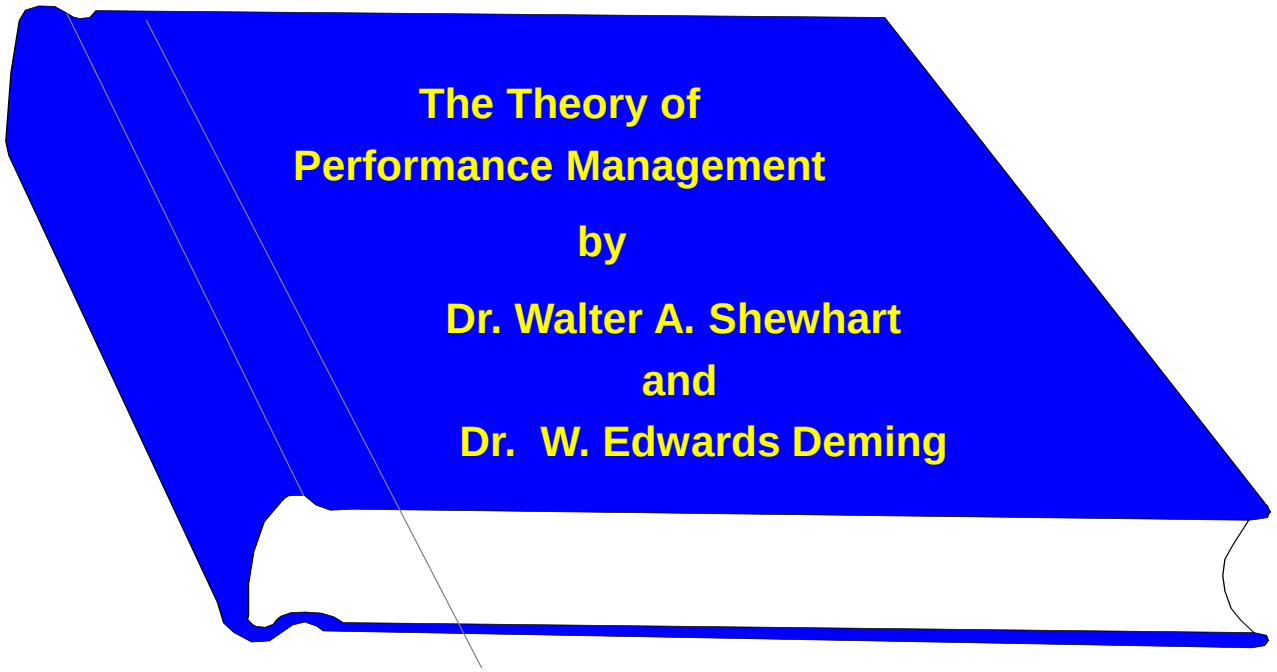
An Introduction to the Principles of Performance Management

Presented to the International Association of Commercial Administrators

Managing the Hidden Employees

The Shewhart and Deming Performance Management Theory



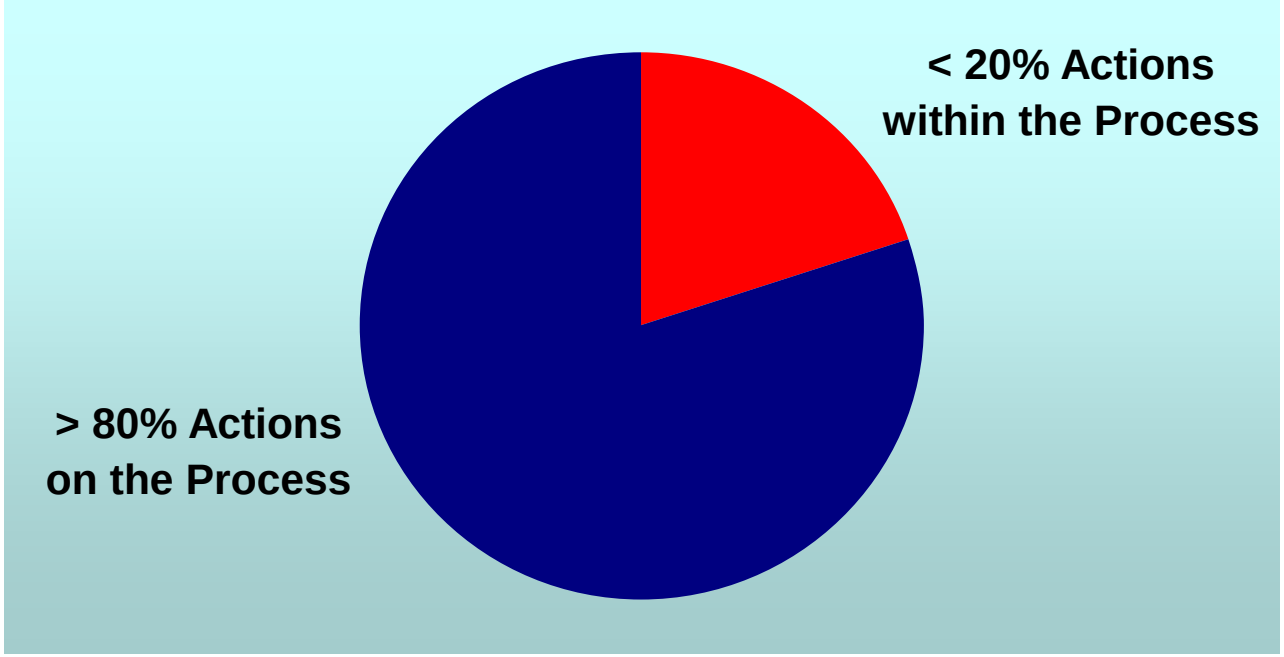
The Shewhart and Deming Performance Management Theory

- In 1931, Dr. Walter A. Shewhart introduced a powerful, new theory of management aimed at optimizing the control of manufacturing processes. This event occurred with the publication of his seminal book

"Economic Control of Quality of Manufactured Product"

- Over the next 60 years Dr. W. Edwards Deming extended the development and application of Shewhart's optimization theory to service and administrative processes.

How is Performance Improved?



The Three Fundamental Axioms of Management

The Axiom of Responsibility

"The primary responsibility of management in any organization is to create means of producing products and services that meet the wants and needs of their customers with the minimum amount of human effort and investment in capital resources."

In order to meet this responsibility, management must tap and optimize the inherent capability of the human and capital resources that have been entrusted to their leadership.

The Three Fundamental Axioms of Management

The Axiom of Action

"In managing systems and people, data are collected and analyzed to generate knowledge and insights to form a rational basis for action."

The Three Fundamental Axioms of Management

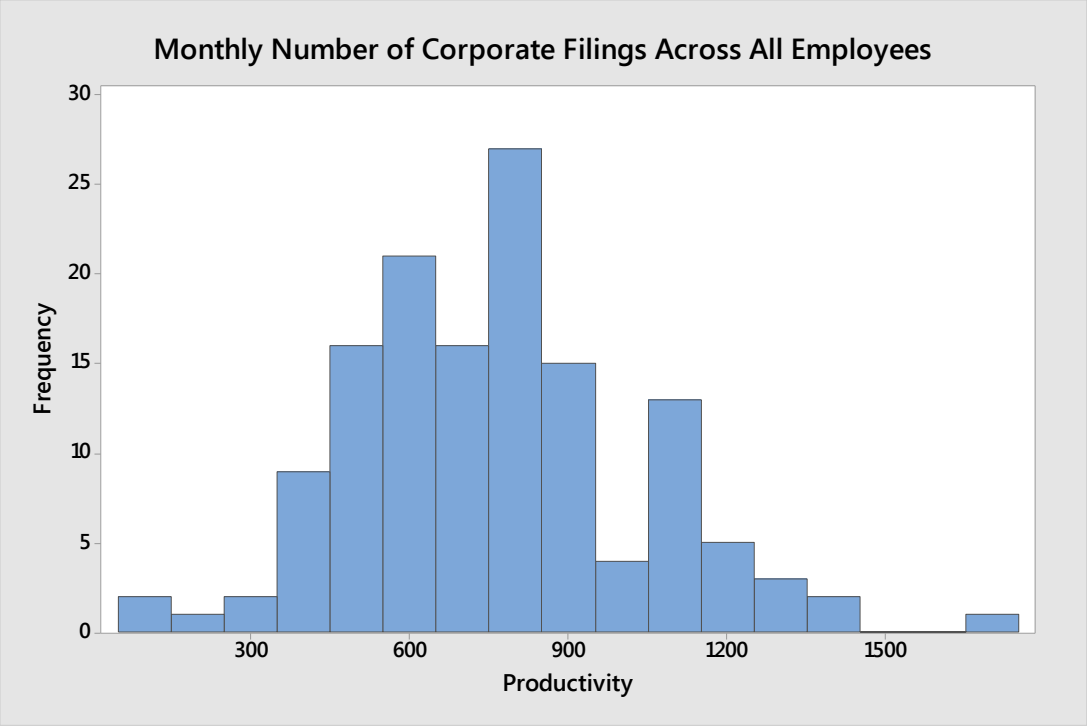
The Axiom of Variation

"Whenever an individual or organization attempts to produce products or services, their performance will vary over time."

Therefore, there is inherently a cause system of variation associated with, and a statistical component to, the management of both human and fixed assets.

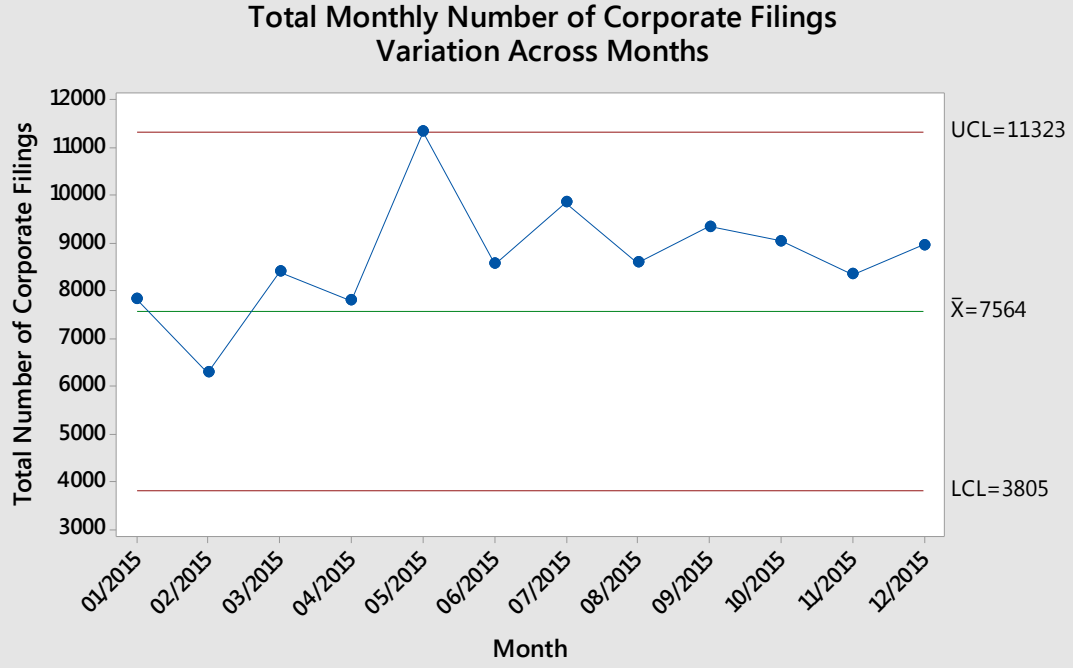
The Three Fundamental Axioms of Management

The Axiom of Variation



The Three Fundamental Axioms of Management

The Axiom of Variation



Data points used for the calculations: 1-4

The Bead Box Experiment

Understanding Unexplainable Random Variation

The Bead Box Experiment

The most famous experiment that demonstrates the effects of pure common causes of variation, and that also helps us understand the behavior of constant cause systems of variation, is Dr. Deming's bead box experiment.

The Components of the Bead Box Experiment

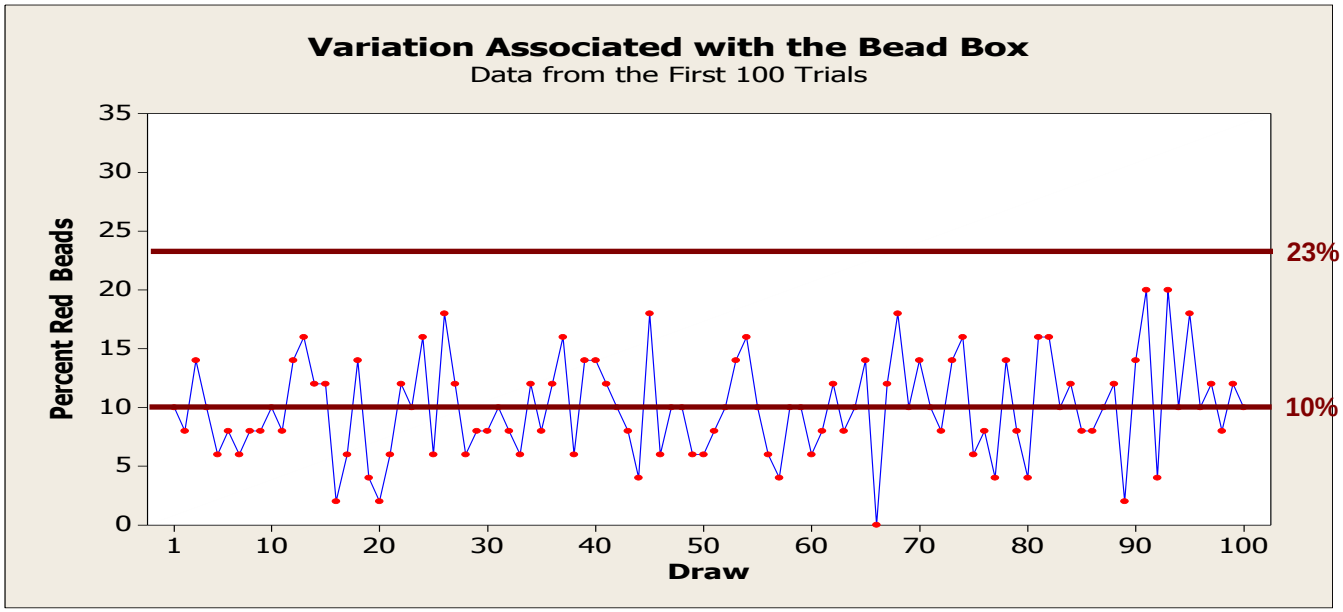
- The experiment consists of a box containing beads and a paddle used to draw beads from the box.
- There are 1000 beads in the box.
- Ten percent of the beads are red and the remainder are white.
- The paddle contains 50 holes.

