Research Methodology

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3.1 Introduction

This chapter presents all the tools and systems used for this dissertation. It discusses the methodological epistemologies and approaches that support mathematical economics and social choice research. The research is based on: mathematical modeling of economic analysis in optimizations, social choice and game theory, voting system, environmental pollution, healthcare, and sustainable economy, NNP, social welfare and sustainability, GHG emissions, global warming and climate change that effects on modern economy, and finally green taxes on environment pollution to reduce GHG emissions.

This chapter introduces the research strategy and the empirical methods for the general approach, and specific techniques to address the objectives for the research. It also presents the research design and the methods used in the selection of the research participants, and for data collection. Research methodology indicates the logic of development of the process used to generate theory that is procedural framework within which the research is conducted (Remenyi et al. 1998). It provides the principles for organizing, planning, designing, and conducting research. Methodological decisions are determined by the research paradigm that a researcher is following. The research paradigm not only guides the selection of data gathering and analysis methods but also the choice of competing methods of theorizing (Sayer 1992).

This study is based on both primary and secondary data that are collected from various sources. Primary data have been collected from the 500 female garment workers of the slum areas of Chittagong City Corporation (CCC) of Bangladesh by random sampling technique through open-ended questionnaire. The open-ended response questions are most beneficial when a researcher conducts exploratory research, especially if the range of respondents is not known. The open-

ended questions can be used to learn what words and phrases people spontaneously give to the free-response questions. The secondary data are collected from the websites, books and e-books, previous published articles, theses, conference papers, case studies, magazines, and various research reports.

Here we have tried to discuss in brief, and clarify how evidence in this study was collected and analyzed, as well as to introduce the research strategy and the empirical techniques applied in this research. The research strategy adopted was face-to-face interview of the garments workers. The mathematical and theoretical data are collected and developed to make this empirical research fruitful.

3.2 Research Approaches

A research approach is a plan of action that gives direction to conduct research systematically and efficiently. There are three main research approaches as (Creswell 2009): i) quantitative (structured) approach, ii) qualitative (unstructured) approach, and iii) mixed methods research. All researches must involve an explicit, disciplined, and systematic approach to find out most appropriate results. Our research falls in the third category. Researchers typically select the quantitative approach to respond to research questions requiring numerical data, the qualitative approach for research questions need textural data, and the mixed methods approach for research questions want both numerical and textural data (Williams 2007). The quantitative method supports the positivist paradigm, whereas the qualitative method also very closely supports to the naturalistic paradigm. In the past, quantitative research has been considered the more rigorous of the two, but recently qualitative has gained more credibility in the modern classic research. Both methods are appropriate for conducting research, and each method can contribute greatly to the scientific research. Also both have their strengths and weaknesses, and advantages and disadvantages; so that, 'neither one is markedly superior to the other in all respects' (Ackroyd and Hughes 1992).

Most of the research involves 4 p's as: people, problems, programs, and phenomena. In our research we have tried to include all of these to enrich our work. Our study is consists of both

positivistic and naturalistic paradigms. We have proved propositions and theorems, and provide mathematical examples to augment the research. In most of the cases of our research we have used mathematics as a tool of our research approach. Accordingly we have obtained our results in term of mathematics. We have also analyzed survey data on about 500 female garments workers of the CCC to develop WTP in the industrial sector of Bangladesh.

3.3 Focus of Research

My research has focused on problems in optimization, social choice, voting system, NNP and social welfare, reduction of environment pollutions, sustainable development, GHG emissions, and environment tax. The research strategy has been employed to identify important problems in the research area, and then find accurate solutions of them. The research is conducted both in the field to collect primary data to calculate WTP in the industry to provide medical facilities to the workers to increase productivity, and to collect secondary data to develop models and obtain mathematical solutions.

The research works of the thesis focused on the followings:

- To provide a mathematical basis for economics and social welfare, including the theoretical arguments for their application in this empirical research.
- To find the linkages between mathematics and economics based on sustainable development and social welfare.
- To set up a methodological framework to analyze the works for the sustainable development of the global economy.
- To present the empirical research results of the green accounting, environment pollutions and behavioral effects of environmental taxes.
- To explore how the environment pollution can be reduced for the welfare of humanity.
- To find out the ways how the GHG emissions can be reduced.

