set, we can do the following analyzes:

- How long do people stay at the hotels?
- What is the optimal length of stay to achieve the best daily price?
- Where do the guests come from?
- When is the best time of year to book a hotel room?
- How much do guests pay for a room per night?
- What if you want to predict whether the hotel will receive a disproportionate number of special requests?
- Which month has the highest number of cancellations?
- Will the reservation be canceled?

4. Experimental research

Experimental studies were conducted on open source Jupyter Notebook software and Python programming language. The Jupyter Notebook is an open-source web application that allows you to create and share documents that contain live code, equations, visualizations and narrative text [www.jupyter.org]. Using the Jupyter Notebook allows: data cleaning and transformation, numerical simulation, statistical modeling, data visualization, machine learning and much more.

The programming language Python is often used to write code in artificial intelligence and an area that is expected to develop in the coming years - machine learning. Python is an interpreted object-oriented programming language. Its high-level built-in data

structures, combined with dynamic typing and dynamic binding, make it very attractive for Rapid Application Development, as well as for use as a scripting or glue language to connect existing components together [<https://www.python.org/doc/essays/blurb/>].

Hotel booking demand data set describes two sets of data with hotel demand data: one of the hotels is a resort hotel in region of Algarve, the other is a city hotel in Lisbon. Hotels are located in Portugal and the distance between these two locations is ca. 280 km by car and both locations border on the north Atlantic. The data structure of both data sets is the same. They have 31 attributes that describe 40,060 resort observations and 79,330 city hotel observations.

Each record in the data set represents one hotel reservation. Both data sets accept bookings from 1 July 2015 to 31 August 2017, including bookings that have effectively arrived and bookings that have been canceled. Since these are real data about the hotel, all data elements related to the hotel or the identification of the customer are deleted. For business and educational purposes, real business data is lacking, which is why these data sets can play an important role in revenue management research, machine learning, data extraction as well as for other purposes. Figure 1 shows the reservations by months. In the picture we can see how city hotels have more customers in all months. Given the ratio of bookings, the resorts seem to be a little closer to city hotels in summer.

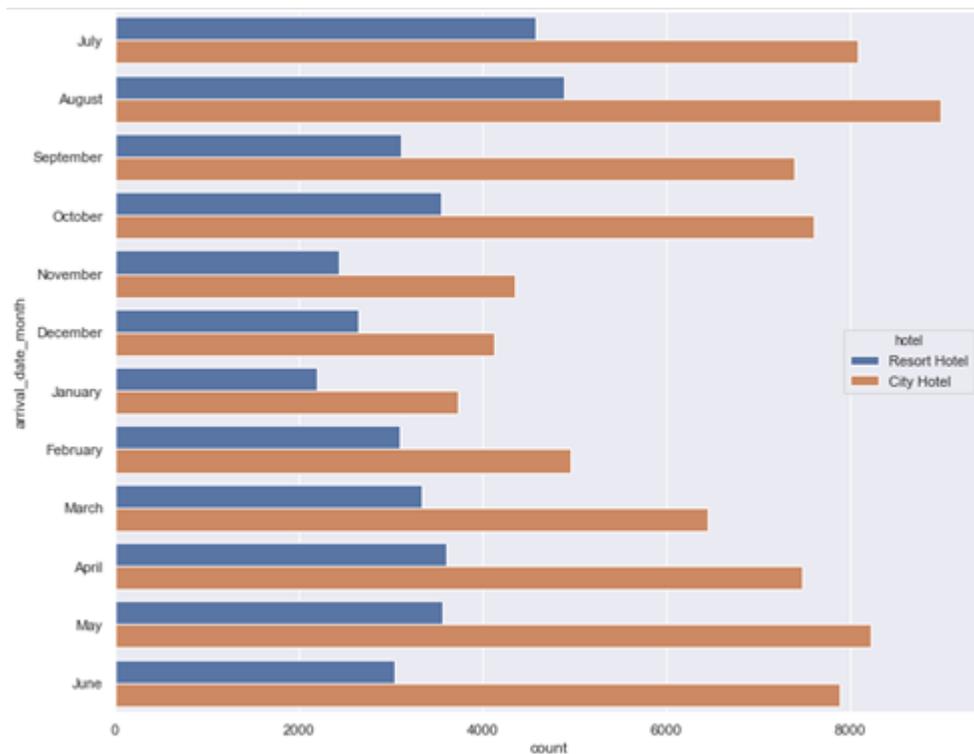


Figure 1. Booking reservations by hotels and months

If we examine two graphs together (Figure 1 and Figure 2) the interpretation is important. In the winter months, a smaller number of customers come, so when we look at the cancellation rates it is quite normal for a smaller number to appear in the winter months. We can observe that these months, city hotel cancellation rates are almost the same as other months even in winter. Because overall cancellation rates in the winter months are low, then the cancellation rates of the resort hotels are low in these months. We can conclude that the possibility of canceling summer resorts in winter is very small.

We presented the canceled and non-canceled reservations depending on whether the guest has already stayed at that hotel on Figure 3. The number of canceled reservations depends on whether the guest has already been to the hotel: if the guest has already been to the hotel, the number of canceled reservations is significantly lower.

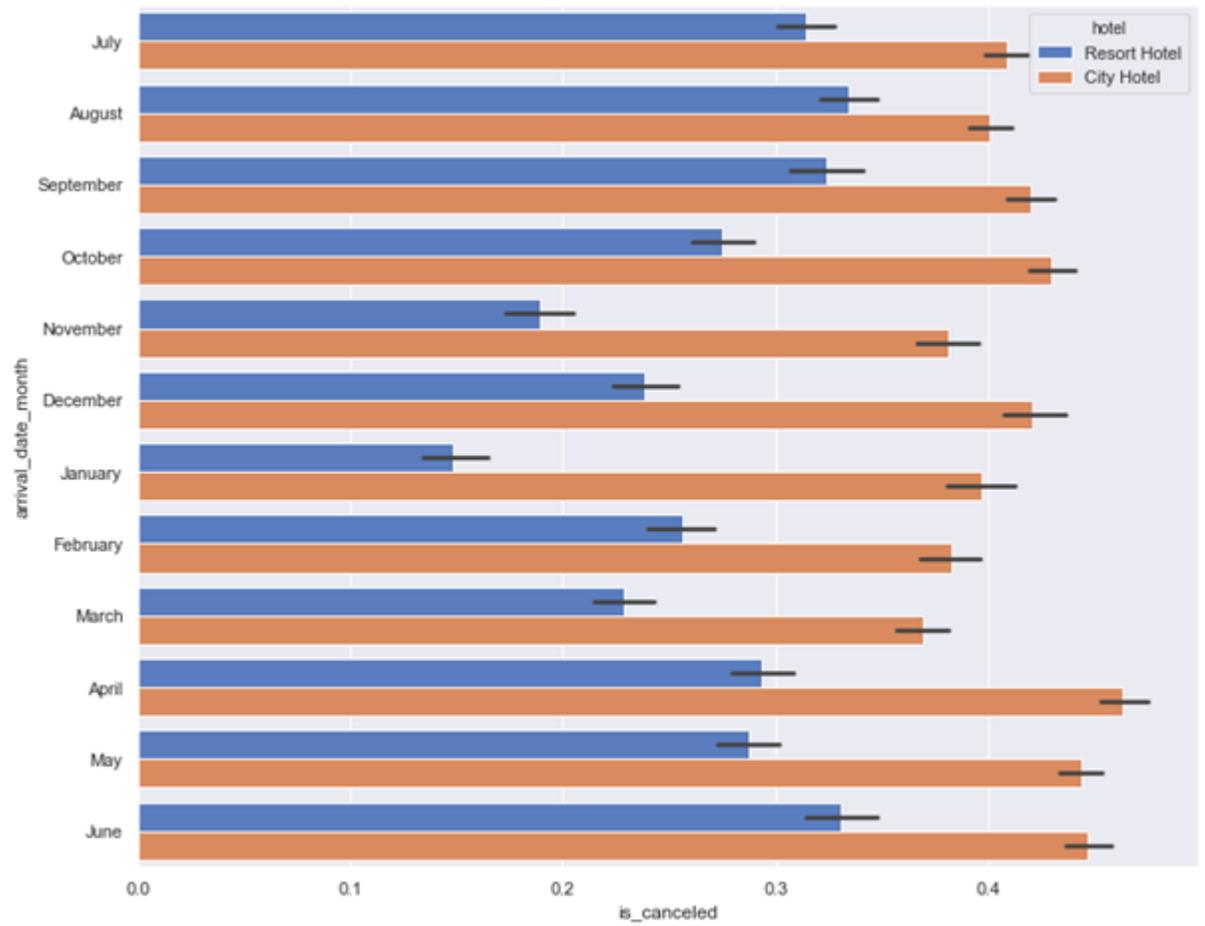


Figure 2. Booking cancellation rates by hotels and months

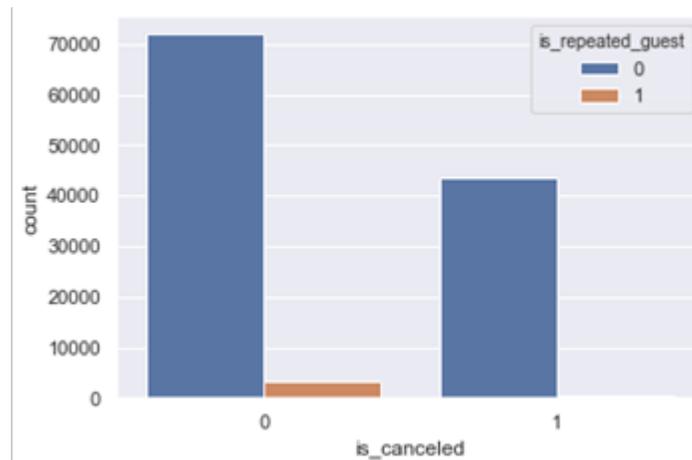


Figure 3. Reservation canceled and non-canceled reservation of repeated guest

We presented distribution of segment by deposit type: no deposit, refundable and non-refund on Figure 4. We can see that the smallest number of bookings was refundable regardless of observed market segments. In the following marketing segments non-refundable bookings are slightly more present: Corporate, Offline TA/TO and Groups. The most common type of reservation in all marketing segments are reservations without deposit (Figure 4).

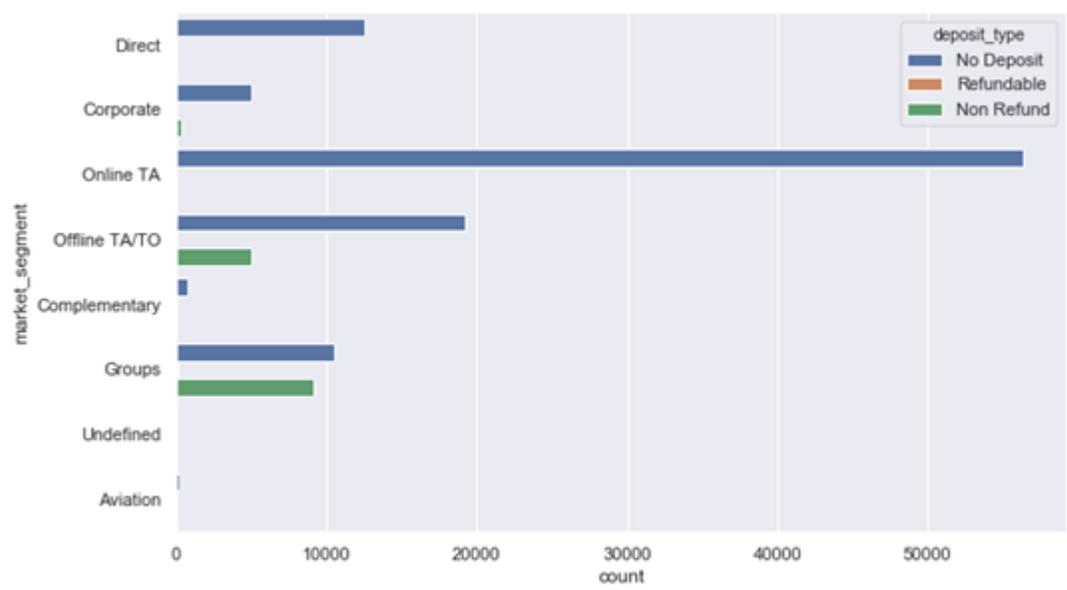


Figure 4. Marketing segments and type of deposit

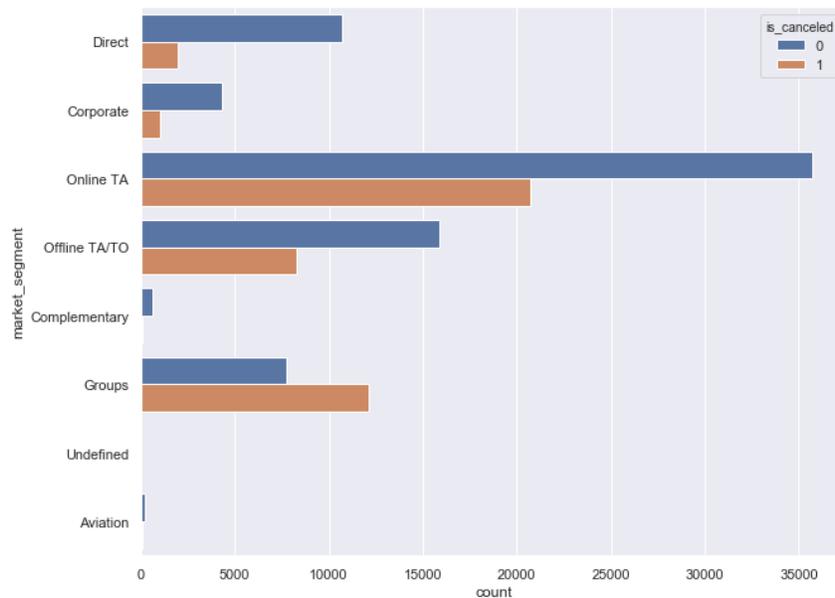


Figure 5. Marketing segments and booking cancellation

We presented on figure 5 that for the marketing segment - Groups, a larger number of reservations was canceled compared to those that were not canceled. In all other marketing segment, the number of reservations that have not been canceled is higher. Booking demand data set has four attributes with missing values:

- children (4 records),
- country (488 records),
- agent (16340 records) and
- company (112593 records).

Due to a large number of missing values, the attribute - company was dropped. It is better to omit this column, as the missing values are equal to 13% of the total data. We have also four missing values in column – children. If there is no data about children, we may assume that these customers do not have children. That is reason why we entered the value 0 in the column of children with missing values. Similarly, the column agent was not considered due to the large number of missing values and we deleted rows with missing values for the column - country.

In the pre-processing phase, we converted all attributes that are object type to integer. At the end of the pre-processing phase - all values are numbers in columns and there are no missing values. In further work, instead of the data set of 31 attributes, we considered a newly created set of 29 attributes.

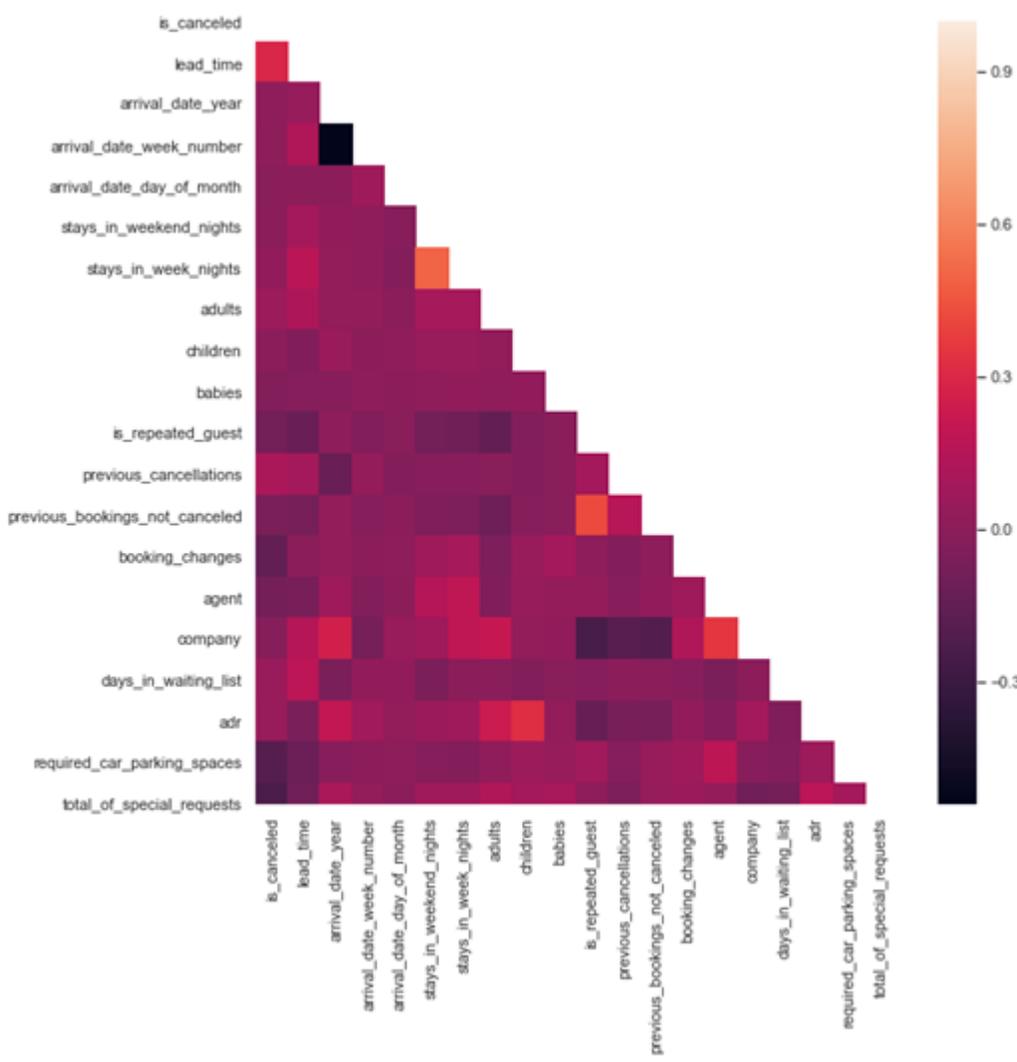


Figure 6. Correlation matrix

The correlation matrix is a table showing the correlation coefficients between the variables. In the table each cell shows the relationship between the two variables. Correlation matrix is used to summarize data, as an input into a more advanced analysis, or as a diagnostic for advanced analyses. In this table the correlation can be: (1) positive, meaning that both variables move in the same direction; (2) neutral or zero, meaning that the variables are not related; (3) negative, meaning that when the value of one variable increases, the values of the other variables decrease.

We presented the correlation matrix for hotel demand data set in Figure 6. The dark shades in the image represent a high negative correlation between the attributes. Highly positive correlations have a light shade. If we discuss the attribute “is canceled”, we can conclude it is strongly correlated with the status of the reservation, the type of deposit, the country and lead time.

Table 1. Classifiers and training accuracy score

Classifiers	Training accuracy
logistic regression	73.0 %
k-neighbor classifier	89.0 %
decision tree classifier	93.0 %
bagging classifier	95.0 %
AdaBoost classifier	85.0 %
random forest classifier	94.0 %

We presented on Table 1 the accuracy of the classification for the training and test data set. We used these popular machine learning algorithms: logistic regression, k-neighbor, decision tree, bagging, AdaBoost and random forest classifier. For hotel reservation data, during the training phase logistic regression showed the weakest performance of the classification (Table 1). K-

neighbors and AdaBoost classifiers had better classification accuracy. Decision tree, bagging and random forest classifier showed the best accuracy results.

For the mentioned classifiers in training phase, we used grid search during cross validation to find the classifiers with the best parameters. We showed in Table 2 the training accuracy of the classification and the standard deviation for the classifiers with the best parameters.

Table 2. Grid search, cross validation and accuracy score

Classifiers	Training accuracy	Standard deviation
logistic regression	73.72%	0.004156763498398077
k-neighbor classifier	89.26%	0
decision tree classifier	75.04%	0
bagging classifier	95.45%	0.001922178000588199
AdaBoost classifier	87.06%	0
random forest classifier	90.4%	0

As we see in Table 2, the results are now significantly different. The bagging classifier had the best results, while the worst, which is to expect was logistic regression. The standard deviation had higher values for logistic regression and bagging classifier.

