



**ADDIS ABABA UNIVERSITY  
OFFICE OF GRADUATE STUDIES PROGRAM  
COLLEGE OF NATURAL SCIENCES  
DEPARTMENT OF STATISTICS**

**DETERMINANTS OF DELAY OF CRIMINAL LITIGATION  
TRIALS IN THE FEDERAL FIRST INSTANCE COURT AKAKI  
DIVISION AND THE OROMIA STATE HIGHER COURT EAST  
SHOA DIVISION**

**BY  
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**A thesis submitted to the office of Graduate Studies Program of the Addis Ababa  
University in partial fulfillment of the requirement for the Degree of Master of Science in  
Statistics (Biostatistics stream)**

**December 2010**

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## **Acknowledgment**

Glory be to Allah, and then many thanks to my advisor, Dr. Girma Taye who stood by my side in the entire course of this study. My appreciation goes to my wife W/ro Zahara Tariku for her heartfelt cooperation and encouragement throughout my study. And last but not least I would like to thank all other people who helped me in accomplishing my study.

# Abstract

Delay in court process is one of the social evils in the administration of justice. It is generally agreed that there is problem of delay in our courts especially in criminal cases. In light of this reality, it is important to study the problem of court delay in order to find possible remedies. The objective of this research is to examine the influence of some causes of delay on the speed of a criminal case in the time just after an indictment is filed and prior to post-trial processes. The data set includes 660 criminal cases filed from Sep. 26, 2007 to Nov. 26, 2007. The follow up period was one year and all cases adjourned beyond Nov. 26, 2008 are taken to be censored. The survival behaviors are estimated and tested for significance using the Kaplan-Meier estimators along with the log-rank and the Wilcoxon tests. The tie among causes of delay in criminal trials and the speed of disposal of criminal cases is assessed using the Stratified Cox proportional hazards model. The factor criminal offense (p-value = 0.0158, HR = 1.243) is found to be a significant contributor to the pace of litigation in criminal proceedings. Therefore, quick adjustment is crucial on the justice delivery system of the two courts through giving trainings at all levels to upgrade the capacity of judges, prosecutors and court supporting staff.

# 1. Introduction

## 1.1 Background

A court is a judiciary tribunal established to administer justice. It is also defined to be a person or body of persons whose task is to hear and submit a decision on cases at law.<sup>1</sup> A crime is an act which is prohibited and made punishable by law. An act consists of the commission of what is prohibited or the omission of what is prescribed by law.<sup>1</sup> Therefore, a criminal court is a session of judicial assembly who are assigned to administer criminal cases. Although criminal laws are of many varieties, most criminal proceedings include the following steps: investigation, arrest, charge, bail, sentencing and appeal.

At the very beginning law enforcement personnel investigate a criminal activity and the police or sheriff makes a decision to refer it to the prosecutor. Once the prosecutor filed a charge, he or she should obtain a warrant so that the police make an arrest. Following the defendant's arrest, the judge will order him/her to be bound for a trial or the judge will dismiss the case by releasing him/her on a preliminary hearing. If the defendant is bound for a trial with a bailable charge then he/she may be released pending trial on personal recognition. A trial may be held before a judge or a jury. Typically, the jury may recommend a sentence and the judge sentences the defendant. If the defendant is found guilty, he/she can appeal the decision within a specified time after the court officially pronounces the sentence.<sup>2</sup>

Though the criminal justice system is clearly bounded by law, delays in court process threaten the very foundations of it. Court delay is one of the social evils in the administration of justice since it has a strong impact on the society at large and on individuals in criminal litigation. Court delay adversely affects litigants. Moreover, the lag in the administration of justice incalculates pessimism and suspicion in the public at large.<sup>3</sup>

There are problems of delay in our courts especially in criminal cases. In recent years this problem has received the attention of the community at large. Our courts are crowded by the ever increasing excessive backlog of cases and lengthy trials. Speedy judiciary process kept on deteriorating and it needs an immediate solution.<sup>3</sup>

In light of these realities, studies need to be done to alleviate the problem of delay in criminal proceedings. Thus, this study is focused on assessing the influence of causes of delay in criminal

proceedings on the pace of the processes after filing of a compliant and before an appeal. Owing to the vastness of the subject of delay, available causes were studied to identify the extent of their influence in aggravating delay.

## **1.2 Statement of the problem**

Ethiopia, one of the first signatories of the Universal Declaration of Human Rights, recognized the right to speedy trial. <sup>4</sup> The Federal Constitution of Ethiopia recognized and adopted this right. <sup>5</sup> In addition to this, the right is accorded by the Ethiopian Penal and Criminal Procedure. <sup>6</sup> But delay in criminal proceedings which violates the right to speedy trial remains unavoidable. It is thus important to assess factors causing delay in criminal trials in order to recommend solutions for sluggish trials. And the result obtained from empirical analysis of these determinants is one good source of information to help improve the justice delivery system in Ethiopia.

## **1.3 Objective of the study**

The primary objective of this study is to identify factors that are causes of delay on criminal proceedings in the Federal First instance Court Akaki Division and the Oromia Higher Court East Shoa Division. The special objectives are

- To identify the available factors contributing to delay,
- To select and establish a proportional hazards model suitable for the data,
- To estimate the survival time of a criminal case which is adjusted for the effect of the causes of delay

## **1.4 Significance of the study**

The data under the justice registration system of Ethiopia is handled manually and even those few higher courts that already implement computerized systems provide limited information. This necessitates a means to combat in getting better information. One way is to use statistical approaches. The dimension and direction of justice delay in criminal proceedings can be measured empirically following statistical analysis of the data. Moreover, government bodies and all other concerned stakeholders could implement statistical findings of this research to overcome the problem of justice delay. These include policy measures, budgetary affairs and

practitioner acts. In addition to this, it is hoped that further statistical studies draw on the findings of this study.

## **1.5 Limitation of the study**

- Some crucial causes of delay were not included as a result of lack of information in the courts' registration system. Ethical evaluation of judges, prosecutors and the police was not part of the data. Most of the filed cases had no record on advocates and causes attributed to the defendant such as level of education, economic status, employment status, cultural background and previous crime history. The data did not incorporate the specificity of the courts with respect to manpower (especially prosecutors, advocates and supportive staffs), technologies implemented, court management and case load which are possible sources of difference in court performance. Hence the magnitude of the influence of these factors could not be determined.
- The experience, income and age of judges and age of defendants on a case were taken on the average measure since there were two or more judges and/or defendants on some of the cases.
- Given that this is a new area, there is limited literature free of cost making it difficult to learn from past experiences.

## 2 .Literature review

The system of justice is so ambiguous and miserable for the mass people that it cannot be explained in a word. At present, the only demand of mass people is the speedy approach to justice. Certainly, the right to speedy trial constitutes one of the fundamental human rights which are procedural in their nature pertaining to trials considered as a corner stone of a society.<sup>3</sup> Almost all countries of the world incorporate this right in their domestic constitutions. The United States Constitution guarantees that “in all criminal proceedings, the accused shall enjoy the right to speedy and public trial.”<sup>7</sup> The Ethiopian constitution due process clause substantiated the provision of the right to speedy trial.<sup>5</sup> Moreover, the General code of Ethiopia states that the accused person is protected from being charged with a crime if guaranteed there has been long delay from the commission of the crime to the initiation of criminal proceedings.<sup>6</sup>

The right to speedy trial is a flexible concept that its interpretation has presented a dilemma for legal scholars and practitioners alike. On the one hand, the defendant must be protected from the disadvantage of prolonged pendency of charges. Among the disadvantages are stigma and financial loss, limitation on freedom of movement, the psychological strain of an uncertain future and the possible prejudice to defense through loss of witness or faded memories. At the same time, the state must protect its interest in seeking reprisal for violation of law. Dismissal of charge for failure to prevent trial delay may act to impose the dispensation of justice. It has been argued that a prolonged legal proceeding may have a number of social damaging effects. As cases pend over a long period of time, prosecution may be thwarted through defense challenges evidence, the unavailability of witnesses, a waning prosecutorial enthusiasm, and jury disenchantment with an offense that occurred in the remote past. The guilty that are released before trial, it is feared also have time to commit more crime or flee the jurisdiction, while defendants who are not bailed are unduly exposed to criminal learning environment. Finally, postponement exacerbates court congestion, which leads to greater reliance on plea bargaining and a weakening of the deterrent effect of the law, as well as a delay in rehabilitation of the guilty.<sup>8</sup>

Traditional solution to the dilemma have placed the onus of speedy trial guarantees on the accused, who must demonstrate that delay tactics are not being used to disadvantage the

prosecutor or unduly advantage the defense. It is argued that criminal cases must be brought to court within 48 hours of arrest.<sup>9</sup>

Having said this much about the legal basis of the right to speedy trial, let's see how cases are processed in a court. A crime committed against a person violates state law and thus is a crime against the state. The prosecuting attorney for the country in which the crime occurred usually handles the case. In a criminal case, the state has the burden of proving beyond a reasonable doubt that the defendant committed the alleged crime. Defendants are presumed innocent and never have the burden of proving their innocence.

The first step in a court process is **investigation**. Law enforcement personnel investigate reports of criminal activity, gather evidence, make arrests, and present the evidence to the prosecuting attorney. Based on the investigation, police or the sheriff may decide that crime has not occurred as defined under state law, there is insufficient evidence to pursue the complaint, or one or more persons may be arrested and the matter referred to the prosecutor. If the police determine that the evidence constitutes an offense and identifies a suspect, the matter is taken to the prosecuting attorney. As the legal representative for the state, the prosecuting or circuit attorney must then determine whether and what formal charges to file. Once a charge has been filed, usually in the form of a complaint, the prosecutor can go to a judge to obtain an **arrest** warrant. The court issues the warrant if there are sufficient facts to show probable cause that a felony has been committed by the defendant. This warrant will allow local law enforcement officials to make an arrest. During a felony trial, witnesses might have to **testify** at one or more of these three occasions: at the preliminary hearing or before the grand jury, at trial or at sentencing.

Felony cases begin with a **preliminary hearing** - a proceeding in which testimony is taken under oath. The defendant may waive a preliminary hearing, and the case usually will be sent directly to circuit court for trial. If the defendant chooses to proceed with a preliminary hearing, the judge, defendant, defendant's attorney, prosecutor, and any victims or witnesses subpoenaed will attend. The prosecutor presents evidence to show the judge that there is probable cause to believe a crime was committed and that it was committed by the defendant. The defense attorney can cross-examine the state's witnesses and produce evidence. If probable cause is established,

the judge will order the defendant to be bound over for trial. If the judge decides that probable cause has not been established, the court dismisses the case and the defendant is released. This also may occur if witnesses fail to appear to testify. In some cases the prosecutor can file another complaint against the defendant at a late stage based on the same crime. At any time, the prosecutor may decide to voluntarily dismiss the charges, called *nolle prosequi*.

A **grand jury** sometimes replaces the preliminary hearing as a method by which criminal charges can be filed. A grand jury is composed of a panel of private citizens, chosen similarly to trial juries, whose job is to look into allegations of criminal activity. Not every country has a grand jury. The prosecutor presents evidence to the grand jurors who decide whether a crime was committed and if the defendant could have committed it. Proceedings are closed to the public, and the accused does not have the right to be present unless subpoenaed, and may not present evidence on his behalf. The jury has the power to issue subpoenas to compel witnesses to testify or to produce documents and other evidence. As with a preliminary hearing, the case is bound over to the circuit court or the defendant is freed. A person charged with a **bailable** offense may be released pending trial on personal recognizance if the judge is assured the person will show up for court. If a preliminary hearing is held and the defendant is bound over for trial, bail is discussed at that time. For grand jury indictments, bail is addressed at the defendant's arraignment. The judge may release the person on bail by imposing any number of conditions as specified under state law. Release on bail is not available for "capital offenses" where the accused is subject to punishment by death. **Arraignment** is the first formal presentation of charges to the defendant, who must enter a plea. Also, the judge can raise or lower the defendant's bond. The arraignment is open to the public. After, an assistant prosecuting or circuit attorney is assigned to the case (for larger prosecutor offices). In some cases, the same prosecutor will be assigned from the onset and the case is added to a judge's docket. The court sets a trial date and hearing dates on pretrial motions. The trial date may change because of requests for continuances or because of other cases on the trial docket for that day. In all criminal cases, a **trial** may be held before a jury or, if the defendant does not want a jury trial, before a judge. Typically, jury-tried cases include a jury selection procedure (general voir dire), a guilt phase, and a sentencing phase. The jury may recommend a sentence. The judge sentences the defendant. Multiple **sentences** run concurrently (at the same time) unless the court specifies them

to run consecutively (one after the other). A defendant will receive credit for time served in jail or prison awaiting trial if the incarceration was not for time served on a different, unrelated offense. The state cannot **appeal** an acquittal of the defendant. If the defendant is found guilty, the defendant must appeal the decision within specified time after the court officially pronounces the sentence. Appeals are heard by the Higher Court, unless a death sentence is imposed. Then the appeal goes directly to the Supreme Court.<sup>10</sup>

One can refer to the question ‘When do we say that there exists delay and violation of the right to speedy trial?’ after having a clear image of a court’s process. This can be determined in two ways. The first is related to cases where the legislation has undertaken to fix a time within which the case is to be disposed of. Some constitutions guarantee the right to speedy trial in a general manner without specifying the time within which a certain criminal case is to be disposed of. For instance, it is stated under the speedy trial act of 1974, adopted by the USA congress, “a trial must commence within 100 days a defy is excluded from computation. The act further breaks down the least day period of arrest of the accused. But the time limit may be extended to some periods stipulating that an indictment or an arrest or service with summons. Trial is to commence within 70 days of filing of the indictment or information or the litigant’s first appearance in courts whichever occurs late.”<sup>11</sup> Compliance must be with the statute requiring the bringing of the accused to trial within a specified time. When courts or the law enforcement agencies fail to dispose a certain criminal case within the time period provided by the statute of limitation then there is delay in criminal proceeding. The accused is entitled to discharge or dismissal of proceeding in such cases.<sup>3</sup>

The second refers to cases where the constitution guarantees the right to speedy trial without specifying the period of time within which a case is to be disposed of. In countries like Ethiopia what constitutes delay is determined by the courts discretion depending on facts and circumstances in each and every case. In the absence of statutory limitation time is not the only factor to be taken into account in determining delay of a proceeding. This is clearly specified in Barker versus Wing case of the USA Supreme Court. The court offered four balancing tests to determine whether a defendant’s right to speedy trial had been violated or not. These are the length of prosecution, the reason for delay, defendant’s assertion of his right and the prejudice cause to the defendant.<sup>12</sup>

**Length of prosecution:** The passage of time is a condition for allegation how much time must pass to provoke which varies with the circumstances and the nature of the case. The court in this case suggests that delay that can be tolerated for an ordinary street crime is considerably less than for that of a serious complex conspiracy charge. That is to mean a longer delay is to be tolerated more on a serious charge than on an ordinary street crime. The prosecutions pre-trial preparation may take more time in complex cases involving many witnesses and complicated financial transactions than that of an ordinary street crime where preparation for trial after arrest commences easy prosecution.<sup>13</sup>

**Reason for delay:** Once unreasonable delay is established the reason for delay must be considered. Delay caused by the accused cannot be the basis for claiming the violation of the constitutional right.<sup>14</sup> When the accused has delayed the trial by his/her own act or failure to act, it is deemed as if he/she waived his/her constitutional right.<sup>15</sup> However, if delay is caused by a public prosecutor, overcrowded courts and by any other not attributed to the accused then it is a sufficient ground for the accused to raise his/her constitutional right.<sup>16</sup>

**The defendant's assertion of his constitutional right:** This refers to the fact that defendant's failure to raise the violation of his/her rights constitutes waiver of his/her right. The issue of delay is to be discussed if the accused raised it. If he/she fails to do so then it amounts to the waiver of his/her right.

