Non-parametric Estimation of the Effect of Financial Crisis on Swedish Local Governments Debt Maturity Structures

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Semester and year: Autumn 2019
Degree Project: 2nd Cycle, 15 Credits
Subject: Applied Statistics, Independent Project (ST - 413A)
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I would like to express my gratitude to my supervisor, Assistant Professor Dr. Stepan Mazur whose guidance and encouragement has greatly helped me to accomplish this thesis. I would like to thank my examiner Assistant Professor Dr. Farrukh Javed for scrutinizing my thesis paper and providing helpful recommendations. Finally special thanks to David Knezevic and Mattias Bokenblom of Kommuninvest I Sverige AB for their suggestions and guidance.
Abstract

Swedish municipalities borrow from Kommuninvest, banks and bond markets for short-term while investing in projects on long-term. This strategy causes asset-liability mismatch which could lead to roll-over risk. The financial crisis of 2008-09 turns the market illiquid and when a considerable proportion of total loans is matured in the period of the illiquid credit market, the borrower’s ability of repaying the loans shrinks that could result in bankruptcy in extreme circumstances. Knezevic [2018] developed a fixed effect linear regression model to estimate the effect of the financial crisis of 2008-09 on intertemporal diversification of debts. According to his results, financial crisis had a positive correlation with the Swedish municipalities debt maturity structure. In this thesis, we tested the assumptions of fixed effect linear regression model proposed by him. Furthermore, in contrast to the fixed effects linear regression model, we estimated the effect of financial crisis on debt maturity structures utilizing an alternative non-parametric approach known as matching. We estimated the average treatment effect, i.e. the effect of financial crisis using matching on covariates and propensity score matching. Our results also suggest that the financial crisis indeed positively effected the intertemporal diversification measures.
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Chapter 1

Introduction

In this chapter, we introduce the objective of this thesis project. Furthermore, a brief introduction of the risks associated with short-term loan maturity and asset-liability mismatch followed by relevant terminology are discussed.

1.1 Introduction

Swedish local governments (municipalities and county councils/regions) and their subsidiaries borrow from Kommuninvest, banks or by directly issuing bonds in capital market to invest in the public sector in order to provide services to the inhabitants. A few examples of these types of investments could be the establishment of schools, hospitals, housing, public transport etc. In general, these loans are borrowed for short-term, usually on an average of 2 to 2.5 years whereas the investments are made on long-term projects, typically on average of 20 years. This mismatch in the period of time between borrowing and investing causes mismatch in asset-liability structure. Note that, the mismatch in asset-liability is highly correlated with the rollover risk [Bologna, 2018]. Rollover risk refers to the situation when a borrower is in risk of paying higher interest expenses because of rolling over to a new loan. If the interest rate increases in future, the borrower would have to pay higher interest expenses because of refinancing. The global financial crisis of 2008-09 caused major trouble for short-term borrower due to the fact that the credit market turned illiquid during this period. When considerable proportion of total loans is matured in the period of the illiquid credit market, the borrower’s ability of repaying the loans shrinks that could result in bankruptcy in extreme circumstances [Diamond, 2007]. If we consider a debt portfolio of a Swedish municipality that is more scattered in terms of maturity of its loans, it is likely that the municipality will be able to sustain such extreme situations like the financial crisis of 2008-09 more comfortably since a smaller portion of the loans is going to be matured during this period. Such a debt management strategy is commonly known as the intertemporal diversification of debts.

Knezevic [2018] developed a fixed effect linear regression model to estimate the effect of the financial crisis of 2008-09 on intertemporal diversification of debts. Five different measures of intertemporal diversification of Swedish local governments debt were proposed namely, Weighted Standard Deviation of Time to Maturity, Interquartile Range of Time to
Maturity, Weighted Mean Interquartile Range of Time to Maturity (I & II) and Weighted Mean of Time to Maturity. These five estimates were used as the dependent variable on five different models while the financial crisis variable and macroeconomic features such as market liquidity, interest rates along with other financial features were utilized as the independent variables.

In this thesis, we are interested in testing the assumptions of fixed effect linear regression model. We utilized the models developed by Knezevic [2018] to demonstrate several important assumptions regarding linearity, independence, multicollinearity, serial correlation, and homoscedasticity. Furthermore, in contrast to the fixed effects linear regression model, we estimated the average treatment effect utilizing matching on covariates and propensity score matching [Wooldridge, 2010; Abadie and Imbens, 2016].

### 1.2 Relevant terminology

Asset-liability management ensures that a company properly manages its asset and cash flows such that any financial loss from not repaying the liability on time can be avoided. It is mostly related to the timing of cash flow to repay the liabilities in due time. Thus, a well-defined asset-liability management can be seen as having enough assets on time to repay the liabilities on time. For instance, if we consider that a Swedish municipality borrowed a single loan from a bank for a period of two years but invested that fund in a long-term project say, ten years then this will cause asset-liability mismatch since the cash flow from the investment will take much longer time than the time left to repay the loan with interest. However, since Swedish municipal sectors are based on strong economy, it was not a major problem until the global financial crisis of 2008-09 which turned most of the assets into illiquid state. Illiquid state of an asset refers to the situation when a company is unable to sell its assets easily or without a considerable loss. Furthermore, a company is in the illiquid state when it is unable to have adequate cash inflow to repay its debts. During the financial crisis, the commercial banks decided to lower their risk-taking which resulted in lower amount of funding in public sectors. As an alternative, local governments in Sweden focused their attention on Kommuninvest to fund their investment projects and since then Kommuninvests’ percentage of market share in public sector investment has increased. By jointly issuing bonds in capital markets Kommuninvest collects the fund and lends it to the municipalities to meet the investment requirements of Swedish local governments. However, the trend of borrowing short-term loans by the Swedish local governments still exists and in many case, these loans are refinanced. If the interest rate increases in future, local governments will be needed to repay higher amount due to refinancing. That is, rollover risk is still present in Swedish public sector financing.

In Knezevic [2018], it is shown that per capita income, financial ratios, tax base volatility, debt-to-tax base ratio, market illiquidity, interest rate including political factor such as election have statistically significant effect on Swedish local governments borrowing strategy. According to his findings, however, this effect did not last long. The author argued that, since municipalities and local governments cannot use their asset as collateral to take up loans and vital portion of their assets comes from tax revenue which varies a lot over time, a well-planned intertemporal diversification of their loans could be an alternative to deal
1.3. THESIS STRUCTURE

Figure 1.1: Short-term borrowings by municipalities and county councils and long-term investments in public sectors could cause asset-liability mismatch.

with liquidity risks. A simpler explanation of intertemporal diversification is that, instead of having higher number of loans with maturity dates close to each other, municipalities can take large number of loans with relatively smaller amount and the maturity structure of these loans should be scattered. In such a way, a smaller number of loans, and thus smaller amounts will be needed to repay at a time which in turn will reduce the risk of refinancing.

1.3 Thesis structure

In chapter 2, we briefly discuss the Swedish government administrations, functions of Kommuninvest, investment and loan scenarios of Swedish local governments, basic concepts of causal inference and intertemporal diversification measures proposed by Knezevic [2018]. In chapter 3, we introduce the assumption of fixed-effects linear regression models and statistical methods used to test these assumptions. The data used in this thesis are described in chapter 4. We present our analysis and findings in chapter 5 and finally, in chapter 6, we draw our conclusion regarding the analysis and discuss the possibility of future research.
Chapter 2

Background

In this chapter, we focus on Swedish government administrative structure, functions of Kommuninvest as well as the debt scenarios of the Swedish local governments. In addition, we utilized the intertemporal diversification measures developed by Knezevic [2018] as well as the basic concepts of causal inference.

2.1 Swedish government administration

Sweden has a tradition of decentralization of public administration and it was regulated in the 1862 Local Government Ordinance [Ministry of Finance, 2005]. Swedish public sector is divided into three levels: state, regional/county and municipal. Because of decentralization, regional and municipal authorities are responsible for providing public services as well as decision making. At present, municipal and county governments are dispensing two-thirds of total public services [Standard and Poor’s, 2011]. Regional and municipal authorities have the autonomy when it comes to taking important decisions in various areas. For instance, the local governments have the freedom of imposing tax rates. This self-governance of municipalities and regions is being a part of constitution since 1974 [Ministry of Finance, 2005]. Satisfying the legal and constitutional requirements they can resolve the means of providing the required public services to the residents.

The Swedish parliament, Riksdag, dictates the legal framework regarding the activities of municipalities and counties. The state government supervises the municipal and regional governments through government agencies, however, the government agencies are not authorized to postpone any of local government’s decision [Ministry of Finance, 2005]. The local government act, 1992 regulates the activities of the municipalities and regions including the financial administration. In some cases, local governments have the constitutional rights to impose their own local regulations. This illustrates the implementation of self-governance of the local authorities incorporating the economic freedom and financial stability for all of the municipalities and regions. The municipal assembly and county council assembly are the elected authorities responsible for taking important decisions including setting up budgets, tax rate etc. In addition to the assembly, the municipalities and county councils form an executive committee and crisis management committee [Ministry of Finance, 2005]. Financial administration also falls on the domain of functions of the executive committee and they act
2.1. SWEDISH GOVERNMENT ADMINISTRATION

<table>
<thead>
<tr>
<th>No.</th>
<th>Compulsory</th>
<th>Voluntary</th>
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<tr>
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<td>Public transport</td>
<td>Health and care</td>
<td>Culture</td>
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<td>Energy supply</td>
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<td>Tourism</td>
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<td>4</td>
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<td>Business development</td>
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<td>Sanitation and waste</td>
<td>Housing construction</td>
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<td>6</td>
<td>Water/sewerage</td>
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<td>7</td>
<td>Emergency services</td>
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<tr>
<td>8</td>
<td>Library operations</td>
<td></td>
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<tr>
<td>9</td>
<td>Crisis contingency planning</td>
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<tr>
<td>10</td>
<td>Housing provision</td>
<td></td>
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</tbody>
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1 Each municipality should construct at least one public library.