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3.4 Data Collection

Data refer to raw facts without any processing, organizing or analysis, and hence they have little meaning, and few benefits to the managers and decision-makers. They are un-interpreted materials on which a decision is to be based, and depend on facts which may include anything known to be true or exist. They are bits of content in either text or numerical format (sequences of numbers, letters, pictures, etc.). They are meaningless in themselves. They are indicated by a set of 'discrete intention details about events'. They are normally structured, but do not bear any information to use them in a particular context (Mohajan 2016).

Researchers can identify and use relevant data at the following stages of the data "life cycle" as (Osorio 2014): i) study concept, indicating key elements, definitions and concepts, ii) data collection, including questionnaires and coding instruments, iii) data processing, containing the data and specifying the content of the information, iv) data archiving, indicating procedures to guarantee the preservation of data and confidentiality, v) data distribution, indicating the terms of use and citation, vi) data analysis, providing replication codes and publications, and vii) data repurposing, indicating the procedures for post hoc harmonization and data transformation.

In the thesis we have used both the primary and secondary data to perform the job properly. This study focuses the collection and analysis of only two primary data, and some secondary data that are available from the qualitative and quantitative data collection processes. This thesis analyzes all the chapters with sufficient theoretical analysis and mathematical calculations to make it interesting to the readers. The models contain detail mathematical calculations to reflect the core concepts of the models. The results of the research are presented in some chapters in types of examples, propositions, and theorems with proof. So that future researchers can also develop them by identifying if there are lacks of skill in the thesis.

3.4.1 Primary Data Collection

Primary data are collected from the garments workers of the slum areas of the Chittagong City Corporation (CCC) of Bangladesh. Sample size of the study was 500. Furthermore, the surveys

data are given in the tables reflect the opinions of the garment workers for willing to pay (WTP) system in the industries of Bangladesh. In this study, interviews have been conducted on a one-to-one open-ended basis with a single participant, and scientific honesty is maintained for the validity of the data, that is, manipulation of design and methods were not applied in the research. To calculate the results we have used Statistical Package for Social Sciences (SPSS) 17.0. The SPSS is a commercial computer software package that has been used in research since the early 1960s. For the data analysis of the primary data various statistical techniques such as, mean, median, standard deviation, etc., have been used depending upon the requirements. In this survey anonymity and confidentiality were maintained strictly. The anonymity was censured by not disclosing the participants' name on the questionnaire and research reports. Confidentiality means that the information they provide will not be publicly reported in a way which identifies them. Finally, we can demand that ethical standards, reliability and validity of the data collection and statistical analysis were followed for the better result.

We have divided the sample into two sub-samples *A* and *B*. Sub-sample *A*, is asked about their WTP to avoid one or more additional days of symptoms for the next 12 months in the light of experience obtained in the last 12 months. Sub-sample *B*, is asked about their WTP to avoid 14 additional days of symptoms for the next 12 months.

3.4.2 Secondary Data Collection

At present, a lot of secondary data are being collected and archived by researchers all over the world for research that are becoming more widespread (Andrews et al. 2012). Secondary data are collected by someone else for his primary research purposes which provide basic research principles. The researchers who have limited time and resources, they can use the secondary data for their researches.

For the collection of secondary data we have used both published and unpublished data. Published data are collected from: i) various publications of the federal or local governments (e.g., census reports, annual reports and financial statements of companies, statistical statement, reports of government departments), ii) various publications of foreign governments or of

international bodies and their subsidiary organizations (e.g., UNO, IMF, World Bank, ILO, WHO, etc.), iii) various research reports are prepared by research scholars, universities, economists, etc., in different fields, iv) books of various authors, magazines, and newspapers, v) various sources from university libraries, vi) technical and trade journals, vii) websites, and viii) public records and statistics, historical documents and other sources of published information.

The unpublished data are collected from many sources. They are found in diaries, letters, unpublished biographies and autobiographies, and also from scholars and research workers, trade associations, labor bureaus, and other public/private individuals and organizations.

Secondary data are classified as 'internal or external' in terms of its source. Internal secondary data are information acquired within the organization where research is being carried out. On the other hand, external secondary data are obtained from outside sources. The two major advantages of using secondary data in the research are time and cost savings.