**Prejudice to the defendant:** The most significant prejudice is that which impairs the defendant's ability to defend himself. Such prejudices arise when the defendant witnesses have died or disappeared or are unable to recall the past events accurately owing to the delay. Personal prejudice such as loss of employment or the experience of public scorn is also considered.

Generally delay in bringing the accused to trial must be justified on the ground of reasonableness and good cause. Good cause of delay is determined from all facts and circumstances of a particular case. Circumstances to be considered depend on gravity of the charged offense, character of evidence, number and residence of witnesses, nature of defense and others. There is no fixed rule to determine good cause of delay in a trial. It rests on the discretion of the court which cannot be exercised arbitrarily. It should be based on all the facts and circumstances presented to the court.<sup>17</sup>

Some of the causes of delay are as follows: lack of manpower, the habit of adjournment, the joinder of defendants, and absence of witnesses and/or judges.

**Lack of manpower:** The fact that there are few criminal court divisions is one of the causes of delay in criminal proceedings. Also courts are overburdened with compiling a number of cases due to less number of judges. Judges are known in how many cases they have adjourned not in how many cases they have decided. Yet a large number of cases is forwarded to the courts each and everyday. But few judges with a small number of supportive staff are assigned to the criminal divisions.<sup>18</sup>

**The habit of adjournment:** The defendant usually denies the charge which is framed against him/her in trial proceeding. The court would never give judgment on what the accused is merely saying. Evidence is needed to prove that the accused is guilty of the crime or not. Adjournment is needed to establish guilt of the accused beyond reasonable doubt. The reasonable doubt standard is constitutionally required against erroneous conviction which is the corner stone of criminal law. Adjournment needed for the accused is difficult to be determined overnight. If the court gives decision in haste, it may erroneously convict an innocent defendant.<sup>19</sup> This does not mean that the court should not dispose a case in the shortest possible time. Hence there has to be balance between two conflicting principles, the right to speedy trial and principle of reasonable doubt standard. The laws governing adjournment in the criminal procedure fail to compromise these interests effectively. For instance, provision governing adjournment in the Criminal Procedure Code of Ethiopia has loopholes which give a wide discretionary power to the court. It creates a practical problem in application which in effect causes delay in trial proceeding. The first problem is related to interpretation. Different judges perceive criminal code articles in different ways. This makes its application very difficult. The other problem is in relation to those grounds of adjournments that it should be granted for indefinite period of time. The law gives a wide discretionary power to the judge to grant adjournment for a definite time that he/she consider is sufficient to carry out the case on proceeding. In addition to this, there is also a problem in relation to court power to grant further adjournment. It is stated under the Ethiopian Criminal Code that the purpose for which the adjournment was granted should not been carried out for a reason not attributable to the faulty of prosecution. Under this circumstance the law

does not specify for how many consecutive terms further adjournment should be granted.<sup>19</sup> All in all, the law should explicitly describe adjournment with regard to its application.

**Joinder of defendants:** A crime may be committed in a group and in organized manner. The perpetrators may act in the same capacity or the role of each may differ. Here lies the necessity of bringing all those who participated in commission of a certain crime together. Joinder of defendants refers to conditions where two or more defendants are charged with the same criminal activity.<sup>20</sup> It is exception to the general rule that every person should be tried separately. Joinder of defendants may do injustice to some of the defendants. Joint trial may hamper a defendant in the process of making his/her defense. Some of the defendants may fail to appear or to present their evidences which usually cause further adjournment. Again individual defense may be antagonistic where one throws blame on the other. The court cannot give judgment separately. The case should be tried altogether. Hence delay caused by some may adversely affect others.<sup>3</sup>

**Absence of the accused and/or the judge:** It is the general rule that the accused has a constitutional right to be presented throughout his/her trial. The rationale behind this principle is to enable the court to execute judgment against the accused and afford the accused the opportunity to defend himself/herself. Also the continued presence of the judge during the entire course of trial is essential to the validity of the proceedings. There can be no court without a judge.<sup>21</sup> And hence at least the judge should be present at every stage of the criminal proceeding in order that he/she may conduct the trial and protect the right of both parties in the litigation. But this is not the reality litigants face today. Judges keep on exercising unreasonable absence which in turn contributes to further adjournments.

Even though there are limited statistical findings on survival approach to the issue of identifying factors of delay in criminal litigation, some researchers made efforts to address the problem. An overarching result from the best of the earlier statistical studies are marked by the modest conclusion that “courts differ” in what shapes processing time<sup>22</sup> and the acknowledgment that no one has covered “a small number of common, influential factors” to explain why one case takes longer to resolve than another. Moreover, even with the development of larger sets of individual factors, prospects for stronger results are considered to be dim. For example, Flemming, Nardulli, and Eisenstein (1987) warn that “substantial limits may exist for building theories of case processing time solely on the basis of case and disposition information.

Courts display idiosyncratic patterns of statistically significant variables that undermine prospects that a few key indicators of a court's 'raw material' or its 'technology' can substantially explain case processing times.<sup>23</sup> This despairing view is magnified by Luskin and Luskin (1986), who see virtually no systematic patterns between potential causal determinants and processing time. They write: "Not every variable varies in every court, and even the variables that do have varying effect."<sup>22</sup> The inability of case-related factors to account for why some cases take longer than others to be resolved has led some researchers to stress the importance of organizational factors, such as the type of judicial calendar, the number of filings per judge, the existence of speedy trial rules, and the extent of interagency cooperation among the professional participants in the criminal justice process. In fact, a good deal of attention has focused on the point that timely case processing is primarily the result of the beliefs and behavior of judges, prosecutors, and criminal defense attorneys. Nimmer (1978) observed that the "local discretionary system" is a major obstacle to criminal court reform efforts. He went on to claim that lengthy case processing times are "most directly associated with prevailing informal norms of the judicial process and with the personal motivations of participating attorneys and judges." After a study in 21 state courts, Church and Carlson (1978) developed the idea of "local legal culture" to describe this blend of informal court system norms and practices. The concept of local legal culture has come to imply that the pace of litigation is primarily governed by shared beliefs, expectations, and attitudes within the local court community about how fast criminal cases should move. Since this landmark study, the concept of local legal culture has become a regular part of the discourse about the criminal court process. Yet, few researchers have ventured to probe the nature and effects of local legal culture on criminal adjudication.

While incorporating court contextual factors into the analysis of case processing time has strong appeal, the traditional approaches used have run into at least four methodological problems. First, early attempts to assess and measure local legal culture were primarily qualitative. For example, Church's argument for local legal culture rests on visual inspection of data on timeliness and practitioners' views in one instance<sup>24</sup> and comparisons of responses to hypothetical cases by participants in four courts in another.<sup>23</sup>

The second concern arises because the opportunity to analyze the simultaneous influence of several contextual variables is quite restricted. Quantitative studies of case processing time

employ a statistical model that validly can incorporate only a limited number of contextual factors. As a result, the contextual factors must be selected carefully—unless the number of courts examined is very substantial. A detailed and extensive analysis of contextual factors remains difficult due to the high cost of gathering information on individual case characteristics. In addition, theoretical knowledge of what aspects of context “matter” remains relatively primitive, thus inhibiting the correct choice of the specific factors that will have the most explanatory payoffs. Absence of a better understanding of the precise contextual factors to examine, most studies are said to be shooting in the dark when selecting a handful of potential contextual indicators to include in a statistical model.<sup>25</sup> A third concern is the strong possibility that many contextual factors are mutually intertwined and therefore difficult to distinguish individually. Moreover, the limits on the number of variables that can be included in the model preclude the possibility of turning each possible combination into separate variables. The fourth, and most fundamental, concern is that identifying the existence of a particular aspect of context is not the same as measuring its actual effect. Many courts have, for example, implemented delay reduction programs with specific procedures, but the actual consequences of these procedures on case processing time vary dramatically. A successful delay reduction effort depends on the interaction of numerous (and often difficult to measure) factors, such as judicial leadership in articulating and enforcing time goals; interagency cooperation between the judiciary, prosecution, and defense bar in achieving the time goals; efficient use of resources; and sufficiently skilled attorneys. The objective of assessing many contextual factors is not simply to note their presence or absence, but to measure the level of acceptance and effectiveness among the critical court actors.

Hence, a general observation that one can draw from the literature is that the efficient resolution of criminal cases is an interactive process requiring the cooperation and coordination of judges, prosecutors, and defense attorneys. And therefore, the issue of identifying the factors that determine court processes needs in depth analysis of covariates associated with the above iterative process.

## **3. Data and Methodology**

### **3.1 The Data**

The data includes 660 criminal indictments. Out of these 173 cases were filed under the Oromia State Higher Court East Shoa Division and the remaining were from the Federal First Instance Court Akaki Division. Information was gathered on cases with files opened from Sep.26, 2007 to Nov.26, 2007. The follow up ended on Nov.26, 2008. That is, all cases which had been adjourned beyond Nov. 26, 2008 are taken to be censored. The statistical package SAS 8.0 was used to analyze the data.

### **3.2 The Variables in the Study**

The response variable is the speed of court process in criminal trials, which is the measure of duration in days from filing of a compliant to its disposal or until it is censored. The explanatory covariates include

- Factors attributed to the judge
  - Average age of judges in complete years
  - Average income of judges in birr
  - Average experience of judges in complete years
  - Number of judges on a case
- Factors attributed to the court
  - The court where the case was processed
  - The charge at indictment
- Factors attributed to the defendants
  - Average age of defendants
  - Number of defendants on a case
- Factors attributed to all parties
  - Number of adjournments on a case

Table 3.1 Covariates and their description

Covariates	Description	Category	Design variable	Coding
JNUM	Number of judges on a case	Less than four	jnum1	0(reference)
		Four to six	jnum2	1
		More than six	jnum3	2
CRIME	Criminal Offense	Against National Interest	nati	0(reference)
		Against Public Interest	pubc	1
		Against Family	fami	2
		Against Property	prop	3
JAGE	Average age of judges on a case	Less than 39 years	jage1	0(reference)
		39 to 43 years	jage2	1
		Over 43 years	jage3	2
JEXP	Average experience of judges on a case	Less than nine years	jexp1	0(reference)
		Nine to thirteen years	jexp2	1
		Over thirteen years	jexp3)	2
ADJ	The number of adjournment on a case	Less than two	adj1	0(reference)
		Two to three	adj2	1
		Three or more	adj3	2

Table 3.1 (Continued)

Covariates	Description	Category	Design variable	Coding
DAGE	Average age of defendants on a case	Less than twenty-five	dage1	0(reference)
		Twenty-five to thirty-three	dage2	1
		Over thirty-three	dage3	2
JINC	Average income of judges on a case	Less than 2655 birr	jinc1	0(reference)
		2655 to 3000 birr	jinc2	1
		More than 3000 birr	jinc3	2
JOINDER	Joinder(number) of defendant on a case	One	join1	0(reference)
		Two	join2	1
		Three or more	join3	2
Covariates	Description	Category	Design variable	Coding
COURT	The court where the case was processed	Oromia State Higher Court East Shoa Division	oroh	0(reference)
		Federal First Instance Court Akaki Division	fed1	1

### 3.3 Methodology

The methods of survival analysis through the Kaplan-Meier estimator and the Cox proportional hazards model are used in this study.

### 3.3.1 Theoretical Background of Survival Analysis

Survival analysis is the name given to the techniques for studying data related to the time to an event. The data frequently come from medicine, demography (time to death) or engineering (time to failure of component of a machine). The terminology varies from discipline to discipline. Survival analysis is the name used in biostatistics and it is applied in medical and public health studies. The analytical technique is known as failure-time (reliability) analysis in engineering, event-history analysis in sociology and duration modeling in economics.

Survival time refers to the time from a particular starting time to the occurrence of an event or a particular end point of interest. There are certain aspects of survival data, such as censoring, truncation and non-normality, which generate great difficulty during analysis using standard statistical models. Censoring is a form of missing data problem which is common in survival analysis. This study focused on right censoring which occurs when a case is adjourned beyond the study period or the case is transferred to higher appellate courts. If the case's processing time is known to be less than certain duration then the case is said to be left censored. Left censoring occurs when cases included in the study are on appeal to judgment. If we only know the interval of time during which the event occurred then it is known as interval censoring. Truncation is a process of screening out or selecting cases that satisfy a certain criteria. It is different from censoring, since for a left censored datum, we know the case exists but for truncated datum we may be completely unaware of the case.

The prospect of censoring complicates a research design and the statistical analysis. Thus censoring creates some casual problem because such data cannot be handled properly by standard statistical methods. New developments in statistical theory followed by new developments in statistical computing have changed how researchers can study survival data. The method known as survival analysis was developed by biostatisticians modeling human life times (Cox, 1972, Cox and Oaks 1984; Kalbfleisch and Prentice, 1980) in medical and biological sciences. And that has been extended by economists and sociologists studying social transitions (Allison, 1984) as well as in engineering (reliability and failure time analysis).

Three different methodologies exist for the analysis of survival data, non-parametric, parametric and semi parametric approaches. No assumption is required about the distribution of

the data in non-parametric methods. Nonparametric methods include descriptive methods to estimate the survival function or the distribution of the survival time from a sample using life table methods, Kaplan-Meier estimator, Nelson-Aalen estimator and Fleming-Harrington estimator. Non-parametric survival comparisons involve techniques that are available for comparing two or more survival distributions. The most commonly used technique is the Log-rank test or Mantel-Haenzel test. There are also other tests such as the Generalized Wilcoxon test, Tarone-Ware test, Peto-Prentice test, Harrington-Fleming test and likelihood ratio test. Parametric methods involve specification of the distributional form of the survival time with long tail to the right. This in turn specifies the survival function and the hazard function. Semi-parametric regression models are used in survival analysis to examine the relationship between survival experience and one or more predictors, usually termed as covariates in the literature.