Table 2.1: Distribution of responsibilities of municipalities and county council/regions. Retrieved from Kommuninvest [2018c]

Local governments have the authority to decide the means of providing public services. For instance, they can choose limited companies or voluntary organizations to dispense specific public services. Majority of the state-owned enterprises are participating in basic industry/energy sector (43%) and property sector (12%) [Government offices of Sweden, 2018]. Furthermore, local governments can follow their own international policy. For instance, they can avail funds for participating in joint projects with other countries [Ministry of Finance, 2005].

Local governments are responsible for carrying out public activities by maintaining macroeconomic balance. In addition to considerable changes to the system of state grants in 1993 and 1996, local government financial equalization was implemented in 1st January 2005 such that the local governments can perform their activities with financially solvent manner. In addition, since 2000, according to Local Government Act, it is required to have a balanced budget. This means that the expense should be less than income [Ministry of Finance, 2005; O’sullivan and Sheffrin, 2003]. However, with reasonable causes, it is practicable to have a budget with deficit but the deficit should be mitigated within the next two years. According to the Local Government Act, maintenance of sound financial management by local governments is a major requirement. One feature of sound financial management is that the local authorities should meet their contemporary costs through contemporary revenues.

Local government financial equalization system that incorporates revenue equalization and cost equalization was introduced in 1st January 2005. Municipalities and county councils are eligible to utilize separate equalization systems. Municipalities and county councils
2.2 Kommuninvest

Kommuninvest of Sweden is a local government funding agency with the mission of providing municipal and regional government financial support in the form of loans. Local governments need access to the capital market to invest in various sectors such that they can improve and continue their services to the inhabitants. For example, a municipality needs funds for building hospitals, schools, recreational centers, housing etc. Kommuninvest provides favorable loans to its members (municipalities & country councils/regions) such that they can
2.2. KOMMUNINVEST

continue building these infrastructures or providing the services. At present Kommuninvest is the largest lender to the local government sector and accounts for more than 40% of local government sector borrowings [Kommuninvest, 2018b].

By jointly issuing bonds in Europe, Japan, and other countries, the municipalities and regions gain access to the capital market through Kommuninvest. Since a single municipality/region has limited capability of accessing the capital market, the cooperation built by joint issuance of the bonds through Kommuninvest gives all municipalities and regions higher capability of taking loans. The capital that Kommuninvest gathers through the issuance of bonds is loaned out to the municipalities and regions on favorable interest rate. Unlike other financial institutions like banks, Kommuninvest does not seek for profit. The main purpose of Kommuninvest is to provide loans to the local governments with the lowest possible interest rate in long-term conditions [Kommuninvest, 2018b].

In order to gain access to capital market for borrowing with favorable terms, Kommuninvest was established in 1986 with 9 municipalities and regions of Örebro county. Its unique and cost-efficient idea of borrowing attracted other local authorities to become a member.

Since 1992, Kommuninvest consists of Kommuninvest Cooperative society, a membership organization with municipalities and county councils as the members and Kommuninvest I Sverige AB, a wholly-owned credit market company [Kommuninvest, 2018d]. As of June 2018, 277 municipalities and 11 regions are the members of Kommuninvest Cooperative society and Kommuninvest I Sverige AB is owned and directed by its’ members.

Since its establishment, Kommuninvest has proved itself as a dependable and creditworthy entity to both the investors and borrowers. Internationally recognized credit agencies like Moody’s and Standard & Poor’s have rated Kommuninvest as Aaa/AAA, which is the highest possible rating. According to the law, municipalities and regions cannot be declared bankrupt or cease to exist. In addition, local governments can levy taxes on financial activities which strengthen their ability of repaying loans. All these factors make Kommuninvest a highly reliable financial institution resulting in high attraction from investors around the world. Additionally, Kommuninvest is supervised by Finansinspektionsen (the Swedish Financial Supervisory Authority) and a member of Riksbank’s RIX payment system.

As of 30th June 2018, Kommuninvests’ lending portfolio of 331 Billion SEK is distributed as the following- municipalities 41%, municipal housing companies 30%, municipal energy company 6%, other municipal company 22% and county councils/regions 1% [Kommuninvest, 2018a]. In general, municipalities and regions finance their loans from three different sources, namely, Kommuninvest, Banking sector and bond markets. Since 2000, borrowings through Kommuninvest have increased substantially while due to rigid financial regulations and economic recession, the landing capability of the banks decreased gradually. At the end of December 2017, Kommuninvest accounted for 50% of public sector loan financing in contrast to 18% by banks and 32% by local authorities own bonds, commercial paper programme [Kommuninvest, 2017].
2.3 Investments & loans of Swedish local governments

According to Kommuninvest [2018c], the need for capital in healthcare and education sector will increase in coming years due to the fact that the working age population will increase slowly compared to non-working age population. This will result in a slow increase in tax revenue for municipalities and regions while at the same time cost will gradually increase. Thus, to provide the necessary services to the inhabitants local governments may have to increase the tax rate or employment rate or borrowings from financial institutions and bond markets or a combination of all of these three factors.

![Borrowings of municipalities from different sources between 2013-2017](image)

Figure 2.2: Borrowing distribution of municipalities between 2013-2017 from three different sources Kommuninvest, banks and bond market. The percentage of amount borrowings from Kommuninvest and market programme is increasing whereas a decreasing trend can be observed for the banks. Source: Kommuninvest [2018c]

In 2017, the total investment of 165.3 billion SEK in public sectors by municipalities, county councils, and their subsidiaries can be decomposed as - municipalities 61.2 billion SEK, municipal companies 72.2 billion SEK, county councils and their companies 31.9 billion SEK.
SEK. Comparing to investments of 2016, this represents a 16% increase by municipal groups (municipalities and municipal companies) and 8% increase by county council groups (county councils and county council companies).

Of total investments by municipalities, 56% were associated with properties and housing in contrast to 21% in infrastructure, 9% in water and sewerage systems, 9% in energy and 6% in other sectors. County councils invested 52% in properties, 25% in infrastructure, 16% in medical equipment, 3% in public transport and 3% in other sectors.

Total borrowings by municipalities and county councils in 2017 summed up to 601.1 billion SEK, a 4.2% rise compared to 2016. The average borrowing per inhabitant was 59,400 SEK, an increase by 1,600 SEK compared to 2016.

Of the total borrowing of SEK 601.1 billion, 51% was financed via Kommuninvest, 32% was financed directly by issuing bonds and other securities to capital market and the remaining 17% was borrowed from the banks. There is an increasing trend of borrowing from Kommuninvest in contrast to a negative trend of borrowing from banks. Approximately 100 billion SEK has been borrowed from banks, a 17% decrease compared to 2016. 88% of loans of members of Kommuninvest who are borrowing less than 6 billion SEK are financed by Kommuninvest while it is 29% for the members borrowing more than 6 billion SEK. Non-member of Kommuninvest are mostly borrowing directly from the capital market.
Two patterns can be observed when local government sector actors are borrowing. The first one is fixed interest rate with short-maturity of loans and the second one is floating interest rate with long-maturity of loans using a derivate, usually swap rate to reduce the interest rate sensitivity over time. Out of 308 billion SEK loan financed by Kommuninvest, 57% were borrowed with floating rate, usually 3-month STIBOR (Stockholm Interbank Offered Rate).
2.4 Intertemporal diversification measures

Swedish municipalities and county councils borrow loan in short-term periods while investing in public sector for long-term periods. This results in an asset-liability mismatch and thus increase the probability of rollover risk. Rollover risk refers to the situation when a borrower is in risk of paying higher interest expenses because of rolling over to a new loan. If the interest rate increases in future, the borrower would have to pay higher interest expenses because of refinancing. Knezevic [2018] analyzed the effect of the financial crisis of 2008-09 on various measures of debt maturity structures of Swedish municipalities and county councils. Using the data of issued loans by Kommuninvest from 1997 to 2016, these measures were created and then used as the dependent variable in fixed effect multiple linear regression models. Several macroeconomic variables are used as the explanatory variable in the models.

The regression models were fitted for \( i = 1, 2, \ldots, N \) municipalities over the periods \( t = 1, 2, \ldots, T \) as following,

\[
y_{i,t} = v_i + m'_t \beta_1 + x'_{i,t} \beta_2 + z'_t \beta_3 + u_{i,t},
\]

(2.1)

where

- \( m'_t \) is a 2-dimensional row vector of time-variant crisis variables;
- \( x'_{i,t} \) is a 3-dimensional row vector of fiscal control variables;
- \( z'_t \) is a 6-dimensional vector composed of interest rate and other time-variant controls;
- \( v_i \) is the municipal fixed effects;
- \( u_{i,t} \) is the idiosyncratic error terms.

To represent the intertemporal diversification of loans of Swedish local governments and subsidiaries, Knezevic [2018] developed five different measures of debt maturity structures. These measures are discussed below.

1. Weighted Standard Deviation of Time to Maturity:

\[
\sigma_{i,t} = \sqrt{\frac{N_{i,t}}{N_{i,t} - 1} \sum_{j=1}^{N} w_{i,t,j} (M_{i,t,j} - M_{i,t})^2},
\]

(2.2)

where \( M_{i,t} = \frac{\sum_{j=1}^{N} w_{i,t,j} M_{i,t,j}}{\sum_{j=1}^{N} w_{i,t,j}} \) and \( w_{i,t,j} = \frac{P_{i,t,j}}{\sum_{j=1}^{N} P_{i,t,j}} \).