We have studied research works of various scholars in details during our research works. We have tried our best to present every chapter in some detailed mathematical techniques with some new concepts.

The analysis was undertaken to develop the skill of the techniques of mathematics in economics and social choice. In addition, this thesis includes two appendices to provide full satisfaction when one goes through the related topics.

The major advantages of analysis of secondary data are the cost effectiveness and convenience it provides. When good secondary data are available, researchers can utilize them for high quality empirical researches. These provide researchers with opportunities to work effectively to test new ideas, theories, frameworks, and models of research design (Smith 2008).

3.5 Research Design

The research design is the conceptual structure within which the research is conducted; it constitutes the blueprint for the collection, measurement and analysis of data. So the research design can be defined as a master plan for the determined methods, structure, and strategy of a research to find out alternative tools to solve the problems, and to minimize the variances (Kothari 2004). Research design 'deals with a logical problem and not a logistical problem' (Yin 2003).

It optimizes the validity of data for a given research problem. Research design is the overall configuration of a piece of research to gather good results from the collected data. We have used SPSS 17.0 to find our results of the survey data. In our study we have introduced some propositions, and prove them with mathematical procedures. We also provide sufficient examples to make the study easier to the readers. We have also displayed diagrams to describe the theoretical analysis and mathematical procedures efficiently. This mathematical economic research provides various aspects of economic theories, methods, and analysis to present in a coherent, logical, reliable, and useful manner. We have divided our research into seven sections as follows:

5.3.1 Mathematical Techniques in Optimization

Optimization is defined as an act, process, or methodology of finding fully perfect, functional, or effective as possible the best solution that can be applied to all the quantifiable problems. The general optimization problem consists of finding minimum cost or maximum profit of a quantified parameter, objective function, by varying design variables under given design constraints. Selection of an optimization method for a given problem depends on the following considerations (Wetter 2000):
- structure of the objective function (linear, non-linear, convex, continuous, number of local minima or maxima, etc.),
- availability of analytic first and second order derivatives,
- number of design variables, and

- design constraints.

In our optimization problem we have used the method of Lagrange multipliers in multivariable calculus, and have been used to facilitate the determination of necessary conditions which is considered as a device for transferring a constrained problem to a higher dimensional unconstrained problem. We have used sufficient conditions for implicit functions by considering the determinant of Jacobian matrix is negative, and the determinant of the Hessian matrix is positive. We have also used the above techniques to explain cost minimization of a competitive firm, output maximization of an agency subject to both linear and nonlinear constraints, and utility maximization subject to multiple constraints, such as, Cobb-Douglas production function. We have used twelve comparative statics to predict the situation of production and consumption. We have introduced three explicit models which satisfy the optimization conditions. In our study of optimization we have used detail mathematical analysis which satisfies necessary and sufficient conditions mentioned above.

3.5.2 Social Choice and Game Theory

Arrow's theorem shows that it is impossible for a social welfare function to satisfy five conditions namely: i) Completeness and Transitivity, ii) Universality, iii) Pareto Consistency, iv) Independence of Irrelevant Alternatives (IIA), and v) Non-dictatorship simultaneously (Arrow 1963). By the Arrow's theorem we have shown in the study that there is a flaw in democratic vote to reflect the preferences of all the individuals in the society. In this study we have shown both combinatorial approach and geometrical approach to Arrow's Theorem with mathematical analysis, and displaying a geometrical diagram. We have also discussed two simple versions of Arrow's Theorem for single-profile case only. To analyze these we have proved some propositions and theorems.

We have used the 'Battle of Sexes' game theoretic model to show how political institutions can be formed to elect democratic leaders, and how a patriotic leader can serve the country efficiently. We have tried to show the different aspects of unitary and federal democracies with their benefits and drawbacks by the use of mathematical techniques.

In a present dangerous perturbed world the main victim is innocent common people. We use Prisoners' Dilemma game to describe two rival countries' strategy for establishing a peaceful society in the world. We have shown that the war gives only violence and destruction. For example, Psychopathic militarists like Hitler become a threat to our civilization only when ordinary rational people become motivated to support them as leaders.