### 3.3.2 The hazard and the survival functions

An important concept in survival analysis is the hazard rate about which an intuitive idea can be obtained from visual inspection of data with discrete time. For discrete time, the hazard rate is the probability that a case will be disposed at time  $t$  while it is at risk of being disposed. Thus, the hazard rate is just the unobserved rate at which a case is disposed. Yet it controls both the occurrence and the timing of disposal of cases. Another important aspect of the hazard function is to understand how its shape will influence the other functions such as the survival function and the density function. Once the hazard rate is modeled the other functions can be obtained easily.

If time is taken as a continuous random variable  $t$  which is the duration of stay in the state then the population is assumed to be homogenous with respect to the systematic factor, regressor variables, which affect the distribution of  $t$ . This means that every criminal case's duration of stay will be a realization of random variables and have the same probability distribution (Lancaster, 1990). The interest is to estimate the probability of disposal of a criminal case within the next period after delaying for  $t$  days as a result of different factors. This study will focus on cases that are filed and model their survival probabilities. The survival function denotes the probability of survival of a criminal case beyond a particular time  $t$ . This function is obtained from what is known in survival literature as the failure function  $F(t) = \text{prob}(T \leq t)$  which is the probability that a case will be disposed before time  $t$ . Thus the survival function  $S(t)$  is

$$S(t) = \text{prob}(T > t) = 1 - F(t)$$

The probability density function  $f(t)$  will be

$$f(t) = \frac{dF(t)}{dt} = \frac{d(1 - S(t))}{dt} = -\frac{d(S(t))}{dt}$$

The hazard function  $h(t)$  is the instantaneous rate of disposal of cases which depends on time. It is given by

$$h(t) = \lim_{\Delta t \rightarrow 0} \frac{\text{prob}(t < T < t + \Delta t / T > t)}{\Delta t}$$

After some mathematical manipulation,

$$h(t) = \frac{f(t)}{S(t)} = \frac{-dS(t)}{dt} \cdot \frac{1}{S(t)} = -\frac{d}{dt} \ln S(t)$$

Integrating both sides

$$-\int_0^t h(u) du = \int_0^t \frac{d}{du} \ln S(u) du$$

Exponentiating both sides

$$S(t) = \exp\left(-\int_0^t h(u) du\right) = \exp(-H(t))$$

Clearly,

$$f(t) = h(t)S(t) = h(t)\exp(-H(t))$$

Therefore the density function is determined by the hazard function. Modeling of survival data usually employs the hazard or the log hazard function. For instance, the exponential distribution has a constant hazard,  $h(t) = v$ .

$$f(t) = ve^{-vt}$$

Other common hazard models include  $\log(h(t)) = v + g \cdot t$  which leads to the Gompertz distribution of survival times and  $\log(h(t)) = v + g \cdot \log(t)$  leading to the Weibull distribution (Cox and Oakes, 1984).<sup>26</sup>

### 3.3.3 Estimation of survival functions and model parameters

The Kaplan-Meier estimator is used to estimate the survival function. This is described in the following subsection.

#### 3.3.3.1 The Kaplan-Meier Estimator

The Kaplan-Meier estimator of the survival function, also called the product limit estimator, is the estimator used to estimate processing time of a criminal case and to construct survival curve which is helpful in comparing survival experience of cases among different levels of a categorical covariate. The estimator at any point in time is obtained by multiplying a sequence of conditional survival probability estimators. Each conditional probability estimator is obtained from the observed number at risk of being disposed and the observed number of disposed cases and is equal to  $\frac{(n-d)}{n}$ . It is also called the product limit estimator. It is defined by<sup>26</sup>

$$\hat{S}(t) = \prod_{t_{(i)} \leq t} \frac{n_i - d_i}{n_i}$$

where  $t_{(i)}$  is the  $i^{th}$  ( $i=1,2,\dots,m$ ) distinct disposal time observed in the data

$d_{(i)}$  is the number of disposed cases at time  $t_{(i)}$

$n_{(i)}$  is the number of cases at risk just before the  $i^{th}$  failure time.

#### 3.3.3.2 Comparison of survival functions

The standard statistical procedures, such as t-test, rank sum test and ANOVA may be applied on uncensored observations. But a modification is required for censored observations. It is always a good idea to begin with a graphical display of the data in each group. The figure in general shows the difference in the pattern of one survival function with the other. The basic

question is whether the observed difference in the figure is statistically significant or not. A number of statistical tests have been proposed to answer this question which includes log-rank, Tarone-Ware and generalized Wilcoxon tests. The calculation of each test is based on the contingency table at each observed survival time. Most software packages base their estimators on the hypergeometric distribution. Thus the expected number of failures and its variance are computed as follows

$$\hat{e}_{1i} = \frac{n_{1i} d_i}{n_i} \quad \text{and}$$

$$\hat{v}_{1i} = \frac{n_{1i} n_{0i} d_i (n_i - d_i)}{n_i^2 (n_i - 1)}$$

$n_{0i}$  is the number of cases at risk at survival time  $t_{(i)}$  in group 0

$n_{1i}$  is the number of cases at risk at survival time  $t_{(i)}$  in group 1

$d_{0i}$  the number of observed disposed cases in group 0

$d_{1i}$  the number of observed disposed cases in group 1

$n_i$  the total number of cases at risk at time  $t_{(i)}$

$d_i$  the total number of disposals .

The test statistic is defined as follows

$$Q = \frac{\left[ \sum_{i=1}^m w_i (d_{1i} - \hat{e}_{1i}) \right]^2}{\sum_{i=1}^m w_i^2 \hat{v}_{1i}} \quad 26$$

where  $w_i$  is the weight considered by the different tests. For instance, the log rank test is based on weights equal to one,  $w_i=1$ . Thus the log rank test statistic is

$$Q_{L.R} = \frac{\left[ \sum_{i=1}^m (d_{1i} - \hat{e}_{1i}) \right]^2}{\sum_{i=1}^m \hat{v}_{1i}}$$

Under the null hypothesis  $H_0:\beta=\beta_0$  against  $H_1:\beta\neq\beta_0$  the significance of  $Q_{LR}$  can be tested comparing the calculated value of  $Q_{LR}$  based on the given data with the tabulated value of  $\chi^2(1)$  at  $\alpha$ -level. In the manner similar to the two group case, the expected number of events for each of the  $K$  ( $K>2$ ) groups is compared under the assumption of same survival function, that is

$$\hat{e}_{ki} = \frac{d_i n_{ki}}{n_i}, \quad k=1, 2, \dots, K.$$

The observed and the expected number of disposed cases for  $K-1$  of the groups is given by

$$d_i = (d_{1i}, d_{2i}, \dots, d_{(K-1)i})'$$

and

$$\hat{e}_i = (\hat{e}_{1i}, \hat{e}_{2i}, \dots, \hat{e}_{(K-1)i})'$$

An estimator of the covariance matrix of  $d_i$  is  $\hat{V}_i$  assuming that the observed number of disposed cases followed a multivariate central hypergeometric distribution (Johnson and Kotz, 1997). The diagonal elements of this matrix are

$$\hat{v}_{kki} = \frac{n_{ki}(n_i - n_{ki})d_i(n_i - d_i)}{n_i^2(n_i - 1)} \quad k=1, 2, \dots, K-1.$$

And the off-diagonal elements are

$$\hat{v}_{ksi} = -\frac{n_{ki}n_{si}d_i(n_i - d_i)}{n_i^2(n_i - 1)} \quad k, s=1, 2, \dots, K-1, \text{ where } k \neq s.$$

The test statistic to compare the survival experience of the  $K$  groups is

$$Q = \left[ \sum_{i=1}^m W_i (d_i - \hat{e}_i) \right]' \left[ \sum_{i=1}^m W_i \hat{v}_i W_i \right]^{-1} \left[ \sum_{i=1}^m W_i (d_i - \hat{e}_i) \right]$$

Where  $W_i = \text{diag}(w_i)$  is a  $(K-1) \times (K-1)$  diagonal matrix of the value of the weight  $w_i$  at time  $t_{(i)}$  in all  $K-1$  groups. <sup>26</sup>

### 3.3.3.3 Proportional hazards regression model

The proportional hazards model, also called the Cox model, is a classical semiparametric method of analysis in survival studies. It shows the relationship between the time to disposal of cases, usually called failure time, and a number of explanatory variables known as covariates.

The hazard function for the  $i^{\text{th}}$  case is

$$h(t, x_i) = h_0(t) \cdot c(x_i) \quad i = 1, 2, \dots, n$$

where  $x_i = (x_{i1}, x_{i2}, \dots, x_{ik})$  is a column vector of  $k$  measured covariates for the  $i^{\text{th}}$  case,  $h_0(t)$  is the baseline hazard function and  $c(x_i)$  is a link function. Cox proposed a link function

$$c(x_i) = e^{(x_i \beta)}$$

where  $\beta = (\beta_1, \beta_2, \dots, \beta_k)'$  is a vector of regression parameters. The Cox proportional hazards model is thus defined as

$$h(t, x_i) = h_0(t) \cdot e^{(x_i \beta)} \quad i = 1, 2, \dots, n$$

**The Cox proportional hazards model has the following properties**

➤ The survival function

$$S(t, x_i, \beta) = [S_0(t)]^{\exp(x_i \beta)}$$

where  $S_0(t) = \exp\left(-\int_0^t h_0(u) du\right)$  is the baseline survival function.

➤ Proportionality of hazards ratio

Consider two cases which differ in their covariates values with respect to the corresponding linear predictor

$$Y_i = \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_k x_{ik}$$

and

$$Y_j = \beta_1 x_{j1} + \beta_2 x_{j2} + \dots + \beta_k x_{jk}$$

The hazards ratio for these cases remains constant overtime.

$$\frac{h_i(t)}{h_j(t)} = \frac{h_0(t).e^{Y_i}}{h_0(t).e^{Y_j}} = \frac{e^{Y_i}}{e^{Y_j}}$$

That is, the risk of disposal of a criminal case is the same no matter how long the case has been followed which is the main assumption of the Cox proportional hazards model.

➤ Interpretation of the regression coefficients

Consider a  $\Delta$  units increase in one of the covariates, say  $x_p$ , while the effects of other covariates remain constant.

$$x_{i0} = (x_{i1}, \dots, x_{ip}, \dots, x_{ik}) \text{ and } x_i = (x_{i1}, \dots, x_{ip} + \Delta, \dots, x_{ik})$$

Thus the log hazards ratio is

$$\ln \left[ \frac{h(t, x_{i0})}{h(t, x_i)} \right] = \ln \left[ \frac{h_0(t) e^{\beta_1 x_{i1} + \dots + \beta_p (x_{ip} + \Delta) + \dots + \beta_k x_{ik}}}{h_0(t) e^{\beta_1 x_{i1} + \dots + \beta_p x_{ip} + \dots + \beta_k x_{ik}}} \right] = \Delta \beta_p$$

Therefore  $\Delta \beta_p$  is the change in log hazard ratio at any time with  $\Delta$  units change in the  $p^{th}$  covariate after adjusting the effect of other covariates. The rate of change in hazards is

$$\frac{h(t, x_{i0}) - h(t, x_i)}{h(t, x_i)} = e^{\Delta \beta_p} - 1$$

**Estimation of parameters in the Cox model**

The data for the Cox model is denoted by the triplet  $(t_i, \delta_i, x_i)$  where  $t_i$  is the length of time the  $i^{th}$  criminal case is processed with the vector of covariates  $x_i$  and censoring indicator  $\delta_i$  where

$$\delta_i = \begin{cases} 1, & \text{if the case is disposed} \\ 0, & \text{otherwise} \end{cases}$$

An application of methods of calculus shows that the density function is the ratio of the hazard function to the survivorship function which yields the expression

$$f(t_i, \delta_i, x_i) = h(t_i, \delta_i, x_i) * S(t_i, \delta_i, x_i)$$

The likelihood for a right censored data is

$$\begin{aligned} L(\beta) &= \prod_{i=1}^n f(t_i, \delta_i, x_i)^{\delta_i} . S(t_i, \delta_i, x_i)^{1-\delta_i} \\ &= \prod_{i=1}^n [h(t_i, \delta_i, x_i)]^{\delta_i} S(t_i, \delta_i, x_i) \\ &= \prod_{i=1}^n [h_0(t) . \exp(x_i' \beta)]^{\delta_i} [S_0(t)]^{\exp(x_i' \beta)} \end{aligned}$$

The log likelihood becomes

$$l(\beta) = \sum_{i=1}^n \delta_i h_0(t) + \sum_{i=1}^n n \delta_i x_i' \beta + \sum_{i=1}^n \exp(x_i' \beta) \ln(S_0(t))$$

This is referred to as the full likelihood. Unless the baseline hazard  $h_0(t)$  is explicitly specified one cannot get the maximum likelihood estimator of  $\beta$  from the full likelihood. Cox proposed a partial likelihood approach to avoid the specification of the baseline hazard function. He speculated that the resulting parameter estimators from the partial likelihood function would have the same distributional properties as full maximum likelihood estimators.