For municipality \( i \) and at time point \( t \), \( \sigma_{i,t} \) represents the standard deviation of time to maturity. \( N_{i,t} \) is the number of active loans. \( M_{i,t,j} \) represents time to maturity of an active loan \( j \) of municipality \( i \) whereas weighted mean time to maturity for all active loans in the portfolio is \( M_{i,t} \). \( P_{i,t,j} \) is the principal amount of loan \( j \) and sum of weights \( \sum_{j=1}^{N} w_{i,t,j} \) is one.
2.4. INTERTEMPORAL DIVERSIFICATION MEASURES

2. Interquartile Range of Time to Maturity (IQR):

\[ IQR_{i,t} = Q_3\{M_{i,t,1}, \ldots, M_{i,t,n}\} - Q_1\{M_{i,t,1}, \ldots, M_{i,t,n}\} \]
\[ = P_{75}\{M_{i,t,1}, \ldots, M_{i,t,n}\} - P_{25}\{M_{i,t,1}, \ldots, M_{i,t,n}\}. \] (2.3)

Equation 2.3 represents the difference in time to maturity between 3\(^{rd}\) and 1\(^{st}\) quartile, alternatively, the difference in time to maturity between 75\(^{th}\) and 25\(^{th}\) percentile.

3. Weighted Mean Interquartile Range of Time to Maturity (WMIQR (i),(ii)):

\[ WMIQR_{i,t} = \sum_{M \in A} w_{i,t}^1 M_{i,t} - \sum_{M \in B} w_{i,t}^2 M_{i,t}. \] (2.4)

Equation 2.4 is the range between two weighted means. Two measures were estimated for this equation. First measure, WMIQR (I) includes 25\(^{th}\) highest and lowest observation for range calculation while for the second measure, WMIQR (II) all loans were considered to measure the range.

4. Weighted Mean of Time to Maturity:

\[ \mu_{i,t} = \frac{\sum_{j=1}^{N} w_{i,t,j} M_{i,t,j}}{\sum_{j=1}^{N} w_{i,t,j}}. \] (2.5)

To portray the frequency of refinancing the loan of municipality \(i\) at time point \(t\), weighted mean time to maturity \(\mu_{i,t}\) was calculated.

In Knezevic [2018] exploratory data analysis, the mean time to maturity for all loans was found as 2.201 years whereas the mean weighted time to maturity was 2.210 years.

Variables introduced as the explanatory variables in equation 2.1 are as following,

1. Financial crisis variables;
2. Fiscal control variables;
3. Financial ratios;
4. Interest rate control variables;
5. Financial market liquidity;
6. Election control variable.

Finally, according to his analysis financial crisis had statistically significant impact on debt maturity structures of Swedish local government and subsidiaries. Results are presented in appendix figure B.1.
2.5 Treatment effects

In this thesis, we want to estimate the effect of the financial crisis of 2008-09 on Swedish local government loan maturity structures. Here financial crisis can be considered as treatment and the loan maturity structures as the response variable. In the following, we briefly go through the basics of treatment effect analysis.

In treatment effect or causal effect analysis, we are interested in knowing the effect(s) of a treatment on the dependent (outcome) variable $y_i$, where $i = 1, 2, \ldots, N$. For example, we can observe the effect of education on earnings or the effect of exercise on blood pressure. In the former case, education can be considered as the treatment and earnings as the dependent variable while in the second case, exercise and blood pressure are treatment and dependent variable respectively.

To observe the difference in outcome variable $y_i$, we can compare two individuals, the one who is receiving the treatment and the one who is not. Other than the treatment status (i.e., receiving treatment or not), if the two observed individuals are identical, the difference in outcome variable can be regarded as the treatment effect. For each individual, we will observe only one outcome and we refer it as observed outcome while the unobserved outcome is known as counter-factual. Note that, it is impossible to find two identical individuals varying only in treatment status at the same point in time, thus we won’t be able to estimate the treatment effect in this way. In such a case, we can estimate the treatment effect in two different ways:

1. We can compare two groups of individuals with similar characteristics but different treatment status (treated or untreated).

2. We can compare two groups of individuals with treatment status and adjust the differences in their characteristics, which is known as control for covariates.

For each individual $i$, the potential outcomes are $y_{ij}$, where $j = 1$ in the presence of treatment and 0 in the absence. Then for in individual $i$, the treatment effect can be defined as $y_{1i} - y_{0i}$ and such a treatment effect is known as counterfactual causality. The treatment is a dummy variable $d_i$, for $i-th$ individual and takes value 1 in the presence of treatment and 0 otherwise. In that case, the observed outcome can be defined as,

$$y_i = d_i y_{1i} + (1 - d_i) y_{0i}.$$  

The group of individuals receiving the treatment, i.e. $d_i = 1$, is called the treatment group and the group without the treatment, i.e. $d_i = 0$, is the control group.

Since we are unable to observe both $y_{0i}$ and $y_{1i}$ for the same individual, the individual treatment effect $(y_{1i} - y_{0i})$ is not identifiable. However, we can observe some aspects of $y_1 - y_0$ distribution such as average treatment effect (ATE) $E(y_1 - y_0)$, median treatment effect $Med(y_1 - y_0)$, $\alpha$-quantile treatment effect $Q_\alpha(y_1 - y_0)$. The most popular one is the ATE which states that,

$$E(y_1 - y_0) = E(y_1) - E(y_0).$$

That is, the average treatment effect can be estimated from the averages of the treatment and control groups.
### 2.5. TREATMENT EFFECTS

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<th>Control Group</th>
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<td>d = 1 ) (Observed)</td>
</tr>
<tr>
<td>untreated</td>
<td>( y_{0i}</td>
<td>d = 1 ) (Counterfactual)</td>
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</tbody>
</table>

Table 2.2: Observed and counterfactual outcomes categorized in Treatment and Control groups.

When the observed outcome \( y_0 \) and \( y_1 \) are mean-independent of \( d \), then

\[
E(y_j | d) = E(y_j), \quad j = 0, 1.
\]

Under the mean independence, the average treatment effect can be expressed through group-mean differencing [Lee, 2005]

\[
E(y | d = 1) - E(y | d = 0) = E(y_1 | d = 1) - E(y_0 | d = 0) = E(y_1) - E(y_0) = E(y_1 - y_0) \equiv ATE.
\]

We can also estimate the conditional average treatment effect \( E(y_1 - y_0 | x) \) upon fulfilling the following two assumptions for all \( x \):

1. Overlapping \( x : 0 < P(d = 1 | x) < 1 \), i.e. some individual from treatment and control group share same values of \( x \).
2. \( x \)-conditional mean-independence of \( d \) from \( y_j : E(y_j | d, x) = E(y_j | d) \), \( j = 0, 1 \).

Under these two conditions, conditional ATE \( E(y_1 - y_0 | x) \) can be estimated from the conditional group mean differences

\[
E(y | d = 1, x) - E(y | d = 0, x) = E(y_1 | d = 1, x) - E(y_0 | d = 0, x) = E(y_1 | x) - E(y_0 | x) = E(y_1 - y_0 | x).
\]

To explain the effect of \( d_i \) on \( y_i \), we need to consider whether observables \( x_i \) and unobservables \( \epsilon_i \) are affecting \( d_i \) or \( y_i \) or both. If \( x_i \) and \( \epsilon_i \) differ across \( i \), the extent of the effect of \( d_i \) on \( y_i \) is not identifiable. Thus controlling for \( x_i \) and \( \epsilon_i \) that varies across different \( i \) is crucial in treatment effect analysis. When treatment \((T)\) group differs from control \((C)\) group in \( x \), then \( E(y | d = 1) \neq E(y | d = 0) \) is probably due to the variation in \( x \), not in \( d \). Situations when differences in \( x \) contributes to \( E(y | d = 1) \neq E(y | d = 0) \) we experience overt bias. Similarly, when differences in \( \epsilon \) contributes to \( E(y | d = 1) \neq E(y | d = 0) \) we experience hidden bias. In treatment effect analysis, we control for \( x \) to remove the overt bias while to remove hidden bias we control for \( \epsilon \).

If \( E(y_j | d) \neq E(y_j) \), the group mean difference cannot be accepted as the treatment effect. We can portray this problem with the following regression model where potential outcomes are expressed as,
2.5. TREATMENT EFFECTS

\[ y_1 = \alpha_1 + x'\beta_1 + u_1, \text{ where } E(u_1|x) = 0 \]

and \[ y_0 = \alpha_0 + x'\beta_0 + u_0, \text{ where } E(u_0|x) = 0 \]

Then the individual treatment effect becomes,

\[ y_1 - y_0 = \alpha_1 - \alpha_0 + x'(\beta_1 - \beta_0) + u_1 - u_0. \]

And the average treatment effect is,

\[ E(y_1 - y_0) = \alpha_1 - \alpha_0 + E(x')(\beta_1 - \beta_0). \]

Depending on treatment status \( d \), the average outcomes take the form,

\[ E(y|d = 1) = \alpha_1 + E(x|d = 1)' \beta_1 + E(u_1|d = 1), \]

\[ E(y|d = 0) = \alpha_0 + E(x|d = 0)' \beta_0 + E(u_0|d = 0). \]

Then the group mean difference \( E(y|d = 1) - E(y|d = 0) \) is,

\[ \alpha_1 - \alpha_0 + E(x|d = 1)' \beta_1 - E(x|d = 0)' \beta_0 + E(u_1|d = 1) - E(u_0|d = 0) \]

\[ = \underbrace{\alpha_1 - \alpha_0 + E(x)'(\beta_1 - \beta_0)}_{\text{ATE}} + \underbrace{E(u_1|d = 1) - E(u_0|d = 0)}_{\text{Hidden Bias}}. \]

\[ + \underbrace{[E(x|d = 1) - E(x)]' \beta_1}_{\text{Overt Bias}} - \underbrace{[E(x|d = 0) - E(x)]' \beta_0}. \]

In the equation 2.6, if the observed variables \( x_i \) are balanced across T and C groups, i.e. \( E(x|d) = E(x) \), overt bias will no longer exist. Similarly, hidden bias will disappear if the unobserved variables \( u_j \) are balanced in the terms \( E(u_1|d = 1) = E(u_0|d = 0) \) [Lee, 2005].