The Experimental Procedure

- The beads are thoroughly mixed by hand prior to inserting the paddle.
- The paddle is inserted into the box and 50 beads are drawn from the box.
- The percent of red beads in the paddle is recorded.
- The beads are then returned to the box, the beads are thoroughly mixed again and the experiment is repeated.
- This procedure is repeated a large number of times.

The Basis for Predictability in the Bead Box Experiment

Why is there such predictability hidden within the random behavior of the data?



The Student Loan Process Case Study

Evaluating Employee Performance within the Student Loan Application Data Entry Process

Project Background

- In the early 1990's the Ohio Student Loan Commission (OSLC) was responsible for the intake and processing of student loan applications for the state supported colleges.
- Students submitted their loan applications by mail to the OSLC where a staff of eight data entry clerks, referred to as "keyers" entered the data on the hand written application forms into the OSLC student loan application database.
- The president of OSLC funded a seminar presenting the Shewhart and Deming management theory aimed at optimizing organizational and employee performance.

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Project Background

- During the seminar the supervisor over the data entry process raised objections to the validity of the concepts being presented relative to the management and improvement of human performance within administrative processes.

- This particular supervisor managed the eight keyers who were responsible for keying the data contained on the student application forms into the OSLC application database.

- The eight keyers were State of Ohio unionized employees.

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Project Background

- The supervisor was unhappy with what she perceived to be inconsistent and unacceptably high error rates associated with the data entered into the application database by the keyers.
- The supervisor believed that data entry errors were under the control of the keyers and that the data entry errors were due to poor work habits of the keyers.
- She argued that she was helpless to reduce the keying errors because the keyers could not be disciplined or fired because they were members of the union.
- The president of OSLC decided to use the data entry process to test the efficacy of the application of the Deming management theory to the management of the OSLC business departments.

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Project Goals and Objectives

- The goal of this project is to improve the overall accuracy of the data entered into the student loan application database.

- The specific project objectives include:
  - the creation of a process analysis and monitoring system aimed at:
    - the assessment of the stability of the process error rates over time
    - the identification of the causes of data entry errors
    - the determination of the appropriate local and global actions to take to remove causes of data entry errors from the process.

Table 1. Loan Application Fields

Application Field	Label
1	Loan #
2	SSN
3	Applicant Name
4	Address
5	City
6	State
7	Zip Code
8	Loan Amount Requested.
9	Default
10	Borrower Type
11	Reference
12	Student SSN
13	Student Name
14	S-Sign Date
15	School Code
16	Loan Period
17	Grade Level
18	Proj. Grad. Date
19	Est. Cost of Ed.
20	Est. Fin. Aid
21	School Cert. Amt.
22	SLS Addendum
23	Interest Amount
24	Sch. Sign/Date
25	Lender Code
26	Approved Amt.
27	L-Sign/Dated
28	P-Note Amt. Req.
29	Maker Sign/Date
30	Co-Maker Info.
31	Birthdate
32	Prior % Rate
33	SFC
34	Non-Approved

Management Questions of Interest

- Q1: Is the process daily error rate stable over time?
- Q2: Are the keyer daily error rates $\{ER_{kd}\}$ stable over time?
- Q3: Are there detectable differences in the average daily error rate across the eight keyers?
- Q4: Are there any detectable differences in the volume of keyer errors across the 34 loan application fields?
- Q5: What local and/or global actions can be taken to reduce the future number of application field errors and the keyer daily error rates?

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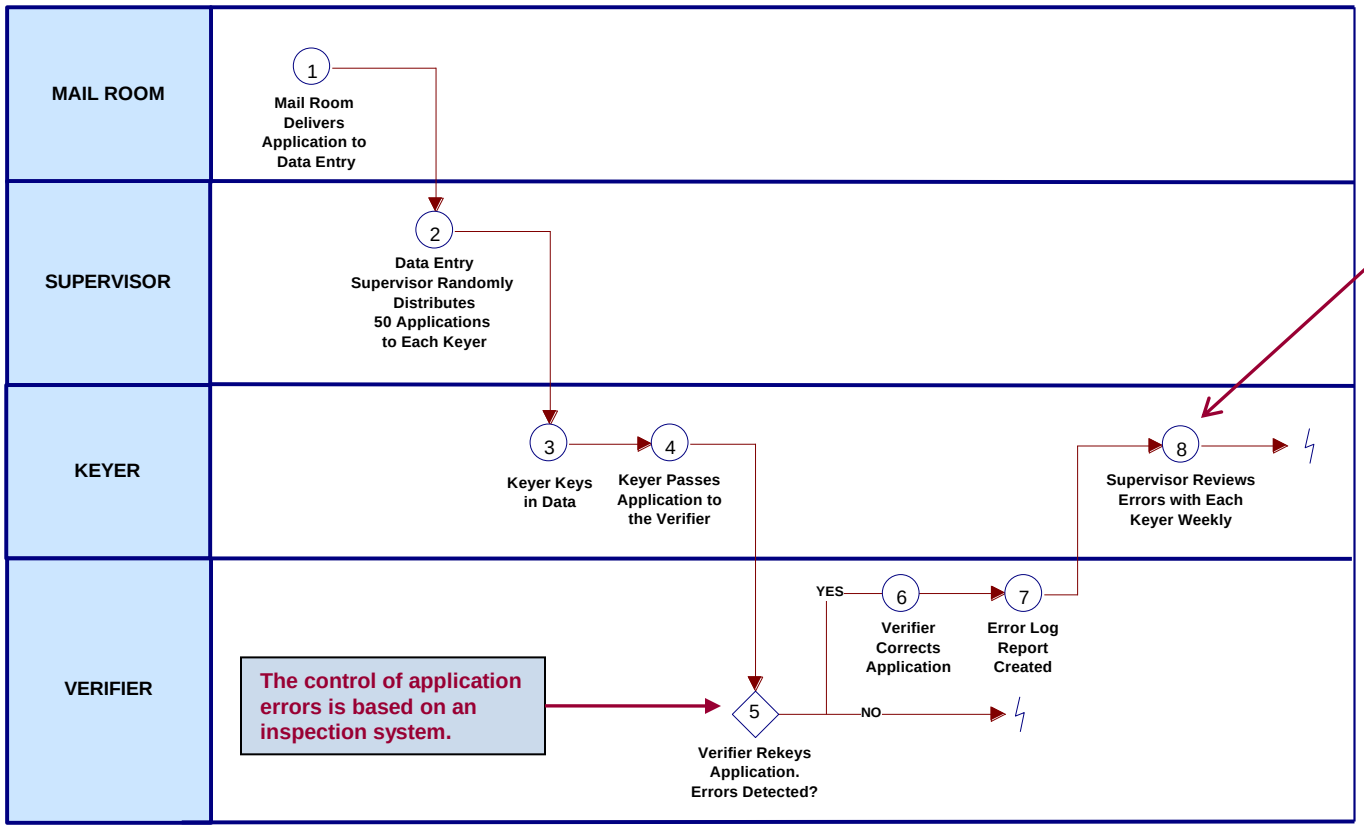
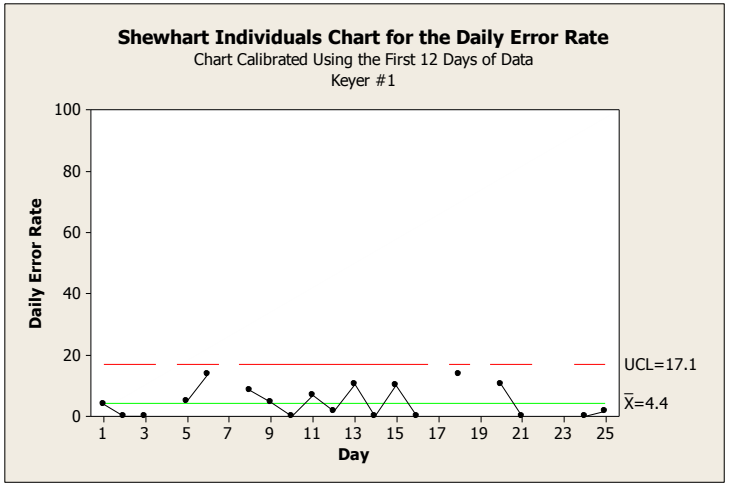
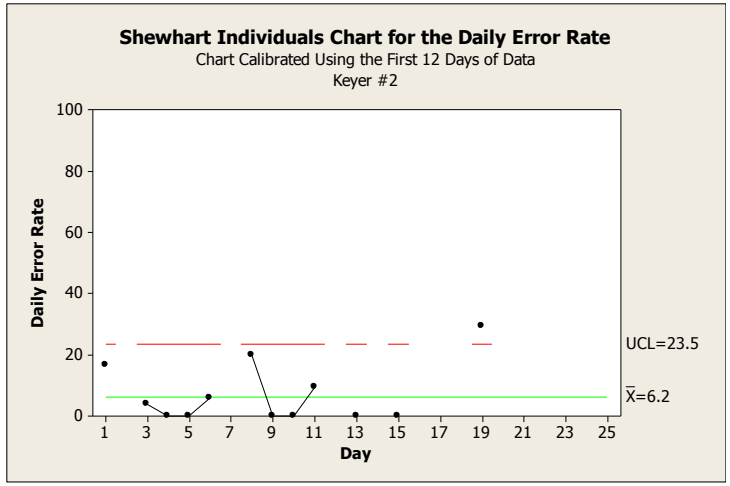
Cause System Design Diagram



Analysis of Keyer Daily Error Rates

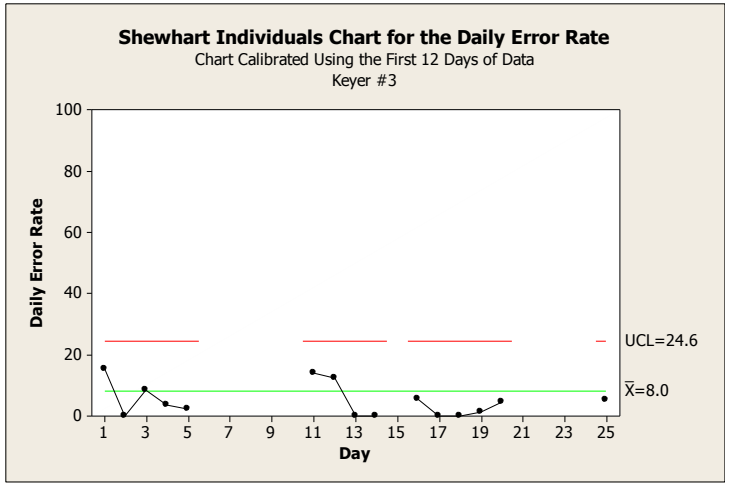


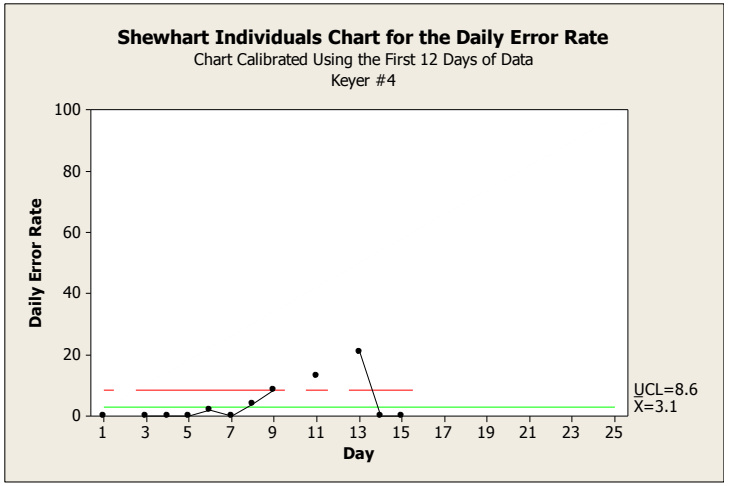
Keyer #1 appears to be behaving like a “bead box”



Keyer #2 appears to be behaving like a “bead box” except possibly on one day (day 20)

Analysis of Keyer Daily Error Rates

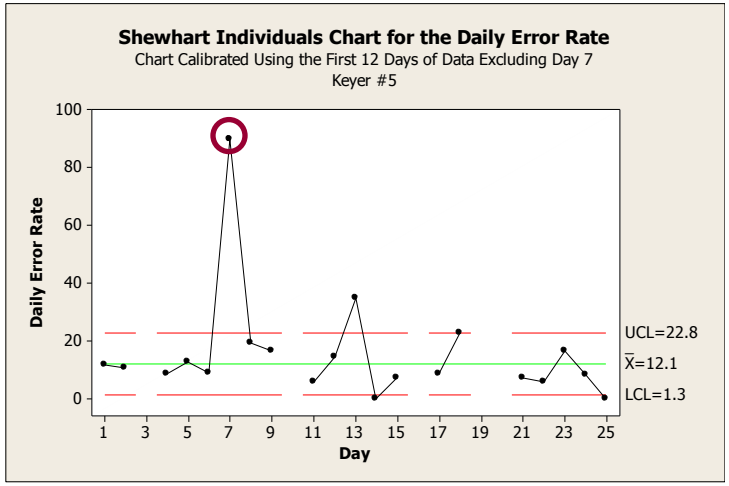




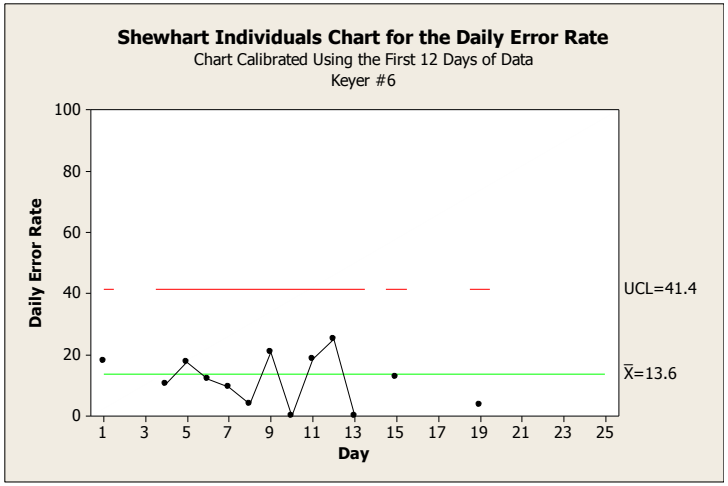
Keyer #3 appears to be behaving like a “bead box”

Keyer #4 appears to have an upward trend in the error rate over days 8-13, but then the error rate drops to 0 on days 14 and 15. And despite this possible trend, this keyer has the lowest overall average error rate.