Let  $x_{(i)}$  be the vector of covariates at the ordered disposal time  $t_{(i)}$  after ordering the  $m$  distinct disposal times. The partial likelihood becomes

$$L_p(\beta) = \prod \left[ \frac{\exp(x_{(i)}' \beta)}{\sum_{j \in R_{(i)}} \exp(x_j' \beta)} \right]$$

The log partial likelihood function is

$$l_p(\beta) = \sum_{i=1}^m \left\{ x'_{(i)} \beta - \ln \left[ \sum_{j \in R_{(i)}} \exp(x'_j \beta) \right] \right\}$$

The maximum likelihood estimator is obtained by differentiating  $l_p(\beta)$  with respect to  $\beta$  and then equating the result to zero. The derivative is as follows

$$U(\beta) = \frac{\partial l_p(\beta)}{\partial \beta} = \sum_{i=1}^m \left\{ x_{(i)} - \bar{x}_{wi} \right\}$$

$U(\beta)$  is the score vector ,

$$\bar{x}_{wi} = \sum_{j \in R_{(i)}} w_{ij}(\beta) x_j, \text{ and}$$

$$w_{ij}(\beta) = \frac{\exp(x'_j \beta)}{\sum_{j \in R_{(i)}} \exp(x'_j \beta)}$$

The maximum partial likelihood estimator of  $\beta$  is denoted by  $\hat{\beta} = (\hat{\beta}_1, \hat{\beta}_2, \dots, \hat{\beta}_k)'$

The observed Fisher's information matrix, denoted by  $I_o(\beta)$ , is computed from the second order partial derivative of the log partial likelihood with respect to  $\beta$ . That is

$$I_o(\beta) = -\frac{\partial^2 l_p(\beta)}{\partial \beta \partial \beta'}$$

The diagonal elements are

$$\frac{\partial^2 l_p(\beta)}{\partial \beta^2} = -\sum_{i=1}^m \sum_{j \in R_{(i)}} w_{ij} (x_{ik} - \bar{x}_{w_{ik}})^2$$

And the off diagonal elements are given by

$$\frac{\partial^2 l_p(\beta)}{\partial \beta_k \partial \beta_l} = -\sum_{i=1}^m \sum_{j \in R_{(i)}} w_{ij} (x_{jk} - \bar{x}_{w_{jk}})(x_{jl} - \bar{x}_{w_{jl}})$$

The estimator of the covariance matrix of the partial likelihood estimator is the inverse of the observed Fisher's information matrix evaluated at the estimated value of the regression coefficient. Mathematically,

$$\widehat{Var}(\hat{\beta}) = \left[ I_0(\hat{\beta}) \right]^{-1}$$

If there are ties in the data set then the true partial log likelihood function involves permutations and can be time consuming to compute. In such cases one can apply either of the Breslow (1974), the exact or the Efron (1977) approximations. The following are their respective partial likelihoods:

$$L_{pB}(\beta) = \prod_{i=1}^m \frac{\exp(x'_{(i)+}\beta)}{\left( \sum_{j \in R_{t(i)}} \exp(x'_j\beta) \right)^{d_i}}$$

$$L_{pE}(\beta) = \prod_{i=1}^m \frac{\exp(x'_{(i)+}\beta)}{\sum \exp(s'_j\beta)}$$

$$L_{pEJ}(\beta) = \prod_{i=1}^m \frac{\exp(x'_{(i)+}\beta)}{\prod_{k=1}^{d_i} \left\{ \sum_{j \in R_{t(i)}} \exp(x'_j\beta) - \left( \frac{k-1}{d_i} \right) \sum_{j \in R_{t(i)}} \exp(x'_j\beta) \right\}}$$

where  $d_i$  is the number of ties at  $t_{(i)}$ ,  $x_{(i)+}$  is the sum of the covariate values of the tied cases and  $s_j$  is the sum of covariate values of the possible selection of ties at a time from their respective risk sets.

Sometimes the maximum likelihood estimator may fail to produce a solution; hence another technique is required to make estimation possible. One such technique is the Newton-Raphson algorithm. It involves iterative procedures until a certain criterion of convergence is fulfilled

among consecutive estimates. Let  $\hat{\beta}^{(k)}$  be the estimate of  $\beta$  at the  $i^{th}$  iteration. The iterative

equation is set as  $\hat{\beta}^{(k+1)} = \hat{\beta}^{(k)} + I^{-1}(\hat{\beta}^{(k)})U(\hat{\beta}^{(k)})$  with the convergence criterion to be

$\hat{\beta}^{(k+1)} - \hat{\beta}^{(k)} < a$  where  $I(\beta)$  is Fisher information matrix,  $U(\beta)$  is the score vector and  $a$  is an arbitrary constant close to zero.

### 3.3.3.5 Tests in Cox proportional hazards model

Three distinct tests are available to test the significance of the estimates of the Cox model. These are the partial likelihood ratio test, the Wald test and the score test.

➤ **The partial likelihood ratio test**

The test compares the partial log likelihood difference among the model with the fitted parameters and with no effect of covariates or without the covariates. The test statistic is

$$G = 2 \left\{ l_p(\hat{\beta}) - l_p(0) \right\}$$

where  $l_p(0) = -\sum_{i=1}^m \ln(n_i)$

➤ **The score test**

The test is based on the score function,  $U(\beta)$ . The score test statistic is

$$\chi_s^2 = U'(0) [I_o(0)]^{-1} U(0)$$

where  $I_o(0)$  is the observed information matrix evaluated at  $\hat{\beta} = 0$

➤ **The Wald test**

It uses the estimated coefficients along with the estimated variances. The Wald test statistic is

$$\chi_w^2 = \hat{\beta}' [I_o(\hat{\beta})]^{-1} \hat{\beta}$$

where  $I_o(\hat{\beta})$  is the observed information matrix evaluated at  $\hat{\beta}$

Under the assumption of the null hypothesis holds all the three test statistics follow an approximate  $\chi^2(k)$ .<sup>27</sup>

### 3.4 Practical issues in proportional hazards model

#### 3.4.1 Model development

In any applied setting, performing a proportional hazards regression analysis requires a number of critical decisions. It is likely that the data will have more covariates than what is reasonably expected to be included in the model. So a decision must be made on a method to select a subset of the total number of covariates. Issues such as adjustment for confounding as well as statistical significance must be considered when selecting covariates. Once the subset is selected, it must be checked whether the model is 'linear' in the continuous covariates and, if not, what transformations are suggested by the data and subject specific considerations. Which interaction, if any, should be included in the model is another important decision.<sup>26</sup>

##### 3.4.1.1 Selection of covariates

There are three distinct methods to select a subset of covariates namely purposeful selection, stepwise selection and best subset selection.<sup>26</sup>

##### ➤ Purposeful selection of covariates

It begins with the bivariate analysis at 0.20 to 0.25 level of significance and deliberate inclusion of important non significant covariates. Then the multivariable model will be developed with a p-value of p (usually  $p < 0.1$ ). Some essential covariates are retained even though they proved to be non significant. Finally the significance of the removed covariates needs to be tested.

##### ➤ Stepwise selection of covariates

It involves the forward selection which is followed by backward elimination. The forward selection process adds to the model the covariate that is most significant among those in the model with a p-value of  $p_E$ . The backward elimination process checks each covariate in the model for continued significance with a p-value of  $p_R$ .

➤ **Best subsets selection of covariates**

The conceptual basis for best subsets selection of covariates in the proportional hazards regression is the same as in linear regression. The procedure requires criteria to judge a model. Mallows's  $C$ ,  $C=W_q + (p - 2q)$  where  $W_q$  is the Wald test statistic [Mallows (1973)], can be used as a criterion for best subsets. Good models will be those with small values of  $C$ . The value of the Score test can also be used to approximate  $C$  as  $C = S_q + (p - 2q)$  where  $S_q$  is the Score test statistic from a model excluding  $q$  of the  $p$  covariates. The value of the score test for the exclusion of the  $q$  covariates from the full  $p$  variables model is approximately  $S_q = S_p - S_{p-q}$  where  $S_{p-q}$  denotes the score test for the model containing a particular set of  $p-q$  covariates. Given the criteria, models containing  $q$  covariates will be screened and the covariates in the best, say 5, models will be reported for  $q=1, 2, \dots, k$ , where  $k$  denotes the total number of covariates.

**3.4.1.2 Checking linearity of continuous covariates**

Checking linearity of the continuous covariates can be achieved by using either the plots of log hazards ratios versus the midpoint of each cluster of the covariate or the plots of martingale residual of each subject versus its covariate value. The covariate need to be grouped into clusters for the first plot where midpoint and hazards ratio of the covariate are computed in each cluster. If the resulting plot is a straight line then it shows linearity in the covariate. The second plot takes in to account martingale residuals which are computed as follows: <sup>27</sup>

$$M_i = \delta_i - \hat{H}(t_i, x_i^{(-)}, \hat{\beta}^{(-)})$$

where  $M_i$  is martingale residual for the  $i^{th}$  case,  $\delta_i$  is the censoring indicator,  $\hat{H}$  is the estimated cumulative hazards ratio for the  $i^{th}$  case,  $x_i^{(-)}$  is the covariate vector for the  $i^{th}$  case after the continuous covariate is excluded and  $\hat{\beta}^{(-)}$  is the estimated coefficient vector excluding the coefficient of the continuous covariate.

The plot should result in no systematic pattern, that is, the plot should be random to indicate linearity. Any nonlinear pattern gives a clue for possible transformation of the covariate.

### 3.4.1.3 Interaction of covariates

This is checked through partial likelihood-based tests where each one of the interaction terms is included in the multiple Cox model at a time and tested for significance. Finally the Cox model is fitted with all significant interactions included and tested for their significance.<sup>26</sup>

### 3.4.2 Assessment of model adequacy

Model adequacy refers to how well the fitted regression surface describes the data cloud. The requirements are checking the proportionality of hazards ratio, overall summary of goodness of fit and subjectwise diagnostics of outliers and influential points.

#### 3.4.2.1 Checking proportional hazards model assumption

The proportional hazards assumption is vital to the interpretation and uses of a fitted proportional hazards model. There are many ways to check this assumption. Analysis of Schoenfeld residuals is useful in this regard. In its simplest form the  $i^{\text{th}}$  Schoenfeld residual,  $r_i$  for the  $i^{\text{th}}$  case is

$$r_i = x_{(i)} - \frac{\sum_{j \in R_{(i)}} x_j \exp(x'_{(j)} \hat{\beta})}{\sum_{j \in R_{(i)}} \exp(x'_{(j)} \hat{\beta})}$$

Consequently, a graph of  $r_i$  versus  $t_i$  provides an assessment of the proportional hazards assumption. Suppose that the coefficients of  $x_{ik}$  vary with time so that the  $j^{\text{th}}$  coefficient can be expressed as

$$\beta_j(t) = \beta_j + \gamma_j g_j(t)$$

where  $j=1,2,\dots,k$  and  $g(t)$  is some function of time.

The proportional hazards assumption requires that  $\gamma_j = 0$ . Cox (1972) suggested the function

g(t) = ln(t) followed by testing the null hypothesis,  $H_0 : \gamma_j = 0$  for all t. This is equivalent to saying that the proportional hazards assumption is true.<sup>26</sup> Another equivalent test is checking for constant nature of log hazards over time (Cleves and Gould, 2004).

### 3.4.2.2 Stratified Proportional Hazards Model

The rationale for creating a stratified proportional hazards model is the same as that for other stratified analysis. The model is also sometimes used to accommodate non-proportional hazards in a nominal scale covariate. If the hazard function for a continuous covariate has been identified as being non-proportional then a grouped version of the covariate could be created and it is treated as if it were a nominal scale covariate. The proportional hazard function for stratum s is

$$h_s(t, \underline{x}, \underline{\beta}) = h_{s_0}(t) e^{\underline{x}' \underline{\beta}} \quad s = 1, 2, 3, \dots, S$$

Hazard ratios are computed and interpretations are applied within each stratum. The full stratified partial likelihood is obtained by multiplying the contribution of each stratum to the likelihood, namely

$$l_{s_p}(\underline{\beta}) = \prod_{s=1}^S \left\{ \prod_{i=1}^{n_s} \frac{\exp(\underline{x}_{si}' \underline{\beta})}{\sum_{j \in R_{(t_{si})}} \exp(\underline{x}_{sj}' \underline{\beta})} \right\}$$

The general steps in model building and assessment are the same for the stratified model as for non stratified model except that the stratified analysis is based on the partial likelihood in the above equation.<sup>26</sup>

### 3.4.2.3 Identification of influential and poorly fit subjects

Another important aspect of model is examination of regression diagnostic to identify which particular case exert undue influence on estimates of the parameters and/or have undue influence on the fit of the model. Leverage is a diagnostic means that measures how 'unusual' the value of the covariates is for a case. The score residuals are sometimes referred to as the leverage or partial leverage residuals. The plot of the martingale residual versus the covariate value is an indicator of outliers. The  $i^{th}$  martingale residual for the  $i^{th}$  case is defined as

$$M_i = \delta_i - \hat{H}_i$$

where  $\hat{H}_i$  is the estimated cumulative hazard rate for the  $i^{th}$  case and  $\delta_i$  is censoring indicator with value 1 for disposed cases and 0 for censored cases. Criminal cases with martingale residual having large absolute values are taken to be outliers.<sup>28</sup>

The next step in the modeling process is to identify explicitly the cases with extreme values, refit the model deleting these cases, and calculating the change in the individual coefficients. The percentage change in a coefficient is calculated as

$$\Delta \hat{\beta}_j \% = 100 \times \frac{\Delta \hat{\beta}_j}{\hat{\beta}_{jall}} = \frac{100(\hat{\beta}_{jreduced} - \hat{\beta}_{jall})}{\hat{\beta}_{jall}}$$

where  $\hat{\beta}_{jall}$  stands for the estimate of the  $j^{th}$  coefficient from the model with no case deleted and  $\hat{\beta}_{jreduced}$  stands for the estimate of the  $j^{th}$  coefficient from the model with cases deleted.<sup>27</sup>

The final decision on the continued use of the case's data to fit the model will depend on either the observed actual change  $\Delta \hat{\beta}_j$  or the observed percent change  $\Delta \hat{\beta}_j \%$  in the coefficients that result from deleting the case's data. Criminal cases with large values of both measures influence the overall fit of the model.

#### 3.4.2.4 Overall goodness of fit and measures

One measure of fit in survival analysis is the coefficient of determination ( $R_p^2$ ) which is given by

$$R_p^2 = 1 - \exp\left\{-\frac{2}{n}(l_0 - l_p)\right\}$$

where  $n$  is the number of cases in the study,  $l_p$  is the log partial likelihood for the fitted model with  $p$ -covariates and  $l_0$  is the log partial likelihood for the fitted model without covariates. Another measure is the Cox-Snell residual which is given by

$$r_{ci} = \hat{H}_i(t) = \ln \hat{S}_i(t)$$

where  $\hat{H}_i(t)$  is the estimated cumulative hazard rate for the  $i^{th}$  case and  $\hat{S}_i(t)$  is the estimated survival function for the  $i^{th}$  case. The plot of the estimated hazard rate of the Cox-Snell residuals against the Cox-Snell residuals will be a 45 degree straight line through the origin if the model is good.<sup>27</sup>

## **4. Results and Discussion**

### **4.1 Descriptive analysis**

In any applied setting, a statistical analysis should begin with a univariate description of the data before proceeding to the more complicated models. Thus, the study included 660 criminal cases that were filed from September 26, 2007 to November 26, 2007. Out of these cases, 487 were processed in the Federal First Instance Court Akaki Division that resulted in estimated median survival time of 89 days and the remaining 173 cases with estimated median survival time of 245 days were from the Oromia State Higher Court East Shoa Division. A single judge administered 455 cases (median 242 days) while two and more than two judges were assigned to 109 cases (median 128 days) and 96 cases (median 160 days) respectively. Judges disposed 192 cases (median 109 days) before granting a second adjournment whereas two or three adjournments and more than three adjournments were granted to 288 cases (median 246 days) and 180 cases (median 369 days) respectively. Table 4.1.1(Annex) presents the covariates included with the number of disposed, adjourned and total criminal cases at each category. Table 4.1.2 (Annex) presents estimated median processing time at each of these categories. Thus, results in Table 4.1.1 and Table 4.1.2 indicate that the Federal court prosecuted cases faster than the State court. Moreover, the obvious case where a criminal case with additional adjournment would stay under the court's jurisdiction is proved to be true. In addition to these, increase in a group of judges assigned to see a case resulted in improvement of processing speed.