We can remove the overt bias by using conditional group mean difference conditioned on \( x \):

\[ E(y|d = 1, x) - E(y|d = 0, x) \]

\[ = \underbrace{\alpha_1 - \alpha_0 + x'(\beta_1 - \beta_0)}_{\text{Conditional ATE}} + \underbrace{E(u_1|d = 1, x) - E(u_0|d = 0, x)}_{\text{Hidden Bias}}. \]

If the dimension of \( x \) is large or if \( x \) takes too many different values then overlapping in \( x \) across \( T \) and \( C \) will be limited and this will result in difficulties in estimating equation 2.7.

By using parametric assumptions in above equation, we can avoid the dimension problem in \( x \). Then the linear regression model will take the form

\[ y = \alpha_0 + x'\beta_0 + \gamma_1 d + dx'\gamma_2 + \epsilon, \]

where \( \gamma_1 \equiv \alpha_0, \gamma_2 \equiv \beta_1 - \beta_0, \) and \( \epsilon \equiv u_0 + d(u_1 - u_0). \)
2.6 ATE estimation using matching

The parametric models such as fixed effects linear regression models rely on properly specified functional form. As such, the proper implementation of this method depends on data generation process and other assumptions of fixed effects model. If the functional form is not well specified (e.g. model with omitted variables, wrong functional form) then the resulting coefficients could be misleading. In such a case, we can implement a non-parametric method known as 'Matching', to estimate the average treatment effect. This method is less subject to model specification error since it does not depend on functional form.

2.6.1 Matching on covariates

In this approach, we match covariates $x$ for Treatment (T) and Control (C) groups to observe the effect of treatment $d$ on outcome $y$. But if the covariates $x$ differ significantly across T and C group, one approach is to select subjects that share the same (or similar) values of $x$ across T and C. The values of the covariates of comparison group $C_i$ for treated individual $i$ should be as close as possible to $x_i$. If the dimension of the covariates is high or contain too many values we can match small neighborhood of $x_i$. An alternative solution to dealing with dimension problem is to use the propensity score matching, which we discuss in the next subsection 2.6.2.

For each treated individual, resemblance of a control to treated can be estimated using Mahalanobis distance [Mahalanobis, 1936] as

$$(x_i - x_m)'C_N^{-1}(x_i - x_m),$$

where

- $m = \text{indexes of C group}.$
- $C_N = \text{Sample covariance matrix for } x \text{ using either T or C that is positive definite}.$

An alternative to Mahalanobis distance was proposed by Rosenbaum [1991] as,

$$\sum_{j=1}^{k} |q_{ij} - q_{mj}|$$

where,

- $j = 1, ..., k$ is pooled sample.
- $q_{ij} = \text{rank of } j\text{-th component } x_{ij} \text{ of } x_i \text{ in pooled sample}.$
- $q_{mj} = \text{rank of } j\text{-th component } x_{mj} \text{ of } x_m \text{ in pooled sample}.$

Note that, the treatment group is similar before and after the matching process whereas the control group after matching is different from control group before matching.

Once all treated subjects are matched with control subjects, we need to evaluate the matching success and it can be done in two ways: at individual level and at aggregate level.
At individual level, we evaluate the similarity of the comparison group to its matched treated unit in terms of \( x \) whereas, at aggregate level we evaluate the balanced \( x \) is across T and C groups. The former can be referred as 'distance' and latter as 'balance'.

Evaluation at individual level can be done by estimating average absolute imbalance after matching for \( j \)-th component of \( x_i \) as [Lee, 2005],

\[
M_{[j]} = \frac{\sum_{i \in T} |x_{ij} - |C_i|^{-1} \sum_{m \in C_i} x_{mj}|1[C_i \neq \emptyset]}{\sum_{i \in T} 1[C_i \neq \emptyset]}.
\]

Note that, \( M_{[j]}, j = 1, ..., k \) can be summed up for \( x_i \).

Similarly, average imbalance after matching at aggregate level for \( j \)-th component of \( x_i \) can be observed as,

\[
M_{(j)} = \frac{\sum_{i \in T} (x_{ij} - |C_i|^{-1} \sum_{m \in C_i} x_{mj})1[C_i \neq \emptyset]}{\sum_{i \in T} 1[C_i \neq \emptyset]}
\]

and \( M_{(j)}, j = 1, ..., k \) can be summed up for \( x_i \).

Note that, having similar \( x_i \) across T and C group does not ensure succesful matching. The eventual objective is to find a control group with zero comparison group bias, i.e.

\[
E(y_0) = E(y_0|d = 0) = E(y_0|d = 1).
\]

### 2.6.2 Propensity score matching

In this approach, we match each treatment unit with control unit that has a similar probability or propensity of being treated. Propensity score can be defined as,

\[
\pi(x) \equiv P(d = 1|x) = E(d|x).
\]

In this method, we compute \( \pi(x) \) for both groups and match only on \( \pi(x) \) to estimate the average treatment effect.

In subsection 2.6.1, we discussed matching on covariates to estimate average treatment effect. But if the dimension of \( x \) is high, we need high number of observation to match properly. The propensity score mathching is a way of avoiding such dimension problem since the propensity score \( \pi(x) \) is one-dimensional and we match only on \( \pi(x) \).

Rosenbaum and Rubin [1983] proved that if \( d \perp (y_0, y_1)|x \), that is treatment \( d \) is independent of \((y_0, y_1)\) given \( x \), then \( d \) is also independent of \((y_0, y_1)\) given \( \pi(x) \), i.e.

\[
d \perp (y_0, y_1)|\pi(x).
\]

When \( d \perp (y_0, y_1)|\pi(x) \), the mean effect conditional on \( \pi(x) \) can be estimated as,

\[
E(y|\pi(x), d = 1) - E(y|\pi(x), d = 0) = E\{y_1 - y_0|\pi(x)\}.
\]

Finally, by integrating out the \( \pi(x) \) we can observe the average treatment effect,

\[
E[E\{y_1 - y_0|\pi(x)\}] = E(y_1 - y_0).
\]
Chapter 3

Methods

The assumptions of fixed effects linear regression model and the methods used to test those assumptions are introduced in this chapter.

3.1 Assumptions of fixed effects multiple linear regression

In our analysis, we transformed the time series data into panel data. Panel data also known as longitudinal data contains multiple observations (N) that are observed at two or more time periods (T) [Stock and Watson, 2003]. The advantage of such a data is that it accounts for higher accuracy in estimation. Panel data could be of two types, short panel that regards to a relatively large cross-section of individuals observed over a small time and long panel with small cross-section of individuals observed over many time periods. Note that, the correlation of regression model errors over the time period (T) for a given individual need to be controlled for in order to obtain plausible statistical inference [Cameron and Trivedi, 2005]. Panel data are effective is situations when we speculate that the outcome variable depends on observed explanatory variable that are not observable but correlated with observed explanatory variables. The resulting estimators provide consistent estimates of the effect of the observed explanatory variables when the omitted variables are constant over time.

A multiple linear regression model with individuals $i = 1, 2, \ldots, N$ that are observed over multiple time periods $t = 1, 2, \ldots, T$ can take the form

$$y_{it} = \alpha + X_{it}' \beta + z_i' \gamma + c_i + u_{it},$$

where

- $y_{it}$ is the dependent variable;
- $X_{it}'$ is a $K$-dimensional row vector of time-varying explanatory variables;
- $z_i'$ is a $M$-dimensional row vector of time-invariant explanatory variables excluding the constant;
- $\alpha$ is the intercept;
3.1. ASSUMPTIONS OF FIXED EFFECTS MULTIPLE LINEAR REGRESSION

- $\beta$ is a $K$-dimensional column vector of parameters;
- $\gamma$ is a $M$-dimensional column vector of parameters;
- $c_i$ is the individual specific effects;
- $u_{it}$ is the idiosyncratic error terms.

If we treat individual specific effect $c_i$ as an unobserved random variable and it is correlated with $X'_{it}$, then the above equation is called the fixed effects model. Conversely, if $c_i$ is independent of $X'_{it}$, the model is referred as a random effects model.

In this thesis, we study the fixed effects multiple regression models developed by Knezevic [2018] where he utilized the measures of debt maturity structure constructed from debt portfolio of municipalities and regions as the dependent variable and several macroeconomic variables as the explanatory variable. The regression models were fitted for $i = 1, 2 \ldots, N$ municipalities over the periods $t = 1, 2, \ldots T$ as following,

$$y_{i,t} = v_i + m'_i \beta_1 + x'_{i,t} \beta_2 + z'_i \beta_3 + u_{i,t}, \quad (3.2)$$

where

- $m'_i$ is a 2-dimensional row vector of time-variant crisis variables;
- $x'_{i,t}$ is a 3-dimensional row vector of fiscal control variables;
- $z'_i$ is a 6-dimensional vector composed of interest rate and other time-variant controls;
- $v_i$ is the municipal fixed effects;
- $u_{i,t}$ is the idiosyncratic error terms.

We are interested in validating the assumptions of fixed effects multiple linear regression for the five models developed by Knezevic [2018] describing the relationship between debt maturity structure and various explanatory variables. We consider the following assumptions for a fixed effects multiple linear regression model [Wooldridge, 2015; Schmidheiny, 2011];

1. **Linearity:**

$$y_{it} = \alpha + X'_{it} \beta + z'_i \gamma + c_i + u_{it}, \quad \text{where} \ E[u_{it}] = 0 \ \text{and} \ E[c_i] = 0.$$  

$y_{it}$ is linear combination of $\alpha$, $\beta$, $\gamma$, fixed effect $c_i$ and idiosyncratic error $u_{it}$.

2. **Independence:** Samples are randomly drawn from cross section, i.e.

$$\{X_i, z_i, y_i\}_{i=1}^N$$ are independent and identically distributed.
3.2. METHODS USED TO VERIFY THE ASSUMPTIONS

3. Strict Exogeneity:

\[ E[u_{it} | X_i, z_i, c_i] = 0. \]

The idiosyncratic error term \( u_{it} \) is uncorrelated with the explanatory variables of all time period, i.e. past, present and future time periods of the same \( i \). Such strong assumption rules out lagged dependent variables. It is also assumes that the \( u_{it} \) is uncorrelated with the individual specific effect \( u_i \).