We have shown in Table 3 the results obtained during the training and test phases (previously unused data in training phase) using grid search and cross validation for all classifiers. In this table:

- true positive (TP) means cancelled transaction correctly diagnosed as cancelled transactions,
- false positive (FP) means not cancelled transactions incorrectly identified as cancelled transactions,
- true negative (TN) means not cancelled transactions correctly identified as not cancelled transactions,
- false negative (FN) means cancelled transactions incorrectly identified as not cancelled transactions.

Detailed results in Table 3 allow predictions of booking cancellations. In this way we can see for which class our classifier works better.

Table 3. Grid search, cross validation and accuracy score

Classifiers	Training				Test			
	TN	FP	FN	TP	TN	FP	FN	TP
logistic regression	51090	8838	16068	19125	12720	2097	4036	4928
k-neighbor classifier	59928	0	5258	29935	14514	303	2175	6789
decision tree classifier	59890	38	23700	11493	14806	11	5981	2983
bagging classifier	59920	8	377	34816	14615	202	863	8101
AdaBoost classifier	56793	3135	9254	25939	14069	748	2366	6598
random forest classifier	58027	1901	5793	29400	14282	535	1828	7136

Accuracy can be represented as a proportion of correctly classified cases:

$$\text{accuracy} = (TP+TN)/(TP+TN+FP+FN) \quad (1)$$

Taking into account the equation representing the accuracy of the classification, and based on the data in Table 3, we obtained the results for the accuracy of the classification shown in Table 4. Logistic regression had slightly better results during the test phase for the accuracy of classification for both classes. This means that there was no overfitting. The result for classification accuracy was better for the class without cancellation. K-neighbor classifier had worse results during the test phase for the accuracy of classification for both classes. This means that there was overfitting during training phase. The result for classification accuracy was better for the class without cancellation. Decision tree classifier had slightly better results for cancel class, but slightly worst results for not cancel class. Since the results were not statistically significantly different, we can conclude that in this case there was no overfitting. The result for classification accuracy was better for the class without cancellation.

Bagging classifier had worse results during the test phase for the accuracy of classification for both classes. This means that there was overfitting during training phase. The result for classification accuracy for both classes were high. AdaBoost classifier had slightly worst results for cancel class, but slightly better results for not cancel class. Since the results were not statistically significantly different, we can conclude that in this case there was no overfitting. The result for classification accuracy was better for the class without cancellation. Random forest classifier had worst results for cancel class, and slightly worst results for not cancel class. This means that there was overfitting during training phase. The result for classification accuracy was better for the class without cancellation.

Table 4. Accuracy score – training and test

Classifiers	Training accuracy		Test accuracy	
	Class - cancel	Class – not cancel	Class - cancel	Class – not cancel
logistic regression	54.34%	85.25%	54.97%	85.85%
k-neighbor classifier	85.06%	100%	75.74%	97.95%
decision tree classifier	32.66%	99.94%	33.28%	99.93%
bagging classifier	98.93%	99.99%	90.37%	98.64%
AdaBoost classifier	73.70%	94.77%	73.60%	94.95%
random forest classifier	83.54%	96.83%	79.61%	96.39%

The decision tree had the best results for the class without cancel, but poor results for the class in which cancel occurs. For the studied issues, the prediction for the class with cancel reservation is more important to us. Comparing all classifiers, in the test phase for predicting whether cancellations would occur, the bagging classifier had the best results. Also the bagging classifier had high classification accuracy for both classes, though not the highest for the no-cancel class, but still very high. Finally, we can conclude that the bagging classifier had the best results in predicting booking cancellations.

5. Conclusions

Recent advances in data collection and storage technology have led to vast repositories of data that are extremely difficult for humans to analyze. This is why many data extraction techniques are being developed to support the extraction of different representations of knowledge from such large databases. Machine learning algorithms have the ability to predict test data based on learning from training data. The paper presented the dependence of canceled reservations and each attribute of the real data set, which has information about the reservation for a city hotel and a resort hotel. Also, in the paper we discussed which attributes have the greatest impact on the occurrence of canceled reservations. Experimental research was conducted on open source Jupyter Notebook software and Python programming language. We used and compared the performance of the following algorithms: logistic regression, k-neighbor, decision tree, bagging, AdaBoost and random forest classifier. Comparing all classifiers, in the test phase for predicting whether cancellations would occur, the bagging classifier had the best results. In further research, we will use other classifiers to improve the accuracy of the classification.

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Quality of Education and Economic Growth

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Abstract

Education has an undeniable value for the overall progress. Although the expenditure on education and the share of tertiary education graduates in the total population increased over the past two decades in Europe, the quality of education did not. The sample mean PISA scores in 2018 were almost equal to its 2000 values, even lower on the reading and science scales. It applies to the Human Capital index, with lower values in 2020 compared to 2018. The descriptive statistics analysis shows a strong linear association between the quality of education, output structure, income per person, productivity growth and research and development activities. Applying the panel least square (fixed effects) model to the sample of thirty-five European countries and the period from 1995 to 2020, we found that the contribution to output growth by tertiary educated employees, as well as the outcome of investment in research and development is significant and positive. Due to the relevance of investment in knowledge and human capital for sustainable growth, as quality of education is strongly correlated with both the share of persons with tertiary education and investment in research and development, its improvement is indispensable to foster economic growth.

Keywords: Quality of education, Tertiary Education, GDP growth, Labour productivity, Investment in research and development

1. Introduction

Education has an undeniable value for the overall progress. More human capital is associated with higher earnings and income and is a central driver of sustainable growth. The expansion of scientific and technical knowledge that raises the productivity of labour and other inputs of production has been seen as a source of persistent growth in income per person. “It is clear that all countries which have managed persistent growth in income have also had large increases in the education and training of their labour force. The systematic application of scientific knowledge to production of goods has greatly increased the value of education, technical schooling, and on-the-job training as the growth of knowledge has been embodied in people – in scientists, scholars, technicians, managers, and other contributors to output.” (Becker, 1993, p. 24). Barro (2001) pointed out that the quality of schooling is more important than the quantity, measured, for example, by years of attainment. Hanushek and Kimko (2000) found that scores on international examinations — indicators of the quality of schooling capital — matter more than years of attainment for subsequent economic growth. Drori (1998) also emphasised the importance of science education: “Science, including science education is highly praised as a requirement for any modern, civilized, economically vibrant society. According to the structural-instrumentalist approach, national economic growth depends on the scientific and technical capabilities of the labour force; such capabilities rely on the level of advanced scientific and technical training.” The quality of education is strongly associated with growing scientific knowledge.

As stressed in report by the World Bank Group (2020), “policy makers can promote investment in human capital only if they understand where the needs lie”, so measuring education may raise awareness of the importance of investing in human capital. Human capital consists of the knowledge, skills and health that people accumulate throughout their lives¹.

Although expenditures for education have increased in Europe², the quality of education has not improved over the last two decades, as elaborated in section 3.2. The share of science and technical program graduates has declined. Simultaneously, average annual growth rate of the income per person declined, from 3.1% in 1996 to 2% in 2019.³

Over the past decade, many countries have made improvements to human capital. However, the Covid-19 pandemic threatens to reverse many of these gains (World Bank Group, 2020).

The dynamics of the output growth, productivity, employment and income per person in Europe over the last two decades motivated us to investigate the impact of the stagnating quality of education in Europe. The analysis stresses the distinction between the quantity of education — measured by years of attainment at various levels — and the quality — measured by scores on internationally comparable examinations.

¹ The World Bank Group, 2020

² Sample of 35 European countries

³ Author's calculation based on Eurostat data on GDP per person (chain linked 2010 euro)

Data on students' scores on internationally comparable examinations in science, mathematics, and reading (PISA⁴) and harmonized test scores⁵ were used to measure the quality of schooling. As in Patrinos and Angrist (2018), "harmonized learning outcomes are produced using a conversion factor to compare international and regional standardized achievement tests. These tests include PISA, TIMSS, PIRLS⁶, SACMEQ⁷, LLECE⁸, PASEC⁹ and EGRA¹⁰."

This study had two main components. We explored patterns of education outcomes (quantity and quality) using descriptive statistical analysis. To estimate the impact on output growth by applying the panel least square (fixed effects) method, we estimated production functions with investment in research and development (R&D) as an exogenous factor of total factor productivity. Human capital growth, measured by the level of education, is represented by disaggregated labour (number of employees) into two aggregates: number of employees with tertiary education and other employees (all other levels of education). The key assumption is that human capital growth has a positive impact on GDP growth, while technological progress (as a result of investment in R&D) is the reason for the production of more output.

This paper is organised into five sections. The key objectives and aims of this research are presented in the first section. The most relevant literature is reviewed in the second section; followed by an empirical analysis of the education outcomes, output growth, employment and productivity. In the fourth section, we present the model, methods and results of this study. The final section presents the discussion and the concluding remarks.

2. Literature review

The literature on the relevance of education and knowledge is vast, providing many evidences of the positive impact from knowledge growth for the economic prosperity. Becker (1993) provided strong evidence on relevance of the education and knowledge for sustainable income per person growth. Barro (2001) emphasised importance of the quality of education. Drori (1998) pointed to the importance of the science and scientific knowledge and skills, concluding that "Science is a necessary element of modern education, it is a building block for personal and social development, and its products advance human society and offer prosperity. Science is also considered as an integral part of modernity, of advanced nations and of enlightened and civilized societies. Scientific progress rests on scientific knowledge and scientific skills; hence, science education is essential to future scientific advances and to, in turn, economic prosperity." Deming, Yuchtman, Abulafi, Goldin and Katz (2016) also confirmed the relevance of the quality of education and found that employers seek for quality and view a credential from a for-profit institution as a negative signal of applicant quality in the absence of objective measures.

Researching the sources of different quality of education, Woessmann (2016) explained the large international differences in student achievement with combination of three factors, family background, school resources, and institutions. Those account for more than four-fifths of the total cross-country variation in student achievement. Family background and institutions contribute roughly equally to this exercise, whereas the contribution of school resources is quite limited.

⁴ Student Assessment (PISA) measures the performance of 15-year-olds, who are enrolled in either lower secondary or upper secondary education. Source of data: OECD Programme for International Student Assessment (PISA), extracted from WDB (LO.PISA.SCI), 12/11/2020

⁵ Source: HCI 2020, the World Bank. Harmonized Test Scores are retrieved from the 2020 update of the Global Database on Education Quality (Patrinos and Angrist, 2018).

⁶ TIMSS and PIRLS are international assessments that monitor trends in student achievement in mathematics, science, and reading

⁷ Southern and Eastern Africa Consortium for Monitoring Educational Quality

⁸ Latin American Laboratory for Assessment of the Quality of Education

⁹ The Programme for the Analysis of Education Systems (PASEC) 2014 international student assessment has been administered in 10 countries in Francophone West Africa (Cameroon, Burundi, Republic of Congo, Côte d'Ivoire, Senegal, Chad, Togo, Benin, Burkina Faso, and Niger). PASEC is designed to assess student abilities in mathematics and reading French.

¹⁰ The Early Grade Reading Assessment

3. Empirical analysis of the tertiary education outcomes, output, productivity and employment growth in Europe

3.1. Data and sample

Data used in this research were extracted from Eurostat, World Development Indicators and World Bank's Human Capital Index database. All data are with annual frequency and on the country level. Data on GDP¹¹ were expressed in chain-linked volumes (2010), million euros. Data on employment¹² (total employment domestic concept, thousand persons) were extracted from Eurostat database. Data on education were extracted from Eurostat, World Development Indicators¹³ and World Bank's Human Capital Index database. Data on intramural R&D expenditure (GERD) by sectors of performance were used as the indicator of the investment in R&D.¹⁴

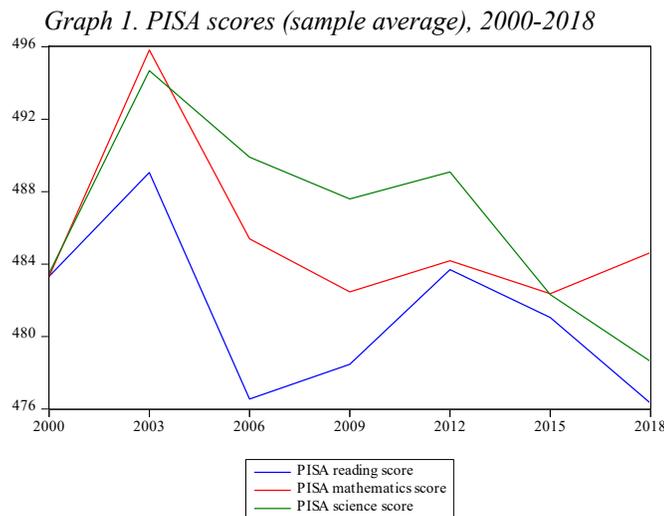
Analysis was conducted using sample of 35 European countries ((27 EU member countries plus United Kingdom, Iceland, Norway, Switzerland, Montenegro, Albania, Serbia and Turkey), and time frame from 1995 to 2020.

3.2. Quality of education and tertiary education outcomes

In this section we explore patterns of education outcomes in Europe using descriptive statistics analysis. Output indicators analyse the characteristics of those exiting the system, such as their educational attainment (our focus are persons with tertiary education). We will also quality of education outcomes, using PISA and Harmonised test scores.

PISA scores for thirty-five European countries from the sample show that there is no improvement in quality of education during the last two decades.¹⁵ Schleicher (2019) concluded same for OECD countries, as "there has also been no real overall improvement in the learning outcomes of students in OECD countries, even though expenditure on schooling rose by more than 15% over the past decade alone".

The panel mean PISA reading score (from 2000 to 2018) has declined, science score also, while only improvement was visible in mathematics score. (Graph 1)



Source: Author's calculation, based on PISA scores

On individual country level, several countries achieved improvements in quality of education. Germany and Luxemburg improved performance on reading and science scales, Estonia on reading and mathematics scale, Italy, Cyprus, Romania, Slovenia and Norway on mathematics scales, Latvia, Portugal and Poland, Montenegro, Albania, Serbia and Turkey on all scales, but the quality of education declines in others. (Table 5, appendix)

Harmonized Test Scores for 2018 and 2020¹⁶ show declining quality of education in most countries from the sample (Graph 2).

¹¹ GDP and main components (output, expenditure and income) [nama_10_gdp]

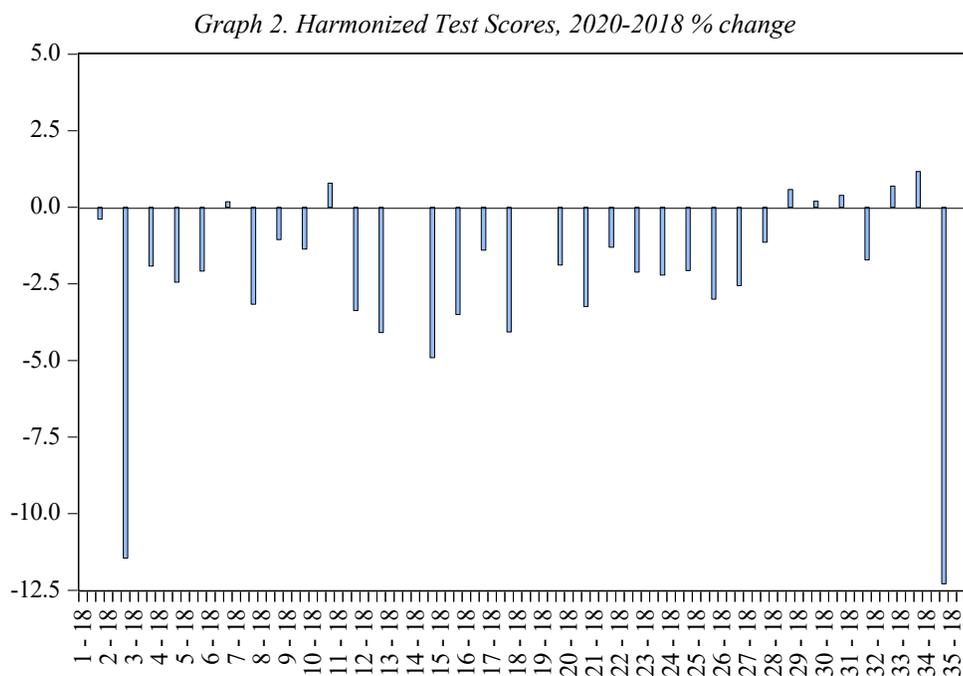
¹² National accounts employment data by industry (up to NACE A*64) [nama_10_a64_e], extracted on 04/12/2020.

¹³ Source: World Development Indicators (original source: UNESCO Institute for Statistics)

¹⁴ Source: Eurostat: Intramural R&D expenditure (GERD) by sectors of performance [rd_e_gerdtot], data extracted on 12/11/20

¹⁵ We also found that PISA scores strongly influence the World Bank's Human Capital index. The HCI calculates the contributions of health and education to worker productivity. The final index score ranges from zero to one, and measures the productivity as a future worker of a child born today relative to the benchmark of full health and complete education.

¹⁶ Source: The World Bank, Human Capital Index



While the quality of education stagnates or decline, number of persons with tertiary education has grown in Europe since 1995, from 14.41% to 28.81% in relation to total population in 2019. The structure of the graduates has changed, with declining share of those graduating in STEM and EMC¹⁸ programs, but growing share of graduates in BAL¹⁹ programs. The share of graduates in all three programs in total graduates was 69% (1998) and 62.6% in 2019. (Table 1)

Table 1. Persons with tertiary education and graduates by program, 1995-2019

Year	Persons with tertiary education (ISCED), From 15 to 74 years, Percentage of total population	Percentage of graduates from Science, Technology, Engineering and Mathematics programs in tertiary education, both sexes (%)	Percentage of graduates from tertiary education graduating from Business, Administration and Law programs, both sexes (%)	Percentage of graduates from tertiary education graduating from Engineering, Manufacturing and Construction programs, both sexes (%)
1995	14.41			
1998	15.22	27.92	24.71	17.01
2000	16.28	22.30	24.95	14.02
2005	18.95	21.07	26.94	13.19
2010	21.74	21.37	27.29	13.73
2015	25.97	23.77	25.09	14.16
2019	28.81	22.54	26.51	13.36
Average	21.13	22.32	26.41	13.90
Obs	755	524	524	524

Source: Eurostat, World development indicators

¹⁷ 1-Belgium, 2-Bulgaria, 3-Czech Republic, 4-Denmark, 5-Germany, 6-Estonia, 7-Ireland, 8-Greece, 9-Spain, 10-France, 11-Croatia, 12-Italy, 13-Cyprus, 14-Latvia, 15-Lithuania, 16-Luxembourg, 17-Hungary, 18-Malta, 19-Netherlands, 20-Austria, 21-Poland, 22-Portugal, 23-Romania, 24-Slovenia, 25-Slovak Republic, 26-Finland, 27-Sweden, 28-United Kingdom, 29-Iceland, 30-Norway, 31-Switzerland, 32-Montenegro, 33-Albania, 34-Serbia, 35-Turkey

¹⁸ Engineering, Manufacturing and Construction

¹⁹ Business, Administration and Law

Our estimation based on the panel mean data shows that growing percentage of graduates in STEM education is positively associated with GDP per person, while it is opposite for BAL programs. Also, growth of STEM and EMC programs graduates are positively associated with the investment in research and development. (Panel 1-3, appendix)

Estimation of the correlation coefficients shows the strongest positive linear association between PISA mathematics scores and GDP per person and labour productivity, followed by reading and science scores, respectively. PISA science score shows stronger positive linear association with R&D expenditures than other scores, while PISA scores in reading and science are positively correlated with employment (total and employment with tertiary education). (Table 2)

Table 2. PISA scores, GDP pc, Labour productivity and Employment, correlation

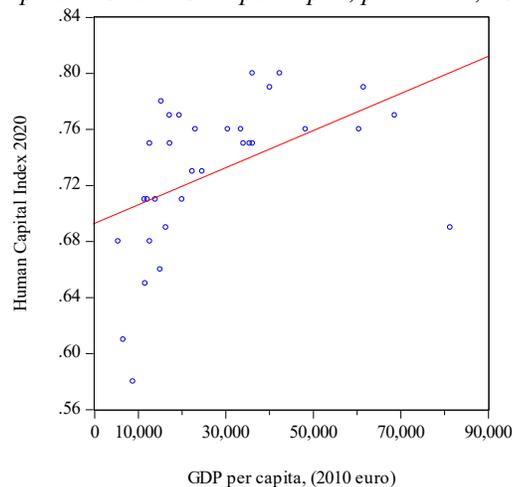
	PISA reading	PISA mathematics	PISA science
PISA reading	1.00		
PISA mathematics	0.88	1.00	
PISA science	0.91	0.91	1.00
GDP per person (2010 euro)	0.42	0.44	0.30
Labour productivity (2010 euro)	0.41	0.41	0.28
Employment	0.08	-0.01	0.08
Employment with tertiary education	0.16	0.09	0.16
R&D expenditures (GERD), 2010 euro	0.24	0.23	0.25

Source: Author's calculation

Descriptive statistics analysis on panel data, using Human Capital Index²⁰ data shows positive linear relation between HCI, GDP and productivity in Europe. HCI is selected as its value reflects the quality of education. "Differences in the quantity and quality of schooling account for the largest part of HCI differences across country-income groups. Of the 33 percentage-point difference between the scores of the average low and high-income country, almost 25 percentage points are accounted for by the differences in learning-adjusted years of school, a measure which combines expected years of school with learning as measured by harmonized test scores" (The World Bank Group, 2020).