After providing an overall description of the criminal cases in this study, attention need to be given to their overall survival experience. The Kaplan-Meier estimates of the overall survival function, presented in Figure 4.1.1(Annex), showed a slow decline as a result of overall slow rate of disposal of cases. The survival experiences of cases across each factor of delay in criminal litigation are quantified for differences among their categories. The Kaplan-Meier survival estimate of each of the factors is presented in Figure 4.1.2(a-i) (Annex). The pattern of one survival function lied above another only in the number of adjournments on a case, that is, criminal cases defined by the upper curve were disposed later than the cases defined by the lower curve. Generalization cannot be made for factors which showed crossing survival curves across their categories. Even though categories within each of the factors showed differences, the

significance of these differences can be identified after applying statistical tests. Table 4.1.3 (Annex) presents the log-rank and the Wilcoxon test results where only four of the factors showed significant difference between their categories at 10 percent level. That is, the number of judges on a case, the average income of judges on a case, the court where a particular case was processed and the number of adjournments granted for a case are found significantly different with respect to their categories. Therefore, these factors are significant contributors to the difference in the pace of processing criminal cases.

## 4.2 Model Development

Regardless of which covariate selection method is used, any statistical analysis necessitates a thorough univariate analysis of the association between survival time and all available covariates. This was partly done by computing Kaplan-Meier estimates of the group specific survival functions, point and interval estimates of the median survival time and the use of the log-rank and the Wilcoxon tests to compare differences in survival experience across the categories of each factor. However, these methods cannot be used to address the more sophisticated questions that can typically be answered through regression modeling techniques. Thus, univariate Cox proportional hazards models containing each of the nine factors one at a time resulted in Table 4.2.1 (Annex). The court that administered a case, the number of adjournments on a case, the average income of judges on a case, the number of defendants on a case and the number of judges on a case are identified to be significant at 10 percent level. The stepwise selection procedure was preferred since there is no need to keep any of the nonsignificant factors for purposeful inclusion and SAS8.0 cannot provide Wald test results to estimate Mallow's C.

The results in Table 4.2.2 (Annex) are obtained using the score test values. There are a total of six steps, counting step0, with entry and removal p-values of  $P_E=0.15$  and  $P_R=0.05$ . At step0, there are 3 covariates with the smallest p-value,  $p<0.0001$ . Since this value is smaller than  $P_E=0.15$ , the variable with the largest score value (132.3918), the number of adjournments on a case, entered the model at step1. At step1 the court that processed a case has the smallest p-value ( $p<0.0001$ ) with the largest score value (782.5987) and it is smaller than  $P_E=0.15$ . So it entered the model at step2. At this step both the number of adjournments on case and the court that

processed the case have p-values to remove ( $p < 0.0001$ ,  $p < 0.0001$ ) which are less than  $P_R = 0.05$  and thus both remained in the model. Among the covariates not included in the model, the number of judges on a case has the smallest p-value ( $p < 0.0001$ ) which is less than the criterion for entry in to the model. Then the three covariates model, that include the previous three covariates, is fitted at step3. None of these covariates have a p-value ( $p < 0.0001$ ,  $p < 0.0001$ ,  $p < 0.0001$ ) larger than  $P_E = 0.15$  which leads to no removal of any of these covariates. The criminal offense a defendant has been accused of is found to have the smallest p-value ( $p = 0.0663$ ) among the excluded covariates at the third step. Therefore, this particular factor is included in the model at step4. But this factor is removed in the next step as a result of its p-value (0.0661) which is larger than  $P_R = 0.05$ . Finally, the three covariates model, which includes the number of adjournments, the number of judges on a case and the court that processed a case, is chosen to be the appropriate preliminary main factors model. This model is shown in Table 4.2.3 (Annex).

The next step in the process of model building is to make sure that none of the six excluded factors are neither significant in their own right nor confounders of the three selected factors. The excluded factors are introduced to the preliminary main factors model one at a time. The percentage change in the estimates of the coefficients of the three factors is found to be less than 20 percent (0.04548% - 6.12235%). Therefore, none of the removed factors is required in the model. Table 4.2.4 (Annex) presents the percentage contribution of each of the excluded factors to the estimates of the coefficients of the selected covariates when they are introduced one at a time.

Following the identification of potential confounding covariates, the scale of continuous covariates in the selected model should be examined. But all the three covariates in the model are either polytomous or dichotomous discrete factors. Therefore, focus is given to consideration of interactions between the factors in the model. This step begins with the creation of a list of possible interactions formed from the factors in Table 4.2.3 (see Table 4.2.5, Annex). The number of adjournments on a case with the court that processed a case and the number of judges with the number of adjournments on a case indicates significant interactions when added one at a time. Both interactions remained significant when they are simultaneously introduced to the model in Table 4.2.3. Thus, the preliminary final model is presented in Table 4.2.6 (Annex).

### 4.3 Assessment of Adequacy of the Model

The fitted model should be assessed for the assumption of proportionality of hazards ratio overtime along with diagnostic check for outlying and influential cases before using the results. Especially the assumption of proportional hazards is vital to the interpretation of the fitted model. Therefore, the extended Cox model is used to test this assumption. The model includes the preliminary final model and, the interaction of all main factors with logarithm of survival time. Table 4.3.1 (Annex) shows that all the interactions with logarithm of survival time are found to be significant at 5 percent score test, that is, all the three selected factors violated the assumption of proportionality of hazard ratio overtime. But the violation of the proportionality assumption must be rectified through some adjustments. One such adjustment is the stratified Cox model. All steps in the none stratified version of Cox model should be repeated after stratifying the data by all of the non-proportional factors. We introduce a new variable  $z' = (z_0, z_1, \dots, z_{g-1})$  where  $g$  is the product of levels of the stratifying factors if there are two or more such factors. In this study,  $g = 18$  strata are used to develop a new model as a result of three stratifying covariates. The stepwise selection of the six covariates which are stratified into 18 strata is shown in Table 4.3.2 (Annex) , that is, criminal offense is the only covariate selected after iteration of four steps with entry and removal p-values of  $P_E = 0.15$  and  $P_R = 0.05$ . The confounding effect of the five excluded covariates is found to be non significant with a maximum percentage change of 13.0541 percent in the coefficient of criminal offense due to the introduction of defendants average age (see Table 4.3.3, Annex). The preliminary main factors model remain to be the one in Table 4.3.4. The inclusion of the interaction of the main factors with the logarithm of survival time to the model in Table 4.3.4 (Annex) indicates that the assumption of proportional hazards is fulfilled at 5 percent level (see Table 4.3.5, Annex). Leverage diagnostics and a check for goodness of the fitted model is the proper step to follow after fixing the non proportionality of covariates.

Another important aspect of model evaluation is examination of the value of regression diagnostics statistics to identify influential and outlying cases. The DFBETA statistic is used to examine the influence of each case on the estimate of the coefficient of criminal offense. The largest absolute difference is observed at the 397<sup>th</sup> case which is from the 9<sup>th</sup> stratum with a value

of 0.025243 (see Table 4.3.6, annex). This difference, which is equal to 0.28\*(standard deviation of the estimated coefficient of crime), is smaller than one-third of the standard deviation of the estimated coefficient of crime. Therefore, all the changes in effect of punishable crime by deleting one case at a time showed no significance. Finally, none of the criminal cases is removed from this study as a result of neither influential nor outlying cases.

The final step in model evaluation is assessing the accuracy of the fitted model in explaining the variation in the processing speed of the observed data.  $R_p^2$  is used to assess the overall goodness of the fitted model and the index plot of deviance residual is used to check the accuracy of fit of the model for each criminal case. The computed value of  $R_p^2$  is

$$R_p^2 = 1 - \left\{ \exp\left[\left(\frac{2}{n}\right)(l_0 - l_p)\right] \right\} = 1 - \left\{ \exp\left[\left(\frac{3888.534 - 3982.477}{660}\right)\right] \right\} = 0.1326718$$

The above low value of  $R_p^2$  indicates the goodness of the fitted model. In addition to this, the index plot of the deviance residuals in Figure 4.3.1 (Annex) shows no systematic pattern in the distribution of the covariate values of crime which is an indicator of the good fit of the model to the cases in this study.

#### 4.4 Interpretation of the Model

The final model, the model stratified by the court that administered a case, the number of adjournments and judges on a case, includes a single polytomous covariate (the criminal offense). One must proceed carefully when computing hazards ratio for such categorical covariates. The first step is to write down the expression for the log-hazard ratio. It is given as follows.

$$g(CRIME) = \beta_{CRIME} * CRIME$$

The next step is to write down the expression for the difference between the category “crime against the nation” and other crime categories.

$$g(CRIME = a \neq 0, CRIME = 0) = a * \beta_{CRIME}$$

Then  $\hat{HR}(CRIME = a, CRIME = 0) = e^{a * \hat{\beta}_{CRIME}}$

The endpoints of the 95 percent confidence interval estimator of the hazard ratio is computed by exponentiating the endpoints of the confidence interval based on the above equation, that is

$$a * \hat{\beta}_{CRIME} \mp 1.96 * SE(a * \hat{\beta}_{CRIME}) = a * \hat{\beta}_{CRIME} \mp 1.96a * SE(\hat{\beta}_{CRIME})$$

Table 4.4.1 presents estimated hazard ratios and 95 percent confidence intervals for the different levels of crime versus crime against the nation. The result in Table 4.4.1 indicate that criminal cases with punishable offense against the public, against the family and against property are disposed at rates that are 24.3%, 54.5% and 92.05% higher than criminal cases with “crime against the nation”, respectively. The 95 percent confidence intervals for these categories suggest that increased disposal rates are as low as 4.17%, 8.51% and 13.03% or even as high as 48.32%, 120% and 226.31% respectively. In other words there is a general increase in the rate of disposal of criminal cases along with a decline in the severity of the criminal act in this study.

**Table 4.4.1 Estimated Hazard Ratios and 95 Percent Confidence Interval for the Different Levels of Crime versus “Crime against the Nation”**

Category	Hazard Ratio	95%CI
Crime Against the Public	1.243	1.0417, 1.4832
Crime Against the Family	1.545	1.0851, 2.2
Crime Against Property	1.9205	1.1303, 3.2631

The composition of a court’s caseload is often considered one of the determinants of case processing time because certain types of cases (e.g., most violent crimes) are thought to be inherently more complex (e.g., they involve more trials, more victims and witnesses). Therefore, such cases require more court time and attention to resolve than do other criminal cases. Some studies confirm that more serious cases take longer to resolve, but others conclude that the

seriousness of an offense has only a weak relationship to case processing time.<sup>29,30</sup> A study from Canada on adult criminal courts in the year 2008/2009 showed that some offences took longer to resolve than others. The study indicated that cases with homicide, sexual assault and attempted murder took longer to reach completion when compared to less severe crimes such as disturbance of peace, breach of probation and theft.<sup>31</sup> Another study on efficiency, timeliness, and quality of nine state criminal trial courts in USA indicated that almost all of the courts took longer to adjudicate the most violent cases, such as murder and rape, than other less serious cases.<sup>32</sup> The finding of this study goes hand in hand with the results from the above two studies.

## **5. Conclusions and Recommendations**

### **5.1 Conclusions**

The empirical analysis in this study resulted in a single strongly significant correlates of delay in criminal trial .That is only criminal offense affects the speedy course of litigation significantly, after stratifying the cases by the three factors of delay which failed to be proportional (the number of adjournments, the number of judges on a case and the court that processed a case). One possible explanation for the variation in the pace of litigation with respect to criminal offense is the difference in interpretation the criminal code. That is, unless judges have significant differences in interpretation of the code for cases with crimes against the nation and other crime categories they would not dispose the previous at a slower rate. Another possible explanation is the nature of the four crime categories. Generally speaking the seriousness and complexity of a crime decline down from crime against the nation to crime against property. In other words, crime against the nation is the most serious criminal act that will usually end up with longer judiciary process.

### **5.2 Recommendations**

Proper steps should be taken immediately to solve the problems of delay in litigation. Talking about the strategies to deal with justice delay, an improved justice delivery system means

- Cutting down the number of adjournments through reduction of the time for arguments and judges and/or witness absenteeism, stopping lawyers from extending cases and so on.
- Equip recruited judges to them with better understanding of criminal codes, proclamations and other legal procedures.
- Continuous improvement in judiciary staff, especially by increasing the number of judges per case and court size or any other measure to minimize case load per judge which decreases processing time indirectly.

- All in all, the focus on the determinants of delay in criminal processing is not limited to the above three correlates. Therefore, further in depth empirical analysis is crucial to minimize the problem and to come to the goal of 'justice just in time'.