4. Error Variance:

a) \( V[u_i | X_i, z_i, c_i] = \sigma^2_u I, \sigma_u^2 > 0 \) and finite (idiosyncratic errors are homoscedastic and there is no serial correlation);

b) \( V[u_{it} | X_i, z_i, c_i] = \sigma^2_{u,it} > 0 \) and finite, and \( \text{Cov}[u_{it}, u_{is} | X_i, z_i, c_i] = 0 \) \( \forall s \neq t \) (no serial correlation);

c) \( V[u_i | X_i, z_i, c_i] = \Omega_{u,i}(X_i, z_i) \) is positive definite and finite.

5. Related Effects:

\[ E[c_i | X_i, z_i] \neq 0. \]

The random variable individual specific effect \( c_i \) is correlated with explanatory variables of past, present and future time periods of the same individual.

6. Effect Variance:

\[ V[c_i | X_i, z_i] = \sigma^2_{c_i} < \infty. \]

Individual specific effect \( c_i \) does not have constant variance

7. Identifiability:

\( \text{rank}(\tilde{X}) = K < NT \) and \( E(\tilde{X}_i' \tilde{X}_i) \) is positive definite and finite.

Here, \( \tilde{X}_{it} = X_{it} - \bar{X}_i \) with \( \bar{X}_i = \frac{1}{T} \sum_t X_{it} \).

Here, we are assuming that the perfectly multicollinearity does not exist among the time-varying explanatory variables \( X_{it} \), that they have non-zero within-variance (i.e. variation over time for a given individual) and do not contain too many extreme values. Thus, \( X_{it} \) cannot hold a constant or any time-invariant variables. Note that only the parameters \( \beta \) are identifiable, i.e. they are unique in the fixed effects model. Neither \( \alpha \) nor \( \gamma \) are identifiable.

3.2 Methods used to verify the assumptions

To identify the model between fixed effects and random effects that suits our data better, we run Hausman test, also known as Durbin-Wu-Hausman test [Durbin, 1954; Wu, 1973; Hausman, 1978]. In this test, the null hypothesis is that the random effects model is better. Alternatively, it tests whether there is any correlation between regressors and unique errors \( (u_i) \). Once the suitable model is decided we move forward to verify the assumptions of fixed effects multiple linear regression model. Identification of linear relationship between the
dependent variable and the parameters is done by plotting each independent variable against the dependent variable. Furthermore, we plot the residuals against the fitted values of the model to observe any non-linear relationship. The assumption of independence is examined by the Breusch-Pagan Lagrange multiplier test and Pasaran CD test [Pesaran, 2004]. The null hypothesis in this test is that the residuals across individuals are uncorrelated. Variance Inflation Factor (VIF) is used to test multicollinearity in the models. The assumption of no serial correlation in idiosyncratic errors $u_{it}$ is examined using the Breusch-Godfrey test [Breusch, 1978; Godfrey, 1978]. The null hypothesis in this test is that there is no serial correlation in idiosyncratic errors $u_{it}$. Homoscedasticity of the error terms is tested using the Breusch-Pagan test [Breusch and Pagan, 1979]. The null hypothesis in this case is that the idiosyncratic errors are homoscedastic. Finally, the assumption of normality of the error terms is examined using the Q-Q plot illustrating the distribution of idiosyncratic errors $u_{it}$.

In the end, we used a non-parametric method commonly known as matching. Utilizing matching on covariates and propensity score matching we estimated the average treatment effects. Prior to the estimation of average treatment effects, we transformed the data based on our findings in the verification of the assumptions of fixed effects multiple linear regression model.
Chapter 4

Data

The data source, data processing steps followed by summary statistics is presented in this chapter.

4.1 Description

The dataset for analysis was provided by Knezevic [2018] and based on Kommuninvest proprietary loan data. The initial dataset contains detailed information regarding all loans provided by Kommuninvest from January 1998 to December 2016. As of December 2016, 274 municipalities out of total 290 had loan accounts with Kommuninvest. This cross-sectional dataset was transformed to time series of each month from January 1998 to December 2016. That is, for each loan a time series of 228 months. After that, for each month the time to loan maturity from the starting date of the loan was estimated for each loan. Several other time series data such as taxes paid by municipalities, grants provided to the local governments by the central government, income-per-capita of each municipality was also provided by the Kommuninvest. Finally, these time series data including the aforementioned monthly time series of loan data were transformed to panel data to conduct the analysis. Using the time series of time to maturity of each loan of each month, Knezevic [2018] estimated five different measures of debt maturity structures as mentioned in section 2.5.

4.1.1 Dependent variables

We have used five different dependent variables, that is, five models were fitted. As discussed in section 2.5, measures regarding time to maturity of loans, named as Mean (weighted mean of time to maturity), SD (weighted standard deviation of time to maturity), IQR (interquartile range of time to maturity), WMIQR (I) (weighted mean interquartile range of time to maturity which is constructed from 25% highest and lowest observations) and WMIQR (II) (weighted mean interquartile range of time to maturity which is constructed from all loans) were deployed as the dependent variables.
4.1.2 Independent variables

In this thesis, we intend to estimate the effect of the financial crisis of 2008-09 on Swedish municipalities debt maturity structures. Thus, a dummy variable was created that takes the value 1 if a municipality had active loans during 2008-09 and 0 otherwise. In our treatment effect analysis, we consider this dummy variable as the treatment. Another dummy variable was fitted in the models that accounts for the post-financial crisis. That is, it takes value 1 for loans provided by Kommuninvest after 2008-09 and 0 otherwise. The variable Debt-to-tax ratio was generated for each municipality and each month by taking the ratio of outstanding debt and annual tax base (100 million SEK). For each municipality tax base standard deviation was estimated for a specific year over a five-year interval. We refer this variable as tax base standard deviation. The variable income per capita contains the annual per capita income (in thousand SEK) for each municipality. Operating cash flow variable was estimated from current assets of the municipalities. Equity-to-asset ratio variable indicates a municipality’s capability of dealing with its liabilities in the long-run. The variable surplus-to-tax revenue ratio was estimated from equalization grants and tax revenue of each municipality. STIBOR (Stockholm Interbank Offered Rate) variable refers to a type of floating interest rate valid for 1-day, 1-week, 1-month, 3-months, 6-months or 12-months. We considered 3-months STIBOR since most of the time, municipalities borrow from Kommuninvest at this rate. The variables slope and curvature were generated from STIBOR and government bond rates of 2, 5, 7 and 10 years. The dummy variable negative STIBOR rate takes value 1 if the STIBOR is negative otherwise 0. Monthly turnover of government bonds and the outstanding amount of government debt were used to estimate the market liquidity variable. Finally, to observe whether an election has an impact on how a municipality borrows, the variable election was included in the model which denotes the number of years remained to the next election. In our treatment effect analysis, we controlled for all of these independent variables except the dummy variable financial crisis which we regard as the treatment.

4.2 Summary statistics

Table 4.1 represents the summary statistics of five different measures of intertemporal diversification. In addition, the overall average of time to maturity of all loans between 1998 and 2016 is observed to be 2.20 years with the standard deviation of 1.20 years.
Table 4.1: Summary statistics (in years) of five different measures of intertemporal diversification. These measures are treated as dependent variables in the models. The measures are regarded as following, SD = Weighted Standard Deviation of time to maturity, Mean = Weighted Mean of time to maturity, IQR = Interquartile Range of time to maturity, WMIQR (I) = First measure of Weighted Mean Interquartile Range of time to maturity, WMIQR (II) = Second measure of Weighted Mean Interquartile Range of time to maturity.

<table>
<thead>
<tr>
<th></th>
<th>SD</th>
<th>Mean</th>
<th>IQR</th>
<th>WMIQR (I)</th>
<th>WMIQR (II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.000</td>
<td>0.025</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>1st Qu.</td>
<td>1.195</td>
<td>1.413</td>
<td>1.271</td>
<td>2.318</td>
<td>1.252</td>
</tr>
<tr>
<td>Median</td>
<td>1.639</td>
<td>2.080</td>
<td>2.196</td>
<td>3.490</td>
<td>2.193</td>
</tr>
<tr>
<td>Mean</td>
<td>1.778</td>
<td>2.210</td>
<td>2.324</td>
<td>3.571</td>
<td>2.253</td>
</tr>
<tr>
<td>3rd Qu.</td>
<td>2.199</td>
<td>2.769</td>
<td>3.104</td>
<td>4.598</td>
<td>3.005</td>
</tr>
<tr>
<td>Max.</td>
<td>14.956</td>
<td>15.195</td>
<td>28.479</td>
<td>29.103</td>
<td>27.152</td>
</tr>
<tr>
<td>SD</td>
<td>1.015</td>
<td>1.218</td>
<td>1.691</td>
<td>2.131</td>
<td>1.491</td>
</tr>
<tr>
<td>N</td>
<td>40,742</td>
<td>41,938</td>
<td>41,938</td>
<td>41,938</td>
<td>41,938</td>
</tr>
</tbody>
</table>

Figure 4.1: Illustration of heteroscedasticy over the year 1998-2016 for intertemporal diversification measures.
Figure 4.2: Illustration of heteroscedasticity across the municipalities for intertemporal diversification measures.
Chapter 5

Experiments and results

In this chapter, we present the results of the tests used to verify the assumptions of fixed effects linear regression models. We also provide the results of average treatment effect using matching on covariates and propensity score matching.

5.1 Hausman test (fixed effects vs random effects)

The fixed effects estimator is consistent when individual specific effects are fixed while random effects estimators are inconsistent in such situations. To identify whether the fixed effects model is plausible to prefer we can use Hausman test (Durbin-Wu-Hausman test) [Hausman, 1978]. The null hypothesis is considered as that the random effects model is preferable model whereas the alternative hypothesis is fixed effects model is better. In this experiment, the null hypothesis is rejected if the p-value is less than 0.05.  