3.5.3 Research on Voting Procedures

In voting system every voter's preference ordering, taken collectively, form the input, the output is usually a single certain winner or a set of winners. Here we have discussed voting system, and manipulation of voting. We have discussed Condorcet method and Borda voting in brief. The single transferable vote (STV) is a system of preferential voting designed to minimize wasted votes. We have analyzed Droop Quota of STV, and tie-breaking in STV in mathematical model. We have discussed strategies under approval voting (AV) by a series of propositions with proof and examples. In median voter model we have analyzed along with single-peakedness and single-crossing properties with the illustrative examples, and displaying diagrams. Majority judgment voting and the majority count of Borda and their tie-breaking are discussed with providing examples and propositions.

3.5.4 Environmental Pollution and Healthcare

In our environmental economic model we consider the production of goods and services where we require labor, manufactured capital, and natural resources; and have stressed on the performance of environment policy, and sustainable use of natural capital (wetlands, lakes, forests, agricultural landscape, and coastal water). We have used mathematical techniques to obtain our results of the study. We have tried to highlight on environmental accounting and roles of economics by the sustainable development of wealth; and then have calculated green national accounts. We have calculated that environment pollution decreases economic development. We have developed the three terms of equation (8.25) in our own procedure. Healthy persons are the human asset of a country. We have discussed a mathematical model on the health impacts from

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air pollution in Bangladesh. We have also surveyed on about 500 female garments workers of Bangladesh to establish WTP for the improvement of the labor sector of the country. Finally, we have suggested the ways to develop the future labor sector of Bangladesh.

3.5.5 Research on Sustainable Development

Sustainability is a pioneer policy for the governments, international organizations, and corporations for the concerns over the climate change, environment degradation, and economic instability. The NNP is an important item for a country, and it represents the maximized value of flow of goods and services that are produced by the productive assets of the society. It is important to investigate whether the concept of NNP can serve as an indicator of sustainability (Weitzman 1976). We have used the mathematical tools to furnish this portion. Here we have mathematically shown that the real NNP in sustainable development by the optimal growth in the society, and growth without optimality. We have tried to show the green NNP for the sustainability and social welfare by using the mathematical relations on welfare equivalence income, sustainable income, net social profit, and wealth equivalence income. We have established following relations with sufficient mathematical calculations: i) between green NNP and wealth equivalent income, ii) between green NNP and net social profit, iii) between green NNP and welfare equivalent income, and iv) between green NNP and sustainable income. Then we have discussed global sustainable development in terms of global green economy, sustainable economy, showing discrimination in modern economy. Later, we have tried to find present unsustainable development practices and the recent economy of the world. Finally, we have tried to discuss in brief the open economy of Bangladesh. We have provided propositions to understand the effects of NNP for the sustainable social welfare clearly.

3.5.6 GHG Emissions and Reduction Procedures

A major part of the current world energy supply comes from fossil fuels: oil, coal, and natural gas. As a result, these non-renewable resources are being rapidly depleted. Due to their increased consumption; driven by economic and population growth in the dominating energy markets, it is estimated that the only fossil fuel remaining after 2042 will be coal (Raj and Singh 2012). On the

other hand, it is also widely accepted that the burning of fossil fuels releases GHGs which contribute to the global warming, and overall have a negative impact on the environment (IPCC 2007). The current concentrations of GHG in space have increased since 1750 (Industrial Revolution) due to human activities from a CO_2 equivalent of 280 ppm (parts per million) to 450 ppm, but proposed boundary is 350 ppm (Stern 2007, Mohajan 2015b). In this portion we have used theoretical analysis, and the statistical results of secondary data that are collected from the various survey data of other scholars. Actually we have not done any experiment to show the effect of GHG emissions. In our study we have stressed on the GHG emissions of the USA and China. Because, these two countries are in the leading position in GHG emissions, together emit about 40% of global CO_2 emissions, and about 35% of total GHGs. We have tried to show the effects of GHG emissions, and the ultimate fate of the living organisms. We have also shown the reduction policies of global GHG emissions. We have demanded that recent increase of natural calamities and climate change is due to global warming that is due to GHG emissions. These over natural calamities already diminished the global economic development and social welfare, and will also sloth the sustainable economic improvement. The production of renewable fuel should be increased to reduce GHG emissions.