Panel data analysis at the sample of 35 European countries and data for GDP per capita and HCI in 2020 shows strong positive linear relationship between GDP per capita and HCI (Graph 3).

Graph 3. HCI and GDP per capita, panel data, 2020



Source: Author's calculations based on Eurostat and HCI 2020 data (The World Bank)

Using the same sample and data on the components of HCI and labour productivity (measured as output per person employed), we found that correlation between productivity and quality of education (learning adjusted years of schooling) is stronger than between the first and expected years of schooling (Table 3).

²⁰ As in the World Bank's Human Capital Index report, the Human Capital Index (HCI) measures the human capital that a child born today can expect to attain by her 18th birthday, given the risks of poor health and poor education prevailing in her country.

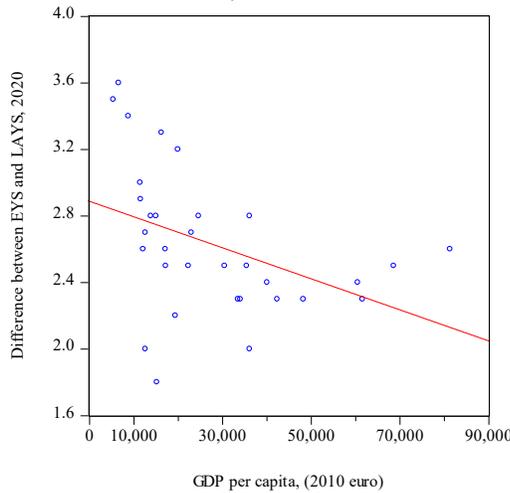
Table 3. Correlation between labour productivity and HCI and its components, panel data

	Labour productivity, 2020 (2010 constant euro)	Human Capital Index 2020	Learning adjusted years of school, 2020
Labour productivity, 2020 (2010 constant euro)			
Human Capital Index 2020 ²¹	0.538		
Learning adjusted years of school ²² , 2020	0.396	0.955	
Expected years of school ²³	0.302	0.871	0.905

Source: Author’s calculations based on Eurostat and HCI 2020 data (The World Bank)

Further analysis shows negative linear relation between GDP per capita and difference between expected years of schooling (EYS) and learning-adjusted years of schooling (LAYS). Correlation is high and negative (-0.413) (Graph 4).

Graph 4. GDP per capita and difference between expected years of schooling and learning adjusted years of schooling, panel data, 2020



Source: Author’s calculations based on Eurostat and HCI 2020 data (The World Bank)

Government expenditures on education have grown since 1995 also, from 4.77% of GDP to 4.99% in 2017 (even above 5% in some years), while on tertiary education from 0.98% of GDP to 1.14%, respectively. Investment in R&D increased also, from 1.13% to 1.40% of GDP, respectively. (Table 4)

Table 4. Government expenditures on education and tertiary education and investment in R&D (GERD), % of GDP, 1995-2017

Year	Government expenditure on tertiary education as % of GDP (%)	st.dev	Government expenditure on education as % of GDP (%)	st.dev	Investment in research and development (GERD), % of GDP (%)	st.dev
1995	0.98	0.47	4.77	1.28	1.13	0.62
2000	1.11	0.48	4.80	1.31	1.16	0.73
2005	1.24	0.45	5.15	1.20	1.18	0.76
2010	1.27	0.42	5.43	1.12	1.29	0.77

²¹ Source: HCI 2020, the World Bank. “The HCI calculates the contributions of health and education to worker productivity. The final index score ranges from zero to one, and measures the productivity as a future worker of a child born today relative to the benchmark of full health and complete education.”

²² Source: HCI 2020, the World Bank. “Learning-Adjusted Years of School are calculated by multiplying the estimates of expected years of school by the ratio of most recent harmonized test scores to 625, where 625 corresponds to advanced attainment on the TIMSS (Trends in International Mathematics and Science Study) test, based on methodology in Filmer et al. (2018).”

²³ Source: HCI 2020, the World Bank. “Expected Years of School is calculated as the sum of age-specific enrollment rates between ages 4 and 17. Age-specific enrollment rates are approximated using school enrollment rates at different levels: pre-primary enrollment rates approximate the age-specific enrolment rates for 4 and 5 year-olds; the primary rate approximates for 6-11 year-olds; the lower-secondary rate approximates for 12-14 year-olds; and the upper-secondary approximates for 15-17 year-olds.”

2015	1.19	0.40	5.16	1.22	1.42	0.78
2017	1.14	0.46	4.99	1.33	1.40	0.80
Average	1.18	0.45	5.11	1.28	1.25	0.76
Obs	578	578	613	613	721	721

Source: World development indicators

As the quantity of education outcomes increased while the quality didn't, it seems that growing expenditures in education influenced only the first. From the long-term growth perspective, this is the issue that should attract substantial attention.

4. Model, data and results

4.1. Data and sample

In addition to the indicators listed in section 3.1, for model's estimation we used also data on the total gross fixed assets (current replacement costs and previous year replacement costs, million euros) for all NACE activities.²⁴ The sample of thirty-five European countries, defined in the section 1 is used here also, although missing data were evidences.²⁵

4.2. Model (panel least square (fixed and random effects))

To estimate the factors of output growth, we follow approach with knowledge accumulation (Romer, 2001, p. 98) and human capital growth (Becker, Murphy, & Tamura, 1993) as central to worldwide growth. Key assumption is that human capital growth has positive impact on GDP growth, while technological progress (as result of investment in R&D) is the reason that more output can be produced. In definition of the production function, investment in research and development (R&D) are exogenous factor of total factor productivity. Human capital growth, measured as the level of education attainment, is represented by disaggregated labour (number of employees) into three aggregates: number of employees with tertiary education in science, number of employees with tertiary education in other fields and other employees (all other levels of education). We estimated panel LS (fixed and random effects). Panel data models secure a reduction in endogeneity, allowing country-specific effects to be correlated with regressors (fixed-effects models).²⁶ Furthermore, panel data increase the sample size and thus allow higher degrees of freedom and more accurate statistical tests.

The aggregate production of an economy can be expressed as a function of capital stock, labour and total factor productivity:

$$Y_t = A_t K_t^\alpha L_t^\beta, 0 < \alpha + \beta < 1, \quad (1.1)$$

where Y_t denotes the aggregate production of the economy at time t , A_t is the total factor productivity, and K_t and L_t represent the capital stock and labour, respectively. The constants α and β represent the share of capital and labour in income.

Further, labour is split into employees with tertiary education ($L_{t,t}^Y$) and other employees (less than tertiary education) ($L_{o,t}^\beta$). It is assumed that total factor productivity (TFP) can be expressed as a function of investment in research and development (GERD) - R_t and other exogenous factors (non-R&D factors of TFP) - C_t :

$$A_t = f(R_t, C_t) = R_t^\delta C_t. \quad (1.2)$$

A combination of Equations 1.1 and 1.2 is then:

$$Y_t = C_t K_t^\alpha L_{o,t}^\beta L_{t,t}^Y R_t^\delta, 0 < \alpha + \beta + \gamma + \delta < 1, \quad (1.3)$$

where Y_t denotes the gross value added of the economy at time t , C_t is other exogenous factor, and K_t , $L_{o,t}$, $L_{t,t}^Y$ and $L_{t,t}^Y$ represent the capital stock, labour with other education and labour with tertiary or higher education, respectively. R_t represents investment in research and development (GERD). The constants α , β , γ and δ represent the elasticity of production with respect to the inputs of production.

²⁴ Source: Eurostat: Cross-classification of fixed assets by industry and by asset (stocks) [nama_10_nfa_st], data extracted on 12/11/20

²⁵ Some structural data were not available for following countries: Luxemburg, Malta, Poland, Sweden, Iceland, Montenegro, Albania, Serbia and Turkey. Also data on employees with tertiary education in high-knowledge manufacturing and knowledge-intensive services only since 2008. All data are available on request.

²⁶ Sequeira and Campos (2005)

After taking natural logs, the following equation is obtained:

$$LY_t = c + \alpha LK_t + \beta LLo,t + \gamma LLL_{t,t} + \delta LR_t + \varepsilon_t, \quad (1)$$

where c is the intercept, α , β , γ and δ are constant elasticities and ε_t is the error term.

4.3. Results and key findings

The properties of the variables (defined in section 4.2) were examined by determining the existence of unit roots. Next, we performed the Lagrange multiplier test (Breusch-Pagan) for balanced panels. The null hypothesis of this test considers no evidence of significant differences across municipalities. The Hausman test is used in order to choose between the fixed effects model and random effects model in panel data. As the results of the Hausman test state, the null hypothesis is strongly rejected in the model (equation 1); therefore, we use model with fixed effects.

For equation (1), panel least square (random effects) estimation results are presented in Table 5. The dependent variable is the gross value added of the economy at time t , while the estimated coefficients for the independent variables are as follows.

Table 5. Panel Least Square (random effects), equation (1)²⁷

LY_t	Coef.	St.Err.	Sig
LK_t	.054	.028	*
LLo,t	.467	.046	***
$LLL_{t,t}$.142	.025	***
LR_t	.036	.013	***
Constant	.016	.001	***

*** $p < .01$, ** $p < .05$, * $p < .1$

Source: Authors' calculation

The capital stock growth has a positive impact on output growth in all sectors. The estimated results show that a one-unit growth leads to an output growth of 0.054 units. Respectively, growth of employees with tertiary education leads to output growth by 0.142 units, growth of employees with other levels of education by 0.467, and growth in investment in R&D by 0.036 units, respectively. Growth in other exogenous factors of TFP contributes to output growth by 0.16 units.

5. Discussion and conclusion

As the quality of education in Europe had not been improved, aim of the research was to investigate the impact of the quality of education to the output and productivity growth. We explored patterns of education outcomes (quantity and quality) using descriptive statistics analysis. While both quantity and expenditures for education increased over decades, its quality did not. PISA scores for thirty-five European countries from the sample show that there is no improvement in quality of education during the last two decades. Human Capital indexes in 2020 compared with its 2018 values shows the same. While the quality of education stagnates, number of persons with tertiary education has grown in Europe. As the quantity of education outcomes increased while the quality didn't, it seems that growing expenditures in education influenced only the first. From the long-term growth perspective, this is the issue that should attract substantial attention.

We found that changes in quality of education and output and productivity growth are highly correlated, with the strongest positive linear association between PISA mathematics scores and GDP per capita and labour productivity, followed by reading and science scores, respectively. PISA science score shows stronger positive linear association with R&D expenditures than other scores, while PISA scores in reading and science are positively correlated with employment (total and employment with tertiary education). Using the same sample and data on the components of HCI and labour productivity (measured as output per person employed), we found that correlation between productivity and quality of education (learning adjusted years of schooling) is stronger than between the first and expected years of schooling. Further analysis shows negative linear relation between GDP per capita and difference between expected years of schooling (EYS) and learning-adjusted years of schooling (LAYS).

Applying the panel least square (fixed effects) model on the sample of thirty-five European countries and the period from 1995 to 2019, we found that the contribution to output growth by tertiary educated employees, also the outcome of the investment in research and development in positive and significant.

As quality of education is relevant and important for the output and productivity growth, its improvement is indispensable to foster economic growth.

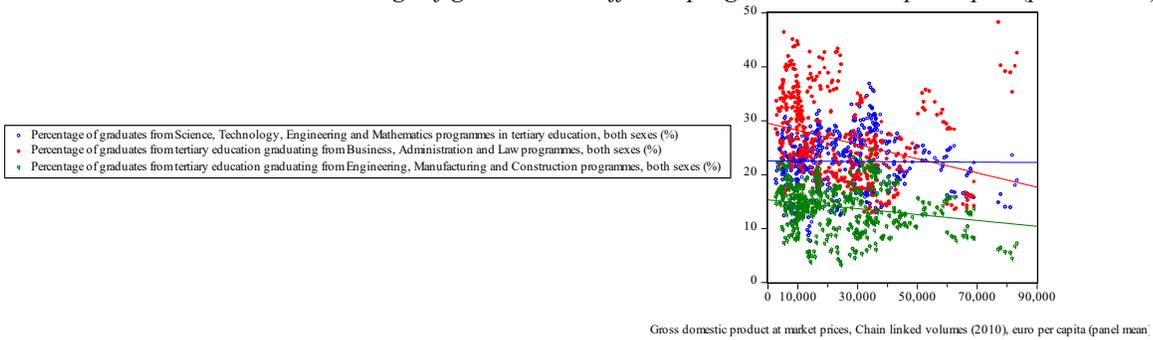
²⁷ Time effects are modeled with dummy variables

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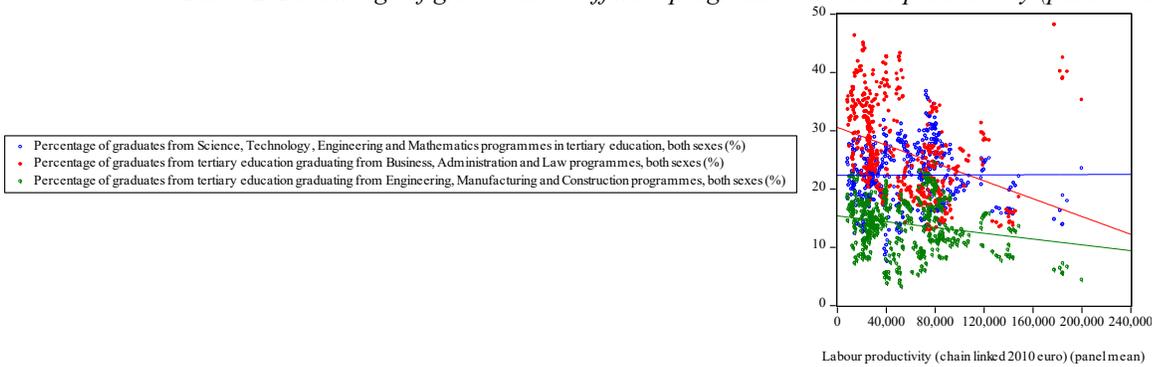
Appendix

Panel 1. Percentage of graduates in different programs and GDP per capita (panel mean)



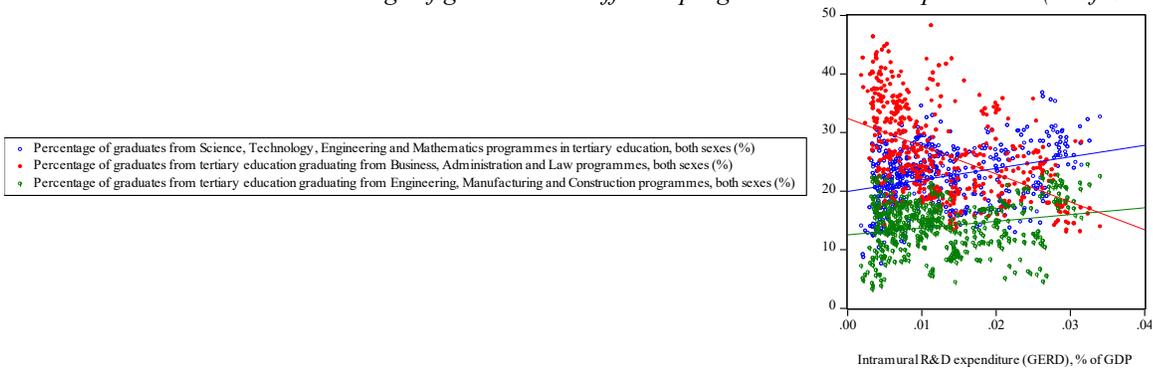
Source: Author's calculations based on Eurostat and The World Bank data

Panel 2. Percentage of graduates in different programs and labour productivity (panel mean)



Source: Author's calculations based on Eurostat and The World Bank data

Panel 3. Percentage of graduates in different programs and R&D expenditures (% of GDP)



Source: Author's calculations based on Eurostat and The World Bank data

Statistical annex

Table 3. PISA: Mean performance on the science scale²⁸

	PISA: Mean performance on the reading scale			PISA: Mean performance on the mathematics scale			PISA: Mean performance on the science scale		
	2000	2018	Change	2000	2018	Change	2000	2018	Change
Belgium	507.1	492.9	-2.81%	529.3	508.1	-4.01%	495.7	498.8	0.61%
Bulgaria*	430.4	419.8	-2.45%	413.4	436.0	5.46%	448.3	424.1	-5.40%
Czech Republic	491.6	490.2	-0.28%	516.5	499.5	-3.29%	511.4	496.8	-2.86%
Denmark	496.9	501.1	0.86%	514.3	509.4	-0.95%	481.0	492.6	2.42%
Germany	484.0	498.3	2.95%	503.0	500.0	-0.58%	487.1	503.0	3.26%
Estonia**	500.7	523.0	4.46%	514.6	523.4	1.72%	531.4	530.1	-0.24%
Ireland	526.7	518.1	-1.63%	502.8	499.6	-0.64%	513.4	496.1	-3.36%
Greece	473.8	457.4	-3.46%	444.9	451.4	1.45%	460.6	451.6	-1.94%
Spain*****	492.6	495.5	0.60%	485.1	481.4	-0.77%	490.9	483.3	-1.57%
France	504.7	492.6	-2.40%	510.8	495.4	-3.01%	500.5	493.0	-1.50%
Croatia**	477.3	479.0	0.35%	467.2	464.2	-0.65%	493.2	472.4	-4.23%
Italy	487.5	476.3	-2.29%	465.7	486.6	4.49%	477.6	468.0	-2.01%
Cyprus****	448.9	424.4	-5.47%	437.1	450.7	3.10%	437.7	439.0	0.30%
Latvia	458.1	478.7	4.50%	483.4	496.1	2.64%	460.1	487.3	5.91%
Lithuania**	470.0	475.9	1.25%	486.4	481.2	-1.08%	495.7	482.1	-2.75%
Luxembourg	441.0	470.0	6.57%	493.2	483.4	-1.98%	443.1	476.8	7.61%
Hungary	480.0	476.0	-0.83%	490.0	481.1	-1.82%	496.1	480.9	-3.06%
Malta***	442.0	448.2	1.41%	462.9	471.7	1.91%	464.8	456.6	-1.76%
Netherlands*	513.1	484.8	-5.52%	537.8	519.2	-3.46%	524.4	503.4	-4.00%
Austria	507.0	484.4	-4.46%	505.6	498.9	-1.32%	504.7	489.8	-2.96%
Poland	479.1	511.9	6.83%	490.2	515.6	5.18%	483.1	511.0	5.78%
Portugal	470.2	491.8	4.60%	466.0	492.5	5.68%	459.0	491.7	7.12%
Romania	427.9	427.7	-0.05%	414.8	429.9	3.65%	441.0	425.8	-3.46%
Slovenia**	494.4	495.3	0.19%	504.5	508.9	0.88%	518.8	507.0	-2.28%
Slovak Rep**	469.2	458.0	-2.38%	498.2	486.2	-2.41%	494.9	464.0	-6.23%
Finland	546.5	520.1	-4.83%	544.3	507.3	-6.80%	537.7	521.9	-2.95%
Sweden	516.3	505.8	-2.04%	509.0	502.4	-1.31%	512.1	499.4	-2.48%
United Kingdom	523.0	503.9	-3.65%	508.3	501.8	-1.28%	532.0	504.7	-5.14%
Iceland	506.9	474.0	-6.50%	515.1	495.2	-3.87%	495.9	475.0	-4.21%
Norway	505.3	499.5	-1.15%	495.2	501.0	1.17%	500.3	490.4	-1.98%
Switzerland	494.4	483.9	-2.11%	526.6	515.3	-2.13%	495.7	495.3	-0.08%
Montenegro**	391.9	421.1	7.44%	399.3	429.6	7.59%	411.8	415.2	0.82%
Albania	348.8	405.4	16.22%	377.5	437.2	15.83%	376.5	416.7	10.70%
Serbia*	411.7	439.5	6.74%	436.9	448.3	2.61%	436.4	439.9	0.80%
Turkey*	440.9	465.6	5.61%	423.4	453.5	7.11%	434.2	468.3	7.85%
Average	476.0	476.9	0.00	482.1	484.6	0.01	481.3	478.6	-0.01

²⁸ Average score of 15-year-old students on the PISA science scale. In PISA 2006 the mean science score for OECD countries was initially set at 500 points (for 30 OECD countries), then was re-set at 498 points after taking into account new OECD countries. Data reflects country performance in the stated year according to PISA reports, but may not be comparable across years or countries. Consult the PISA website for more detailed information: <http://www.oecd.org/pisa/>

*data from 2003; ** data from 2006; ***data from 2009; ****data from 2012

Source: OECD Programme for International Student Assessment (PISA), extracted from WDB (LO.PISA.SCI), 12/11/2020

Monitoring of expenditure and revenue and fraudulent financial reporting

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Abstract

Fraud detection is a discipline that has received special attention in recent years. both in the academic community and in the practical environment. Frauds are analyzed by frequency and severity. Fraud is in continuous evolution, adapting its strategies to new modalities of fraudulent actions. An increasing number of fraudulent activities have called into question the integrity of financial statements. The purpose of this study is to examine financial performance using a ratio analysis technique, and to supplement the results by including a bankruptcy test, as well as non-financial measures, because inconsistencies between financial and non-financial information can be a symptom of fraud with financial statements. This type of fraud is most often carried out by the company's management under pressure to meet the expectations of market analysts and other stakeholders. The findings of this study can help investors (and other stakeholders) make valid economic decisions. Implications for future research are considered.