Analysis of Keyer Daily Error Rates

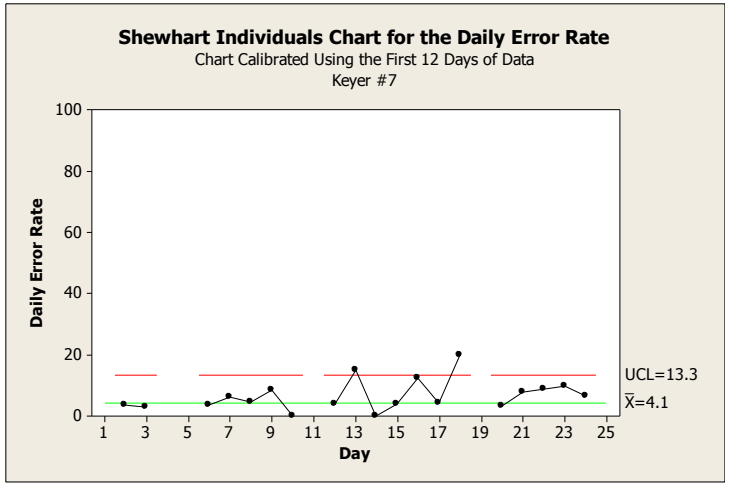


Keyer #5 appears to be behaving like a “bead box” except possibly for the one ephemeral point which was traced to a problem in the forms submitted by the mail department that was outside the control of the keyer

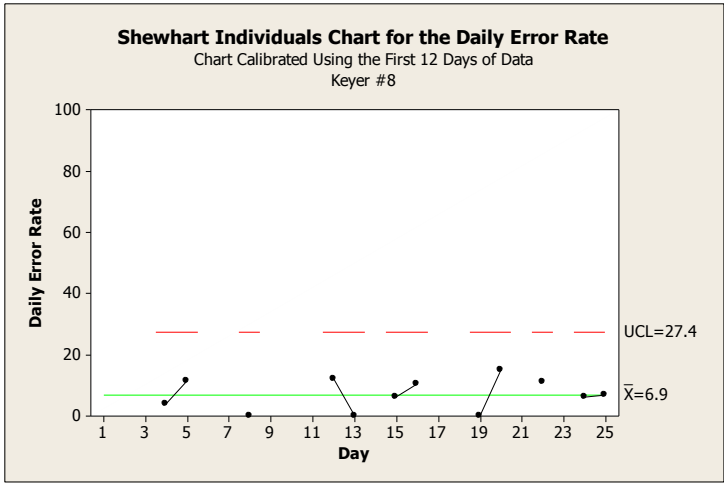


Keyer #6 appears to be behaving like a “bead box”

Analysis of Keyer Daily Error Rates

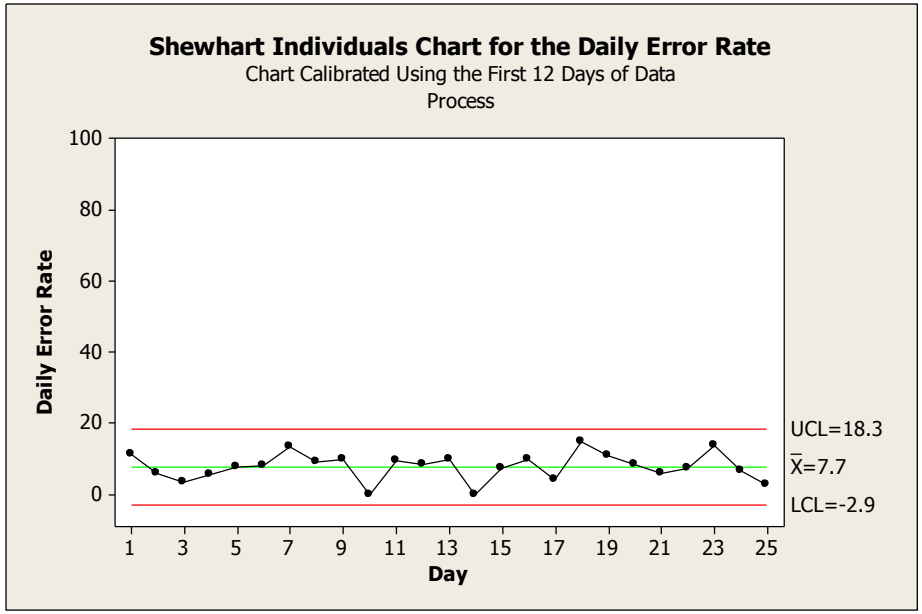


Keyer #7 appears to be behaving like a “bead box”



Keyer #8 appears to be behaving like a “bead box”

Analysis of Process Daily Error Rates



When the error rate is calculated for the process as a whole, it appears to be behaving like a “bead box” around an average error rate of 7.7 errors per 100 application forms keyed

Analysis of Keyer Daily Error Rates

- Based on the analysis of the Shewhart behavior charts we can state the following conclusions regarding the stability of the daily error rates.
  - The overall process daily error rate is stable from day to day about an average of 7.7 errors per 100 applications keyed.
  - From a practical perspective all the keyers are operating in a stable state from day to day with respect to their daily error rates with the possible exception of Keyer #4 who was the only part time keyer and who had the lowest average error rate among the 8 keyers.
  - The behavior of the error rates over the first 12 days was predictive of the error rates for the next 13 days, and therefore it is reasonable to characterize the performance of each keyer by their average error rates calculated using all 25 days of data.

Keyer	Average Daily Error Rate Using all 25 Days
1	4.7
2	7.1
3	4.9
4	4.0
5	11.6 (excluding data from day 7)
6	11.7
7	6.6
8	6.9

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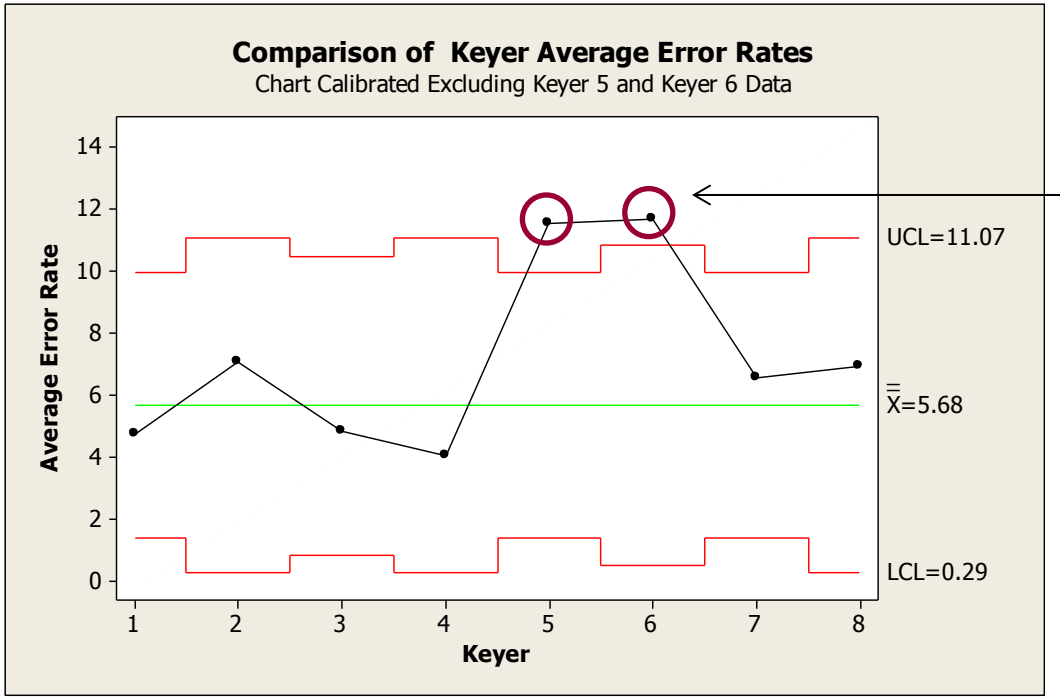
Comparison of Average Keyer Error Rates

- Given that the keyers daily error rates appear to be stable over days, it is legitimate to ask if there are any detectable differences in their overall average error rates.
  - It appears that keyers # 5 and #6 are operating outside the normal system with average error rates that are greater than those for the remaining six keyers.
- This question can be answered by creating a Shewhart behavior chart using the daily error rates as the response and the keyer as the rational subgroup.

Comparison of Average Keyer Error Rates



Based on this analysis there is evidence that keyer #5 and keyer #6 average error rates are detectably higher than the other six keyers.

That is, these two keyers are operating outside the capability of the keying process.

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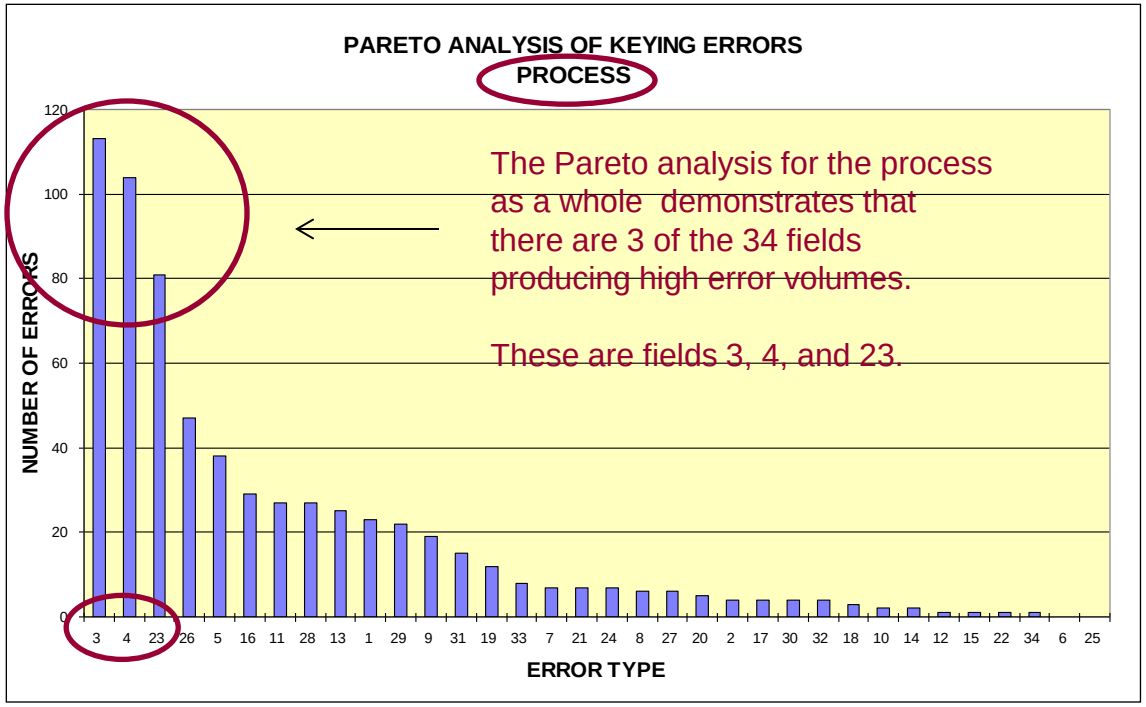
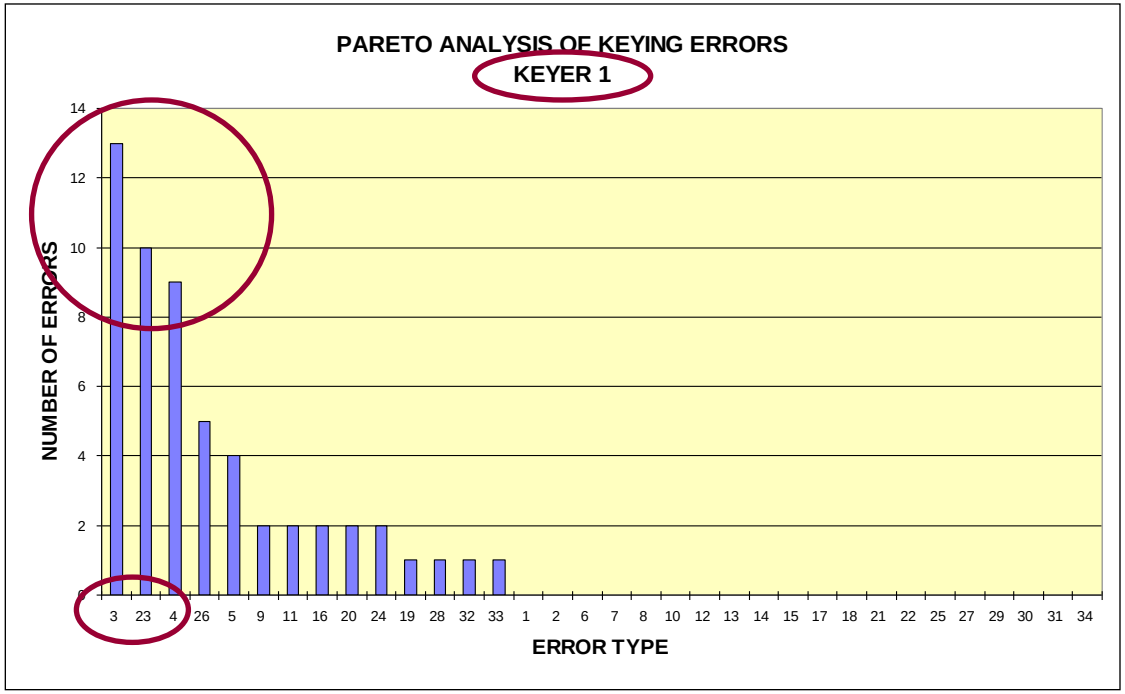
Analysis of Keying Errors by Application Field

- With the analysis of the daily error rates completed, attention was turned to an analysis of the volume of errors produced by each of the 34 fields on the application form.
- The method of Pareto analysis was used to analyze the volume of errors across the 34 fields for the process as a whole and by the individual keyers.
- The following Pareto charts indicate that in all cases, except for keyer #4, who was the only part-time keyer, the dominate errors occurred for application form fields 3, 4 and 23 which where the name, address and interest amount fields.