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Mean</th>
<th>SD</th>
<th>IQR</th>
<th>WMIQR (I)</th>
<th>WMIQR (II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2$</td>
<td>516.4</td>
<td>226.25</td>
<td>140.58</td>
<td>179.7</td>
<td>344.52</td>
</tr>
<tr>
<td>df</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>p-value</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Table 5.1: Results of Hausman test (fixed effects vs random effects). Dependent variables (intertemporal diversification measures - Mean, SD, IQR, WMIQR (I), WMIQR (II)) of five different models are illustrated in the columns. Null hypothesis for all models is rejected since p-values is less than 0.05.

Since the tests are statistically significant we reject the null hypothesis. That is, individual-specific effects are correlated with the independent variables and fixed effects do exist in our models.

1Mean = Weighted Mean of time to maturity, SD = Weighted Standard Deviation of time to maturity, IQR = Interquartile Range of time to maturity, WMIQR (I) = First measure of Weighted Mean Interquartile Range of time to maturity, WMIQR (II) = Second measure of Weighted Mean Interquartile Range of time to maturity.
5.2 Tests for assumptions of fixed effects linear regression

Linearity in parameters

Once we plotted the dependent variables of the five different models against the independent variables we observed non-linear behavior. Figure 5.1, 5.2 illustrate this behavior of non-linearity. Figure 5.1 is the scatter plots of dependent variable (Weighted Standard Deviation of time to maturity) and independent variables. Figure 5.1 is the scatter plot of residuals vs predicted values of $y_{it}$ for all five models. Other scatter plots are presents in Appendix A.

Independence or random sampling

We tested for cross sectional dependence in our panel data models using Breusch-Pegan Lagrange Multiplier test of independence and Pasaran CD test [Pesaran, 2004]. In both tests the null hypothesis is, the residuals across the individuals (municipalities) are uncorrelated. These tests are important since the cross-sectional dependence can produce biased outcomes. We observed the presence of cross-sectional dependence in our models.

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Mean</th>
<th>SD</th>
<th>IQR</th>
<th>WMIQR (I)</th>
<th>WMIQR(II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square</td>
<td>691350</td>
<td>675830</td>
<td>489260</td>
<td>595920</td>
<td>562310</td>
</tr>
<tr>
<td>df</td>
<td>36979</td>
<td>36701</td>
<td>36979</td>
<td>36979</td>
<td>36979</td>
</tr>
<tr>
<td>p-value</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Table 5.2: Results of Breusch-Pegan Lagrange multiplier test of independence suggest the cross-sectional dependence exists for all five models.

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Mean</th>
<th>SD</th>
<th>IQR</th>
<th>WMIQR (I)</th>
<th>WMIQR(II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td>82.98</td>
<td>61.72</td>
<td>64.13</td>
<td>52.11</td>
<td>38.27</td>
</tr>
<tr>
<td>p-value</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Table 5.3: Results of Pasaran cross dependence test indicating the cross-sectional dependence.

Multicollinearity

To examine perfect multicollinearity, we used Variance Inflation Factor (VIF) method for all five fixed effects models. From the test, it is evident that the perfect multicollinearity do not exist in these models. Note that, in the case of perfect multicollinearity the VIF becomes $\infty$. The highest VIF among all models found to be 20.40 for the variable 'year'. In the following we present the mean of VIF for five models.
5.2. TESTS FOR ASSUMPTIONS OF FIXED EFFECTS LINEAR REGRESSION

<table>
<thead>
<tr>
<th>Mean VIF</th>
<th>SD</th>
<th>IQR</th>
<th>WMIQR (I)</th>
<th>WMIQR(II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.97</td>
<td>5.00</td>
<td>4.97</td>
<td>4.97</td>
<td>4.97</td>
</tr>
</tbody>
</table>

Table 5.4: Mean of VIF for all five models. Perfect multicollinearity do not exist in any of the models.

Serial Correlation

One of the assumptions of fixed effects models is that there is no serial correlation in idiosyncratic errors $u_{it}$. Using Breusch-Godfrey [Breusch, 1978; Godfrey, 1978] test we attempted to verify this assumption for all models. The null hypothesis is that there is no serial correlation in idiosyncratic errors $u_{it}$. In our analysis, we observed the presence of serial correlation in idiosyncratic errors $u_{it}$ for all models.

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Mean</th>
<th>SD</th>
<th>IQR</th>
<th>WMIQR (I)</th>
<th>WMIQR(II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square</td>
<td>36175</td>
<td>35282</td>
<td>34232</td>
<td>35280</td>
<td>34077</td>
</tr>
<tr>
<td>df</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>p-value</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Table 5.5: Serial correlation exists in all models according to Breusch-Godfrey test. Null hypothesis is there is no serial correlation in idiosyncratic errors $u_{it}$.

Homoscedasticity

Using Breusch-Pegan test [Breusch and Pagan, 1979] for homoscedasticity we examined the assumption of homoscedasticity for panel data model. Homoscedasticity refers to the independence of variance of the error terms from the covariates. The null hypothesis in this test is that the idiosyncratic errors are homoscedastic. The p-value was less than 0.05 for all models suggesting the heteroscedasticity of idiosyncratic errors $u_{it}$.

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Mean</th>
<th>SD</th>
<th>IQR</th>
<th>WMIQR (I)</th>
<th>WMIQR(II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP test Statistic</td>
<td>97481</td>
<td>38348</td>
<td>75077</td>
<td>55984</td>
<td>68481</td>
</tr>
<tr>
<td>df</td>
<td>287</td>
<td>288</td>
<td>288</td>
<td>288</td>
<td>288</td>
</tr>
<tr>
<td>p-value</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Table 5.6: Idiosyncratic errors $u_{it}$ are heteroscedastic in models.
Figure 5.1: Scatterplot of Weighted Standard Deviation of time to maturity against the independent variables.
Figure 5.2: Scatterplot of residuals vs predicted values of $y_{it}$. If the relationship between dependent variable and independent variables is linear the data points will be distributed around the horizontal line. Any "bowed" pattern reveals non-linear characteristics of the data.
Normality

We utilized quantile-quantile plot to observe the distribution of the idiosyncratic errors $u_{it}$. Figure 5.3 shows that the errors are not normally distributed. We could have observed that the points are lying diagonally if the errors of the models were following normal distribution. However, it should be noted that the normality of the idiosyncratic errors $u_{it}$ is a strong assumption [Wooldridge, 2015].

Figure 5.3: Quantile-Quantile Plot of idiosyncratic errors $u_{it}$ illustrating that the errors are not normally distributed.
5.3 Estimation of average treatment effect

5.3.1 Average treatment effect using matching on covariates

Matching is important to observe the effect of the treatment on the dependent variable. Matching on the covariates refers to comparing treatment and control groups with similar or same values of $x$. In our experiment, we matched on the covariates, namely, operating cash flow ratio, equity-to-asset ratio, surplus-to-tax revenue ratio, STIBOR, slope, curvature, negative stibor rate, market liquidity, election and variables with inverse form, namely, debt-to-tax ratio, tax base standard deviation, income per capita. Using Mahalanobis distance one-to-one matching was performed. That is, each treatment subject was matched with one control subject. Thus, the total number of observations is 10,002 (5,001 treatment subject and 5,001 control subjects). Table 5.7 shows that the financial crisis had positive effect on Swedish municipalities borrowing trend. The average treatment effects for models with dependent variables weighted mean time to maturity, weighted standard deviation of time to maturity, interquartile range of time to maturity, weighted mean interquartile range of time to maturity (I) & (II) were observed as 0.177, 0.10, 0.428, 0.393, 0.349 respectively.

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Mean</th>
<th>SD</th>
<th>IQR</th>
<th>WMIQR (I)</th>
<th>WMIQR (II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Crisis</td>
<td>0.177***</td>
<td>0.10***</td>
<td>0.428***</td>
<td>0.393***</td>
<td>0.349***</td>
</tr>
<tr>
<td>[Treatment]</td>
<td>(0.031)</td>
<td>(0.024)</td>
<td>(0.041)</td>
<td>(0.05)</td>
<td>(0.036)</td>
</tr>
<tr>
<td>Observations</td>
<td>10,002</td>
<td>10,002</td>
<td>10,002</td>
<td>10,002</td>
<td>10,002</td>
</tr>
<tr>
<td>R²</td>
<td>0.121</td>
<td>0.077</td>
<td>0.163</td>
<td>0.218</td>
<td>0.235</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.113</td>
<td>0.068</td>
<td>0.159</td>
<td>0.211</td>
<td>0.227</td>
</tr>
<tr>
<td>t Statistic</td>
<td>5.698***</td>
<td>4.067***</td>
<td>10.432***</td>
<td>7.854***</td>
<td>9.745***</td>
</tr>
</tbody>
</table>

Note: *p<0.1; **p<0.05; ***p<0.01

Table 5.7: Results of average treatment effect using matching on covariates. Financial crisis effected the debt maturity structure of Swedish municipalities.

5.3.2 Average treatment effect using propensity score matching

We estimated the average treatment effect using propensity score matching where the financial crisis variable(dummy variable) was considered as the treatment. Prior to the estimation of the propensity scores, we transformed three independent variables namely, debt-to-tax ratio, tax base standard deviation and per-capita-income to the inverse form since our experiment suggested a better fit with such transformation. The number of treatment subject was 5001. In contrast, the number of control subjects was 37,505. We experimented with several matching methods including exact matching, full matching, subclassification matching,
5.3. ESTIMATION OF AVERAGE TREATMENT EFFECT

Based on the obtained results we preferred nearest neighbor matching since we observed the smallest $p$-value for this method. In this method, each treatment subject was matched with five control subjects. We preferred this matching ratio due to the lack of overlapping between treatment and control groups. Thus, the total number of matched observation is 25,005 (5001 *5).