Keywords: expenses, revenue, risk, management, fraudulent actions, agricultural company.

Introduction

Financial statements are an important source of financial information for various user groups. In other words, financial statements are the result of an accounting process that provides financial (accounting) information and company performance. They are of great importance for the purpose of informing about the financial position and business success of the company to the extent that the main goal has been achieved, to generate profit. It is emphasized that financial reports are the basic carriers of financial information, and it is known that without adequate information, interested users cannot properly make assessments and various business and financial decisions (Mitrović & Mitrašinović, 2019). Many cases of fraud have become a serious problem in the development of business development companies, and one of the most common is fraudulent financial reporting (Annan, 2021:108). False financial statements do not represent the real situation of the company's performance, and can lead to information addressees making business and financial decisions that will initiate a loss.

Financial scandals are well-known on a global level, where companies published a very optimistic image of a business and financial performance in the future in their annual reports, and soon after that, they went bankrupt. What is a big problem for investors and creditors when making decisions based on financial information from the report, is the fact that on the one hand, these reports present the financial picture of their performance management efficiency, and on the other hand, it affects the possibility of rationalization of unrealistic management optimism by treating the annual report as a marketing tool rather than a reporting tool. If added to that the fact that managers are otherwise responsible for financial statements, the cause of fraud is even more transparent. "Accounting fraud is the biggest role of companies in unfair competition. Namely, companies have the opportunity to show the financial position they want, instead of the financial position as it should be, as a result of corruption and fraud in accounting" (Tosun & Özyaral, 2021:577).

The paper is organized into three sections. The first section provides an overview of the literature. The second section deals with the design of the case study and the analysis of the results. The third section deals with concluding remarks and recommendations for future research.

1. Literature review

It is a known fact that many companies have knowledge of what is important from key financial indicators from the point of view of investors and analysts. One of these indicators is the operational efficiency of the company. In this context, it is pointed out that accounting methods are often used to reduce operating costs. These methods are not necessarily illegal, but they can mislead investors and analysts who rely on financial statements when making business-financial decisions. Many methods redirect some operating expenses to other parts of the financial statements, so that operating expenses are reduced and operating profit (which is the difference

between operating income and operating expenses) is increased. It is important to keep in mind that the operating profit is used to evaluate the company by applying certain methods, and if it decreases due to the increase in operating costs, it will affect the final value (Madura, 2004:26).

Kumar (1999:175) points out that tax evasion has different goals, and when looking at indirect taxes, he states the following:

- a) „non-reporting or under-reporting of income;
- b) excessive reporting of expenditures;
- c) fragmentation of revenues to reduce tax liability;
- d) non-reporting or under-reporting of sales and keeping unauthorized financial accounts;
- e) claiming an excessive tax credit;
- f) corporations, especially multinational companies through 'transfer pricing', 'tax farming' 'or inappropriate exchange rate transactions may evade taxes'."

Operating expenses can be viewed by nature and by function. Treated as expenses according to function are costs of sales, administration and distribution, and by nature, they are material costs, salary costs, depreciation costs and other operating costs. This group of costs (operating expenses) is particularly "sensitive" when it comes to possible fraudulent actions in the financial statements. Both false financial reporting and misappropriation of property have become major costs for many organizations, and numerous fraud prevention and detection techniques are now used to reduce the direct and indirect costs associated with all forms of fraud (Bierstaker *et al.* 2006:523).

Common enterprise costs, such as labour and materials, should be classified as operating expenses. It is a well-known case that WorldCom incorrectly classified part of its operating costs as Capital expenditures. This has led to an underestimation of costs and overestimation of earnings, which has misled shareholders, especially given Earnings Per Share - EPS. "CAPEX is cash that is spent for the purpose of initiating future cash flows and achieving a significant Return on Investment (ROA), and it can have two forms - the first, which refers to investing for the existing level of business activity of the company and the second, which is aimed at expansion, i.e., investment in new funds in order to stimulate future growth" (Knežević *et al.*, 2016: 42). It is also known that the WorldCom company reduced the book value of its tangible assets, thus adding them to intangible assets, and this reclassification enabled it to show lower depreciation and thus higher earnings. A well-known practice is that some companies include non-recurring costs in forecasting earnings in order to overestimate earnings (Madura, 2004:30;32).

When it comes to sales revenues, it is pointed out that they are very often the subject of manipulative actions. One of them is the posting of sales revenue only on the basis of an order. Key non-financial performance indicators such as number of facilities/stores, a square meter of the production facility, number of customer accounts, number of employees and their turnover and number of products should be analysed in terms of their relationship to sales revenue. For example, if sales and sales revenue show significant growth, and the number of employees decreases due to layoffs, then this may be a warning sign that it may be an overestimated sales revenue.

Various authors have used financial analysis techniques to assess the business-financial performance of companies, including non-standardized financial metrics (Milojević *et al.*, 2020; Milašinović *et al.*, 2020; Grgur & Milojević, 2020). Fraud in the financial statements generally involves overestimating assets, income and profits, and underestimating liabilities, expenses and losses. Fraud in financial statements is one of the most expensive forms of fraud and can have a direct impact on the business of individuals and companies, and many interested information recipients, and therefore one of the priorities in fraud risk management is the development of more sophisticated tools to prevent and detect fraud in these reports (Knežević *et al.*, 2017). Overall, the most common types of transactions in enforcement actions were loans to related parties, payments to company employees for services that were not approved or did not exist, and sales of goods or services to related parties in which there was an unidentifiable relationship. In contrast, it is much more difficult or impossible to manipulate non-financial information, especially when it is provided by unrelated external sources, such as industry quality rankings and customer satisfaction surveys.

2. Case study

The company on which the case study method was applied is the JOINT STOCK COMPANY STARI TAMIŠ ZA AGRICULTURAL PRODUCTION PANČEVO. This company has been operating since 1975. It has a cash capital of 153.711.420,00 RSD and non-cash capital of 83.777.580,00 RSD. It grows cereals (except rice), legumes and oilseeds. It belongs to the group of companies that are classified as medium-sized enterprises in all observed years. For the purposes of evaluating financial performance, ratio analysis was applied as a technique of financial analysis, and in addition, some other analyses were conducted in order to obtain broader data on the company's operations. Liquidity, solvency, profitability and efficiency testing were conducted as part of the ratio analysis. Further, Altman's Z-Score model was applied to test the company's ability to go bankrupt, and then a non-financial measure such as the number of employees was included in the analysis, in order to include the obtained results in an integral picture of the company's business performance. The results of the analysis are presented below, followed by their interpretation. Empirical data were data from publicly published financial reports of the selected company on the website of the Business Registers Agency (www.apr.gov.rs).

a) Ratio analysis

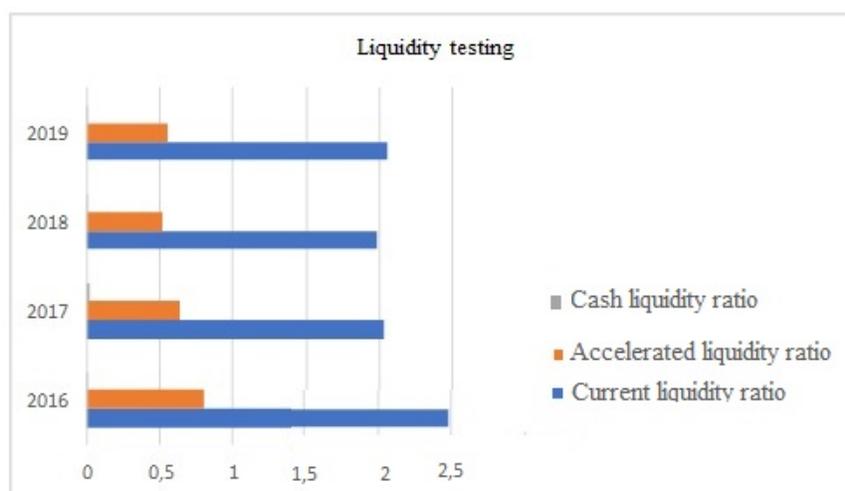
For the purposes of ratio analysis, liquidity testing (Table 1, Figure 1), solvency testing (Table 2), profitability testing (Table 3, Figure 2), efficiency testing (Table 4) was performed, and the obtained results were discussed.

Table 1. Liquidity analysis

Name	2016	2017	2018	2019
Current liquidity ratio	2,5432	2,0271	1,9787	2,05
Quick ratio	0,8082	0,6378	0,5135	0,5597
Cash liquidity ratio	0,0074	0,0186	0,0056	0,007

Source: author's work based on financial reports for the period from 2016-2019 (www.apr.gov.rs)

Reviewing data from Table 2, it can be noticed that the current liquidity ratios in 2016, 2017 and 2019 are in line with the reference value, unlike in 2018, where this is not the case. Quick liquidity ratios are below the orientation norm of 1:1 in all observed years. The cash liquidity ratio shows fluctuations for the observed period. More precisely, for 2016, each dinar of short-term liabilities is covered with 2.54 dinars of current assets and so respectively for the following years with 2.03 dinars (2017), 1.98 dinars (2018), 2.05 dinars for the last observed year (2019). Further, the ratio of quick liquidity in 2016 indicates that each dinar of short-term liabilities is covered with 0.81 dinars of liquid assets, i.e., in the following years with 0.64 dinars (2017), 1.0 dinars, 0.7 dinars and 0.61 dinars in the last year.

Figure 1. Liquidity analysis

Source: Table 1

Table 2. Solvency analysis

Name	2016	2017	2018	2019
Financial leverage	1,1844	1,1815	1,1783	1,1866
Interet coverage ratio	20,4731	19,2664	25,7367	20,9908
Indebtedness ratio	0,1649	0,1459	0,1566	0,1578
Ratio of total liabilities to equity (%)	19,7442	17,083	18,5708	18,741

Source: authors' work based on financial reports for the period from 2016-2019 (www.apr.gov.rs)

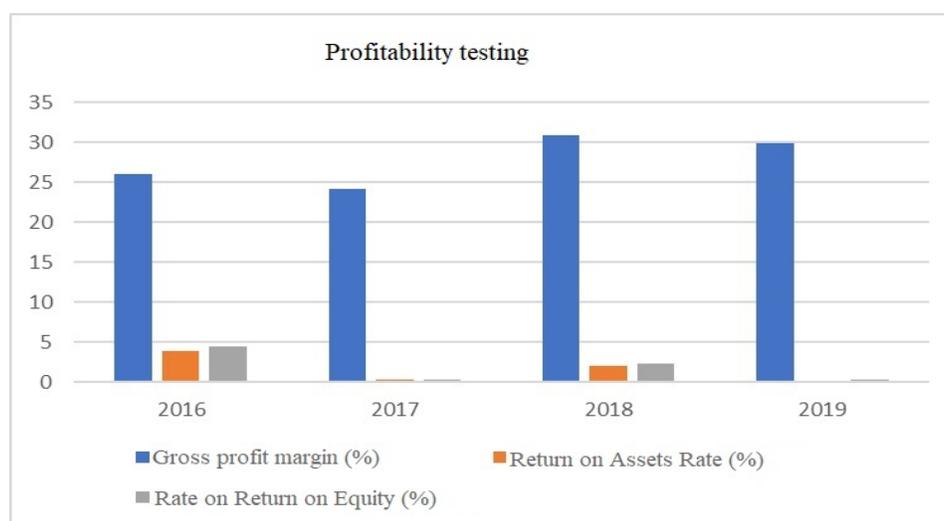
Based on the data presented in Table 1, it can be noticed that by the years (2016-2019) there are no significant changes in the financial leverage indicator, and the same applies to the indebtedness ratio and the ratio of total liabilities to equity. The interest coverage ratio is high in all observed years, but it should be analyzed in more detail that it may not be a question of the company missing the opportunity to increase earnings (yield) through financial leverage.

Table 3. Profitability analysis

Name	2016	2017	2018	2019
Gross profit margin (%)	26,0697	24,2126	30,8943	29,9282
Return on Assets (ROA) (%)	3,8008	0,2197	1,933	0,1961
Return on equity (ROE) (%)	4,5018	0,2595	2,2776	0,2327

Source: authors' work based on financial reports for the period from 2016-2019(www.apr.gov.rs)

The profitability analysis showed that the gross profit margin in 2018 shows the maximum value (30.89%), which is the approximate value of the same indicator in 2019. Return on Assets (ROA) has a negative tendency, because it decreases by years. It showed the highest value in 2016 (3.80%), and the lowest value in 2019 (0.20%). The rate of return on equity (ROE) showed the highest value in 2016 (4.50%) and the lowest in 2019 (0.23%).

Figure 2 Dynamics of profitability indicators

Source: Table 3

Table 4. Efficiency analysis

Name	2016	2017	2018	2019
Average time of collection of receivables (in days)	64,2515	47,5113	43,4091	44,2515
Average inventory turnover time (in days)	118,0618	118,3473	139,983	145,7708
Average payment time to suppliers (in days)	32,1554	34,3992	53,8804	41,665

Source: authors' work based on financial reports for the period from 2016-2019 (www.apr.gov.rs)

Observing the results of efficiency testing, it was noticed that the average collection time of receivables decreases on average by years, with the exception of 2019, but this value is close to that of the previous year. The average time for settling obligations to suppliers increased by years, with the exception of 2019. When looking at the average turnover time, it is seen to grow over the years, to which management should pay attention, and it would be useful to compare these indicators with key competitors, which would more accurately assess the efficiency of managing the company's assets.

b) Testing of bankruptcy possibilities

The application of the bankruptcy test for companies operating in emerging markets is presented below.

Table 5. Bankruptcy test

Name	2016	2017	2018	2019
Altman Z' Score	3,1553	3,7497	3,4051	3,4137
Comment	problem zone	problem zone	problem zone	problem zone

Source: authors' work based on financial reports for the period from 2016-2019 (www.apr.gov.rs)

Based on the application of the custom formula of the original version of the Z3-Score Bankruptcy Model:

$$Z3 = 3,25 + 6,56 \times T1 + 3,26 \times T2 + 6,72 \times T3 + 1,05 \times T4$$

Where T4 is the book value of equity.

According to this model:

- Safe zone > 5,85
- Grey zone is in the interval 3,75-5,85
- Unwanted/problem zone < 3,75

The results of the application of the bankruptcy test show that the company was in the problem zone in all the observed years.

c) Inclusion of non-financial indicator (measures) in the analysis

After this, an analysis was performed using the average number of employees in order to obtain additional information by crossing non-financial measures and financial measures - net profit, operating income and total assets (Table 6, Figure 1).

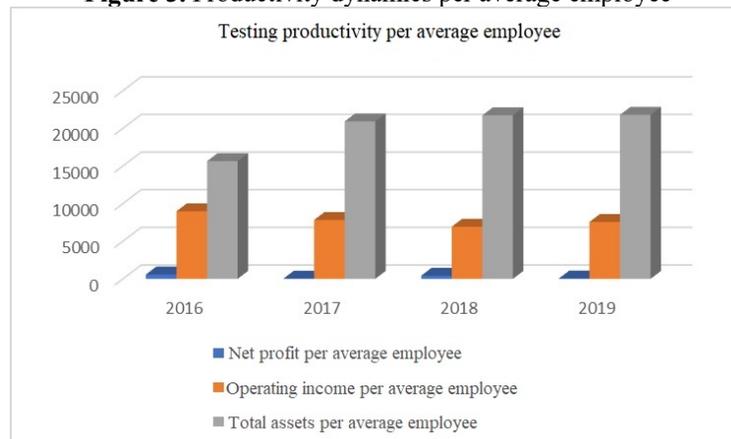
Table 6. Application of non-financial indicator in identifying fraudulent activities

Name	2016	2017	2018	2019
Net profit per average employee	577,7765	38,8247	416,4684	42,6789
Operating income per average employee	8975,6313	7822,2526	6929,1316	7555,2368
Total assets per average employee	15636,7765	20921,3196	21729,3158	21795,2789

Source: author's work based on financial reports for the period from 2016-2019 (www.apr.gov.rs)

Note: the average number of employees by the year 2016-2019 was: 179; 194; 190; 190 and has a positive trend for the observed period.

Figure 3. Productivity dynamics per average employee



Source: Table 6

Observing data related to productivity per average employee shows a positive trend in asset growth. This is not the case with the movement of net profit per employee, which shows huge fluctuations by years, with the maximum value expressed in 2016, and the lowest in 2017. Operating income per employee had the highest value in 2016.

The final conclusion would be that the lowest value of the Z-score test was in 2016 (3.1553), and in that year ROA and ROE showed the highest values, as well as the current and quick ratio. In the same year, the average time of inventory turnover was the shortest in the observed four-year period, and net profit per average employee and operating income per average employee showed the highest values.

3. Conclusions

In order to see the real trend of financial performance on the example of an agricultural company, the method of ratio analysis, bankruptcy test was applied in the paper and a non-financial measure was included in the analysis (number of employees). Based on the obtained results, it was noticed that the company should investigate the causes of very unfavorable tendencies of ROA and ROE, the unsatisfactory value of quick liquidity ratios, and special attention should be paid to the danger of possible bankruptcy, as well as why the net profit per average employee shows sharp fluctuations.

The general conclusion is that these results would need to be supplemented by some more tests to identify fraudulent actions in the financial statements such as the Benford Act, the Beniesh Model and other. Further, the analysis should be supplemented by additional non-financial performance indicators, which would increase the chances of identifying the possibility of fraud in the financial statements. This is supported by the claim that non-financial indicators are the least likely to be manipulated, so it is necessary to emphasize the special importance that non-financial information has effective management of the risk of fraud in the financial statements.