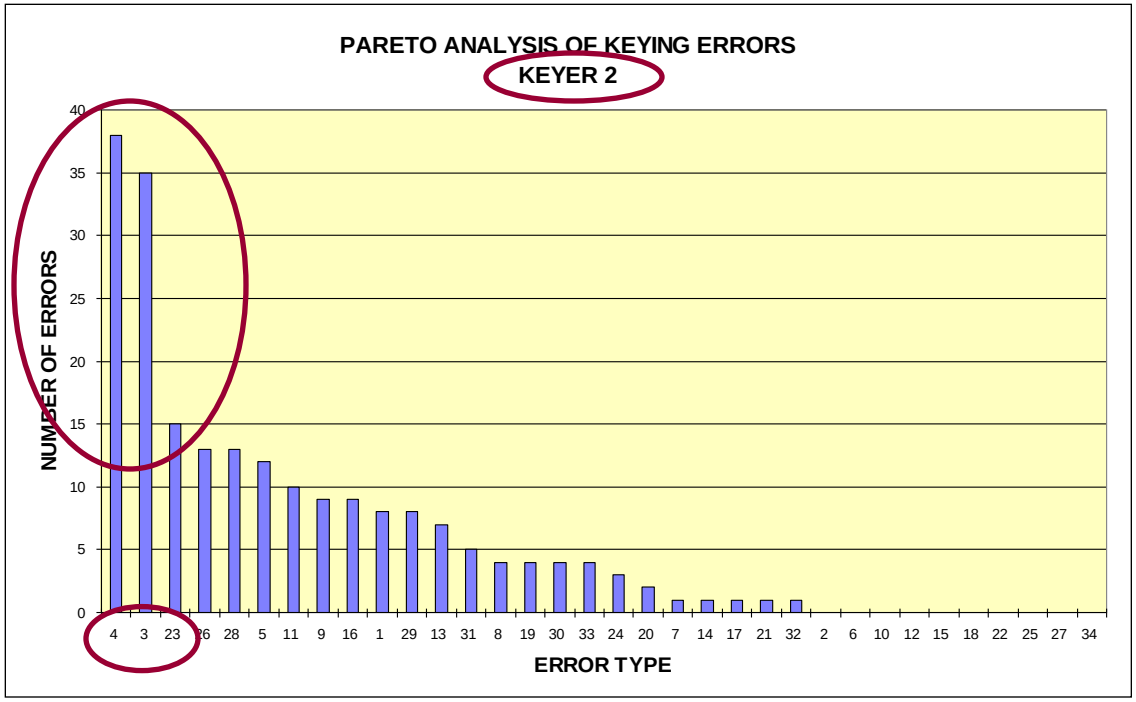
Pareto Analysis of Keying Errors



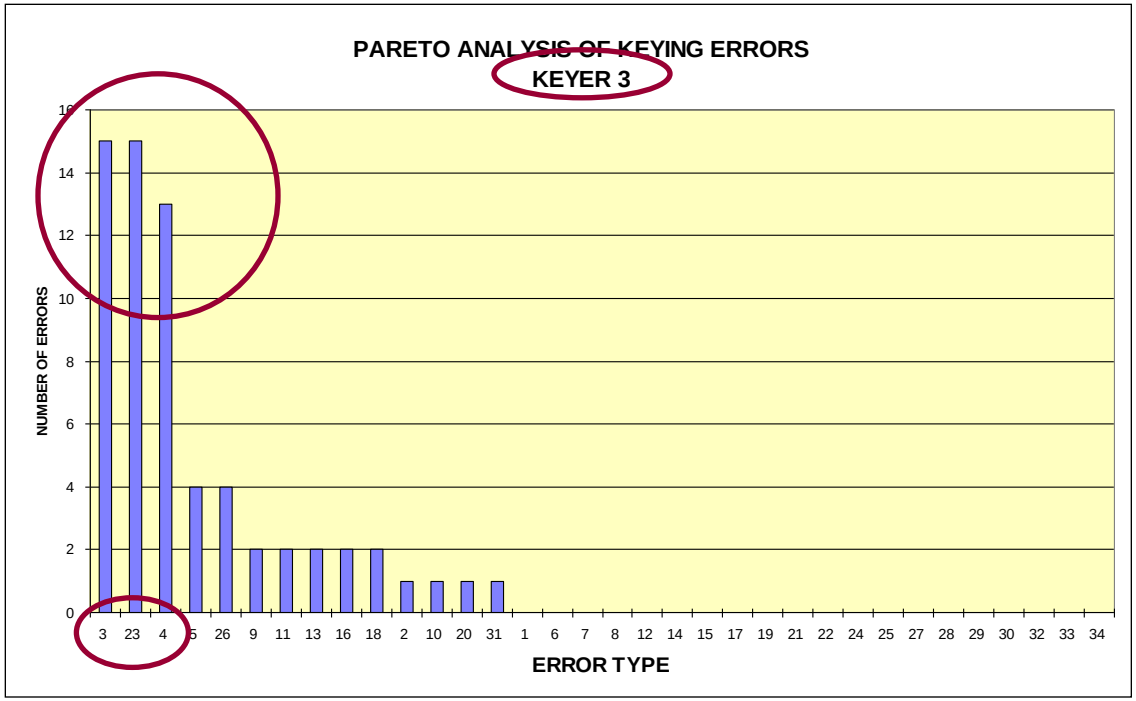
Pareto Analysis of Keying Errors



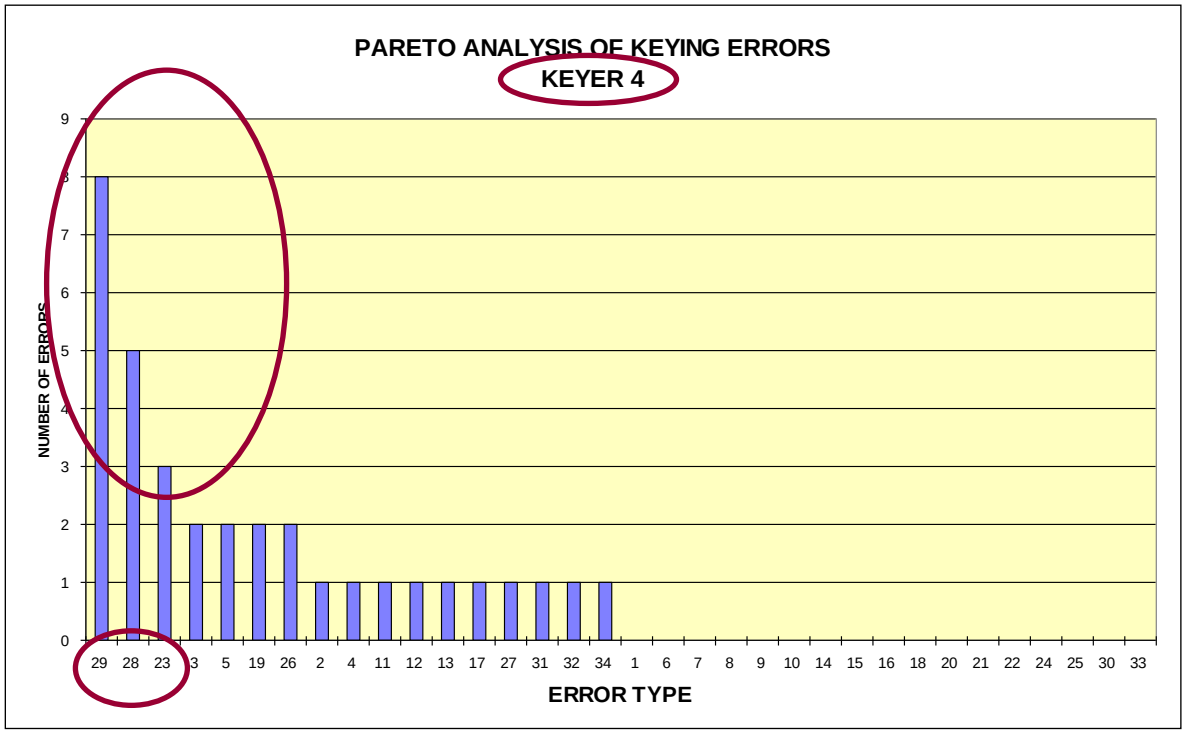
Pareto Analysis of Keying Errors



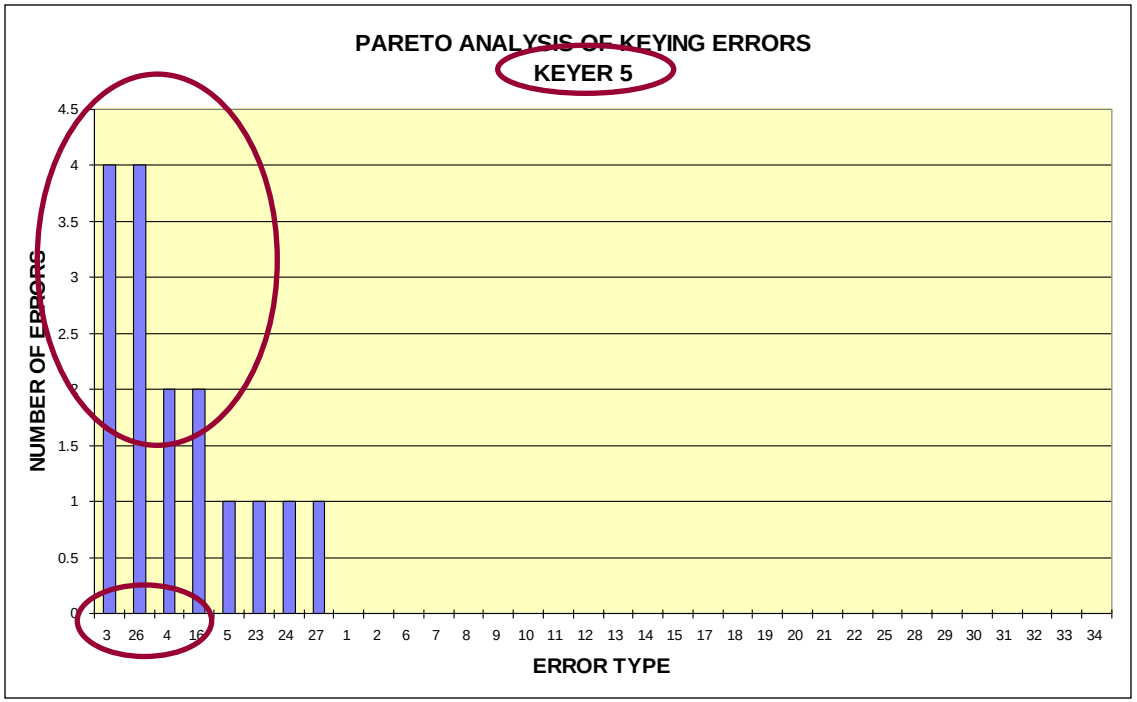
Pareto Analysis of Keying Errors



Pareto Analysis of Keying Errors



Pareto Analysis of Keying Errors



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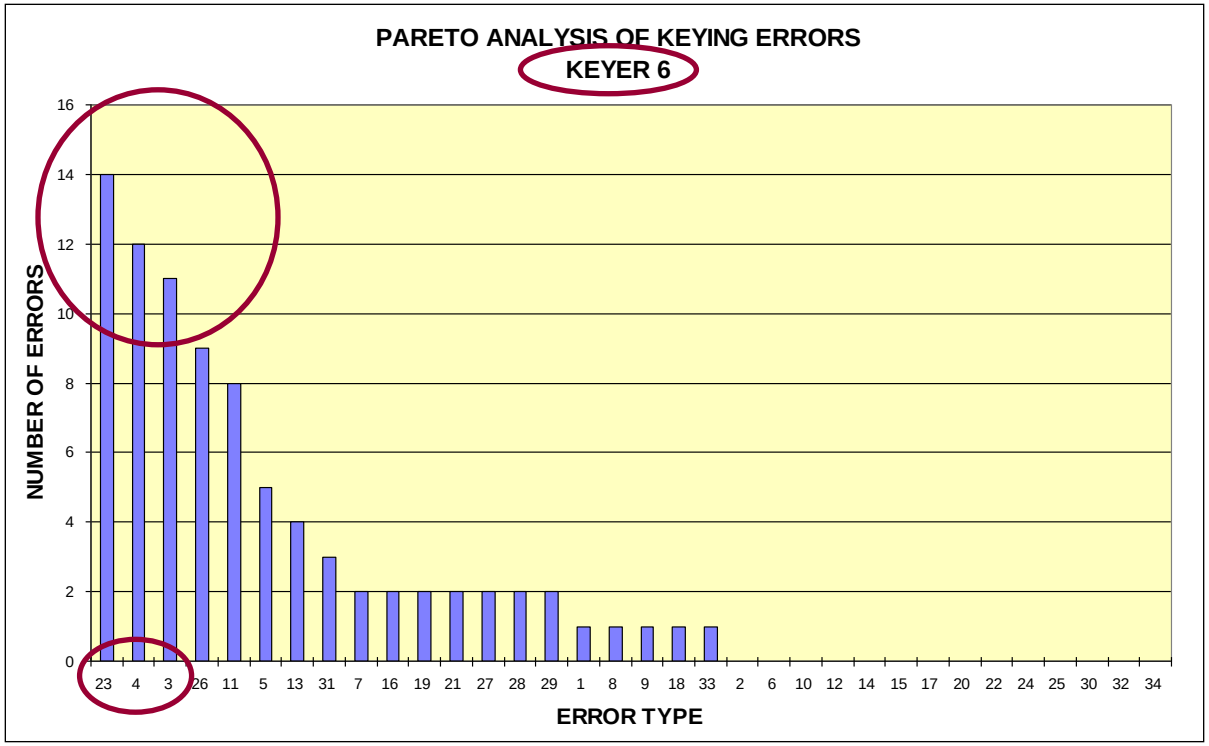