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Mean (1)</th>
<th>SD (2)</th>
<th>IQR (3)</th>
<th>WMIQR (I) (4)</th>
<th>WMIQR (II) (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Crisis</td>
<td>0.400***</td>
<td>0.058***</td>
<td>0.406***</td>
<td>0.284***</td>
<td>0.289***</td>
</tr>
<tr>
<td>[Treatment]</td>
<td>(0.016)</td>
<td>(0.014)</td>
<td>(0.022)</td>
<td>(0.026)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>Observations</td>
<td>25,005</td>
<td>25,005</td>
<td>25,005</td>
<td>25,005</td>
<td>25,005</td>
</tr>
<tr>
<td>R²</td>
<td>0.026</td>
<td>0.001</td>
<td>0.014</td>
<td>0.005</td>
<td>0.009</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.015</td>
<td>0.001</td>
<td>0.003</td>
<td>0.004</td>
<td>0.007</td>
</tr>
<tr>
<td>F Statistic</td>
<td>651.513***</td>
<td>18.027***</td>
<td>350.614***</td>
<td>121.792***</td>
<td>234.739***</td>
</tr>
<tr>
<td>(df = 1; 24730)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: *p<0.1; **p<0.05; ***p<0.01

Table 5.8: Results of average treatment effect using propensity score matching. It is statistically significant that financial crisis effected the debt maturity structure of Swedish municipalities.

In exact matching, each treatment subject is matched with one control subject that holds the exact same value(s) as the treatment subject for the covariates or propensity score. If the covariates hold too many values or the dimension is too high, exact matching is difficult to implement. Full matching utilizes the technique in which each treatment subject is matched with all control subjects. In the subclassification method, at first, the covariates are divided into subclasses based on their similarities. After that, each treatment subject is matched with a subclass. The nearest neighbor method depends on the nearest distance of a treatment subject from the control subjects. The distance is commonly estimated using logistic regression. Optimal matching method matches a treatment subject with a control subject by minimizing the mean absolute distance. Using a computationally intensive genetic search algorithm, genetic matching method attempts to find the optimal balance for the matching procedure. This method performs well for matching on covariates. In coarsened exact matching, Monotonic Imbalance Bounding (MIB) method is utilized to perform the matching. In this method, we match the treatment subject and the control subject on a covariate while retaining the balance of other covariates.

The results in the table 5.8 illustrate the treatment variable, the financial crisis has positive and statistically significant effect on how Swedish municipalities borrowed. The average treatment effect for the models weighted mean time to maturity, weighted standard
deviation of time to maturity, interquartile range, weighted mean interquartile range (I) and weighted mean interquartile range (II) are 0.40, 0.058, 0.406, 0.284, 0.289 (in years) respectively. These results can be interpreted as the following. The weighted mean time to maturity was 0.40 years or 146 days higher during the financial crisis for the first model. For the third model, the interquartile range of time to maturity was 0.406 years or 148 days higher during the financial crisis and so on.
Chapter 6
Conclusion and future works

In this chapter, we briefly discuss the results and the possibility of future research.

6.1 Discussion & conclusion

Knezevic [2018] developed a fixed effect linear regression model to estimate the effect of the 2008-09 financial crisis on Swedish municipalities borrowing behavior. Five models were fitted with five different dependent variables, namely weighted mean time to maturity, weighted standard deviation of time to maturity, interquartile range of time to maturity, weighted mean interquartile range of time to maturity (I) & (II). Figure B.1 in appendix presents his results and we can observe that the financial crisis positively affected five measures of Swedish municipalities debt maturity structures.

In this thesis, we tested the assumptions of fixed effects linear regression for models developed by Knezevic [2018]. We tested the assumption of linearity, independence, multicollinearity, serial correlation, homoscedasticity, and normality. Based on our findings we experimented with several types of variable transformation of covariates and dependent variable including interaction terms, 3rd order polynomial, logarithmic transformation, and inverse form. The plot of residuals vs fitted values for the models with such transformation is presented in the appendix figure A.5. In the end, we preferred the inverse form of few covariates to fit the models. The result of fixed effect linear regression model is exhibited in appendix table B.1. Finally, we presented our results using an alternative method known as matching to estimate the effect of financial crisis on debt maturity structure of Swedish municipalities. To estimate the average treatment effect, we utilized two methods: matching on covariates and propensity score matching. Our results are slightly different than that of [Knezevic, 2018] nevertheless it is evident that the financial crisis had a positive effect on debt maturity measures.

The average treatment effect using matching on covariates can be explained as follows: during the financial crisis, the mean time to maturity is increased by 0.177 years or 65 days. For other models, the time to maturity is increased by 0.10-0.428 years or 37-156 days depending on the models. In contrast, for results obtained by propensity score matching, the mean time to maturity is expanded by 0.40 years or 146 days whereas other measures of time to maturity is increased by 0.058-0.406 years or 22-148 days depending on the models. These
results suggest that the municipalities regarded diversification of debt portfolios as an important measure to deal with financial crisis. This measure is important since the market turns illiquid during such crisis and a relatively smaller share of the portfolio is required to be repaid because of the diversification of the loans.

When mean time to maturity is increased by 0.177 years or 65 days it implies that the municipalities borrowed new loans or refinanced previous loans with higher maturity time. For instance, if the average maturity time of the debt portfolio of a municipality was 750 days before the financial crisis, it became 815 (750+65) days during the financial crisis. Considering the financial crisis as the treatment, mean time to maturity of 0.177 years or 65 days indicates the difference of the average maturity time of the loans between the period with financial crisis and the period without financial crisis. Rather than borrowing with shorter maturity which need to be repaid within short period of time, the municipalities change their strategy to borrowing with longer maturity time. This strategy helped the municipalities to shift the required repayment amounts to a future time instead of paying those amounts during the financial crisis.

However, Knezevic [2018] showed that the positive effect of financial crisis on debt maturity measures did not last long. In his findings, weighted mean interquartile time to maturity (I) & (II) and weighted standard deviation of time to maturity showed a negative trend after the 2008-09 financial crisis. The author argued that the Kommuninvest ability to provide loans even during the financial crisis may have been perceived by the municipalities as diversification of debt portfolio is being an unnecessary measure to take. But, it should be noted that the intertemporal diversification could be crucial to effectively overcome any financial crisis like 2008-09 in future.

6.2 Future works

Swedish municipalities borrow with short-term maturity from financial institutions such as Kommuninvest, commercial banks or directly issuing bonds. The average time to maturity of all borrowings between 1998-2016 is observed as 2.20 years. In addition, most of the loans are borrowed with floating interest rate such as 3-month STIBOR. Any increase in the interest rate in future will result in high interest expenses. Thus, such a strategy involves high risk. On the other hand, borrowing with fixed interest rate and extended maturity e.g. 15 years could be costly as well. Comparison of the risk of high interest rate to the cost of minimizing that risk by longer maturity time and fixed rate could be an interesting topic. The modern portfolio theory [Markowitz, 1952] could be applied to solve such issue. This method is commonly used to maximize the expected return from the portfolio of assets given a risk level. The same method could be examined to observe whether it’s possible to maximize the difference between the income and debt repayment amount of a municipality given a risk level. In short, optimization of the expected cost of a Swedish municipal’s debt portfolios is the major challenge that needs to be solved.
Appendices
Appendix A

Scatter plots

Scatter plot of four intertemporal diversification measures and independent variables in figures A.1, A.2, A.3, and A.4. Scatter plot of residuals vs fitted values in figure A.5.
Figure A.1: Scatterplot of weighted mean of time to maturity and the independent variables.
Figure A.2: Scatterplot of interquartile range of time to maturity and the independent variables.
Figure A.3: Scatterplot of weighted mean interquartile range of time to maturity (l) and the independent variables.
Figure A.4: Scatterplot of weighted mean interquartile range of time to maturity (II) and the independent variables.
Figure A.5: Scatterplot of residuals and fitted values for models with transformed variables
Appendix B

Results of fixed effects linear regression

Results obtained by Knezevic [2018] are presented in figure B.1. Results from our analysis is in table B.1.
Figure B.1: Results obtained by Knezevic [2018].