By applying the traditional analysis and supplementing it with non-financial performance indicators, the reliability of the assessment related to the movement of sales revenues and others trends in the financial statements of the observed company certainly increases.

It is obvious that analytical procedures focused on comparing financial information with non-financial performance indicators can improve the quality of the audit and increase the chances of detecting the symptoms of fraud with the financial statements. The role of non-financial information provided by independent sources is very important in detecting fraud with financial statements, as it is least likely to manipulate them, allowing auditors to assess the reliability of management's explanations of revenue growth and other favorable trends in the company's financial statements.

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Influence of COVID-19 Crisis on Foreign Direct Investments and Future Trends

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Abstract

Foreign Direct Investments (hereinafter referred as FDI) are one of the drivers of economic development for many countries. Global FDI recorded in 2019 was \$1.54 trillion. However, due to COVID-19 crisis, global FDI performance is expected to drop by 40% in 2020 and it will be affected in years to come. The paper is bringing the analysis of the effects of COVID-19 crisis on performance of global FDI and the outlook for future FDI performance. The effect of the crisis on different types of FDI activities and regional predictions will be presented. Consequently, the crisis will change future developments of international production. The paper is presenting the expectations on new trends in setting up international production with more emphasis on nearshoring the operations. National investment promotion agencies (hereinafter referred as IPA) whose one of the main tasks is to attract FDI had to react to the crisis as well. The paper will present the initial response by the IPAs and the expectation on future trends. It is expected that in the new normal, countries will invest more in aftercare services for investors, in promoting new investments of existing domestic and foreign companies and invest in country branding not just as good business and investment destination but as being effective in fighting COVID-19 pandemic.

Keywords: FDI, IPA, COVID-19, future trends

I. 1. INTRODUCTION

The paper examines the impact of COVID-19 crisis on global foreign direct investments (hereinafter referred as: FDI) performance, future outlook and what countries and national investment promotion agencies are doing in order to attract more FDI. The aim of the paper is to determine the trends in FDI and best practice in attracting FDI in the rapidly changing environment, highly affected by Covid-19 crisis. Since the danger of pandemic of the new virus caused countries to react and adopt fast, to close down the borders what intervened and highly affected global value chains and global production. With the experience of the ongoing pandemic, nations and companies are reevaluating investment and investment promotion, and attraction strategies in order to be better prepared for new circumstances. The paper will analyze new trends in global FDI positioning, new investment strategies of companies and what countries and IPAs are doing in order to attract the type of FDI which they mainly see missing during the current pandemic.

II. 2. ANALYSIS OF GLOBAL ECONOMIC PERFORMANCE

A. 2.1. Analysis of GDP performance

Investments including foreign direct investments are significant part of gross domestic product (hereinafter referred as GDP) calculation. When we analyze global GDP performance, we notice significant disturbances.

The current crisis caused by Covid-19 changed the world and global economy dramatically. There is no country or territory that is not affected. Besides human casualties caused by the new illness for the mankind, which are counted each second by national authorities and the World Health Organization, economic consequences are harder to count. Countries' performance in terms of GDP in second quarter of 2020 turned many economies in red. Winners are those with minimum drop and only rare number of countries did not record negative figures.

When we examine top World's economies, under umbrella of OECD, who experienced 9,8% drop in GDP in Q2 2020, the biggest drop ever recorded in OECD area, we see the danger of the situation for global economy. The table below lists economic areas and their GDP performance a quarter before the announcement of the pandemic and full 2020 by quarters, in comparison to the previous period to illustrate the seriousness of the moment. (OECD, 2021)

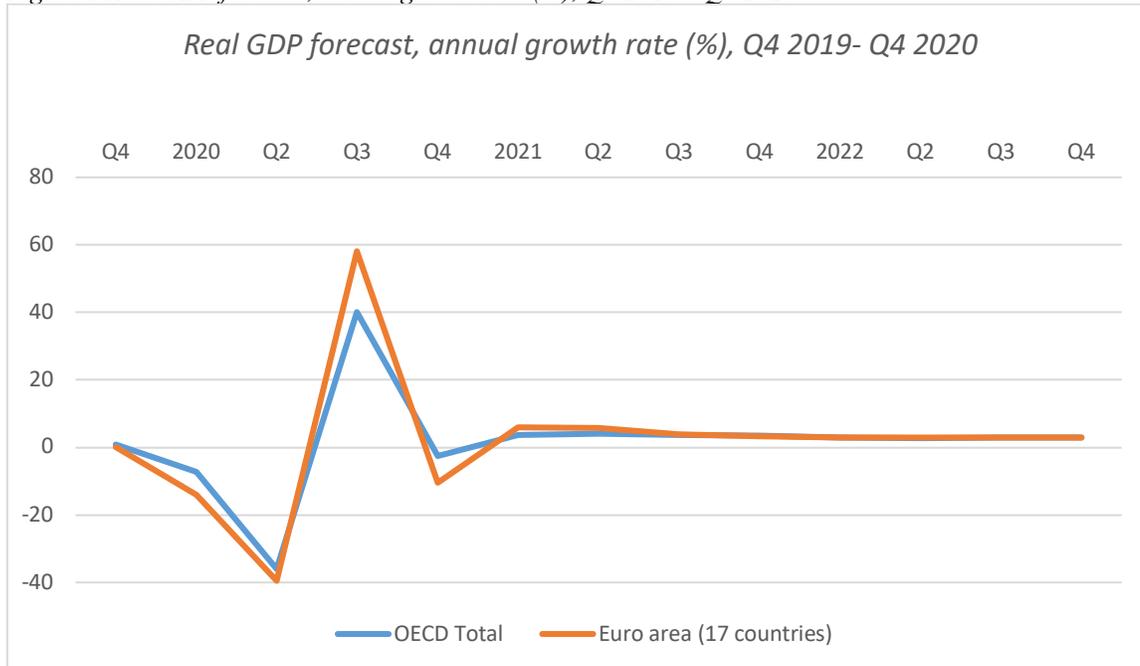
Table 4 GDP performance - percentage change, previous period

BRICS	2019 Q4	2020 Q1	2020 Q2	2020 Q3	2020 Q4
BRAZIL	0,2	-1,5	-9,6	7,7	/
CHINA	1,2	-9,7	11,6	3,0	2,6
INDIA	0,9	0,7	-25,2	21,9	/
RUSSIA	-0,7	-0,9	-3,2	1,5	/
SOUTH AFRICA	-0,4	-0,4	-16,6	13,5	/
G7	2019 Q4	2020 Q1	2020 Q2	2020 Q3	2020 Q4
CANADA	0,1	-1,9	-11,3	8,9	1,9
FRANCE	-0,2	-5,9	-13,7	18,5	-1,3
GERMANY	-0,0	-2,0	-9,7	8,5	0,3
ITALY	-0,4	-5,5	-13,0	16,0	-2,0
JAPAN	-1,8	-0,6	-8,3	5,3	3,0
UK	0,0	-2,9	-19,0	16,1	1,0
USA	0,6	-1,3	-9,0	7,5	1,0

(OECD, 2021)

Forecasting real GDP rates for next two years, OECD’s outlook, based on figures in 2020 seems optimistic. Figure 1 below brings real GDP forecast developed by OECD.

Figure 1 Real GDP forecast, annual growth rate (%), Q4 2019 – Q4 2020



(OECD, 2021)

However, when one sees World’s top economies underperforming, one thing might be certain and that is global recession. The only hope for global economy is that the medicine will either find the cure soon or we will have to accept the new reality and should not expect recovery soon.

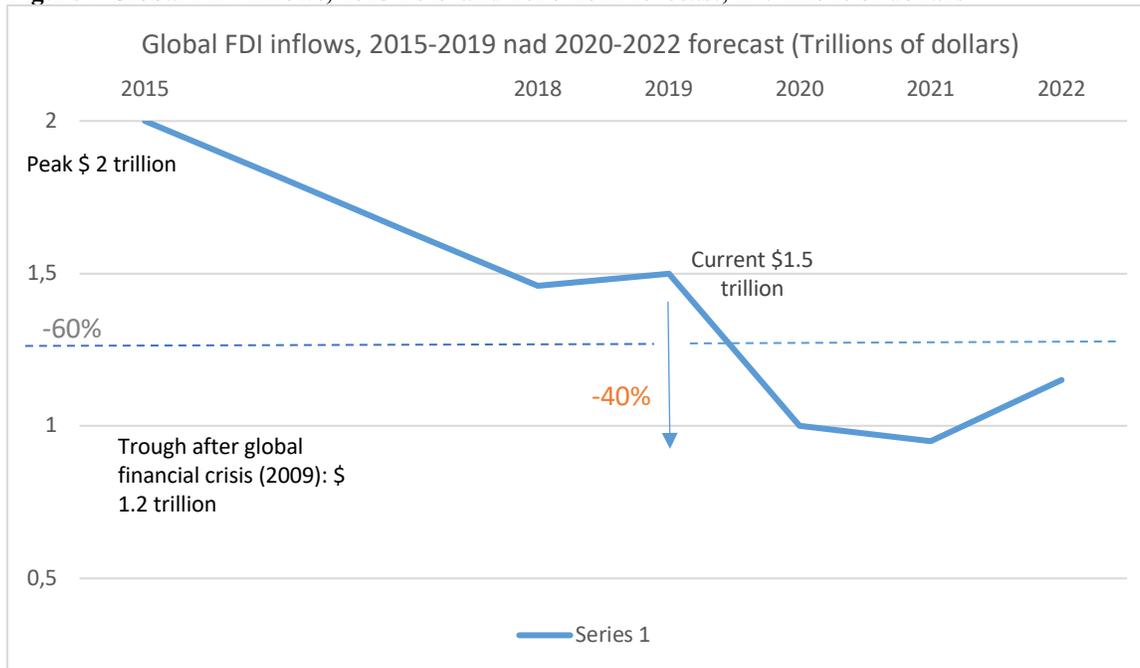
B. 2.2 Analysis of FDI performance and the impact of COVID-19 to global FDI

With the drop in GDP, one of the components of GDP that is the most likely to be immediately affected by global turmoil are investments or foreign direct investments who's drop will definitely follow. Like tourism, investments and mostly FDI are one of the things that react to every bad news with extreme caution.

Therefore, initial predictions in spring 2020 of global FDI performance by UNCTAD was drop by 40% in 2020, from the value of \$1,54 trillion in 2019. This significant decrease in FDI will cause its first drop below \$1 trillion since 2005. If global economic outlook does not experience more severe disruption in 2021, it is expected that FDI in 2021 will drop another five to ten percent on the annual basis.

The expected drop in FDI is actually continuation of negative trend in global FDI performance. Recent years were marked with disruptions and negative rhetorics in trade relations among biggest global economic powers, what negatively affected cross boarder investments. With current trends and future perspective, reaching figures from 2015 of global FDI being on the level of \$2 trillion seems long term goal, hard to be seen in next couple of years. (UNCTAD, 2020)

Figure 1 Global FDI inflows, 2015-2019 and 2020-2022 forecast, in trillions of dollars

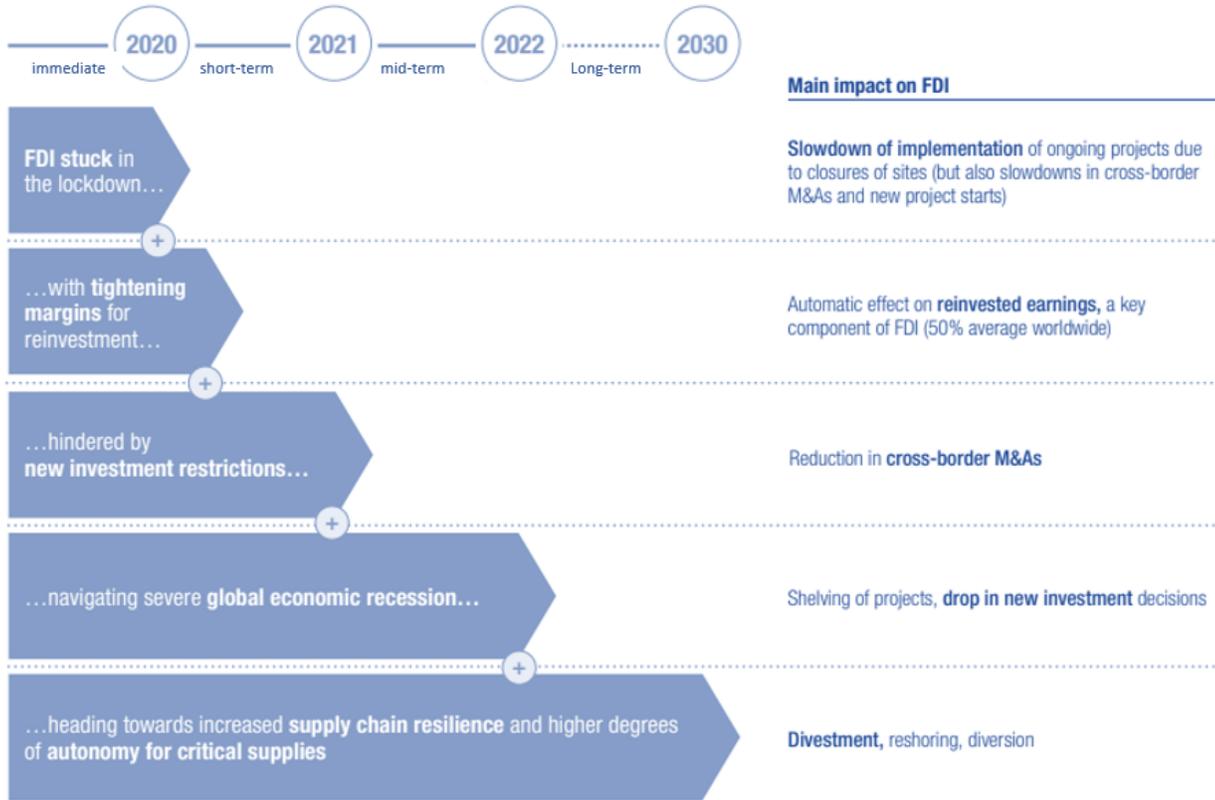


(UNCTAD, 2020)

When pandemic hit hard, one of the nations' first responses were lockdown, closing down borders, closing down regions and cities. Besides interference on global trade, what was relatively short period for most of the territories, impact on FDI and especially on new FDI prospects like greenfield projects was more severe. This situation is going to continue until the treat is eliminated and global situation calms down. Even mergers and acquisitions are affected, with financial markets pricing down the stocks of companies whose merger was not approved before the crisis by regulators.

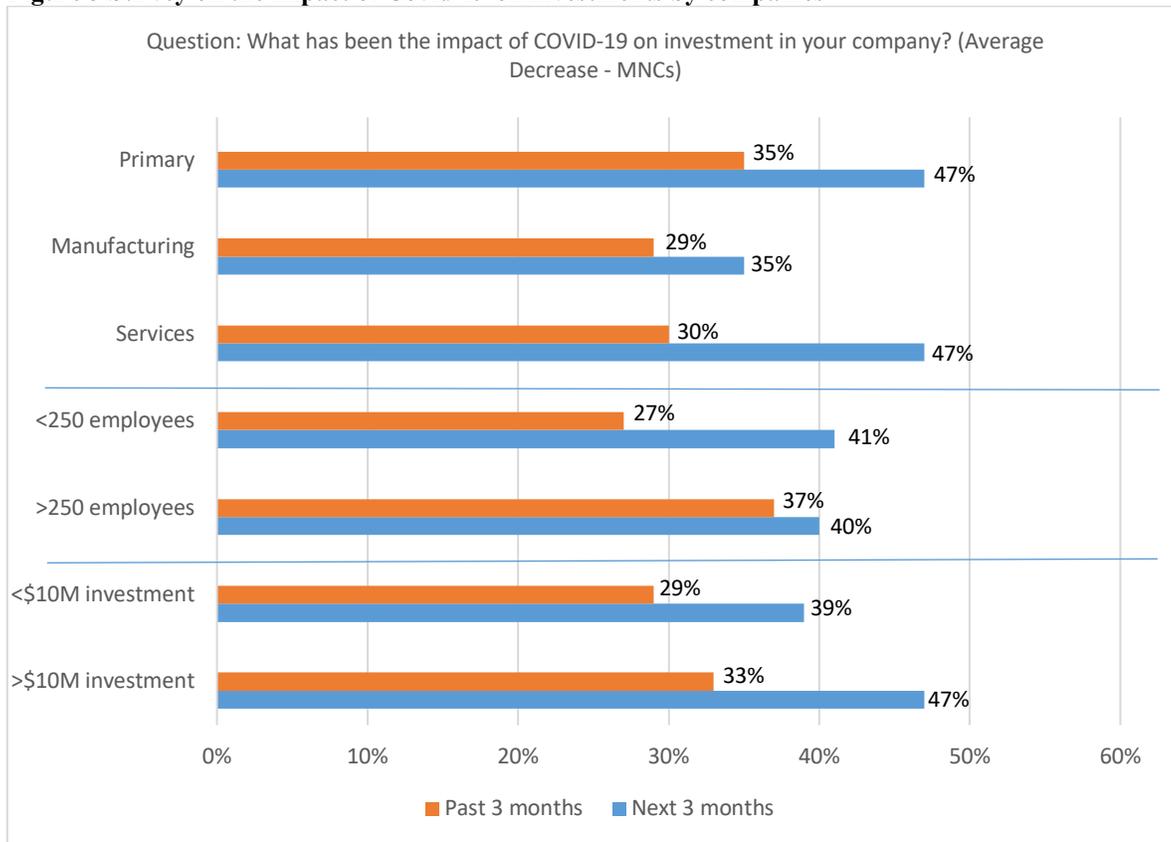
Figure 3 presents the impact of COVID-19 pandemic on global FDI and bring transmission mechanisms.

Figure 2 Impact of the pandemic on FDI: transmission mechanisms



(UNCTAD, 2020)

When we analyze survey conducted by the World Bank among investors in April 2020 and the impact of Covid-19 on investments in their companies, we see that high uncertainty caused by the pandemic will have significant impact on investment plans of their companies. Additionally, many multinational companies report much lower earnings in 2020, estimating drop by an average of 30%. One of the largest component of FDI is reinvested earning; one can expect that significant decrease in earning will have negative effect on re-investments. Figure 4 shows how global crisis results in severe decline of planned investments by companies in the World Bank’s survey. (World Bank Group, 2020)

Figure 3 Survey on the impact of Covid-19 on investments by companies

(World Bank Group, 2020)

III. 3. EXPECTATIONS ON THE NEW TRENDS IN SETING INTERNATIONAL PRODUCTION

With the new normal, nations and companies are evaluating different strategies in order to adopt to new circumstances and to be better prepared for more serious lockdown or even greater threat.

In a short term, nations are increasing stocks of vital products for citizens, like food, medicine, energy resources or even weapons. Retail companies are increasing stocks in order to secure supply in complete lockdown. Production companies are increasing stocks for the products that proved to be essential in past period in order to be able to produce and sell during another lockdown.

Ongoing and growing economic nationalism, imperative on sustainability and new industrial revolution were all hard challenges for international production and they are now emphasized more than ever. On top of this Covid-19 pandemic changed the prospects and created the *new normal*.

In a long run, in the new normal, international production will go under significant change in structure and the way the decisions are made. It is expected that four major was for transformation of international production that include: reshoring, diversification, regionalization and replication.

Reshoring, which was already noted trend with the cost of production raising in Asian destinations, concern over intellectual property and global turmoil in trade relations, will be one of the dominant trends in international production. With the experience of offshoring production from developed countries and negative consequences for host economies in recent decades, more companies implement strategy to invest near headquarters everything that is high-tech, robotics-enabled, digital and automatic. This strategy preserves higher value added in local economies and enables companies to easily control and preserve intellectual property.

Diversification will bring wider range of economic activities. The most affected area will be services and intensive manufacturing activities. This will create opportunities for new economies and new companies in global value chains.

Regionalization will shorten transit time and therefore reaction time. It will give more opportunities to countries in vicinity and more control over the subsidiaries for companies. Therefore, regional economic cooperation will have high impact on future FDI trends. This will probably be more recognized in country unions like European Union for instance.