3.5.7 Green Taxes on Environment Pollution

In the last part of the 20th century and in the beginning of the 21st century the area of cities of the world has expanded, and new cities and towns have grown rapidly. As a result in vehicle-miles traveled increases. Emissions from vehicles pollute air that worsened human health, diminishing visibility, and caused global warming (Fullerton and West 2002). Actual vehicle emissions depend not only on vehicle size and age, but also on qualities of the fuel, maintenance of the car's pollution control equipment (PCE), frequency of cold start-ups, temperature of the air, speed of the vehicle, and aggressive driving (Fullerton and West 2002).

For regulating GHG emissions, there are two policies; a cap and trade policy, and a carbon tax policy. Cap and trade is a quantity control policy, and carbon tax is a price control policy. Price increases through energy or carbon tax would be necessary to limit energy demand, and increase of GHG emissions (Stern 2007). We have given a brief discussion on these two policies. In the

two mathematical models we have calculated taxes on car and gasoline; one for homogenous consumers, and the other for heterogeneous consumers. We also show a detail mathematical analysis on second-best taxes on gasoline and size. Yet Bangladesh has not imposed emission taxes on vehicles properly. We have tried to encourage Government of Bangladesh to develop vehicle tax rates of Bangladesh to reduce environment pollution in the cities of this country. We have shown optimal environmental taxes due to health effect, and beneficial sides of environmental tax; and finally, optimal environmental tax to reduce GHG emissions, and to create a healthy environ in the society.

3.6 Two Criteria for Good Measurement

Measurement is the assigning of numbers to observations in order to quantify phenomena. There are two criteria for evaluating measurements in research: i) validity, and ii) reliability. These two criteria are the most important and fundamental characteristics of all researches. A research becomes good or poor depending, respectively, on the strength or weakness of these two aspects (Brink 1993). Before and after collecting the data, the researchers need to consider the validity and reliability of their data to do a good research. In our study we have tried to create reliable and valid tests and questionnaires in order to enhance the accuracy of their assessment and evaluations.

When we compare reliability and validity, latter is more essential. If a research is not valid, it is of course not reliable. But, to enrich our research we will try to show that our study will be both reliable and valid.

3.6.1 Validity in Research

Validity in research is alarmed with the accuracy and truthfulness of scientific findings (Le Comple and Goetz 1982). It is a very important feature in a measuring instrument. It refers to the methodological soundness or the appropriateness of the instruments used (Hashim et al. 2007). It is the ability of a measure to measure what is supposed to measure (Robson 2011). It indicates that how well the data collection, and data analysis of the research captures the reality being

studied (Mohajan 2017c). An important aspect of any research should always be the degree of validity present in the procedures and conclusions (Graziano and Raulin 2006). According to Burns (1999) "*Validity is an essential criterion for evaluating the quality and acceptability of research.*" According to Bond (2003) research validity is "*Foremost on the mind of those developing measures and that genuine scientific measurement is foremost in the minds of those who seek valid outcomes from assessment.*"

Campbell and Stanley (1963) have defined two major forms of validity that encompass the many types: i) internal validity, and ii) external validity. The both validities are important to the overall validity of the study. Internal validity refers to whether or not the manipulation of the independent variable really makes a true reflection or representation of reality on the dependent variable. In brief, it refers to whether a study can be replicated (Willis 2007). It is the extent to which factors influencing a true reflection of reality rather than the result of the effects of extraneous or chance variables, not necessarily related to factors influencing contraceptive non-utilization. It is mainly concerned with the congruence of the research findings with the reality. It also deals with the degree to which the researcher observes and measures what is supposed to be measured. External validity refers to the degree or extent to which representations or reflections of reality are legitimately applicable across groups. It is concerned with the applicability of the findings in other settings or with other subjects outside of the sample (Graziano and Raulin 2006).

We not only want to the findings to be due to the intervention, but we would also like to generalize those findings to a larger population (Wilson 2010). In our research primary data are collected in random open-ended questionnaires basis, and anonymity and confidentiality are strictly followed. We have tried to represent the true information for the data collection. Directly after the interviews we have compiled the data from interviews, and transformed them into precious information. The validity of the result has been discussed with my supervisors with valuable feedback. The secondary data are verified with mathematical calculations, illustrative examples, and propositions with proof. Most of the secondary data are collected from scholarly sources or reliable news sources, improving the accuracy and trustworthiness of this study. Therefore, we hope that in our study the results seem to us have of high validity.