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ANNEX

Table 4.1.1 Distribution of Factors Causing Delay in Criminal Litigation

Covariates	Category	Disposed	Censored (%)	Total
Number of judges on a case	Less than four	353	102(22.42)	455
	Four to six	92	17(15.6)	109
	More than six	86	10(10.42)	96
Crime	Against National Interest	7	2(22.22)	9
	Against Public Interest	31	6(16.22)	37
	Against Family	379	98(20.55)	477
	Against Property	114	23(16.79)	137
Average age of judges on a case	Less than 39 years	92	21(18.58)	113
	39 to 43 years	97	17(14.91)	114
	Larger than 43 years	342	91(21.02)	433
Average experience of judges on a case	Less than nine years	55	15(21.43)	70
	Nine to thirteen years	107	21(16.41)	128
	Larger than thirteen years	369	93(20.13)	462
The number of adjournment on a case	Less than two	187	5(2.6)	192
	Two to three	245	43(14.93)	288
	Three or more	99	81(45)	180
Average age of defendants on a case	Less than twenty-five	185	42(18.5)	227
	Twenty-five to thirty-three	176	38(17.76)	214
	Larger than thirty-three	170	49(22.37)	219

Table4.1.1 (Continued)

Covariates	Category	Disposed	Censored (%)	Total
Joinder(number) of defendant on a case	One	412	93(18.42)	505
	Two	74	19(20.43)	93
	Three or more	45	17(27.42)	62
The court where the case was processed	Oromia State Higher Court East Shoa Division	164	9(5.2)	173
	Federal First Instance Court Akaki Division	367	120(24.64)	487
Average income of judges on a case	Less than 2655 birr	322	99(22.97)	431
	2655 to 3000 birr	67	19(22.09)	86
	More than 3000 birr	132	11(7.69)	143

Table 4.1.2 Kaplan-Meier Estimates of Median, Standard Error and 95 percent Confidence Intervals for Survival Time of Criminal Cases

Covariates	Category	Median	Std. Error	95% CI
Number of judges on a case	Less than four	242	6.5484	236,245
	Four to six	128	14.5306	67,200
	More than six	160	10.6646	142,189
Crime	Against National Interest	122	36.1	2,244
	Against Public Interest	110	27.7467	43,370
	Against Family	231	6.127	193,241
	Against Property	200	12.5026	35,114
Average age of judges on a case	Less than 39 years	231	13.1593	168,245
	39 to 43 years	190	13.0959	127,239
	Larger than 43 years	225	6.6668	156,239
Average experience of judges on a case	Less than nine years	231	16.5278	147,249
	Nine to thirteen years	231	12.3798	133,247
	Larger than thirteen years	217	6.4272	159,239
The number of adjournment on a case	Less than two	109	4.3639	39,114
	Two to three	246	6.731	244,249
	Three or more	369	8.6161	308,430
Average age of defendants on a case	Less than twenty-five	192	8.5581	142,237
	Twenty-five to thirty-three	231	9.2736	131,245
	Larger than thirty-three	232	10.19	168,244

Table4.1.2 (Continued)

Covariates	Category	Median	Std. Error	95% CI
Joinder(number) of defendant on a case	One	205	6.0996	146,239
	Two	232	15.0506	162,251
	Three or more	238.5	17.3496	168,251
The court where the case was processed	Oromia State Higher Court East Shoa Division	98	7.943	69,116
	Federal First Instance Court Akaki Division	245	6.1574	243,249
Average income of judges on a case	Less than 2655 birr	244	6.5631	239,247
	2655 to 3000 birr	214	15.6518	134,239
	More than 3000 birr	116	10.5019	98,132

Table 4.1.3 Test Statistics, Degrees of Freedom, Chi-square Values and p-Value for the Equality of the Survival Function for Each Category in the Factors

Covariates	DF	Test	Chi-sq	p- Value
Number of judges on a case	2	Log-rank	14.2417	0.0008
	2	Wilcoxon	14.9981	0.0006
Average age of judges on a case	2	Log-rank	1.5644	0.4574
	2	Wilcoxon	1.2987	0.5224
Average experience of judges on a case	2	Log-rank	0.3143	0.8546
	2	Wilcoxon	0.1689	0.919
The number of adjournment on a case	2	Log-rank	446.1997	<0.0001
	2	Wilcoxon	442.2081	<0.0001
Average age of defendants on a case	2	Log-rank	0.4912	0.7822
	2	Wilcoxon	0.2977	0.8617
Joinder (number) of defendant on a case	2	Log-rank	2.8058	0.2459
	2	Wilcoxon	1.8134	0.4038
The court where the case was processed	1	Log-rank	119.7044	<0.0001
	1	Wilcoxon	126.148	<0.0001
Average income of judges on a case	2	Log-rank	44.119	<0.0001
	2	Wilcoxon	48.8933	<0.0001
Crime a defendant has been accused	3	Log-rank	1.9891	0.5747
	3	Wilcoxon	5.9559	0.1138

Table 4.2.1 Estimated Coefficients, Standard Errors, Chi-square Values and p-Value for the Proportional Hazards Model in the Univariate Analysis of Cases in the Two Criminal Courts

Covariate	DF	Parameter Estimate	Std Error	Chi-sq	p-Value
Number of judges on a case	2	0.03706	0.02198	2.8415	0.0919
Average experience of judges on a case	2	0.00457	0.01086	0.1773	0.6737
Average age of judges on a case	2	-0.004292	0.01095	0.2023	0.6529
Average income of judges on a case	2	0.0009469	0.0001234	58.9136	<0.0001
The number of adjournment on a case	2	-0.45492	0.03808	142.7001	<0.0001
Joinder (number) of defendant on a case	2	-0.09657	0.04779	4.0831	0.0433
Average age of defendants on a case	2	-0.00527	0.00386	1.8646	0.1721
The court where the case was processed	1	-1.01205	0.09677	109.3859	<0.0001
Crime a defendant has been accused	3	-0.00383	0.08243	0.0022	0.9629

Table 4.2.2 Resulting Stepwise Selection of Covariates- values for Entry to the Right and p- Value to remove to the Left of the Solid Line in Each Row for the Data in this Study.

Covariate/Step	0	1	2	3	4	5
The number of adjournment on a case	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
The court where the case was processed	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001
Number of judges on a case	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001
Crime a defendant has been accused of	0.9629	0.1136	0.056	0.0663	0.0661	0.0663
Average age of defendants on a case	0.17	0.2032	0.7867	0.9658		0.9658
Joinder(number) of defendant on a case	0.0435	0.0135	0.3197	0.3651		0.3651
Average age of judges on a case	0.6529	0.5371	0.936	0.7011		0.7011
Average experience of judges on a case	0.6715	0.9105	0.4663	0.7572		0.7572
Covariate/Step	0	1	2	3	4	5
Average income of judges on a case	<0.0001	<0.0001	0.0784	0.1826		0.1826

Table 4.2.3 Degrees-of-freedom, Estimate Coefficients, Standard Errors,  
Chi-square Values and p-Values for the Preliminary Main Effects Model

Covariate	DF	Parameter Estimate	Std Error	Chi-sq	p-Value
The court where the case was processed	1	-2.99128	0.20093	221.6233	<0.0001
The number of adjournment on a case	2	-0.87964	0.04801	335.6366	<0.0001
Number of judges on a case	2	0.1965	0.05006	15.406	<0.0001

Table 4.2.4 Excluded Covariates and their Percentage Contribution

to Change in the Estimates of the Selected Covariates

Confounder/Covariate	The number of adjournment on a case	The court where the case was processed	Number of judges on a case	Chi-sq	p-Value
Crime a defendant has been accused	-0.7392	-0.08451	0.660827	3.3763	0.0661
Joinder(number) of defendant on a case	-0.38391	0.225159	0.31652	0.8211	0.3648
Average age of judges on a case	-0.23024	0.198637	-1.15694	0.1475	0.7011
Average experience of judges on a case	0.127487	-0.14388	0.867512	0.0955	0.7572
Average income of judges on a case	0.137746	-6.12235	3.836398	1.766	0.4826
Average age of defendants on a case	0.004548	0.00234	-0.08186	0.0018	0.9658

Table 4.2.5 Degrees-of-Freedom and p-Values for Interactions

Formed from the Preliminary Main Factors

Interaction Between Covariates	DF	p-Value
The number of adjournment on a case and the court where the case was processed	2	<0.0001
The number of adjournment on a case and number of judges on a case	4	<0.0001
The court where the case was processed and number of judges on a case	2	0.2128

Table 4.2.6 Degrees-of-Freedom, Coefficient estimates, Standard errors  
and p-Values for the Interactions and the Preliminary Main Factors

Covariate	DF	Parameter Estimate	Std Error	Chi-sq	p-Value
The court where the case was processed	1	-2.27732	0.31538	52.14	<0.0001
The number of adjournment on a case	2	-0.83151	0.10634	61.1385	<0.0001
Number of judges on a case	2	-0.16812	0.07119	5.5765	0.0182
The Interaction Between the number of adjournment on a case and the court where the case was processed	2	-0.45601	0.11177	16.645	<0.0001
The Interaction Between the number of adjournment on a case and number of judges on a case	4	0.05025	0.01434	12.2791	0.0005

Table 4.3.1 Estimated Coefficient, Standard Errors, Chi-square Values and p-Value for the Three Interactions with Log-time Added to the Model in Table 4.2.6

Covariate	DF	Parameter Estimate	Std Error	Chi-sq	p-Value
The court where the case was processed	1	-5.11664	0.42428	145.4345	<0.0001
The number of adjournment on a case	2	3.70906	0.95762	15.0019	0.0001
Number of judges on a case	2	-1.63975	0.49448	10.9963	0.0009
The Interaction Between the number of adjournment on a case and the court where the case was processed	2	0.14142	0.14843	0.9078	0.3407
The Interaction Between the number of adjournment on a case and number of judges on a case	4	-0.04155	0.02564	2.6256	0.1052
The court where the case was processed*	1	0.7193	0.0745	93.2112	<0.0001
The number of adjournment on a case*	2	-2.06281	0.27757	55.2308	<0.0001
Number of judges on a case*	2	0.40037	0.11422	12.283	0.0005
Global Test	3	.	.	188.5098	<0.0001

\* Interaction of the covariates with logarithm of survival time

Table 4.3.2 Resulting Stepwise Selection of Covariates- values for Entry to the Right and p- Value to remove to the Left of the Solid Line in Each Row for the Stratified Data in this Study.

Covariate/Step	0	1	2	3
Crime a defendant has been accused	0.0159	0.0158	0.0109	0.0158
Joinder(number) of defendant on a case	0.2249	0.1481	0.1483	0.1481
Average age of defendants on a case	0.9677	0.3764		0.3764
Average age of judges on a case	0.8234	0.705		0.705
Average experience of judges on a case	0.2081	0.2836		0.2836
Average income of judges on a case	0.2655	0.2475		0.2475

Table 4.3.3 Excluded Covariates and their Percentage Contribution

to Change in the Estimates of the Selected Covariates for the Stratified Model

Confounder/Covariate	Crime a defendant has been accused of	Chi-sq	p-Value
Average age of defendants on a case	-13.0541	6.4849	0.3766
Joinder(number) of defendant on a case	-6.27343	2.0901	0.1483
Average age of judges on a case	-0.9787	0.1433	0.705
Average experience of judges on a case	3.580782	1.1494	0.2837
Average income of judges on a case	-0.53953	1.3463	0.2459

Table 4.3.4 Degrees-of-freedom, Estimate Coefficients, Standard Errors,

Chi-square Values and p-Values for the Stratified Preliminary Main Effects Model

Covariate	DF	Parameter Estimate	Std Error	Chi-sq	p-Value
Crime a defendant has been accused	3	0.21753	0.09015	5.8232	0.0158

Table 4.3.5 Estimated Coefficient, Standard Errors, Chi-square Values and p-Value for the Three Interactions with Log-time Added to the Model in Table 4.3.5

Covariate	DF	Parameter Estimate	Std Error	Chi-sq	p-Value
Crime a defendant has been accused	3	0.69506	0.32873	4.4705	0.0345
Crime a defendant has been accused*	3	-0.09518	0.06716	2.0082	0.1565
Global Test	3	.	.	2.0082	0.1565

\*Interaction between covariate and logarithm of survival time

Table 4.3.6 The Six Highest Differences in Parameter Estimates of the Covariate in Table 4.3.5 When the Value for Each Case is deleted from the Model

Deleted Case	Absolute Difference
397	0.025243
652	0.01804
571	0.017959
20	0.01709
50	0.016208
107	0.01445

Table 4.1.1 Kaplan—Meier Estimates of the Overall Survival Behaviour

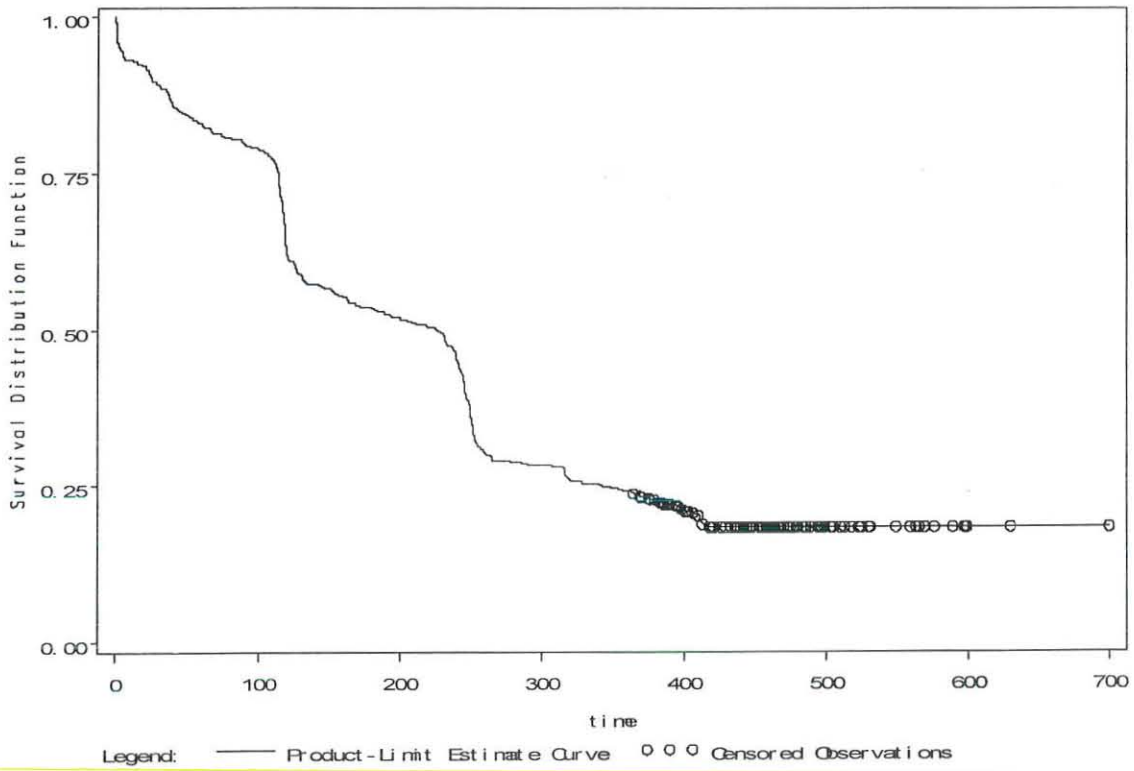


Table 4.1.2(a) The estimated survival functions for the two courts in this study

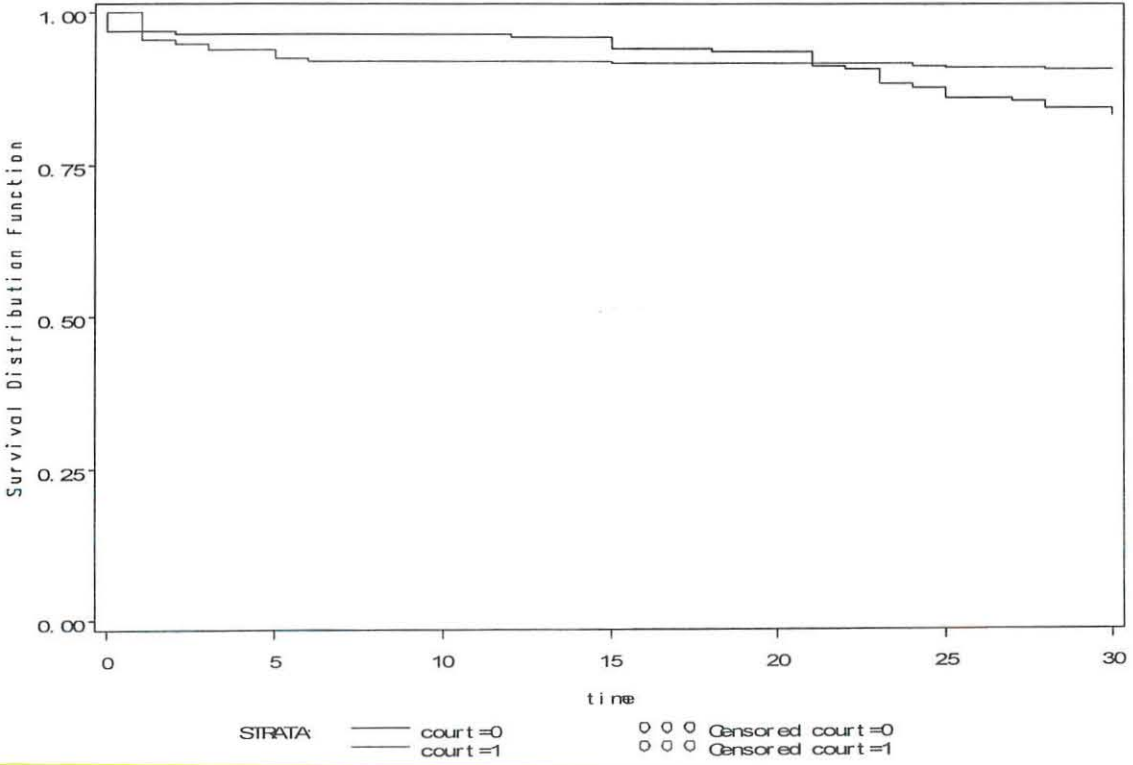


Table 4.1.2(b) The estimated survival functions for the criminal Offense in this study