<table>
<thead>
<tr>
<th></th>
<th>IQ range</th>
<th>WMIQR (i)</th>
<th>WMIQR (ii)</th>
<th>SD</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crisis</td>
<td>0.717***</td>
<td>0.434***</td>
<td>0.428***</td>
<td>0.117***</td>
<td>1.156***</td>
</tr>
<tr>
<td>Post-crisis</td>
<td>0.094*</td>
<td>-0.334***</td>
<td>-0.157***</td>
<td>-0.264***</td>
<td>1.145***</td>
</tr>
<tr>
<td><strong>Financial ratios and fiscal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log debt–tax base ratio</td>
<td>0.087***</td>
<td>0.187***</td>
<td>0.103***</td>
<td>0.024***</td>
<td>-0.057***</td>
</tr>
<tr>
<td>Log tax base standard deviation</td>
<td>0.148***</td>
<td>0.238***</td>
<td>0.087***</td>
<td>0.093***</td>
<td>-0.028***</td>
</tr>
<tr>
<td>Log per capita income</td>
<td>-6.346***</td>
<td>-5.055***</td>
<td>-5.397***</td>
<td>-6.372***</td>
<td>-12.043***</td>
</tr>
<tr>
<td>Operating cash flow ratio</td>
<td>0.001***</td>
<td>0.002***</td>
<td>0.001***</td>
<td>0.000</td>
<td>-0.001***</td>
</tr>
<tr>
<td>Equity-to-asset ratio</td>
<td>-0.011***</td>
<td>-0.023***</td>
<td>-0.013***</td>
<td>-0.006***</td>
<td>-0.004***</td>
</tr>
<tr>
<td>Surplus-to-tax revenue ratio</td>
<td>-0.010***</td>
<td>-0.011***</td>
<td>-0.007***</td>
<td>-0.005***</td>
<td>-0.006***</td>
</tr>
<tr>
<td><strong>Financial market</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-month STIBOR</td>
<td>-0.097***</td>
<td>-0.128***</td>
<td>-0.068***</td>
<td>-0.044***</td>
<td>-0.065***</td>
</tr>
<tr>
<td>Slope</td>
<td>-3.991***</td>
<td>-4.867***</td>
<td>-3.046***</td>
<td>-1.859***</td>
<td>-1.901***</td>
</tr>
<tr>
<td>Negative 3-month STIBOR</td>
<td>0.301***</td>
<td>0.404***</td>
<td>0.273***</td>
<td>0.246***</td>
<td>0.263***</td>
</tr>
<tr>
<td>Market liquidity</td>
<td>-0.435***</td>
<td>-0.643***</td>
<td>-0.224***</td>
<td>0.001</td>
<td>0.641***</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Election</td>
<td>0.016*</td>
<td>0.026**</td>
<td>0.009</td>
<td>0.002</td>
<td>0.045***</td>
</tr>
<tr>
<td>Year trend</td>
<td>0.107***</td>
<td>0.107***</td>
<td>0.137***</td>
<td>0.136***</td>
<td>0.201***</td>
</tr>
<tr>
<td>Constant</td>
<td>35.744****</td>
<td>31.159***</td>
<td>30.084***</td>
<td>34.393***</td>
<td>62.719***</td>
</tr>
<tr>
<td>N</td>
<td>41,349</td>
<td>41,349</td>
<td>41,349</td>
<td>39,944</td>
<td>41,349</td>
</tr>
<tr>
<td>R² (within)</td>
<td>0.043</td>
<td>0.045</td>
<td>0.035</td>
<td>0.106</td>
<td>0.162</td>
</tr>
<tr>
<td>σₑ</td>
<td>1.066</td>
<td>1.408</td>
<td>1.019</td>
<td>0.861</td>
<td>1.371</td>
</tr>
<tr>
<td>σₑ</td>
<td>1.449</td>
<td>1.705</td>
<td>1.239</td>
<td>0.797</td>
<td>1.021</td>
</tr>
<tr>
<td>ρ</td>
<td>0.351</td>
<td>0.406</td>
<td>0.403</td>
<td>0.539</td>
<td>0.643</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
*p < 0.05, **p < 0.01, ***p < 0.001
### Table B.1: Fixed effect linear regression model results in transformed data

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Mean</th>
<th>SD</th>
<th>IQR</th>
<th>WMIQR(I)</th>
<th>WMIQR(II)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
<tr>
<td>Financial crisis</td>
<td>1.185***</td>
<td>0.086***</td>
<td>0.659***</td>
<td>0.395***</td>
<td>0.432***</td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td>(0.019)</td>
<td>(0.033)</td>
<td>(0.039)</td>
<td>(0.028)</td>
</tr>
<tr>
<td>Post-financial crisis</td>
<td>1.161***</td>
<td>-0.199***</td>
<td>0.094***</td>
<td>-0.194***</td>
<td>-0.025</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.021)</td>
<td>(0.036)</td>
<td>(0.043)</td>
<td>(0.031)</td>
</tr>
<tr>
<td>Inverse Debt-tax ratio</td>
<td>0.002***</td>
<td>0.0001</td>
<td>-0.005***</td>
<td>-0.009***</td>
<td>-0.005***</td>
</tr>
<tr>
<td></td>
<td>(0.0001)</td>
<td>(0.0001)</td>
<td>(0.0002)</td>
<td>(0.0002)</td>
<td>(0.0002)</td>
</tr>
<tr>
<td>Inverse taxbase standard dev.</td>
<td>0.027***</td>
<td>0.011***</td>
<td>0.019***</td>
<td>0.010**</td>
<td>0.030***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.002)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Inverse per capita income</td>
<td>337.666***</td>
<td>-533.873***</td>
<td>-164.147***</td>
<td>-146.251***</td>
<td>-192.838***</td>
</tr>
<tr>
<td></td>
<td>(42.127)</td>
<td>(35.276)</td>
<td>(60.092)</td>
<td>(70.459)</td>
<td>(51.304)</td>
</tr>
<tr>
<td>Operating cash flow ratio</td>
<td>-0.001***</td>
<td>-0.001***</td>
<td>0.001***</td>
<td>0.002***</td>
<td>0.001***</td>
</tr>
<tr>
<td></td>
<td>(0.0002)</td>
<td>(0.0001)</td>
<td>(0.0002)</td>
<td>(0.0003)</td>
<td>(0.0002)</td>
</tr>
<tr>
<td>Equity-to-asset ratio</td>
<td>-0.007***</td>
<td>-0.007***</td>
<td>-0.011***</td>
<td>-0.023***</td>
<td>-0.014***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Surplus-to-tax revenue ratio</td>
<td>-0.003**</td>
<td>-0.005***</td>
<td>-0.006***</td>
<td>-0.007***</td>
<td>-0.004***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Stibor</td>
<td>-0.119***</td>
<td>0.017**</td>
<td>-0.048***</td>
<td>-0.057***</td>
<td>-0.048***</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.009)</td>
<td>(0.015)</td>
<td>(0.017)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>Slope</td>
<td>-2.778***</td>
<td>-0.826***</td>
<td>-3.646***</td>
<td>-3.979***</td>
<td>-2.807***</td>
</tr>
<tr>
<td></td>
<td>(0.157)</td>
<td>(0.131)</td>
<td>(0.223)</td>
<td>(0.262)</td>
<td>(0.191)</td>
</tr>
<tr>
<td></td>
<td>(0.648)</td>
<td>(0.543)</td>
<td>(0.924)</td>
<td>(1.084)</td>
<td>(0.789)</td>
</tr>
<tr>
<td>Negative stibor rate</td>
<td>0.044*</td>
<td>0.203***</td>
<td>0.149***</td>
<td>0.323***</td>
<td>0.241***</td>
</tr>
<tr>
<td></td>
<td>(0.024)</td>
<td>(0.020)</td>
<td>(0.035)</td>
<td>(0.041)</td>
<td>(0.030)</td>
</tr>
<tr>
<td>Market Liquidity</td>
<td>0.553***</td>
<td>0.171***</td>
<td>-0.345***</td>
<td>-0.416***</td>
<td>-0.112*</td>
</tr>
<tr>
<td></td>
<td>(0.047)</td>
<td>(0.039)</td>
<td>(0.067)</td>
<td>(0.079)</td>
<td>(0.057)</td>
</tr>
<tr>
<td>Election</td>
<td>0.044***</td>
<td>-0.007</td>
<td>0.012</td>
<td>0.017**</td>
<td>-0.0001</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.004)</td>
<td>(0.007)</td>
<td>(0.008)</td>
<td>(0.006)</td>
</tr>
<tr>
<td></td>
<td>(0.771)</td>
<td>(0.646)</td>
<td>(1.100)</td>
<td>(1.289)</td>
<td>(0.939)</td>
</tr>
</tbody>
</table>

|                     | Observations | 42,506 | 42,506 | 42,506 | 42,506 | 42,506 |
|                     | R²            | 0.180  | 0.137  | 0.053  | 0.062  | 0.045  |
|                     | Adjusted R²   | 0.175  | 0.131  | 0.047  | 0.056  | 0.038  |
|                     | F Statistic   | 618.513*** | 445.984*** | 157.557*** | 187.144*** | 132.388*** |
|                     | (df = 15; 42217) |        |        |        |        |        |

*Note: *p<0.1; **p<0.05; ***p<0.01*
Bibliography


Bologna, P. [2018], *Bank’s maturity transformation: risk, reward, and policy*, International Monetary Fund. 1


Cameron, A. C. and Trivedi, P. K. [2005], *Microeconometrics: methods and applications*, Cambridge university press. 18

Diamond, D. [2007], ‘Banks and liquidity creation: a simple exposition of the diamond-dybvig model’. 1

Durbin, J. [1954], ‘Errors in variables’, *Revue de l’institut International de Statistique* pp. 23–32. 20

Godfrey, L. G. [1978], ‘Testing against general autoregressive and moving average error models when the regressors include lagged dependent variables’, *Econometrica: Journal of the Econometric Society* pp. 1293–1301. 21, 28

Government offices of Sweden [2018], ‘Annual report for state-owned enterprises 2017’. 5


Knezevic, D. [2018], ‘Intertemporal diversification of sub-sovereign debt’, *Empirical Economics* pp. 1–35. ii, v, 1, 2, 3, 4, 11, 12, 19, 22, 35, 36, 44, 45

Kommuninvest [2017], ‘Kommuninvest cooperative society annual report 2017’. 7

Kommuninvest [2018a], ‘Interim report 2018’. 7

Kommuninvest [2018b], ‘Kommuninvest’. 7

Kommuninvest [2018c], ‘Local government debt 2018’. 5, 6, 8, 9, 10

URL: https://kommuninvest.se/ 7

Lee, M.-J. [2005], Micro-econometrics for policy, program, and treatment effects, Oxford University Press on Demand. 14, 15, 17

Mahalanobis, P. C. [1936], On the generalized distance in statistics, National Institute of Science of India. 16

Markowitz, H. [1952], ‘Portfolio selection’, The journal of finance 7(1), 77–91. 36

Ministry of Finance [2005], ‘Local government in sweden – organisation,activities and financier’. 4, 5, 6


Pesaran, M. H. [2004], ‘General diagnostic tests for cross section dependence in panels’. 21, 27


Rosenbaum, P. R. and Rubin, D. B. [1983], ‘The central role of the propensity score in observational studies for causal effects’, Biometrika 70(1), 41–55. 17

Schmidheiny, K. [2011], ‘Panel data: fixed and random effects’, Short Guides to Microeconometrics pp. 2–7. 19

Standard and Poor’s [2011], ‘Public finance system overview: Swedish local and regional governments’. 4


Wooldridge, J. M. [2010], Econometric analysis of cross section and panel data, MIT press. 2

Wooldridge, J. M. [2015], Introductory econometrics: A modern approach, Nelson Education. 19, 31