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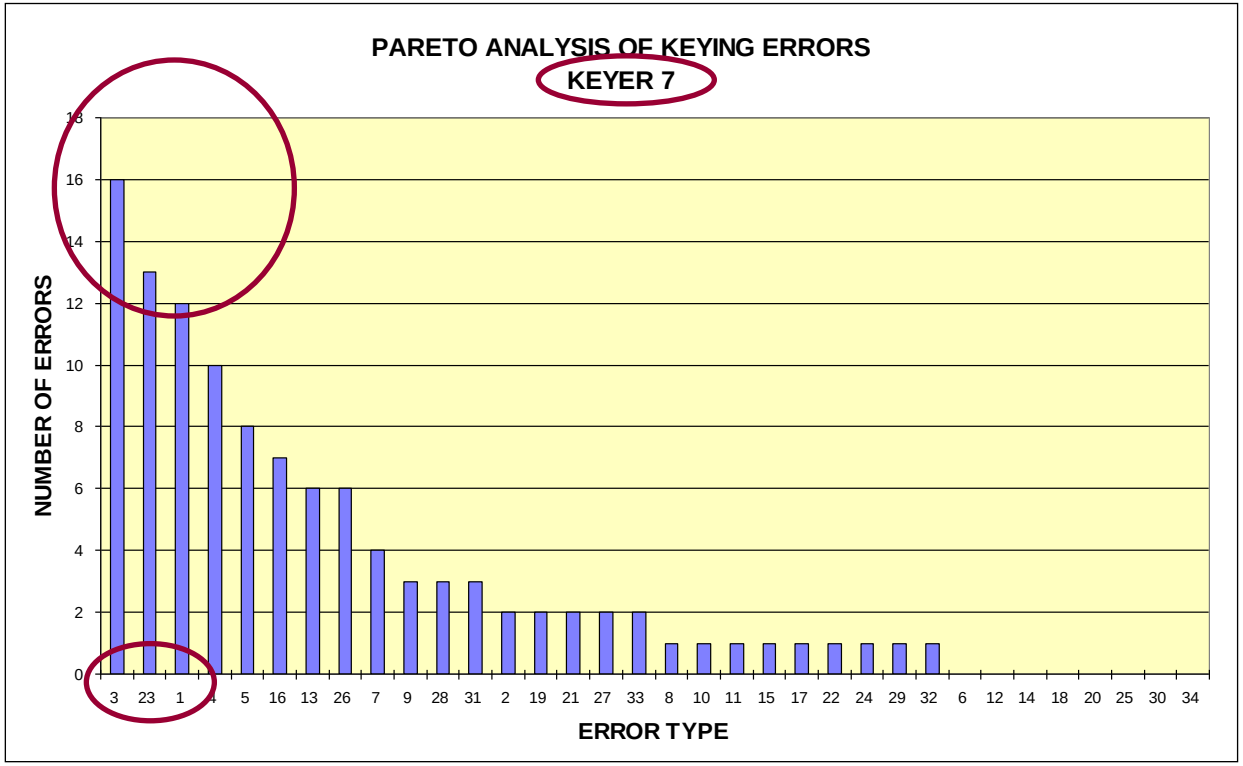
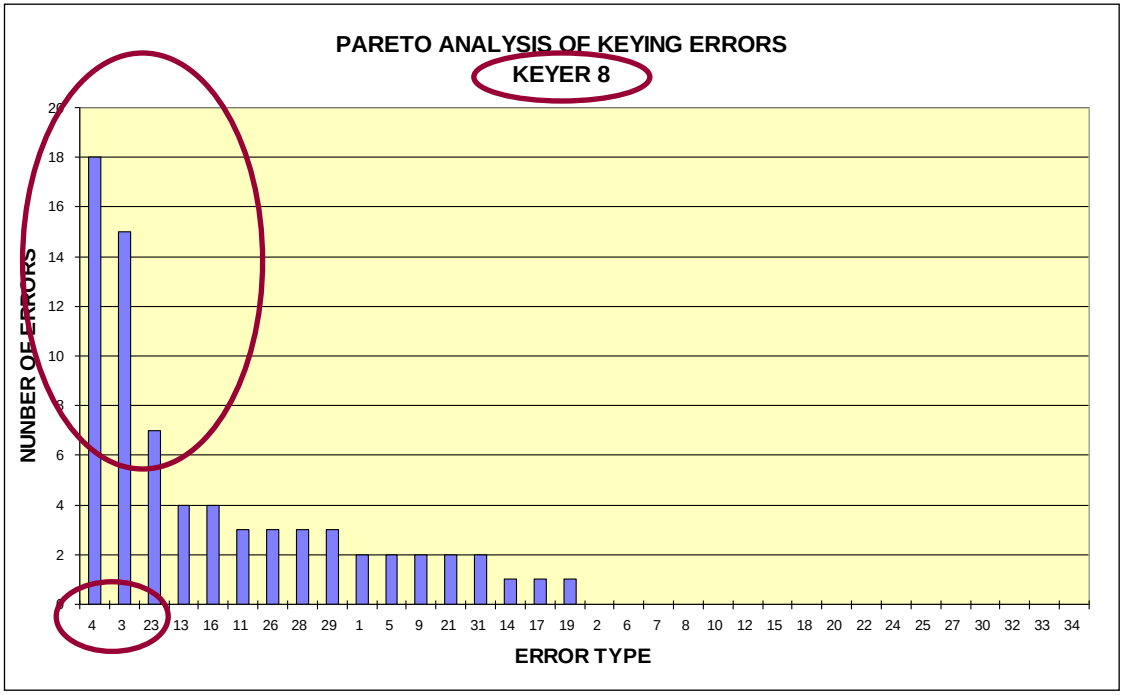


Pareto Analysis of Keying Errors



Summary of Error Analysis

- The insights produced by the analysis of the keyer daily error rates, and the analysis of the volume of errors by application field produced the process as a whole and the individual keyers, are summarized below.

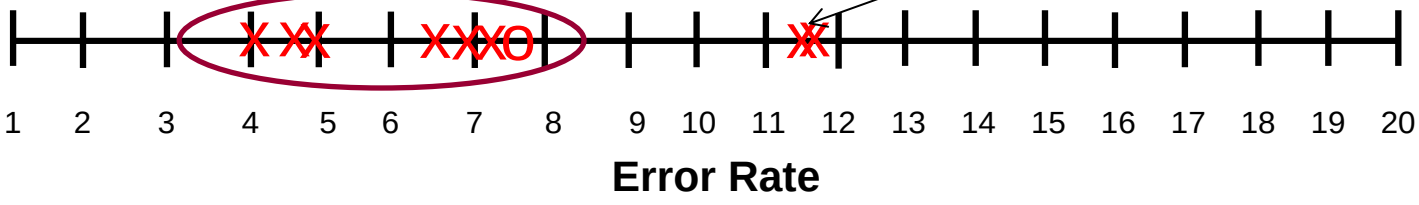
The keyers predominant errors occur on application fields 3, 4 and 23.

Source of Errors	Top 3 Application Fields	Consistent?	Error Rate
Process	3, 4, 23	YES	7.7
Keyer #1	3, 23, 4	YES	4.7
Keyer #2	4, 3, 23	YES	7.1
Keyer #3	3, 23, 4	YES	4.9
Keyer #4	29, 28, 23	YES	4.0
Keyer #5	3, 26, 4	YES	11.6
Keyer #6	23, 4, 3	YES	11.7
Keyer #7	3, 23, 1	YES	6.6
Keyer #8	4, 3, 23	YES	6.9

The process and keyers daily error rates are stable over time.

The process and keyer average error rates are plotted on the simple graph below which illustrates the fact that 6 of the 8 keyer error rates are clustered together.

Keyers 5 and 6 are performing outside the normal system and need individual help to lower their daily error rate.



Conclusions

- C1: In general, the keyers are performing in a stable manner over time.
- C2: Keyers 5 and 6 appear to be operating with higher error rates than the other six keyers and may need local help to improve their error rates.
- C3: In general the keyers are making the same common errors on fields 3,4, and 23 which must be due to process design problems because the process design is the only thing the keyers have in common.
    - Fields 3 and 4 are name and address fields which are free form
    - Field 23 is the loan interest amount field that is currently manually calculated by the keyer using daily interest rate tables provided by management.

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Answers to the Research Questions

- Q1: Is the process daily error rate stable over time? - Yes
- Q2: Are the keyer daily error rates $\{ER_{kd}\}$ stable over time? - Yes
- Q3: Are there detectable differences in the average daily error rate across the eight keyers? - Yes, Keyer #5 and Keyer #6 are operating outside the normal system.
- Q4: Are there any detectable differences in the volume of keyer errors across the 34 loan application fields? - Yes, fields 3, 4 and 23 are the dominant fields producing keying errors.
- Q5: What local and/or global actions can be taken to reduce the future number of application field errors and the keyer daily error rates? – See recommendations

Recommendations

- R1: Management should immediately take action to remove the causes of the errors for application fields 3, 4, and 23 that are common to all keyers.

  - Fields 3 and 4 are Applicant Name and Address which are currently free text fields. The application form should be redesigned to block the name and address fields to force the applicant to print their name and address.

  - Field 23 is the Loan Interest Amount field that is currently manually calculated by the keyer using daily interest rate tables provided by management. This calculation should be automated which will eliminate this error category entirely.

Recommendations

- R2: Because the keyers are operating in a stable manner over time, and are subject to making the same common errors associated with application fields 3, 4, and 23, the weekly counseling sessions involving the supervisor are ineffective at reducing the error rates and should be discontinued.
    - These sessions are an attempt to take local action to remove common causes of variation and will not be successful.
- R3: Management should take local action on Keyer 5 and Keyer 6 in an attempt to help them reduce their average error rates because although their daily error rates are stable over time, they are operating at an average error rate that is outside the capability of the system.

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Recommendations

- R4: Management should use the performance measurement database to create a monitoring system capable of capturing and analyzing the keyer error rates on a daily basis.

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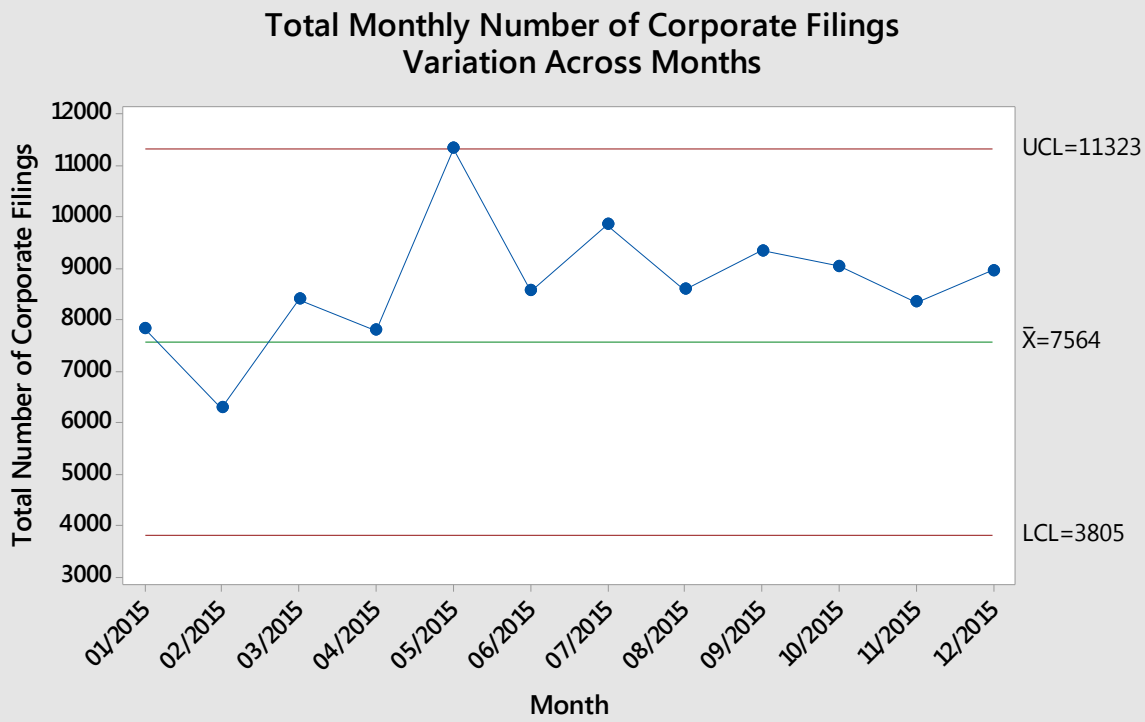