3.6.2 Reliability in Research

One of the main requirements of any research process is the reliability of the data and findings. Reliability deals with the consistency, dependability, and replicability of the results of any research. It is an important concept in research because; it can be used to reduce errors during the analysis of responses to questionnaires (Neuman 2012). It indicates that the scores of an instrument are stable and consistent (Creswell 2009). Reliability coefficients range from 0 to 1, with higher coefficients indicates higher levels of reliability (Traub and Rowley 1991). Reliable data are dependable, genuine, trustworthy, sure, unfailing, authentic, and reputable (Mohajan 2017c).

Reliability is the strength of the quantitative research. It is the degree to which measures are free from error, and therefore, yield consistently the same results over repeated testing periods. It means that the operation of a study, such as, the data collection procedures, can be repeated with the same results every time. Therefore, it is concerned with the consistency, stability and repeatability of the informant's accounts as well as the researchers' ability to collect and record information accurately (Seltiz et al. 1976).

Hence, the researchers can develop scoring results by reliability to reduce measurement errors. For example, a tailor measuring fabric with a tape measure obtains a true value of the fabric's length. If he takes repeated measures of the fabric, and each time comes up with the same length, it is assumed that the tape measure is reliable. Therefore, reliability is the steadiness, constancy, and sureness of a measurement tool. We can assure that reliability is maintained throughout our research. Any researcher can depend on our works for the future research.

Many qualitative researchers avoid the terms validity and reliability, and use terms such as credibility, trustworthiness, truth, value, applicability, consistency and conformability for evaluating the scientific merit of qualitative research (Leininger 1991). Neutrality and trustworthiness in research increase the reliability and validity (Golafshani 2003).

Reliability does not imply validity. For example, while there are many reliable tests of specific abilities, not all of them would be valid for predicting. Reliability is a necessary, but not sufficient item of a research. For a test to be reliable, it also needs to be valid. For example, if a scale is off by 10 kg, it reads the weight every day with an excess of 10 kg. The scale is reliable because it consistently reports the same weight every day, but it is not valid because it adds 10 kg of true weight. It is not a valid measure of the weight. Reliability may be improved by clarity of expression, lengthening the measure, and other informal means. Psychometric analysis is considered the most effective way to increase reliability (Cortina 1993). It is possible to have reliability without validity, but it is logically impossible to demonstrate that an unreliable test is valid.

However, tests that are reliable are not always valid. For example, let a thermometer was a degree off. It would be reliable by giving the same results each time, but not valid because, the thermometer was not recording the correct temperature.

Because of the lack of time, and difficulties of collecting primary data, we have not had a possibility to conduct the survey study more than once. Therefore, it is difficult to draw any conclusions on the reliability of our survey results on the garments workers of CCC. But, in the mathematical calculations to establish propositions, prove theorems, provide examples, display diagrams, and prepare tables we have studied them several times. We hope that these studies are more reliable. Throughout this thesis a consistent and conscious effort was made to ensure that a high level of reliability was accomplished.

3.6.3 Threats to Validity and Reliability

The multiple factors can create risks to the validity and reliability of the findings of a researcher. Error is one of them. Researchers thus must be careful of the sources of errors in plans and implementation of their studies. The major sources of research errors can be obtained from the careless of researcher, the subjects participating in the study, the social context, and the methods of data collection and analysis. Errors of measurement that affect reliability are random errors, and errors of measurement that affect validity are systematic or constant errors. Threats to

research reliability and validity can never be totally eliminated, so a researcher needs to try his best to minimize the threats as much as possible (Mohajan 2017c).

3.7 Ethical Reflections

Ethic is an important characteristic in any research. In the study ethics are maintained by keeping the answers acquired strictly confidential. We have taken prior permission from the respondents before conducting the research, and no false information was given in the research. In the theoretical analysis we have given proper references in the research. We have maintained the ethical formalities throughout our research.

3.8 Conclusion

This chapter has provided an outline and description of the research methodology undertaken in the thesis, and how that is used to draw up the specific research plan for this study. In this chapter, we have presented the methodology that is used throughout the thesis. In this chapter we have mentioned the methodology section-wise that is used in our study. We have also discussed the choices of research methods, and validity and reliability of the thesis.

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