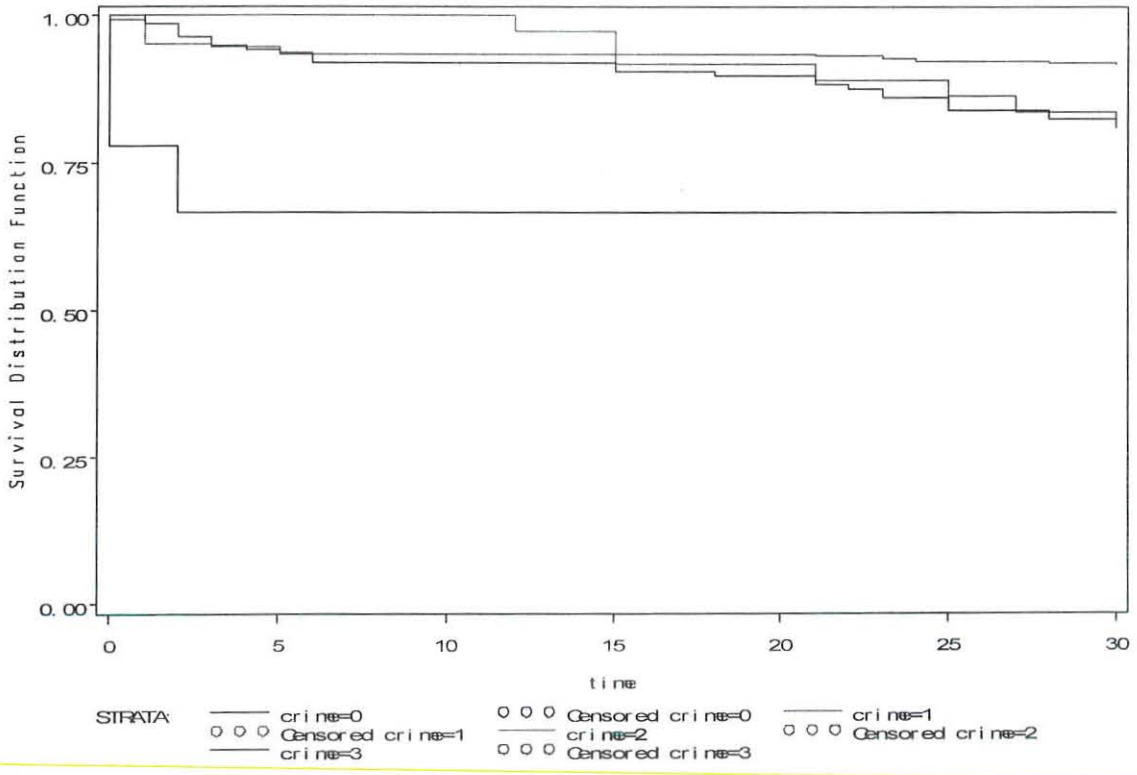


Table 4.1.2(c) The estimated survival functions for the joinder of the accused in this study

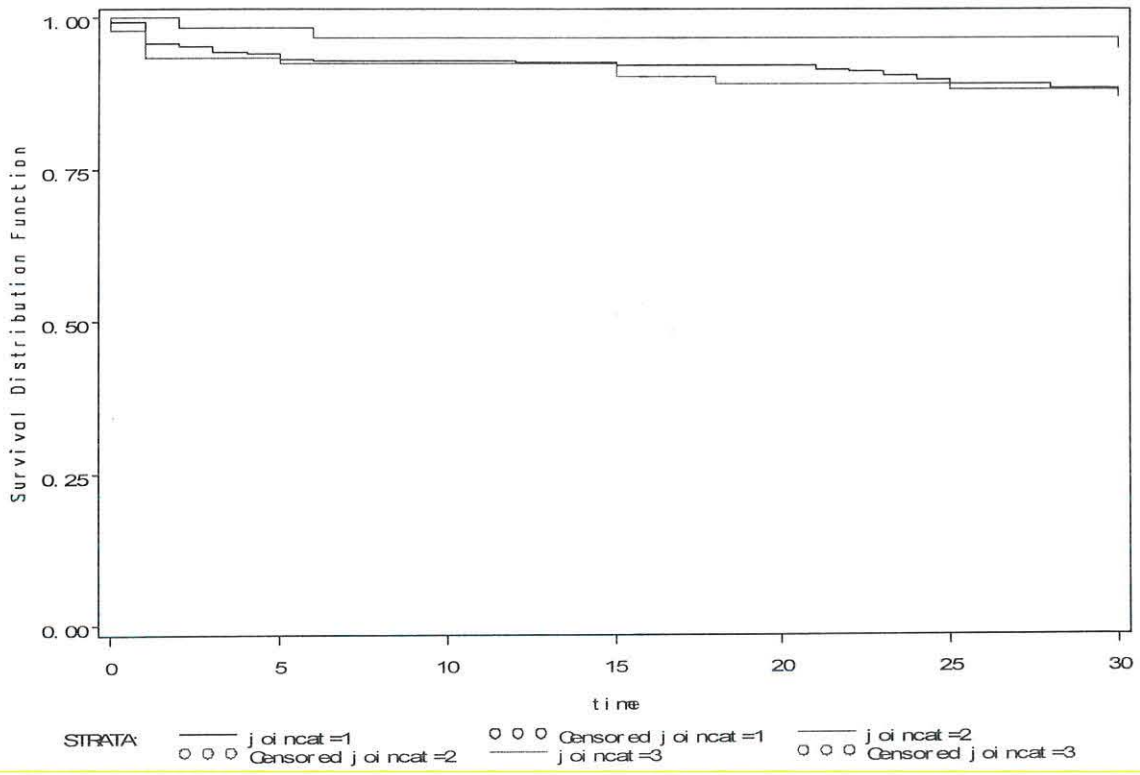


Table 4.1.2(c) The estimated survival functions for the number of adjournments in this study

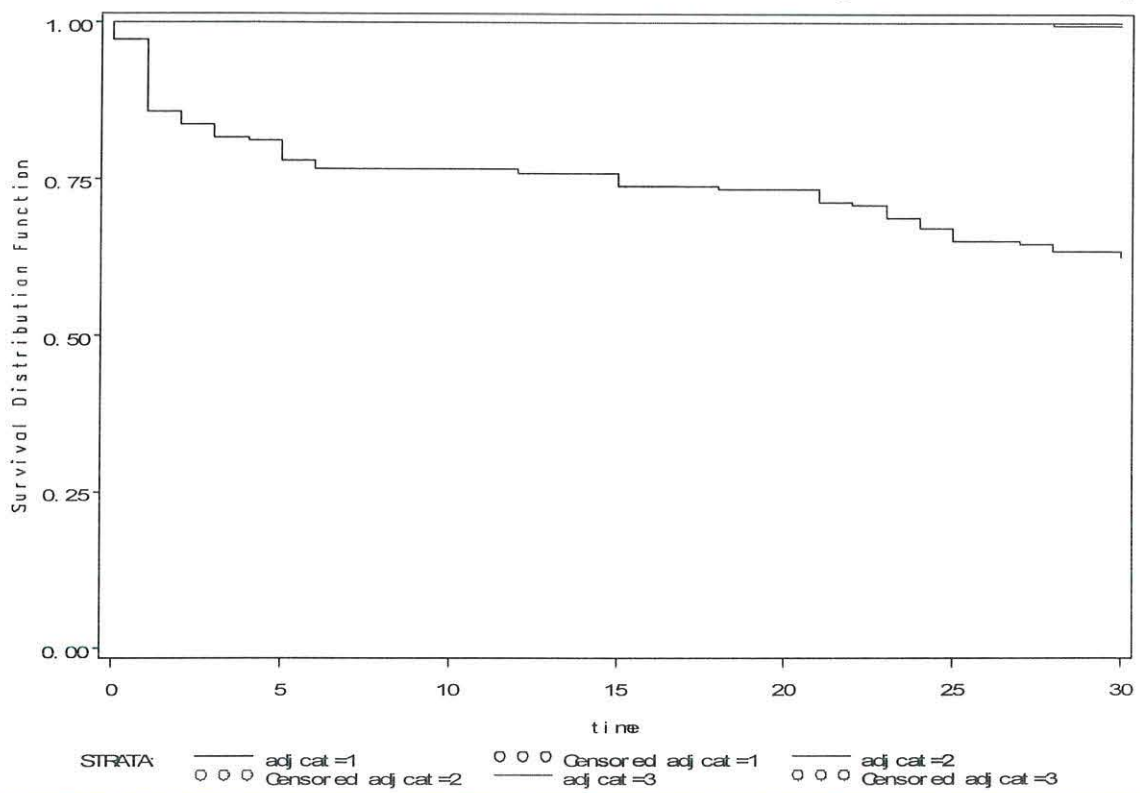


Table 4.1.2(e) The estimated survival functions for the average age of the defendants on a case in this study

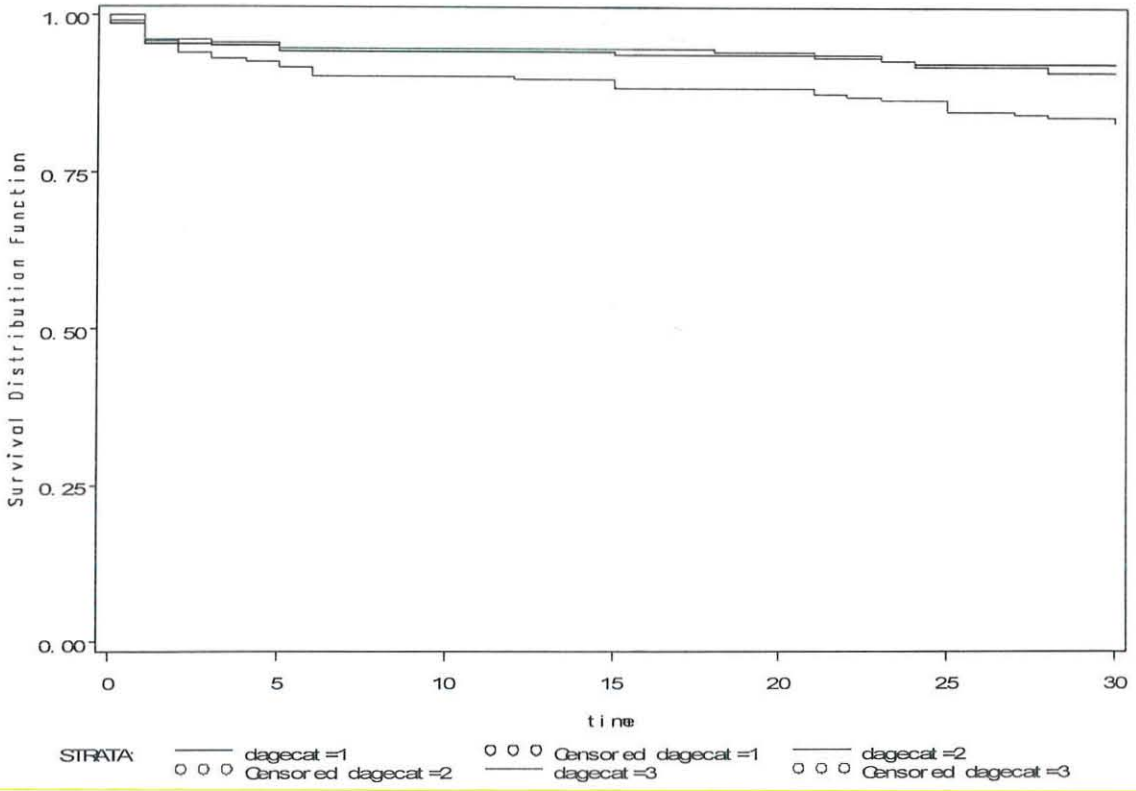


Table 4.1.2(f) The estimated survival functions for the number of judges on a case in this study