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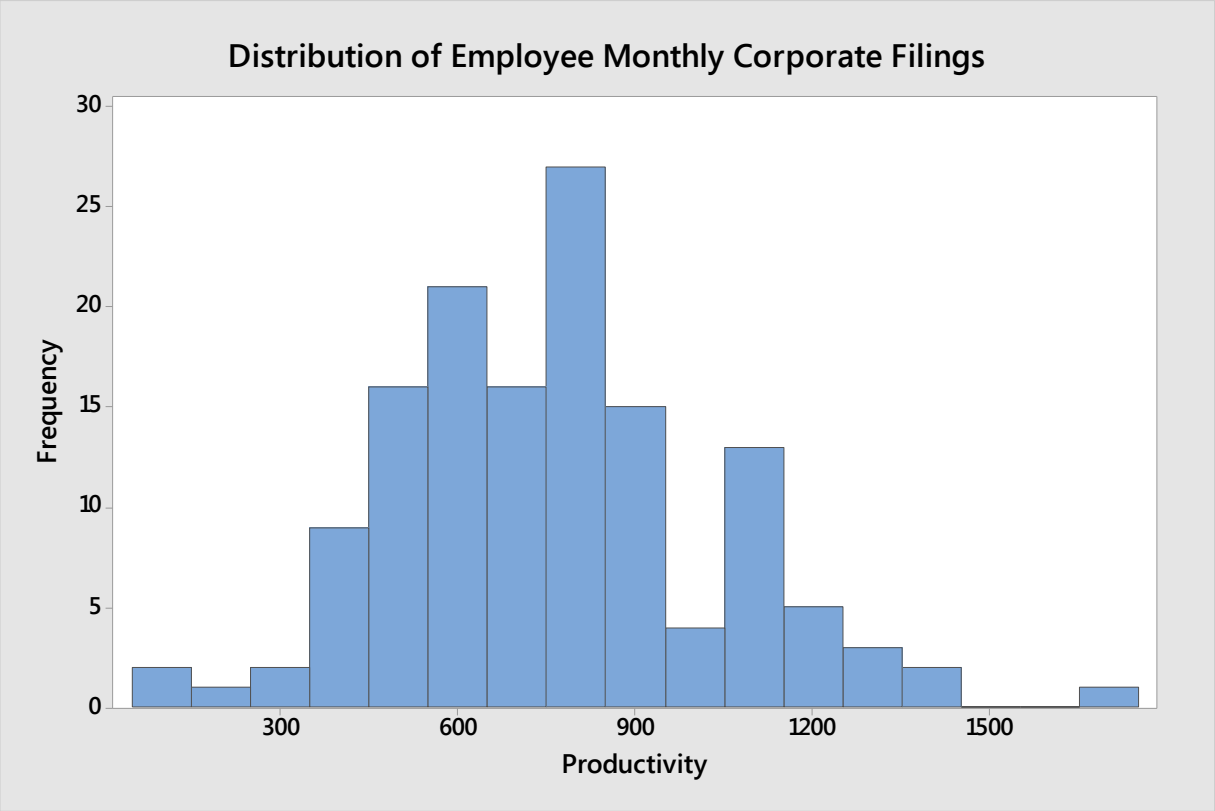
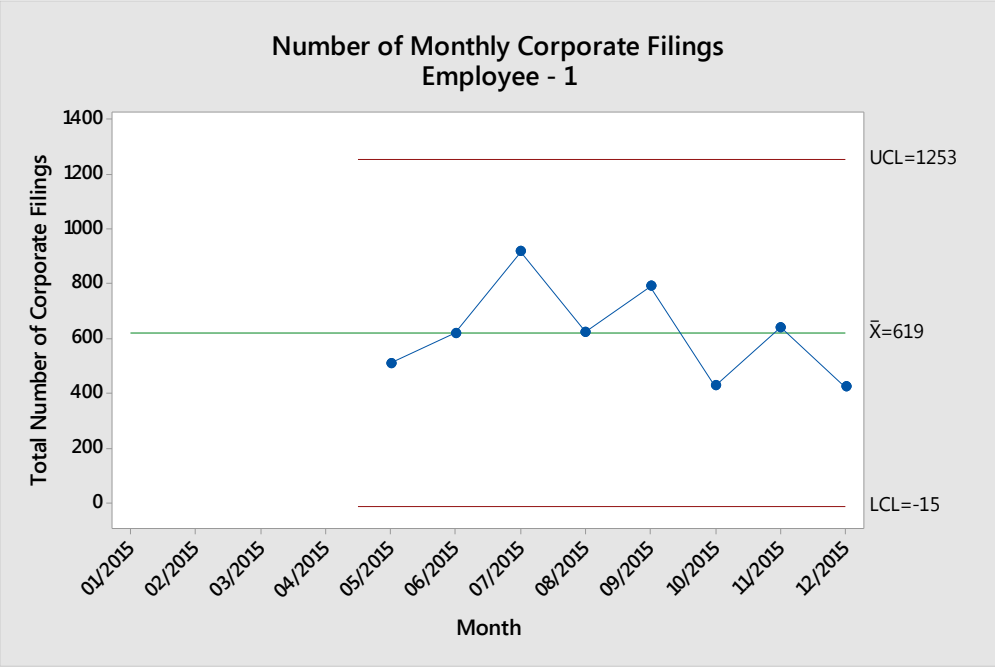
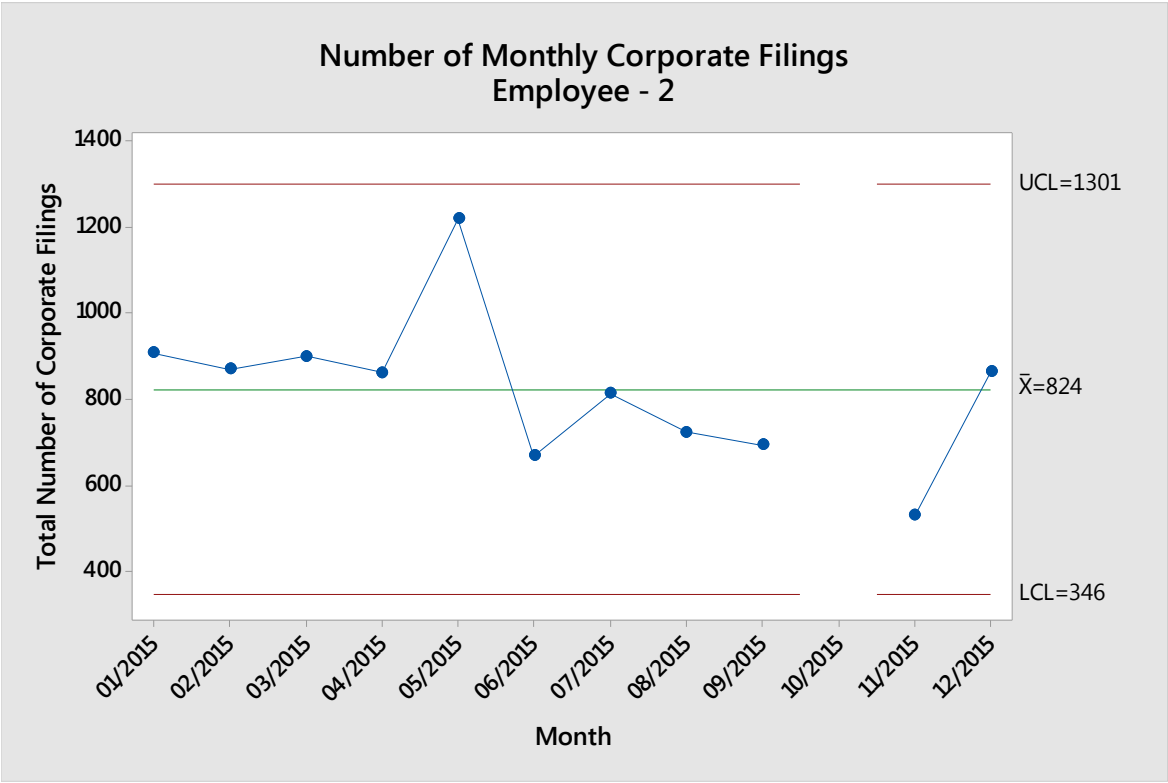

Distribution of Employee Monthly Corporate Filings
Frequency
30
25
20
15
10
5
0
300
600
900
1200
1500
Productivity


Number of Monthly Corporate Filings
Employee - 1
Total Number of Corporate Filings
1400
1200
1000
800
600
400
200
0
UCL=1253
X̄=619
LCL=-15
01/2015
02/2015
03/2015
04/2015
05/2015
06/2015
07/2015
08/2015
09/2015
10/2015
11/2015
12/2015
Month


Number of Monthly Corporate Filings
Employee - 2
Total Number of Corporate Filings
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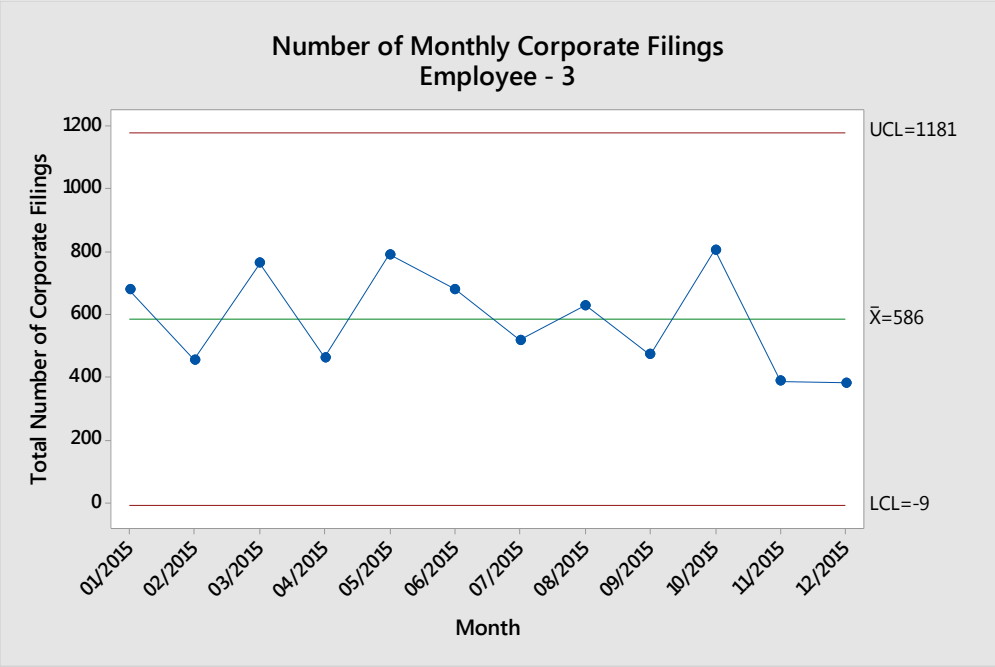
1200
1000
800
600
400
UCL=1301
X̄=824
LCL=346
01/2015
02/2015
03/2015
04/2015
05/2015
06/2015
07/2015
08/2015
09/2015
10/2015
11/2015
12/2015
Month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Employee - 3
Total Number of Corporate Filings
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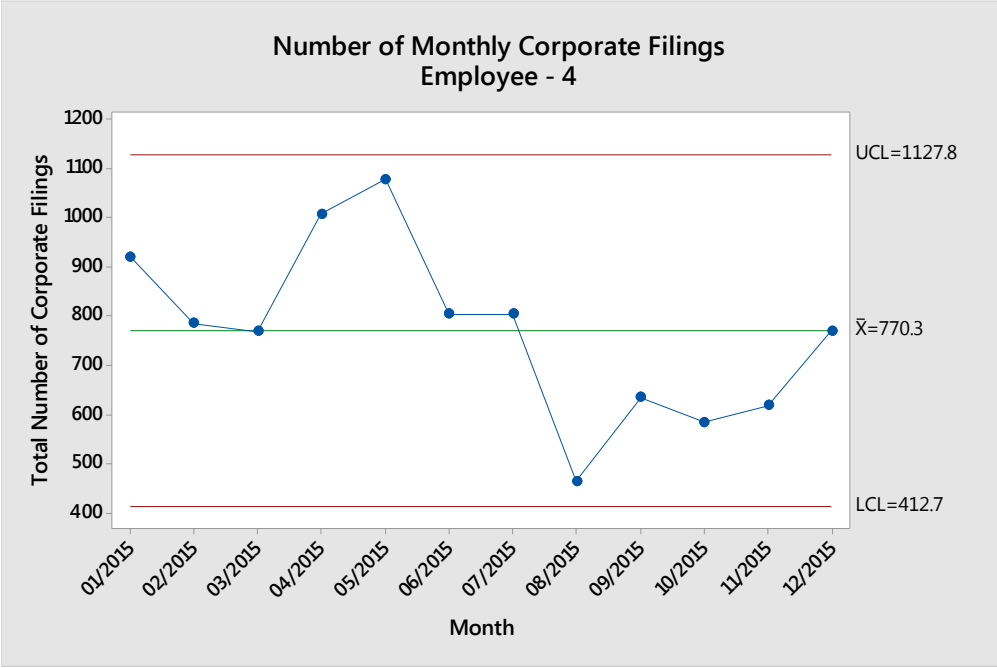
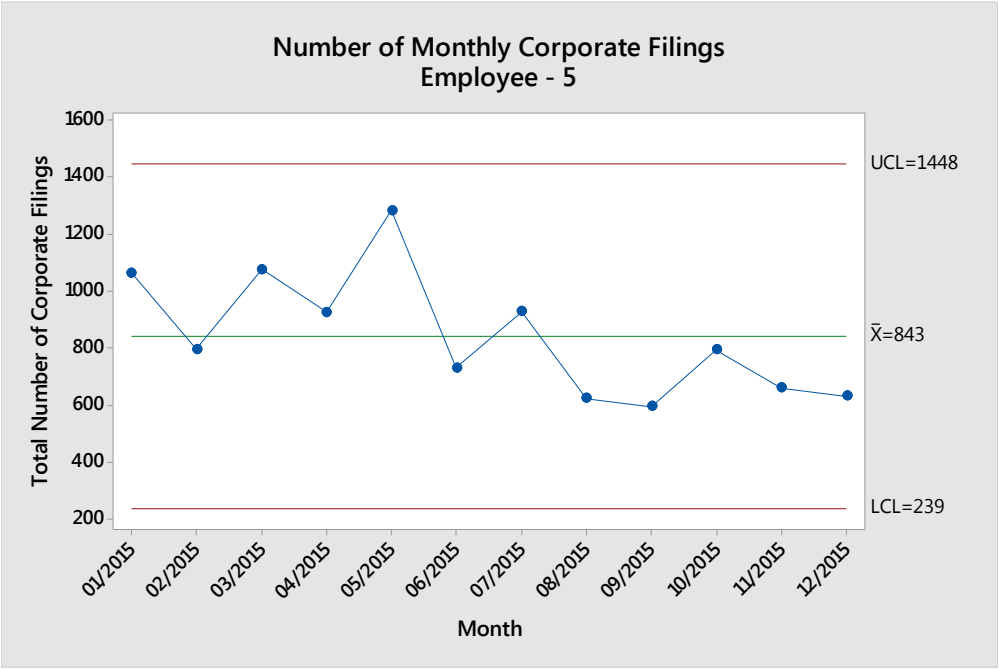
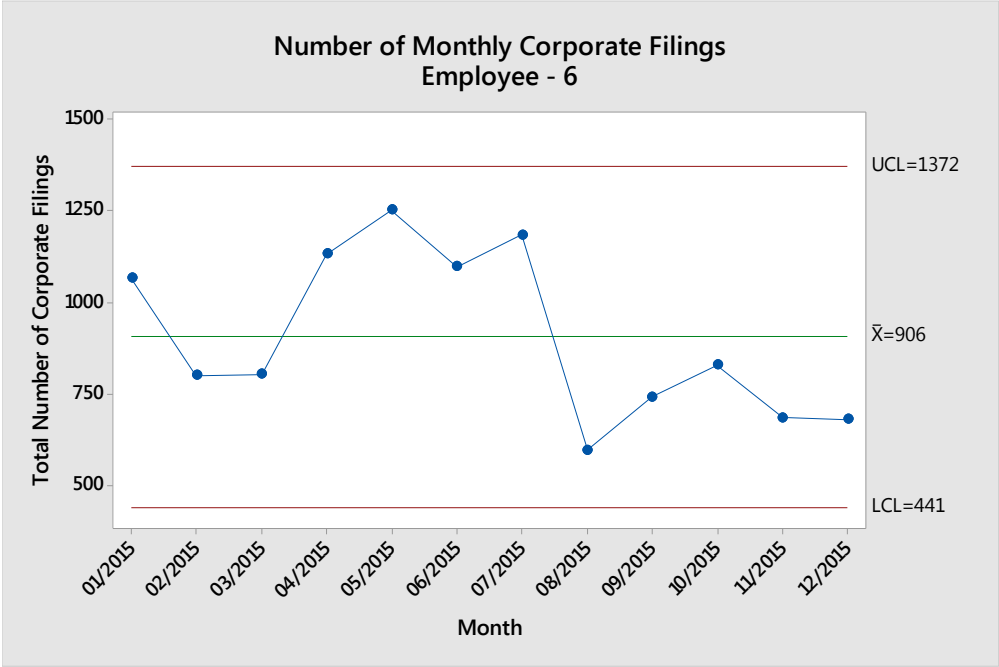
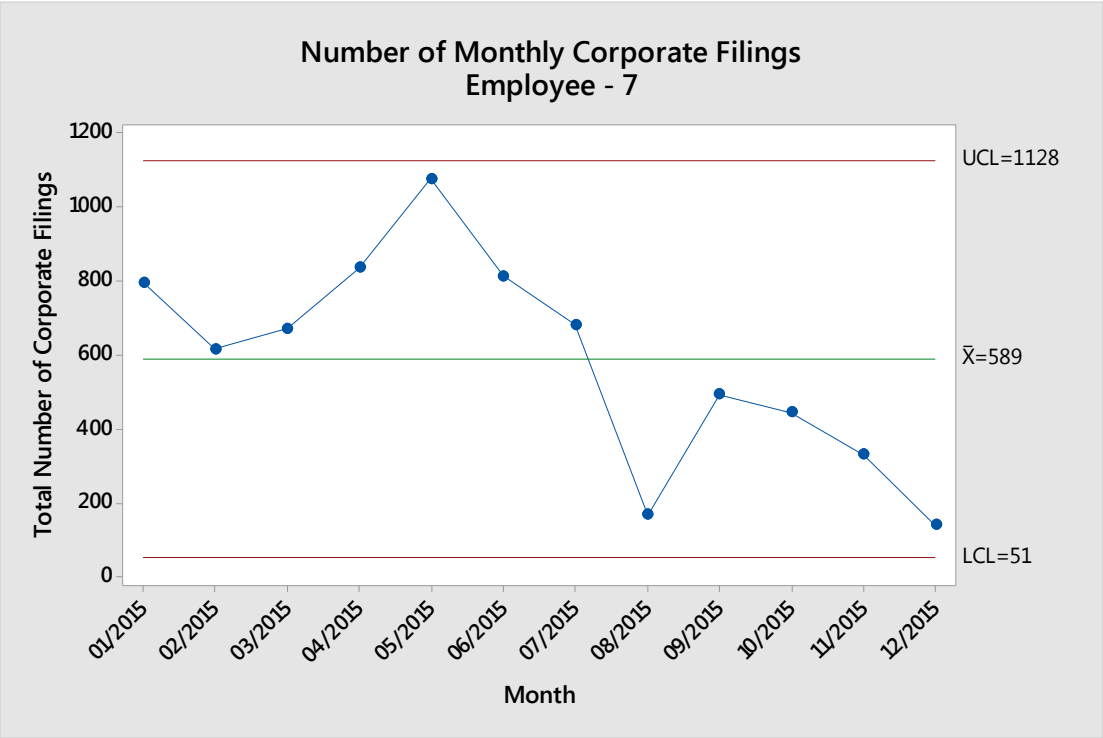
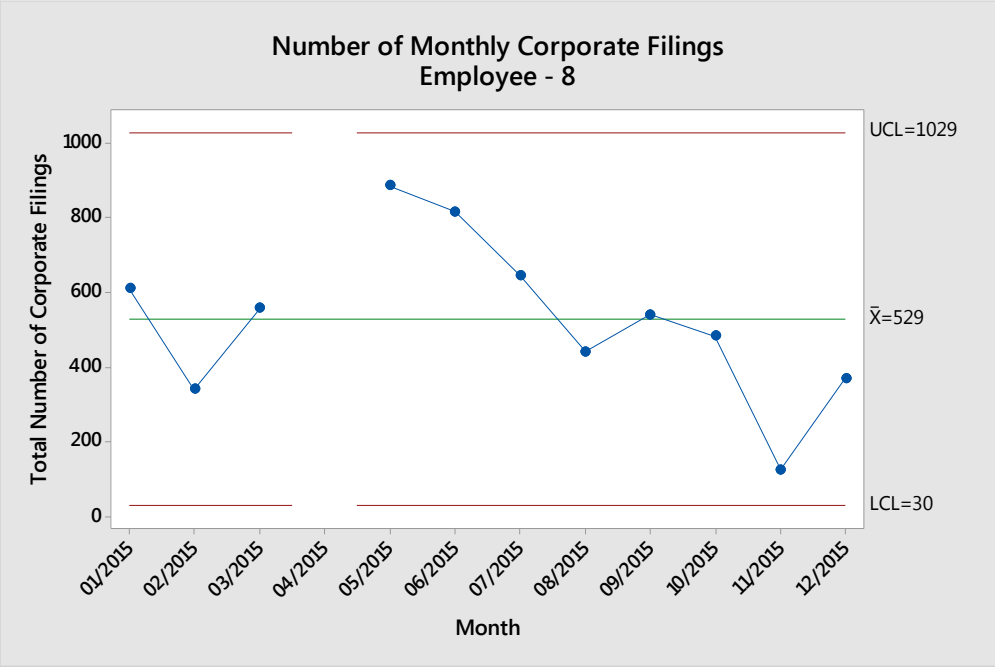
1000
800
600
400
200
0
UCL=1181
X̄=586
LCL=-9
01/2015
02/2015
03/2015
04/2015
05/2015
06/2015
07/2015
08/2015
09/2015
10/2015
11/2015
12/2015
Month