Replication will bring shorter interactions and create new production stages. This might bring the transition from large investments into industrial infrastructure to more lean production sites and distributed manufacturing.

New normal will bring more challenges and more opportunities for nations and companies. It depends on the way and speed one will adopt to the challenges. The availability of new technologies and ability to implement those will define winners and losers. (UNCTAD, 2020)

IV. 4. COUNTRIES AND NATIONAL INVESTMENT PROMOTION AGENCIES RESPONSES

With rapid change in economic environment caused by Covid-19 pandemic and adjustment strategies by companies to survive and develop in the crisis, national investment promotion agencies (hereinafter referred as: IPA) had to adapt their service and attraction strategies as well.

In order to investigate what IPAs around the globe are doing as the initial response to the outbreak, The World Bank Group conducted survey of IPAs. Survey was sent to 162 national IPAs, with only 41 IPAs responding to the survey in the period from April 1 to April 10, 2020.

As a first sight of the Covid-19 outbreak, IPAs responded by prioritizing services like informing investors on operational measures for daily business activities, worked as agent helping to resolve operational issues investors had, advocating measures to support business operations, companies and workplaces. Additionally, in order to improve business environment, IPAs continued to advocate business environment reforms.

The survey conducted, showed that 25% of IPAs reported negative trends by investors in their respective countries, in terms of negative impacts on sales, lower demand, disturbed supply chains and lower investment volumes. Since the survey was conducted in the early stages of the pandemic, during the lockdown of the most of the world, the impact and trends as we see from GDP figures in second quarter are much more negative.

Therefore, the World Bank Group’s survey analysis recommends some important actions IPAs should undertake in order to retain strategic investors and to mitigate negative effects of the crisis to labor market, supply chains and support fast recovery. The recommendations include better online presence, good daily communication to investors, address individual issues investors are facing immediately and advocate between public and private sector in order to solve issues that are affecting private sector and consequently the economy in general. (World Bank Group, 2020)

One of the ideas how to update and develop investment attraction strategies of countries and IPAs is developed through framework designed by IBM – Plant Location International that suggests the following:

- Different scenarios how the crisis may impact futures strategies of companies and how should governments react
- Review drivers of transformation, like technology, society, exogenous factors and economics and their impact on FDI
- Classify FDI impact by sector
- Evaluate the effect of these impacts on location offering and on targeted sectors

Based on the IBM – Plant Location International offerings through the document *Upgrade Investment Attraction Strategy in response to COVID-19 crisis*, these transformation drivers can alter companies’ behavior, modify location decisions and generate new FDI areas or sectors. (IBM - Plant Location International, 2020)

Different categories of transformation drivers are presented in Figure 5, with the subset presented in Table 2.

Figure 4 Transformation drivers across different categories



(IBM - Plant Location International, 2020)

**Table 5 Subset of transformation drivers
TRANSFORMATION
DRIVERS (SUBSET)**

	MARKET	TALENT	EFFICIENCY	RISK
ARTIFICIAL INTELLIGENCE		+	-	+
CLOUD TECHNOLOGY	+		+	+
ENVIRONMENTAL AWARENESS	+	+	-	+
GLOBALIZATION	+		-	+
HEALTH RISK AWARENESS	+		-	+
ROBOTICS AND AUTOMATION		+	-	
TRADE WARS	+		-	+

(IBM - Plant Location International, 2020)

V. 5. CONCLUSION

Business environment changed significantly after the Covid-19 outbreak. Countries, IPAs and investors are changing their strategies and upcoming period is developing new normal. Countries and IPAs will target projects that will serve a short-term goal to reduce supply shortages of vital products, help build resistance for the crisis and that will replace the necessity of importing vital products to the country. Companies, like always will have to react fast and adjust smart in order to resist and continue to operate.

With the new circumstances, application of new strategies for all participating on global scene is must. Countries should act fast in order to position themselves better in the new normal, business and attractiveness wise. Focus should be more on investment attraction with clear focus and goal, modify marketing strategies and invest more in securing vital production and services within their borders. In the time of rising state protectionism, smart countries should act smart, not to depend on foreign factors as much as it is in globalized world possible. Of course, the aim of this paper is not to encourage protectionism and trade wars, but for countries, territories and companies to prepare for all possible scenarios. It is always better to be safe than sorry.

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Towards a sustainable urban development: Challenges, risks, and opportunities in transitioning into circular construction

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Abstract

The traditional (linear) sequence of materials based on a ‘take-make-use-dispose’ practiced in the construction industry has been grossly contributed to the greenhouse gas (GHG) emissions emitted into the environment. The construction industry has also long been considered as one of the largest consumers of raw materials and producers of waste. Recognizing this issue, many of the world’s countries and cities are planning and currently designing policies to adopt the principles of the Circular Economy (CE) (i.e., reuse, reduce, recycle) into their construction sector or the so-called Circular Construction (CC). Literature on CE practices in the construction sector however highlighted that the transition towards CC is a complex process. There is still lacking known about opportunities and risks arising from CC practices. Accordingly, this study aims to explore challenges, risks and opportunities in transitioning towards CC especially at the city or urban level. The study adopted a qualitative exploratory research design by which data were derived from analysis of secondary sources through literature review. In this paper, several challenges in conducting CC are identified which could be categorized under four dimensions: goals, cultural, regulatory, and market. Risks in implementing CC were grouped into one single dimension namely the negative side effects of CC while opportunities were categorized into economic, environmental, and technological. This study suggests adjustments to the goals towards CC, materials platforms development and further research to be conducted to identify unintended negative consequences of CC.

Keywords: Challenges, circular construction, circular economy, opportunities, risks, urban development.

1. Introduction

The traditional (linear) sequence of materials based on a ‘take-make-use-dispose’ practiced in the construction industry has been grossly contributed to the Greenhouse gas (GHG) emissions emitted into the environment (Dijkstra, 2016). Globally, construction and use of buildings were responsible for half of the total energy consumption and liable for 50% of the GHG emissions (UNEP, 2012; Dijkstra, 2016), whereas the construction sector alone has contributed to 23% of the global CO₂ emissions (Stilling, 2019). At the city level, one of Europe’s biggest cities ‘Amsterdam’ has perceived that the use of primary raw materials in the built environment result in a huge amount of CO₂ emissions (Municipality of Amsterdam, 2020). In 2018, the City consumed 1,216 Kilotons of materials and products for three value chains (i.e., food and organic waste streams, consumer goods and built environment) and was estimated to responsible for a total of 13.540 Kilotons of CO₂ emissions by the time (Municipality of Amsterdam, 2020). Apart from its contribution to the GHG emissions, the construction industry has also long been considered as one of the largest consumers of raw materials and producers of waste (Kenniskaarten, n.d.). Recognizing this issue, many countries and cities including the Netherlands and Amsterdam are planning and currently designing policies to adopt the principles of the Circular Economy (CE) (i.e., reuse, reduce, recycle) into their construction sector or the so-called Circular Construction (CC) (Dutch National Government, 2016; Ogunmakinde et al., 2017; Petrovic, 2018; Cate, 2018; Zhu et al., 2018; Bao et al., 2019; Bao & Lu, 2020; Municipality of Amsterdam, 2020).

The transition towards CC however is considered as a complex process by which the take-off phase of the transition is often hampered by a number of barriers and limitations (Ghisellini & Ulgiati, 2019). This has even acknowledged by the City of Amsterdam by which the City is seeking cooperation with the market, knowledge institutions and people in Amsterdam to identify opportunities and risks arising from CC practices (Municipality of Amsterdam, 2020). Moreover, the application of CC principle is still in its infancy and has been largely limited to waste minimization and faced with several threats along with its opportunities (Moreno et al., 2014; Adams et al., 2017; Ogunmakinde et al., 2017). Apart from that, literature review conducted shows that the majority of studies that discuss the barriers and limitations of CE and CC implementation were focused at the macro-level (i.e., national or regional level) (Heshmati, 2017; Pheifer, 2017; Kirchherr et al., 2017). Only a few were focused at the city or urban level (Johnston, 2018). Furthermore, there is also lack of CE application that is specific to the construction industry found in construction literature (Osobajo et al., 2020). Accordingly, this study aims to explore challenges, risks and opportunities in transitioning towards CC

especially at the city or urban level and answer the main research question: ‘what are the challenges, risks, and opportunities in transitioning towards circular construction at the city level?’

2. Conceptual Foundation

2.1 Circular Economy (CE)

The notion ‘circular economy’ arose along with the cognition of the importance of protecting the environment and the consequent call to preserve our planet (Anastasiades et al., 2020). CE however is still loosely defined. It has been multifariously interpreted by many scholars without an agreement on its definition. A study by Kirchherr et al., (2017a) even found 114 different definitions of CE. Of plenteous CE definitions, the European Commission has proposed a simple definition of CE by which CE is defined as an economic space “where the value of products, materials, and resources is maintained in the economy for as long as possible, and the generation of waste minimized” (European Commission, 2015). In 2015, Ellen MacArthur Foundation published a report entitled “Towards a Circular Economy: Business Rationale for an Accelerated Transition” which shows the principle of CE in a diagram. The diagram has widely known as the ‘Butterfly Diagram for CE’ (Ellen MacArthur Foundation, 2015). The butterfly diagram was designed to illustrate a new life cycle of products. The products new life cycle are designed in circular processes to maintain and prolong their usability. These circular processes such as, maintenance, reuse, refurbish, recycle for the technical cycle or biochemical feedstock, anaerobic digestion, and composting for the biological cycle. If we take a closer look at the spine of the diagram, it represents the linear economic model, while the butterfly (the right and left) wings illustrate “the continuous flow of technical and biological materials through value circles” (Kottaridou & Bofylatos, 2019) (see figure 1).

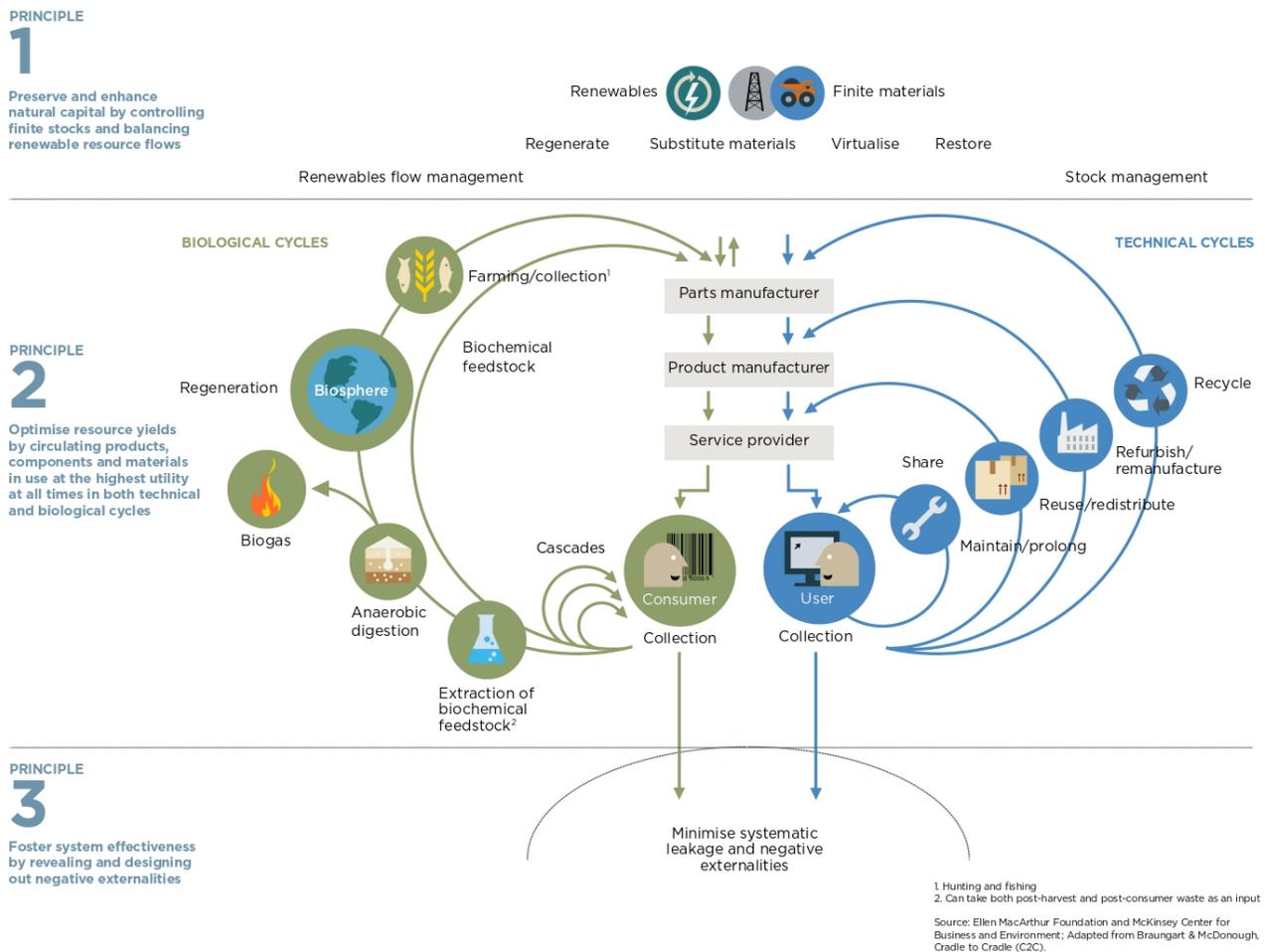


Figure 1: The butterfly diagram for Circular Economy (Ellen MacArthur Foundation, 2015).

CE principle has vastly been adopted in various industrial sectors in many countries, inter alia: Textile industry (Koszewska, 2018; Pandit et al., 2020); Agriculture industry (Toop et al., 2017; Muscio & Sisto, 2020); Automotive industry (Saidani et al., 2018; Maldonado-Guzmán et al., 2020); Furniture industry (Bosch et al., 2017; Barbaritano et al., 2019); Oil and gas industry (Kun & Jian, 2011; Alnuaim, 2019); Construction industry (Zhu et al., 2018; Bao et al., 2019). Regarding the construction industry, CE presents an immense opportunity to reduce material wastage, restrain extraction of finite raw materials and reduce global GHG emissions,

thus achieving environmental sustainability (Ogunmakinde & Maund, 2017). Nevertheless, CE adoption in the construction sector is still limited even though some countries already advocated CE integration into their construction industry. The integration of CE principle into the construction industry is referred to as “Circular Construction” (Ogunmakinde & Maund, 2017). Further description of CC is given in the following section.

2.2 Circular Construction (CC)

CC refers to the adoption of the principle of CE into the construction industry, aimed at maximizing the reuse and recycle of materials throughout construction and demolition phases (Ogunmakinde & Maund, 2017). The UK Green Building Council provided a diagram of possible construction CE model (see figure 2) (UK Green Building Council, 2018). The diagram depicted two cycles in circular construction, the production cycle and the in-use cycle. The production cycle focuses on the production of building materials, the use of materials, the installation and the design for disassembly. On the other side, the in-use cycle concentrates to the use and maintenance of the components of a building.

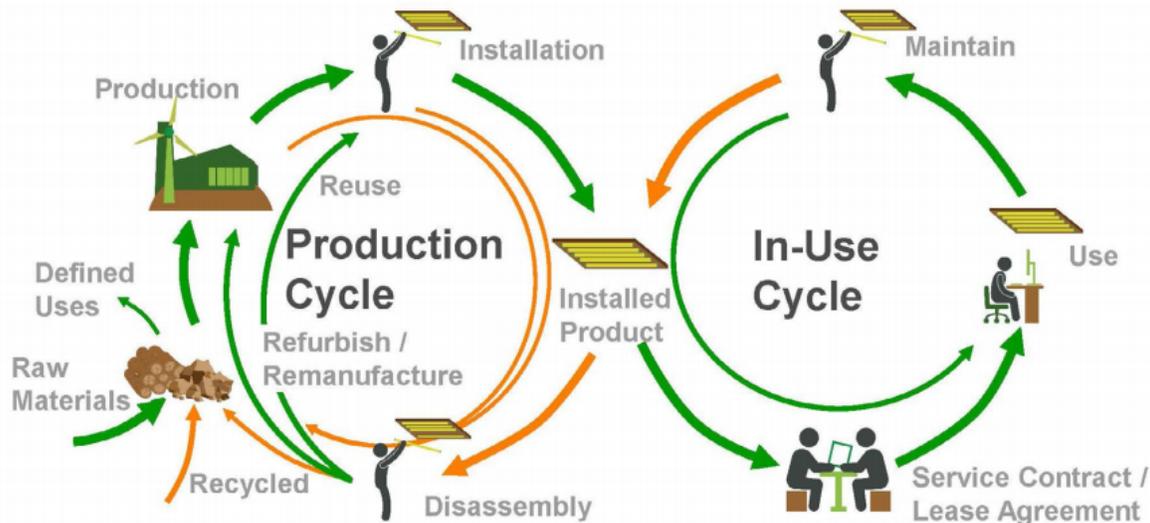


Figure 2: Possible construction circular economy model (UK Green Building Council, 2018).

To achieve CC, the entire actors in the construction supply chain need to be involved (see figure 3). For instance, architects and owners decide to use secondary or upcycled materials; material suppliers offer bio-based building materials; demolition companies implement smart demolition to offer high-grade used building materials for reuse and so on (Sante, 2017). To transform all the construction actors towards circular as well as managing the materials’ supply chain however is considered complex and raises a question regarding challenges, risks and opportunities in implementing CC which this study tries to answer.

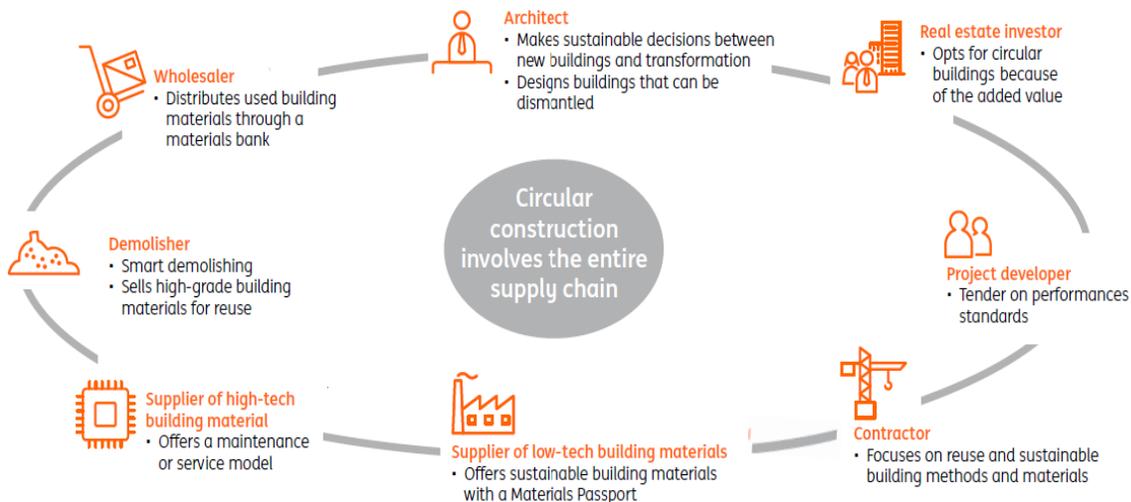


Figure 3: Supply chain partners of circular construction (Sante, 2017), (Further edited by Author).

3. Research Methodology

This study adopted a qualitative exploratory research design and is of a descriptive nature (Neuman, 2014). Data were derived from analysis of secondary sources through literature review. To find relevant literature, electronic searches of several databases were conducted such as Google scholars, Science direct, Elsevier and IOP Science. Keywords and terms used include: circular economy, circular construction, sustainable urban development, sustainable construction, and sustainable waste management. Literatures were refined based on several criteria, namely: it has to be peer-reviewed journals; thesis and dissertations; official documents; articles published by credible organizations and institutions; and time period was limited from 2010 to 2021. In total, 82 literatures were reviewed and analysis of all these literature then yielded challenges, risks and opportunities associated with CC.