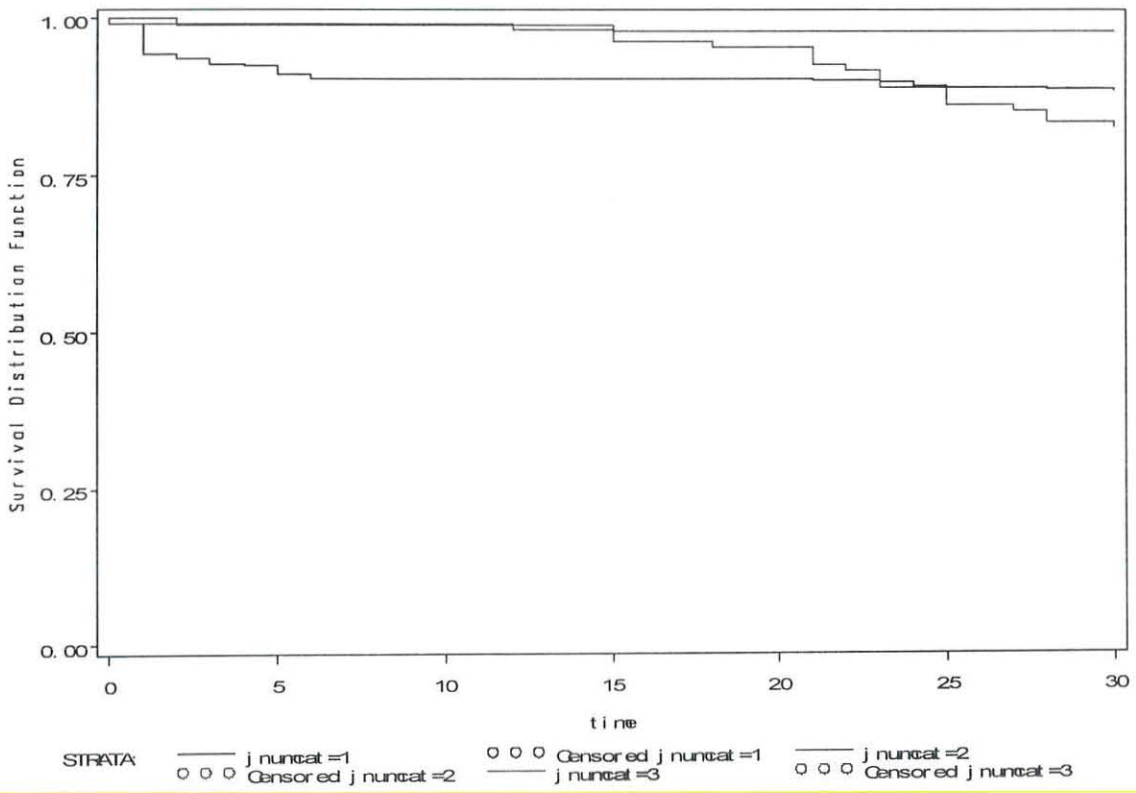


Table 4.1.2(g) The estimated survival functions for the average age of judges on a case in this study

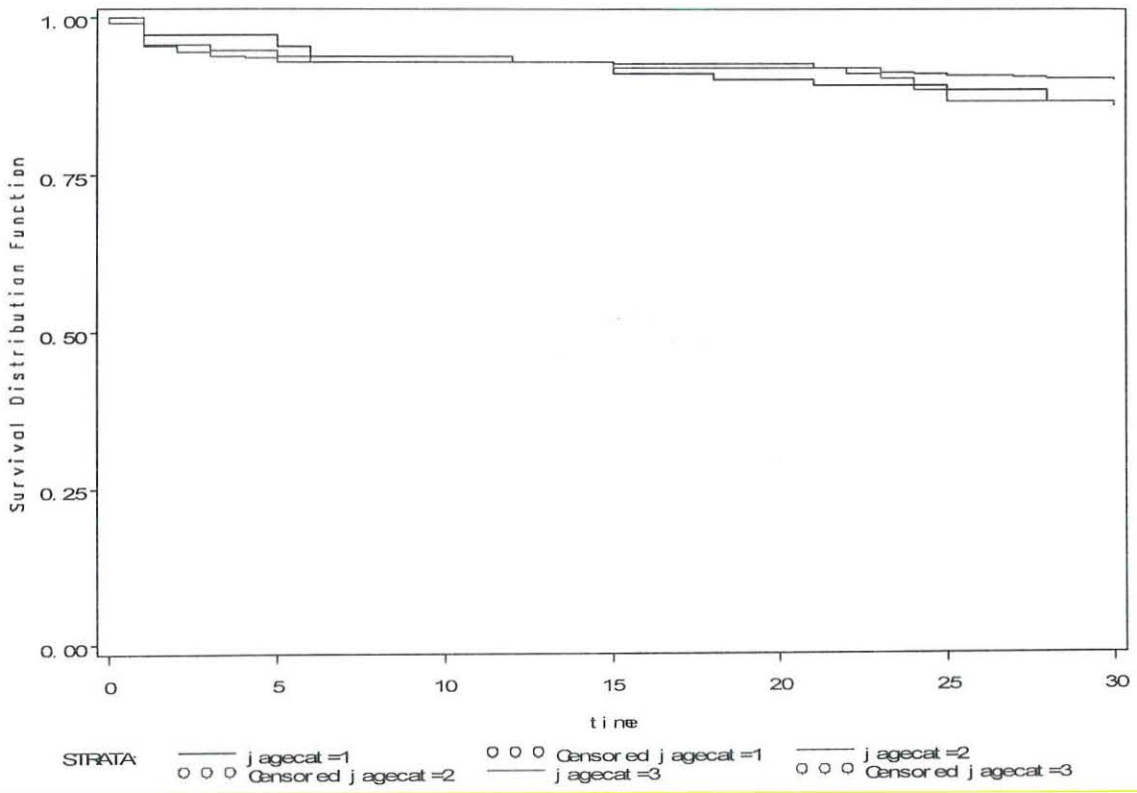


Table 4.12(h) The estimated survival functions for the average experience of judges on a case in this study

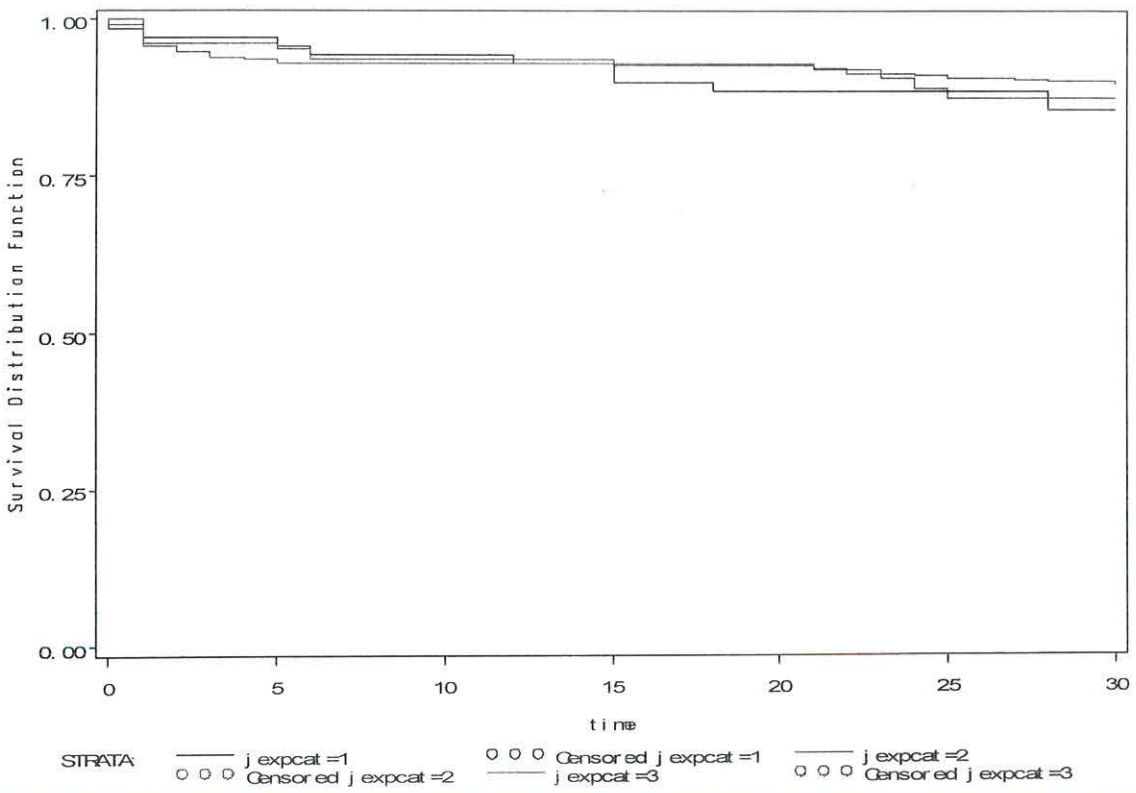


Table 4.1.2(i) The estimated survival functions for the average income of judges on a case in this study

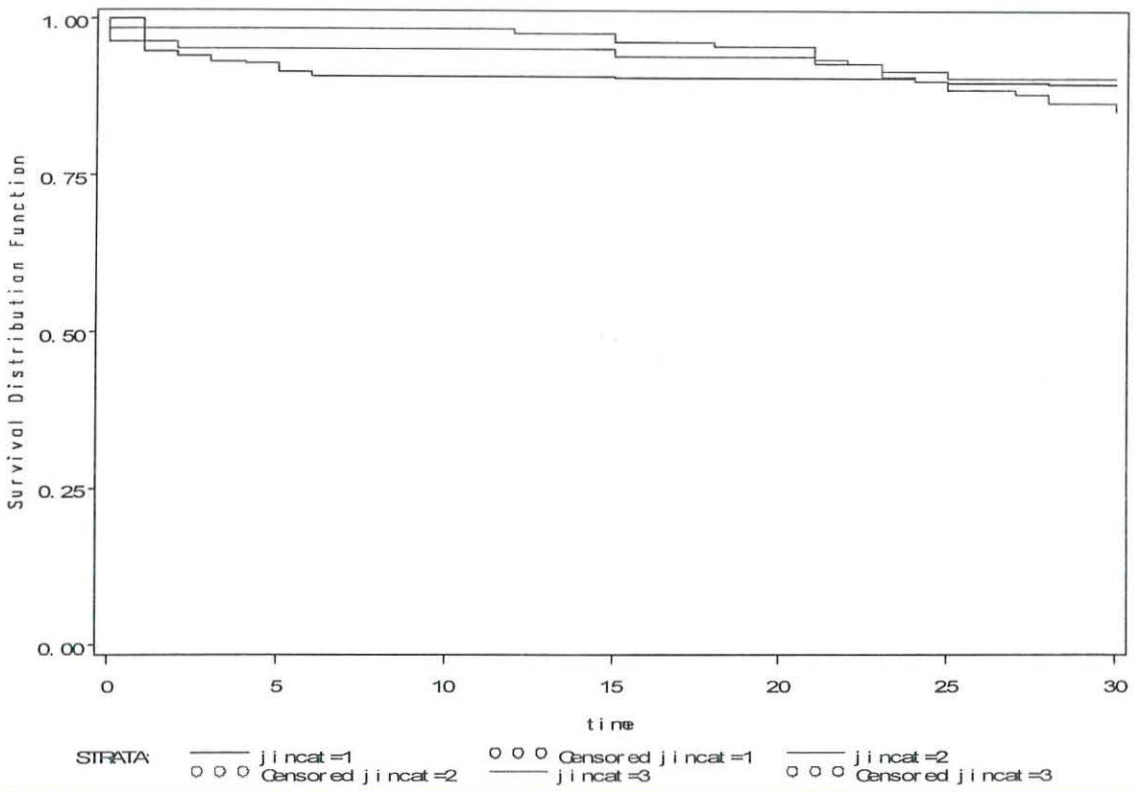
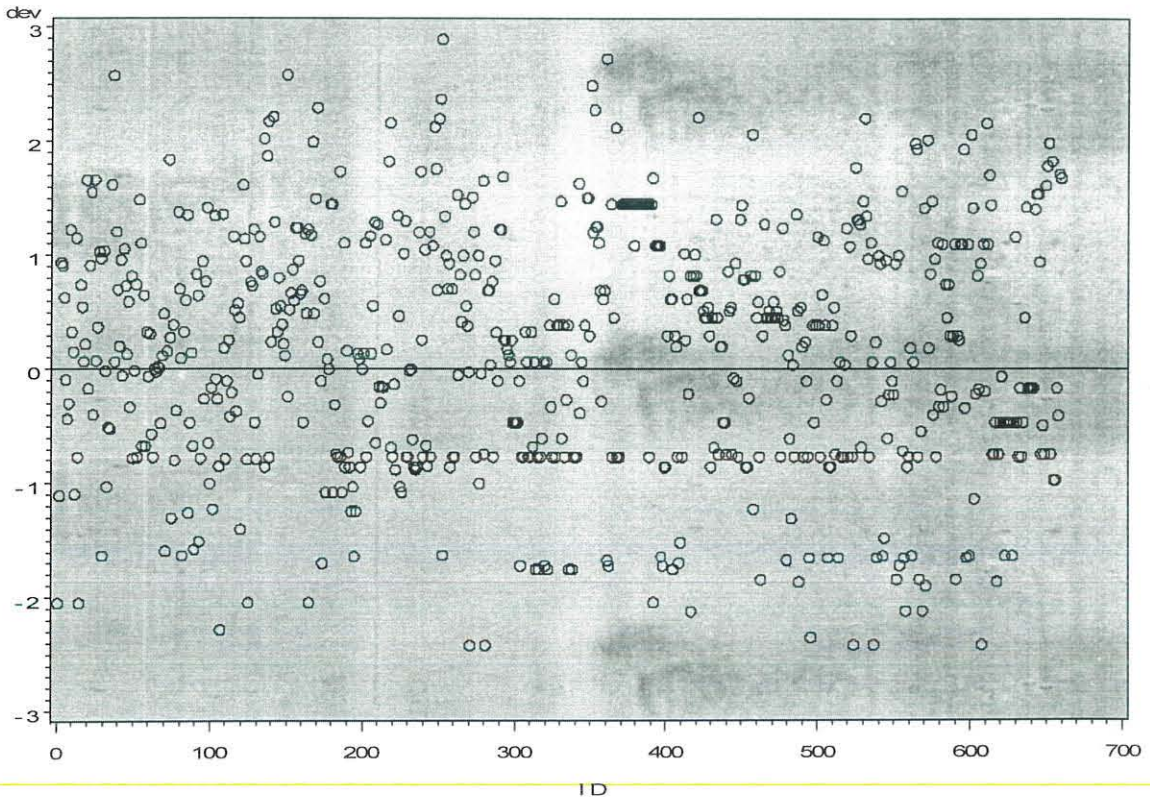



Figure 4.3.1 Index Plot of the Deviance Residuals for the stratified Cox Model goption reset=all



**DECLARATION**

I THE UNDERSIGNED, DECLARE THAT THIS THESIS IS MY ORIGINAL WORK IN PARTIAL FULFILMENT FOR THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN STATISTICS. ALL THE SOURCE OF THE MATERIALS USED FOR THIS THESIS, ALL PEOPLE AND ALL INSTITUTIONS WHO GAVE SUPPORT FOR THIS WORK ARE DULY ACKNOWLEDGED.

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**DATE OF SUBMISSION**.....  


THIS THESIS WORK HAS BEEN SUBMITTED FOR EXAMINATION WITH MY APPROVAL AS A UNIVERSITY ADVISOR.

**DR.GIRMA TAYE**.....  