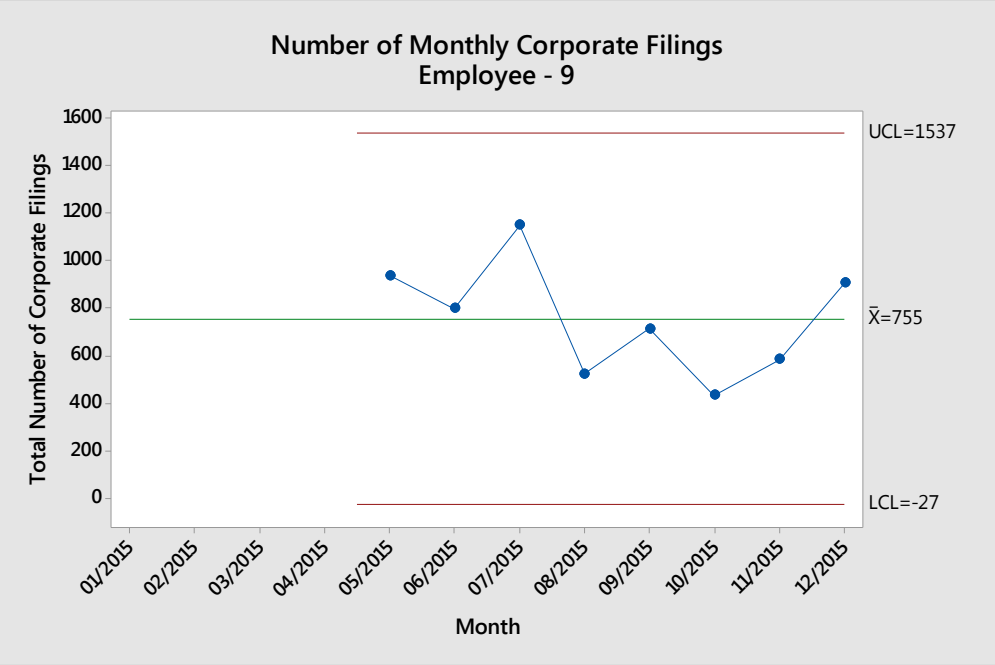

Number of Monthly Corporate Filings
Employee - 4
Total Number of Corporate Filings
1200
1100
1000
900
800
700
600
500
400
UCL=1127.8
X̄=770.3
LCL=412.7
01/2015
02/2015
03/2015
04/2015
05/2015
06/2015
07/2015
08/2015
09/2015
10/2015
11/2015
12/2015
Month

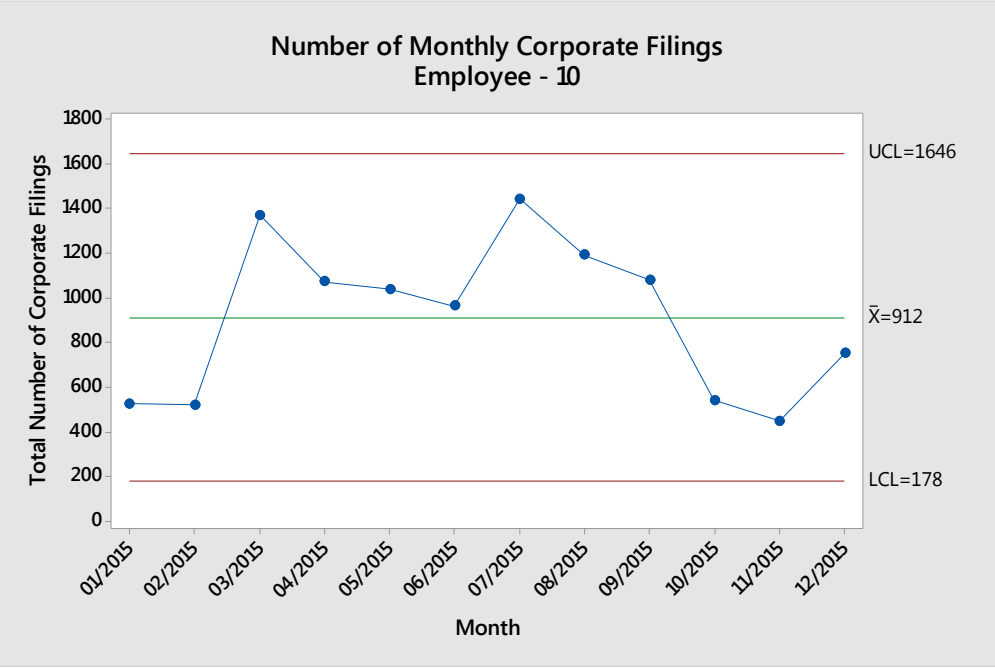

Number of Monthly Corporate Filings
Employee - 5
Total Number of Corporate Filings
1600
1400
1200
1000
800
600
400
200
UCL=1448
X̄=843
LCL=239
01/2015
02/2015
03/2015
04/2015
05/2015
06/2015
07/2015
08/2015
09/2015
10/2015
11/2015
12/2015
Month

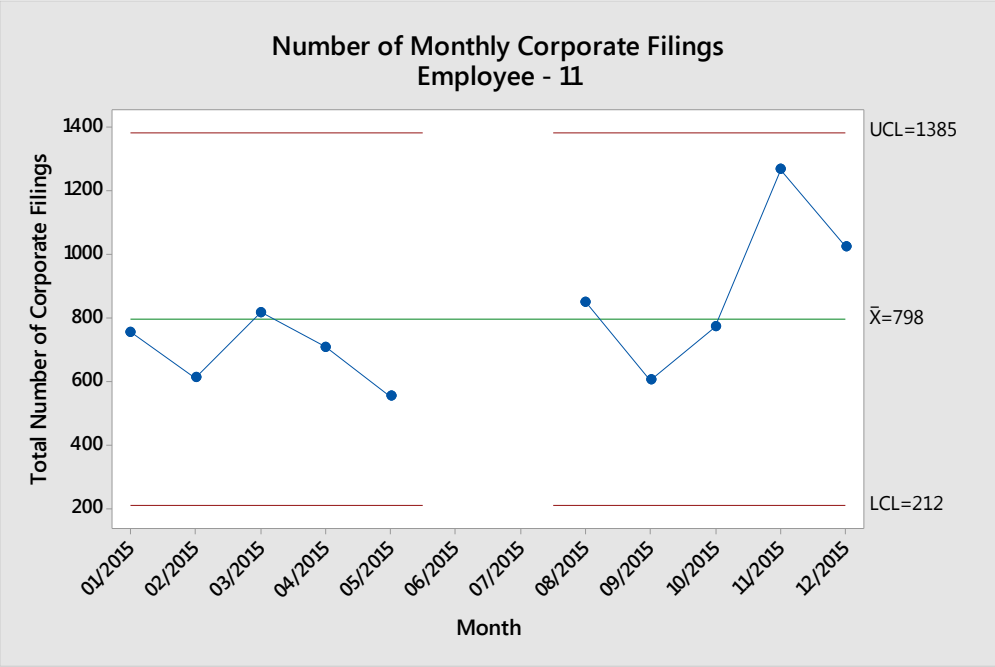

Number of Monthly Corporate Filings
Employee - 6
Total Number of Corporate Filings
1500
1250
1000
750
500
UCL=1372
X̄=906
LCL=441
01/2015
02/2015
03/2015
04/2015
05/2015
06/2015
07/2015
08/2015
09/2015
10/2015
11/2015
12/2015
Month