To analyze the literature, the abstract and preamble of each of the paper and document was screened to find if the paper or document indicate information or data regarding CE or CE risks, challenges or opportunities. At the same time, tables of challenges, risks and opportunities were made. Findings of the literature review were several dimensions in the form of sentences indicating challenges, risks and opportunities of CC. Each of the dimensions was placed in the tables. The findings were re-read and dimensions that considered irrelevance were discarded whilst dimensions that containing similar meanings were merged together to produce themes. These themes were then becoming the findings of this study such as goals, cultural, market, regulatory challenges and so on.

4. Findings and Discussions

4.1 Challenges in implementing CC

Goals-related challenges

In moving towards CC, countries and cities tend to set far-reaching goals. Here I took an example of the goals of the Netherlands and the City of Amsterdam by which the Country and the City want to “halve the use of new raw materials by 2030 and be fully circular by 2050” (Dutch National Government, 2016; Municipality of Amsterdam, 2020). Several research however revealed that such goals are tend to be rhetorical as well as too ambitious and unspecific especially on what does the City actually mean by 100% circular, thus left a lot of room for interpretation (Johnston, 2018; Darmawan, 2021). Goals that are too ambitious, unclear, and tend to be unrealistic would complicate the responsible stakeholders to identify and measure the City’s circular progress and performance. Research of Loewe and Rippin (2015) has underscored the importance of setting clear policy goals and targets. They were to say, “Specific, measurable, agreed, realistic and time-limited goals help to track progress and detect failures in progress towards their achievement. Goals and targets without sufficient specification tend to become marginalized in monitoring reports and therefore lose attention” (Loewe & Rippin, 2015).

In policy implementation theory, Amsterdam’s decisions to set such ambitious goals are not unusual. The set of ambitious goals could be influenced by the breadth of the circular program and the complexity of implementing CE in the City. Meter and Horn (1975) stated that “ambiguity in standards and objectives may be fostered deliberately by policymakers in order to ensure a positive response on the part of those responsible for implementation at other levels of the organization or the policy delivery system” (Meter & Horn, 1975). Nevertheless, unspecific goals, as aforementioned will lead to the difficulty in measuring their progress, let alone their success. Accordingly, cities are expected to have specific, concrete, and practicable goals and targets particularly on what the cities want to achieve with respect to circularity. Cities are also encouraged to further specifying their goals towards circular to prevent ambiguity.

Cultural-related challenges

Cultural challenges encompass the lack of awareness to engage with CC practices and the cultural lock-in in the construction industry. Literature review conducted reveals that the lack of awareness to invest in CC is one of the overriding barriers in the transition towards CC (Ranta et al., 2018; Petrovic, 2018; Kumar et al., 2019; Hart et al., 2019). Somewhat intriguing, there are disparities in regards to the stakeholders’ commitment to engage with CC practices. The commitment to conduct CC has been substantially arising on the side of the Government and the frontrunners construction companies especially in industrialized countries. However, it is contradicting on the clients’ side (Ogunmakinde & Maund, 2017; Darmawan, 2021). There is still a lack of interest from the construction clients to invest in circular construction. Lack of awareness is becoming a major barrier because the construction sector is ‘client-driven’. This means that how buildings or structures being built as well as the materials chosen are very much determined by the clients. At the moment, many of the clients envisaged secondary materials would be less worth it than the first use (Darmawan, 2021). Nevertheless, the clients’ unawareness is not merely because they unwanted to construct based on circular principles. Still, there is a broad range of intertwined factors that influence it (i.e., lack of knowledge on CC and its environmental benefit, no convincing evidence of the economic benefit of circular construction, financial risks of conducting CC by which virgin materials are often cheaper than secondary or upcycled materials, etc.).

The lack of awareness to engage with CC has resulted in a chain effect by which it results in less demand for CC practices, which then contributes to cultural lock-in in the construction industry. Cultural lock-in refers to the inability to change procedures and practices because of cultural entrenched (Johnston, 2018). This means that the traditional (linear) practices that have been practiced for decades by the construction industry are difficult to alter. This is added by the difficulty encountered by the designers or architects in designing circular buildings due to the absence of database to show the availability of secondary materials and the lack of quality systems to verify the quality of the secondary materials (Darmawan, 2021). From the construction industry point of view, moving towards circular also means to permute the way in which a building company operates. Normally, architects or designers start a project by designing the building, and after the whole design, the process continues to decide materials to use. Subsequently, materials will be specified in the models, and thereafter the building is ready to be constructed. In a circular construction, the architects however have to turn things around. The process has to start from thinking about what kind of materials will be available and then use those materials to design a building. The issue however is that there is no database that shows the availability of secondary materials within the City. Therefore, designers, architects, and developers are becoming unaware of where and when these materials exist. Moreover, it is often unclear whether such secondary materials meet the quality, durability and safety standard or not (Darmawan, 2021). To get a better overview, figure 4 below provided a comparison between the linear construction phases with CC phases, including the obstacles encountered by architects and designers in designing circular buildings and structures.

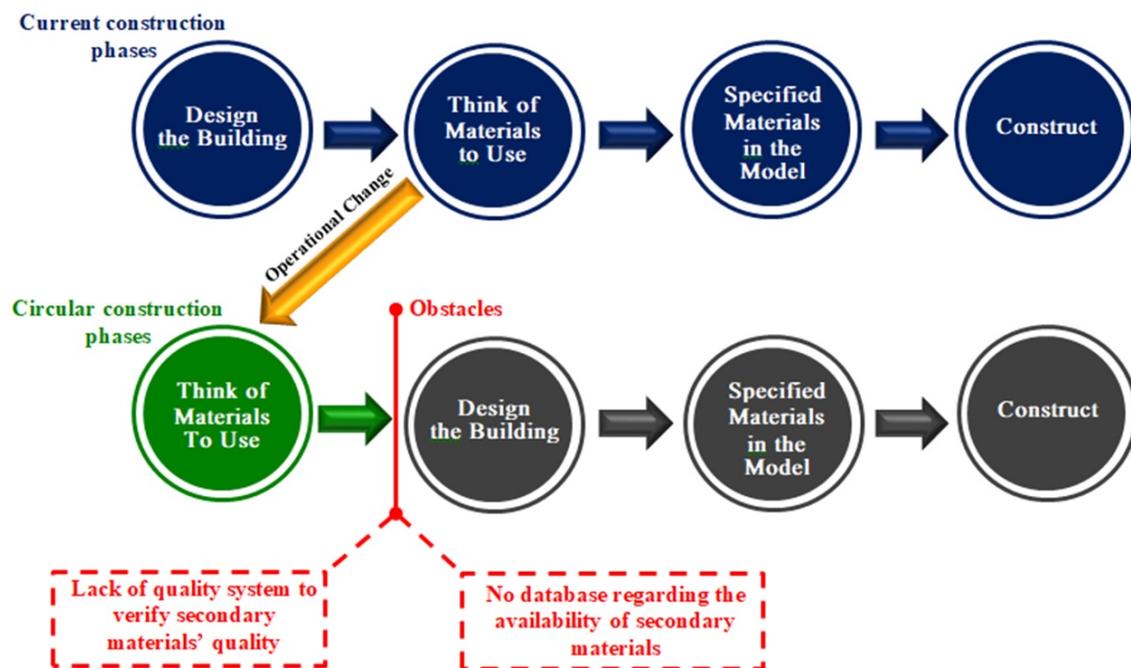


Figure 4: Comparison of the linear construction phases with circular construction phases, including the obstacles in the design phase (Darmawan, 2021).

Regulatory-related challenges

The majority of research on CE revealed that there is still lack of regulation that regulate CE and CC implementation (Ranta et al., 2018; Hart et al., 2019; Garcés-Ayerbe et al., 2019; García-Quevedo et al., 2020). Somewhat interesting, Darmawan (2021) in his research discovered an example of regulatory discrepancy in circular strategy implementation in Amsterdam. An example of regulatory discrepancy is that the amendment of the Building Decree (*Bouwbesluit*) on door size in the Netherlands has been hindering the reuse of secondary doors in new construction. Based on the latest version of the Building Decree, with respect to the increase in the average height of the Netherlands' population, the height of passageways of residential functions has been tightened from 2.1 m to 2.3 m height. And this regulation applies equally to the height of doors (Ministry of the Interior and Kingdom Relations., n.d.). Demolition companies found it is difficult to sell the secondary doors because the buildings that were demolished mostly contain the old doors, the 2.1 m height, and those doors cannot be used in new construction. It is apparent that regulatory discrepancy is somewhat a deterrent, especially to the City's intermediate circular goal. As the goal of the City of Amsterdam is to reduce 50% of the use of new primary materials by 2030, this kind of issue presumably will dissuade the action in minimizing the use of new material for construction.

Market-related challenges

In correspond to previous challenges, the lack of awareness to engage with CC practices has led to the lack of demand to build circular. This then results to a mismatch of supply and demand for secondary construction materials or widely be recognized as ‘market issues.’ Beside the lack of awareness, literature review conducted reveals several causes that lead to the market issue, inter alia: (1) the lack of knowledge about reused materials (Kanters, 2020); (2) demolition sites that produce only a relatively small amount of construction waste compared to the huge demand for new construction. So, materials harvested from the demolition activities do not match the required amount of construction materials in the City. This inevitably results in the difficulty in matching the volumes of demand and supply for secondary construction material (Circle Economy, 2014); (3) the absence of a viable circular business model to show the financial benefits of CC. The business model of the majority of the construction companies is yet still linear and very much profit-oriented (Darmawan, 2021); (4) the construction companies, clients, and developers faced financial risks in conducting CC due to the secondary materials that are often more expensive compared to virgin materials (Eijk & Brouwers, 2002; Ghaffar et al., 2020).

4.2 Risks in implementing CC

Risks in moving towards CC in this study is grouped into one single category namely the negative side effects of CC, or in policy implementation theory, it called the unintended negative consequences of CC. This study revealed 4 examples of the negative side effects of CC, inter alia:

- (1) Conducting CC requires a huge amount of energy. The basic principle of CC is minimizing the use and maximizing the reuse of building’s materials (Sante, 2017). However, to process, collect and restore construction materials back to the “reusable forms take more energy than using virgin raw materials” (VTT, 2019). Therefore, there is a challenge in conducting a functioning CE in the construction sector. The government has to ensure the availability of energy to support recycling and upcycling of construction materials. Another follow-up challenge is to make sure that the energy used to process the materials is generated from completely clean and renewable energy sources. Otherwise, there won’t be a significant impact on GHG emissions reduction from CC practices. Therefore, “emission-free and inexpensive energy must be available in sufficient amounts” (VTT, 2019);
- (2) CE practices in the construction industry will harm the employment within the industry. The negative effects of CC are perceived on labor demand in the extraction activities even though recycling activities is growing (Chewpreecha, 2019). It has been also predicted that there will be several possible alterations in the sectoral composition of employment in 2030 in Europe due to CE implementation. Sectors that produce raw materials are predicted to be decreased in size, whereas the repair and recycling sectors are expected to grow. Construction sector employment is predicted to experience the most loss compared to the other sectors (European Commission, 2018) (See figure 5);

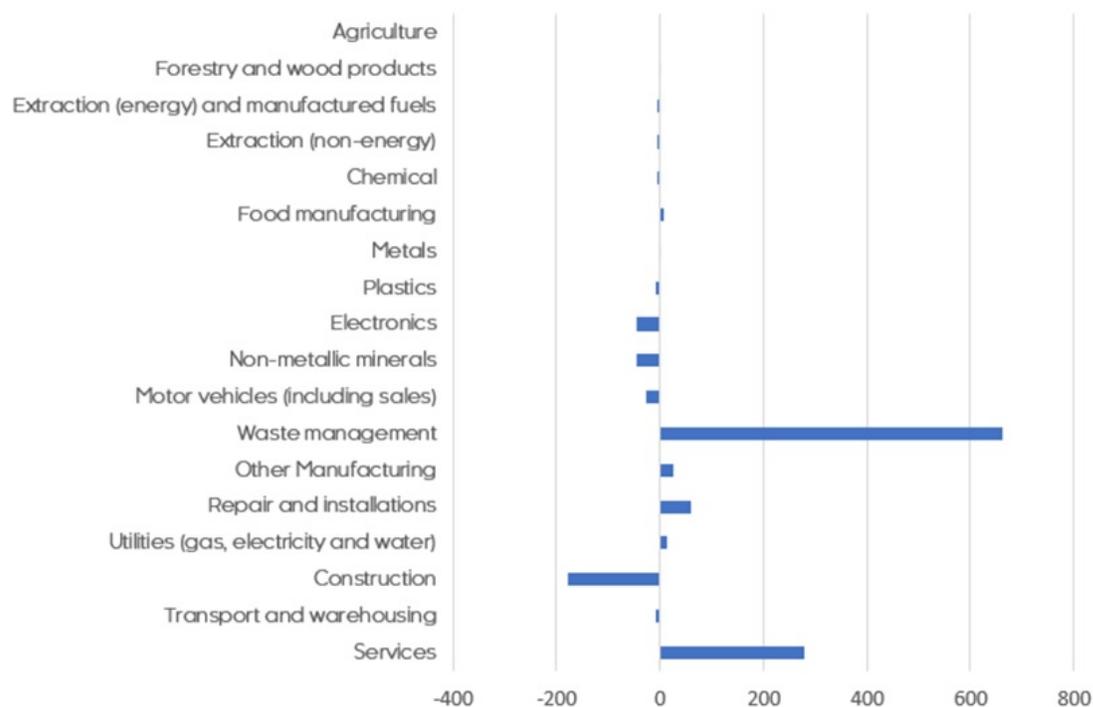


Figure 5: Impacts of the circular economy across the EU28 sectors in 2030 (in thousands) (European Commission, 2018).

- (3) CC practices expose financial risks for the construction companies and clients. Investing in CC requires high upfront-cost and the financial benefits of it are yet still unclear (Moreno et al., 2015; Agyemang et al., 2019; Jaeger & Upadhyay, 2020). As aforementioned, secondary as well as upcycled materials are often more costly compared to virgin materials. Secondary materials can be more expensive because to make it safe for construction, it has to be tested on its performance and quality. This performance test can be expensive, therefore adds to the cost of the materials (Eijk & Brouwers, 2002; Ghaffar et al., 2020). Moreover, from the demolition process point of view, to collect and maintain the quality of materials, it requires a more selective demolition process. This usually costs more money, labor-intensive and more time-consuming (Wahlström et al., 2020). Thus, affects the selling price of the materials harvested from demolition activities. Furthermore, the profit of conducting CC is still yet unclear due to the absence of viable circular business models to show the financial benefits of CC. Thus triggering hesitations of being the first to conduct CC because it means a risk of less financial gain (Darmawan, 2021).
- (4) Several parties in the construction value chain could be harmed and get less benefit from CC. CC practices entail a consequence for many material manufacturing industries, especially companies that produce new materials. According to a report published by the ING Economics Department, there are winners and losers in the supply chain of CC (Sante, 2017). In the report, there are eight supply chain partners of CC recognized (see figure 3). Demolisher and the wholesaler are parties that are predicted to get the most opportunity to gain profit from CC practices. The report explains that “by dismantling buildings rather than demolishing them, demolishers can sell high-grade building materials, thus deliver extra added value” (Sante, 2017). While for the wholesalers, the profit is projected to be obtained from the materials reuse. The report explains that “They can buy used building materials and create a materials bank through which they can sell these materials afterwards” (Sante, 2017). The loser in CC application mentioned in the report is the supplier of low-tech building materials. CC practices would be lowering the demand for primary new or virgin construction materials. Thus, the demand for new low-tech building materials would fall drastically (Sante, 2017).

4.3 Opportunities in implementing CC

Economic opportunities

CC irrefutably will bring several economic opportunities, including material cost reduction through reuse, increase revenue from waste sales, and creates job opportunities from recycling activities. Apart from that, CC could also alleviate price volatility driven by raw material demand and supply risks. Moreover, CC will induce the creation of new business models thereby increasing profits and expand CC practices. Furthermore, CC gives businesses an opportunity to gain a sustainable reputation and become a market differentiator without placing undue pressure on resources (Ogunmakinde & Maund, 2017; Ellen MacArthur Foundation, 2018; Darmawan, 2021).

Environmental opportunities

The application of CE principles in the construction sector induces several environmental opportunities, including: environmental impacts minimization through sustainable energy production, material efficiency, and transport minimization; reduce unsustainable pressure on natural resources by reusing and recycling secondary building materials; increase efficient resource use and prevent waste production; recover the ecosystem through raw materials demand reduction and materials life cycle extension. Furthermore, CC practices could also reform environmental management by increasing public awareness of the significance of conducting CC to prevent the excessive demand for resources (Ogunmakinde & Maund, 2017; Ormazabal et al. (2018); Kumar et al. (2019).

Technological opportunities

CC has been predicted to bring several technological opportunities, inter alia: it allows exploration of modern as well as advanced (sustainable) technology and techniques as solutions to the management and methodologies challenges faced by the construction industry; enables the adoption of clean technology to ensure resource efficiency and waste minimization; and induces sustainable technology development to serve as a support to enhance the quality of life and environmental preservation. Furthermore, CC could also induce industrialization transformation towards industrial symbiosis. One practice in industrial symbiosis could be waste materials exchange among companies within the industrial area (Ogunmakinde & Maund, 2017; Kinnunen & Kaksonen, 2019; Darmawan, 2021).

5. Conclusions and Recommendations

5.1 Conclusions

To answer the main research question: ‘what are the challenges, risks, and opportunities in transitioning towards circular construction at the city level?’ several challenges in conducting CC are identified in this study which then categorized under four dimensions: goals, cultural, regulatory, and market challenges. Risks in implementing CC were grouped into one single dimension namely the negative side effects of CC which comprise four examples namely: CC requires huge amount of energy to processing the secondary materials back to the loop; CC expose financial risks for clients and construction companies; CC could harm several parties in the

CC value chain; and CC practices will induce a massive employment loss in the construction industry. Opportunities in implementing CC were categorized into economic, environmental, and technological opportunities.

5.2 Recommendations

To contribute to spur the move towards circular construction, First, I recommend cities to set specific and clear goals in their circular strategy and policy. Look back to the goal of the city of Amsterdam, by which the City wants to be 100% circular by 2050. But there is a lack of specification on what does the city actually mean by 100% circular. If the city means to put all the secondary resources available for 100% back to the loop, this is a realistic goal. On the other hand, if the city means to completely close the material loop within the City boundary, this is somewhat unrealistic. I would recommend cities to refer to the levels of circularity instead of setting a goal of becoming a 100% circular city (see figure 6). The goal should be to which extent that the cities can reach higher circular level. For example, to re-use all the secondary resources available in the city, that might be more realistic and achievable.

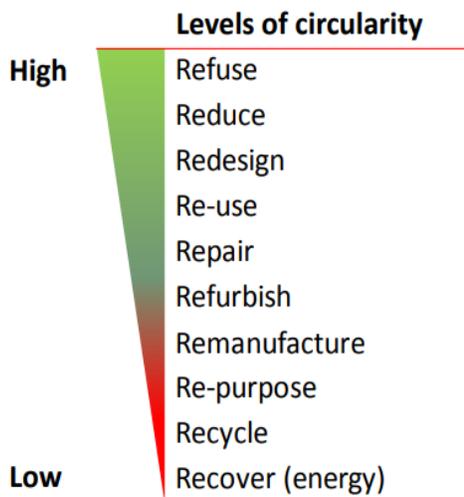


Figure 6: Levels of circularity (NZWC, 2017)

Secondly, I recommend computerized or online material platforms to be developed. This aims to track the cities' progress towards circular, to show (secondary) material availability within the city boundary, to indicate the quality of the material available, to share knowledge regarding sustainable materials, and to induce market development for secondary materials.

For future research, I recommend a further investigation on the unintended negative consequences of CC. I expect that there could be many more unintended negative consequences of CC than those revealed in this study. Therefore, a systematic research to identify negative side effect of CC is encouraged to be conducted.

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Accessibility for Students with Disabilities at UAEU: An Attitudinal and Thematic Analysis

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Abstract

This article provides a report on accessibility resources provided by various departments, units, and colleges at the United Arab Emirates University (UAEU) as it pertains to services offered to students with disabilities (AKA students of determination). In this research, the authors conducted quantitative and qualitative analyses that culminated into an attitude and thematic research study on how both service providers and service recipients view these services, which include academic, administrative and support services. The investigators collected data through surveys and interviews with UAEU students and employees, including teaching faculty members, administrative and support staff, and students with disabilities, and used a Kruskal–Wallis test to analyze the significance level between the student and instructor groups. To conclude their analysis, the authors compiled a list of themes that emerged from the interviews.

Keywords: Accessibility, services for university students with disabilities, perceptions, attitudes

1. Introduction

The number of students with disabilities enrolled at United Arab Emirates University (UAEU) has been growing steadily over the years. As of October 2019, there are 67 students with a documented disability, and who are registered with the Disability Office (officially known as the Students of Determination Center at UAEU). According to the Disability Office, there are 20 students with visual impairments, eight with hearing impairments, five with learning disabilities, 12 with intellectual disabilities, 18 with limited physical mobility, and two with emotional and behavioral disorders. The Disability Office staff member interviewed mentioned that among these students, there is one with dyslexia and another with major depressive disorder. The staff member also added more details to these categories and stated that some students suffer from genetic diseases such as sickle cell beta thalassemia but was not able to supply researchers with specific numbers and conditions for these diseases and disorders.

2. Literature Review

Post-secondary academic institutions worldwide have published a number of research articles on accessibility for students with disabilities. Some of these studies focused on the students' attitudes regarding the services available to them at their respective institutions. Morina et al. (2016) conducted interviews with students with disabilities and compiled a list of suggestions made by these students for improving the services available to them at their respective university. These students recommended that orientation sessions be conducted for them and that academic staff should be trained in how to teach these students. Fleming et al. (2016) gathered comments made by students with disabilities related to services and student support that these students have access to or would like to see implemented at their university. Once again, researchers noticed that students with disabilities were not always satisfied with the services that are available and often had suggestions for improvement. Beyer et al. (2016) gave an account on a focus group at Skidmore College that evaluated the impact of implementation of modifications recommended by the 2008–2009 Assessment of Campus Climate to Enhance Student Success and which included accessibility for students with disabilities. Beyer et al. (2016) recommend training teaching faculty in how to apply the Universal Design of Learning (UDL). Another relevant article by West et al. (2016) investigated the attitudes of instructors on the implementation of the principles of UDL, how much knowledge these instructors have regarding disability laws and policies, and their responsibility level about accommodations for students with disabilities. Kouroupetroglou et al. (2011) proposed a model of accessibility that could be implemented by universities to ensure that services for students with disabilities are fully available. Abreu et al. (2016) studied the link between the visits to the disability support center by students with disabilities and these students' perceptions of the services offered by this center as well as their GPA. When asked by researchers, the students proposed ways to improve these services. An interesting outcome of this study was that

there was a correlation between the number of visits and an increase in these students' GPA. Gallego and Busch (2015) conducted a study on the readiness of teaching assistants, language program directors, and Disability Services Office staff concerning the services offered to students with disabilities who are studying a foreign language in the United States. Ispambetova et al. (2018) investigated the perceptions of students with disabilities about accessibility at the Al-Farabi Kazakh National University in Kazakhstan. Most respondents expressed the need for a simplification of admission procedure for students with disabilities. Costea-Bărluțiu and Rusu (2015) investigated the attitudes of university instructors toward students with disabilities. The results showed that despite the positive attitudes of these instructors toward these students, most of these instructors were not familiar with the laws concerning accessibility in higher education. Osadebe et al. (2019) conducted a study about the availability of services to students with visual impairment at libraries in some universities in Nigeria. Their results confirmed that students with disabilities require more services and technological tools to allow them to perform well academically. It is worth mentioning that little research has been conducted in the domain of accessibility for students with disabilities in the UAE. Alghazo and Gaad (2004) explored the attitudes of mainstream teachers concerning the inclusion of students with disabilities in their regular classrooms. Their results showed that the majority of teachers were not favorable to the inclusion of students with disabilities in their classrooms, and most commented that these students should be tutored separately by special education teachers. A research study by Smadi and Sartawi (1995) examined the attitudes of students without disabilities toward students with disabilities at UAEU. The results showed significant differences between attitudes of female students versus male students, single students versus married ones, and students with previous contact with students with disabilities versus those without previous contact, among other variables. Female students, single ones, and those with previous contact with individuals with disabilities showed more favorable attitudes toward students with disabilities.

3. Methodology and Results

The present article provides an insight into the attitudes and perceptions of, on the one hand, service, support, and academic staff, and on the other hand, the perceptions and attitudes of students with disabilities, regarding services offered to them at UAEU. This study is both quantitative and qualitative. Researchers administered surveys based on a Likert scale to participants and then graphed and statistically analyzed the survey results. Then, following the survey administration, researchers conducted interviews with the same participants who had agreed to answer the surveys. The interviews were semi-structured in order to allow the interviewees to express their opinions freely while at the same time following a structure. The semi-structured section of the interviews guaranteed a certain level of uniformity among the interviewers. The main questions that were asked were about the level of accessibility regarding materials, assessment, and other services offered at the university to students with disabilities. Interviewers asked open-ended questions to elicit answers on specific aspects of the research. Then, researchers grouped themes that were discussed in the interviews into common, recurrent themes and presented them in this article.

Participants

Participants included 44 support and administrative staff as follows: six hostel employees, 13 learning center and library employees, eight health service employees, 10 administration, advising, and enrollment units' employees, and seven extramural activities clubs and sports centers employees. Moreover, 30 instructors (assistant professors, associate professors, and full professors and lecturers) and 30 students with disabilities took part in this study.

Attitudinal Results Through a Quantitative Method

This section presents the results of the surveys that were administered to the participants. Researchers used a five-point psychometric scale based on the Likert scale point (5 = strongly agree, 4 = agree, 3 = neutral/neither agree nor disagree, 2 = disagree, and 1 = strongly disagree). Included here are results of descriptive statistical analyses for all participants as well as results of the Kruskal-Wallis test (developed by Iman and Conover, 1981) for the significance level of the student-instructor survey questions.

Descriptive Statistical Results for Non-instructors

Table 1.: *Statistical Results Table for Non-instructors*

Variable	Mean	Standard Deviation	number	Minimum	Maximum	Median	Standard Error of Mean
Q9 Employee faces difficulties/is not trained assisting students with disabilities	2.95	1.19	20	1.00	5.00	3.00	0.27
Q6 Employee feels trained and knowledgeable in assisting students with disabilities	3.25	1.07	20	2.00	5.00	3.50	0.24
Q5 Activities, services, official documentation or materials are accessible to students with disabilities	3.75	0.97	20	2.00	5.00	4.00	0.22

Q3 Students with disabilities can move easily inside, or from and to a specific facility/building on campus	4.00	0.89	26	2.00	5.00	4.00	0.18
Q1 Campus buildings and facilities are accessible to students with disabilities	4.21	0.88	34	2.00	5.00	4.00	0.15
Q7 Employee encourages and supports students with disabilities (for example, recruits them as volunteers, takes into consideration their suggestions, activities tailored for these students, etc.)	19	1.08	36	1.00	5.00	5.00	0.18
Q2 Alternative solutions are offered when basic services are not available	4.28	0.80	29	2.00	5.00	4.00	0.15
Q8 Employee ensures a healthy, safe environment and delay free services for students with disabilities (for example provide transportation, meal delivery, fast action, etc.)	4.35	0.82	37	2.00	5.00	5.00	0.14
Q4 Students have the freedom of choice when it comes to services and facilities	10	0.44	13	4.00	5.00	5.00	0.12

Most employees who answered the survey questions have a positive attitude toward students with disabilities. They perceive their role and the services they offer to this student population as beneficial and worthwhile. They also strongly feel that accessibility for students with disabilities is not an issue, and it is present everywhere on campus. The only aspect that most of the participants see as lacking is their ability to assist these students in an adequate way. This is understandable because very few training workshops, if at all, are offered to the university's employees in matters related to assisting students with disabilities.

Perceptions of Students with Disabilities About the Disability Services Office

Table 2: Statistical Results Table for Students with Disabilities about the Disability Services Office

Variable	Mean	Standard Deviation	Number	Minimum	Maximum	Median	Standard Error of Mean
Q7 The disability office staff provides a computer lab including all available devices and runs training sessions for students with disabilities, faculty, and staff in the use of specific adaptive technology	2.83	1.42	30	1.00	5.00	3.00	0.26
Q6 The disability office staff provides necessary equipment for students with disabilities	2.93	1.41	30	1.00	5.00	3.00	0.26
Q8 The disability office staff liaises with teaching faculty members to discuss potential adjustment solutions including adaptive technology	3.07	1.34	30	1.00	5.00	3.00	0.24
Q5 The disability office staff offers alternative solutions and services if basic services are not practical for students with disabilities	3.10	1.27	30	1.00	5.00	3.00	0.23
Q2 The disability office staff assists in arranging a needed course, classroom and facilitate the provision of recommended adjustments	3.20	1.19	30	1.00	5.00	3.50	0.22
Q4 The disability office staff focuses on the needs of students and works in coordination with other centers to determine the appropriate learning materials for students with disabilities	3.30	1.26	30	1.00	5.00	3.50	0.23
Q10 The disability office staff provides services regarding identified needs of all students	3.43	1.28	30	1.00	5.00	4.00	0.23
Q3 The disability office staff prepares quiet individual exam proctoring arrangements that are appropriate for the needs of	23.33	40.00	30	1.00	5.00	4.00	0.24

students with disabilities and gives them enough time to complete the exam							
Q1 There is full accessibility to all facilities at the disability office	3.53	1.22	30	1.00	5.00	4.00	0.22

The lowest mean score is attributed to Q7, which is about assistive technology and training availability. This is a good indicator that this area needs improvement. Q1 about accessibility of the premises of the Disability Office has the highest mean score, allowing researchers to infer that the location and the rooms of the disability office possess accessibility features such as electronic doors and other physical aspects.

Perceptions of Instructors and Students with Disabilities

A total of 30 teaching faculty members took part in this study, and 30 students with disabilities answered the survey. The same survey was administered to both groups with only a change in pronoun: In the teachers' survey, researchers used the pronoun "I" to refer to instructors whereas in the students' survey, researchers changed the pronoun "I" to "my teacher." There were 24 female students and 6 male students, and 19 female instructors and 11 male instructors.

Q1: Instructor provides accessible materials: Significant differences were found between instructor and student groups based on an alpha value of 0.05, $X^2(1) = 15.36$, $p < .001$. These results can be explained by the fact that students do not always perceive materials to be fully accessible even though instructors think otherwise.

Q2: Instructor gives equal treatment to students: Significant differences were found between instructor and student groups based on an alpha value of 0.05, $X^2(1) = 12.66$, $p < .001$. Once again, researchers noticed that the difference between both groups was significant. Students with disabilities seem to feel that they do not have the opportunity to express themselves. This attitude was visibly apparent in some of the comments by students with disabilities in the interviews that followed the survey administration.

Q3: Instructor uses differentiation in teaching: There were no significant differences based on an alpha value of 0.05, $X^2(1) = 2.76$, $p = .097$. It is quite interesting to note that both groups agreed on this particular question. Perhaps, instructors are aware they may need to use more differentiation in their teaching, and that this should also be reflected in their teaching methodology. As for students, it is not surprising at all to have such results because most of these students expressed their dissatisfaction with teaching methods that were not tailored to their specific needs and disability types.

Q4: Instructor reinforces self-confidence in students regardless of their abilities/disabilities: Significant differences were found between instructor and student groups based on an alpha value of 0.05, $X^2(1) = 19.47$, $p < .001$. Students with disabilities often seem to have a lower self-confidence level than students without disabilities. This feeling can be exacerbated and magnified in certain situations in which a student with disabilities might feel marginalized.

Q5: Instructor gives equal opportunities in class for students to interact (answer questions/voice opinion):

There were no significant differences based on an alpha value of 0.05, $X^2(1) = 3.54$, $p = .060$. Instructors usually do their best to include all students in class discussions and make their lectures as interactive as possible. However, it is common for some students to somehow feel left out at times. This can be due a number of reasons. Some students with disabilities may not know how to take turns, and instructors may avoid allowing them to answer a question. Because results are not significant, however, researchers could conclude that students with disabilities do not consider interaction in class to be a very crucial aspect in their education.

Q6: Instructor makes necessary accommodations for students with disabilities (gives extra time in exams, etc.): Significant differences were found between instructor and student groups based on an alpha value of 0.05, $X^2(1) = 6.62$, $p = .010$. These results reflect the general feelings of students with disabilities who may often consider, rightly or wrongly, that some instructors are not willing to adapt their teaching to accommodate the needs of students with disabilities.

Q7: Instructor knows/is aware of what to do regarding students with disabilities: There were no significant differences based on an alpha value of 0.05, $X^2(1) = 3.17$, $p = .075$. It is not surprising that results are not significant, as a recurrent comment was the lack of training reported in the interviews by instructors, students, and no-teaching staff members.

Q8: Instructor keeps in touch with the Disability Office: There were no significant differences based on an alpha value of 0.05, $X^2(1) = 2.50$, $p = .114$. Both groups agreed on the fact that collaboration, cooperation, and liaising with Disability Office staff members are not adequate and that perhaps this is a sign that more should be done between on the one hand, instructors, and on the other hand, the Disability Office staff members. Students with disabilities are aware of this gap based on their interaction with both parties. This was often brought up in the interviews.

Q9: Instructor makes live lectures accessible with the use of accessible document formats, loudspeaker, etc.:

Significant differences were found between instructor and student groups based on an alpha value of 0.05, $X^2(1) = 9.08$, $p = .003$. Students with disabilities still need the materials to be presented to them in accessible formats. Sometimes, the adaptation is minimal such as making sure to read information out loud while writing on the board.

Q10: Instructor uses differentiation in homework assignments and projects for students with disabilities:

Significant differences were found between instructor and student groups based on an alpha value of 0.05, $\chi^2(1) = 12.85$, $p < .001$. Some instructors were unsure about how much differentiation they are allowed to apply in homework assignments and projects out of fear of showing preferential treatment for students with disabilities. Indeed, one student stated that her instructor asked her not to mention to her classmates that she was getting extra time to complete her assignment as this instructor worried that her classmates would consider this extra time as preferential treatment.

Thematic Results Through Qualitative Method

Physical accessibility. Even though most participants, except students with disabilities, seemed to acknowledge that physical accessibility is not an issue at all and that it was taken care of, the comments given by students with disabilities sometimes contradicted this. All in all, UAEU has several accessible buildings and facilities. On campus, some bathrooms that are specifically designed for people with disabilities lack the very important automatic-door-opening feature. A student with limited mobility and who uses a wheelchair always needs an assistant to open the bathroom door. In the hostels, there are allocated rooms for students with disabilities. However, a student reported that these rooms are located on the second floor. Therefore, most students with disabilities request rooms on the ground floor. Most students with disabilities praised the food service offered in the hostels whereby students with disabilities can have their meals delivered to their room instead of having to dine in the main cafeteria. Another crucial aspect mentioned by students with disabilities, especially those with visual impairment, is the lack of information regarding change of routes on campus or being made aware of maintenance work on campus. One instructor recommended the installation of grab bars in corridors to prevent falls as well as tactile floor markers to guide students who are blind. A librarian recommended that a room be allocated for the sole use of students with disabilities. Learning centers are all located on the ground floor and hence can be accessed by students with disabilities. One of the librarians strongly recommended designing entrances and gates suitable for all groups including students with disabilities. Another participant added that mobile bookshelves should be available for students with limited physical mobility so they can easily access the books. Most buildings on campus are equipped with automatic doors, and the Disability Office is on the ground floor, which facilitates its access for students with visual impairment as well as students with limited physical mobility. Health clubs are fully accessible but lack appropriate ramps that can be used by students with wheelchairs in the case of power failure or elevators breaking down. There is a bathroom equipped with shower facilities for students with limited mobility, but it is unfortunately not equipped with an electronic door. Lecture halls, classrooms, and laboratories are equipped with the latest technology regarding Smartboards and desktop computers. There is, however, a lack of FM systems to assist students with hearing disabilities, and if this technology is available in classrooms, it is not always being used to accommodate the needs of students who are deaf or hard of hearing. There are desks at the front of each classroom or lecture hall that are designated for students with disabilities. The height of these desks can be lowered to accommodate various sizes of wheelchairs. There are two main clinics on the university's main campus with additional ones in the hostels. These clinics are well equipped to assist students with disabilities. Unfortunately, both clinics on the main campuses are located on the first floor not the ground floor, and students must use the elevator to access them. Several food outlets and restaurants are available on the university's main campus. There is a wide variety of foods and meals students can choose from. Unfortunately, menus are not provided in Braille characters, which makes it difficult for a student with visual impairment to select a meal without the assistance of a friend or of a restaurant staff member.

UDL Through Accessible Materials. While there has been a great improvement in the availability of accessible materials, especially regarding textbooks and documents produced in English, the same cannot be said for Arabic-language books, which still remain largely inaccessible. In contrast, there is a myriad of software programs that can easily transfer the text written in English to speech, and screen readers are also widely available for these books. Instructors can use Blackboard Collaborate Ultra to deliver their classes, but devices such as JAWS screen readers are available only for the English language in Blackboard. There is some contrast between the perceptions of students with disabilities and those of teaching faculty members. The majority of teaching faculty participants agreed with the statement in the survey, "I provide my students with accessible materials." Nonetheless, in the interviews, some of these same instructors acknowledged the fact that they needed to be trained in how to make their materials more accessible to students with disabilities. One mathematics instructor had the following comment with regard to students with disabilities taking math courses: "I strongly advise allowing these students to use formula sheets and also to have access to extra notes for materials or lessons/lectures used in class." Several comments by students with disabilities regarding accessible materials point to the fact that they are not always accessible. For example, a student reported: "Not all materials are easily accessible to me." Regarding teaching methodology another student reported: "Not all teachers are trained to work with or teach students with disabilities." In their 2016 study, Fleming et al. (2016) reported a similar student testimonial: "The majority of professors are seemingly incapable of comprehending that their methods of learning do not work for everyone" (p. 317). The UAEU main library has a rich and extensive online digital library. It is generally accessible to students with disabilities, especially when it comes to texts, books, and documents written in English. There are several magnification devices as well as a digitization unit at the main library on campus. Study participants suggested some improvements, however, including the suggestion by a librarian for making an Adobe software package geared for Arabic texts and books available to students. The Disability Office routinely writes accommodation reports for each student with disabilities who requests such document to be emailed to instructors. These reports indicate the specific accommodations required for examinations such as extra time, use of assistive technology, and the allocation of scribes and readers. Students with learning disabilities often request that the test items are read out loud to them, but in the absence of such a request in the accommodation report, however, instructors are reluctant to do so. The Disability Office provides proctoring services. The Disability Office has a pool of volunteers who act as readers and/or scribes for the tests. One student with disabilities mentioned that scribes and readers volunteers need to be language proficient when reading out loud test questions. UAEU has successfully used the "exam chunking" accommodation for a student with learning disabilities with no reduction in the number of materials, but instead of having one mid-term or final exam, the student took several short tests.

The role of the Disability Office in Advocacy on Behalf of Students with Disabilities. A recurrent theme in the interviews with students with disabilities is that they would like to see more advocacy and proactive action from the Disability Office. The Disability Office staff prepares accommodation reports and emails them to professors upon the request of students with disabilities. These reports are neither routinely discussed nor emailed to students. Moreover, the majority of participants would like to see more training offered to them in the area of applying the precepts of UDL to materials as well as the hiring of assistive technologists, and accommodation specialists.

4. Conclusions

Recommendations and Future Areas of Research

The aim of this study was to explore the attitudes and perceptions of UAEU employees and those of students with disabilities regarding services offered to these particular students. Surveys provided some insight into how those who offer services, academic or administrative, to students with disabilities view the quality of the services they offer. Most employees positively evaluated their work with students with disabilities, while students with disabilities' evaluations of these services were less positive. This preliminary study has shed some light on accessibility for students with disabilities at UAEU. Research drawbacks included difficulty in reaching a vast number of university employees as well as the relatively small number of students with disabilities enrolled at UAEU. Researchers strongly recommend UDL as the approach not only for building and facilities accessibility but especially for academic materials accessibility.

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