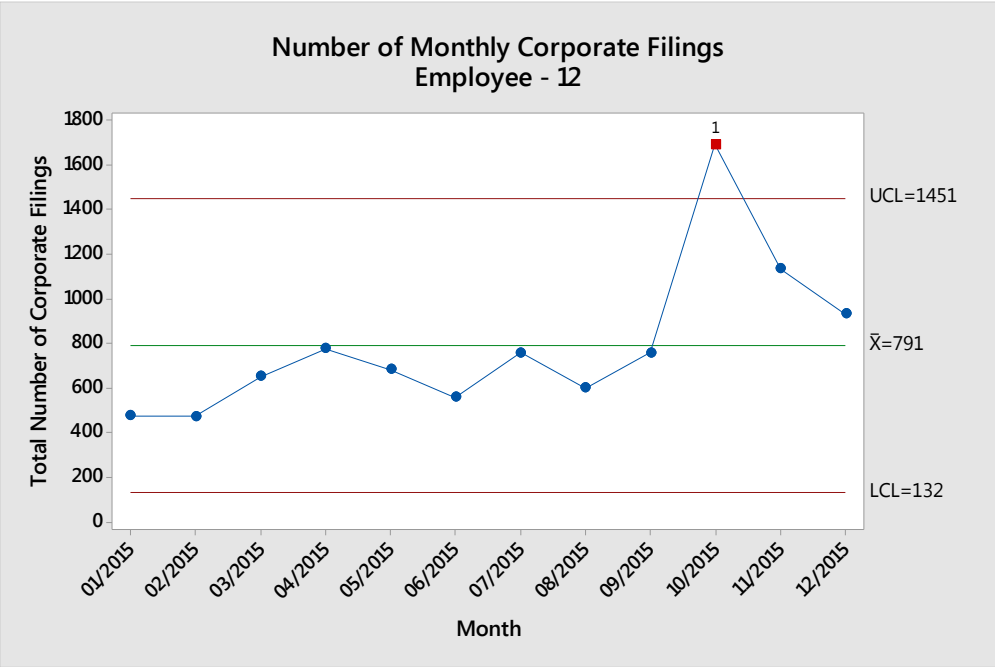

Number of Monthly Corporate Filings
Employee - 7
Total Number of Corporate Filings
1200
1000
800
600
400
200
0
UCL=1128
X̄=589
LCL=51
01/2015
02/2015
03/2015
04/2015
05/2015
06/2015
07/2015
08/2015
09/2015
10/2015
11/2015
12/2015
Month

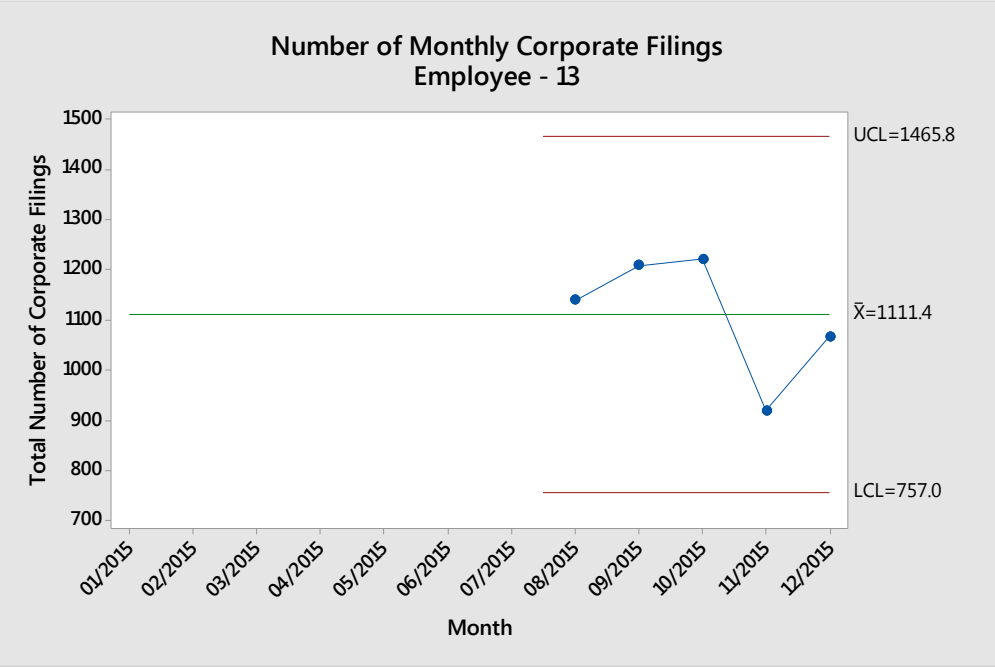

Number of Monthly Corporate Filings
Employee - 8
Total Number of Corporate Filings
1000
800
600
400
200
0
UCL=1029
X̄=529
LCL=30
01/2015
02/2015
03/2015
04/2015
05/2015
06/2015
07/2015
08/2015
09/2015
10/2015
11/2015
12/2015
Month

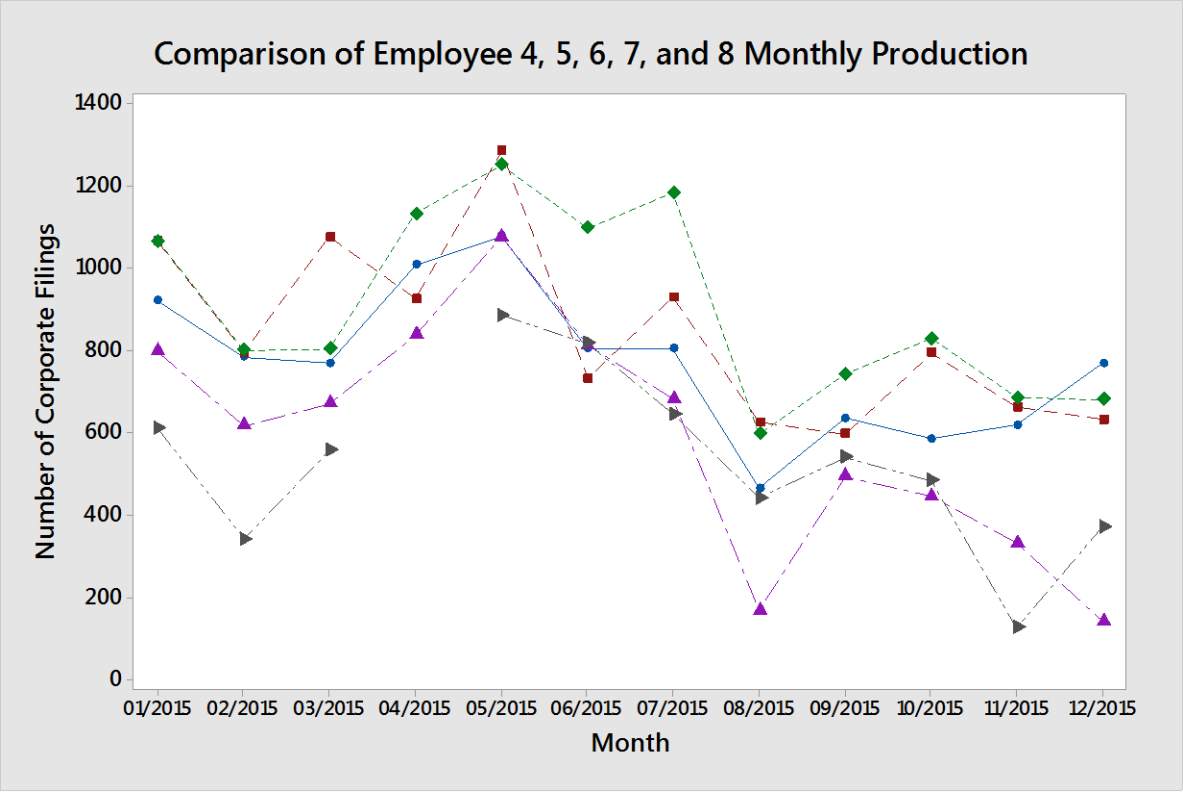

Number of Monthly Corporate Filings
Employee - 9
Total Number of Corporate Filings
1600
1400
1200
1000
800
600
400
200
0
UCL=1537
X̄=755
LCL=-27
01/2015
02/2015
03/2015
04/2015
05/2015
06/2015
07/2015
08/2015
09/2015
10/2015
11/2015
12/2015
Month

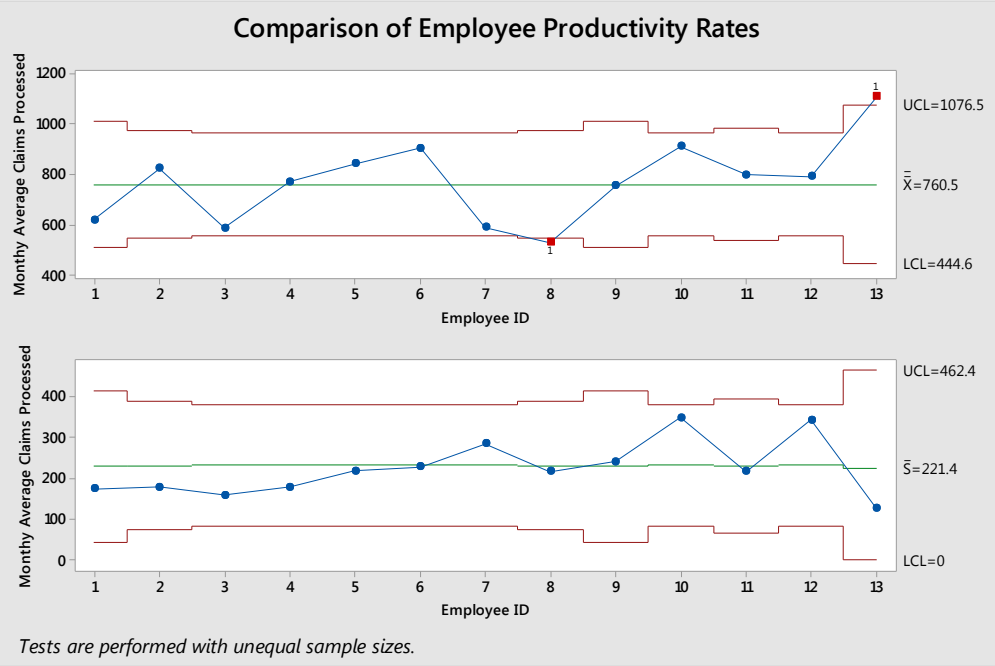

Number of Monthly Corporate Filings
Employee - 10
Total Number of Corporate Filings
1800
1600
1400
1200
1000
800
600
400
200
0
UCL=1646
X̄=912
LCL=178
01/2015
02/2015
03/2015
04/2015
05/2015
06/2015
07/2015
08/2015
09/2015
10/2015
11/2015
12/2015
Month

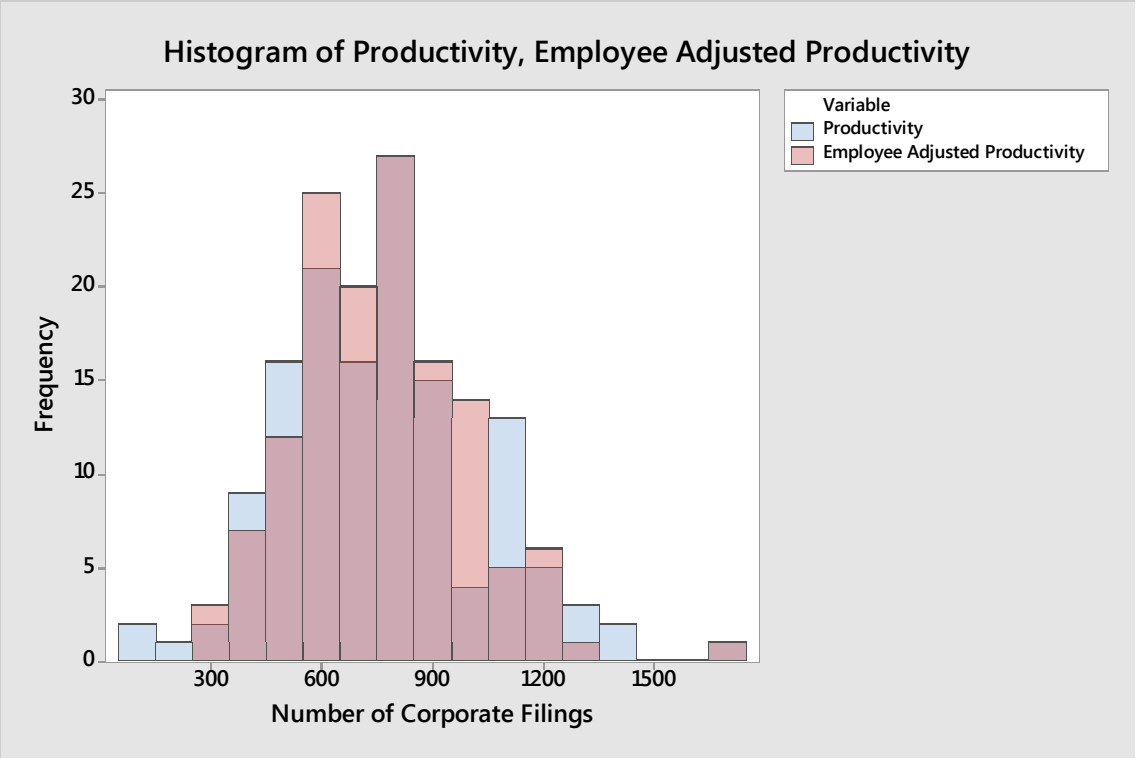

Number of Monthly Corporate Filings
Employee - 11
Total Number of Corporate Filings
1400
1200
1000
800
600
400
200
UCL=1385
X̄=798
LCL=212
01/2015
02/2015
03/2015
04/2015
05/2015
06/2015
07/2015
08/2015
09/2015
10/2015
11/2015
12/2015
Month


Number of Monthly Corporate Filings
Employee - 12
Total Number of Corporate Filings
1800
1600
1400
1200
1000
800
600
400
200
0
1
UCL=1451
X̄=791
LCL=132
01/2015
02/2015
03/2015
04/2015
05/2015
06/2015
07/2015
08/2015
09/2015
10/2015
11/2015
12/2015
Month


Number of Monthly Corporate Filings
Employee - 13
Total Number of Corporate Filings
1500
1400
1300
1200
1100
1000
900
800
700
UCL=1465.8
X̄=1111.4
LCL=757.0
01/2015
02/2015
03/2015
04/2015
05/2015
06/2015
07/2015
08/2015
09/2015
10/2015
11/2015
12/2015
Month


Comparison of Employee 4, 5, 6, 7, and 8 Monthly Production
Number of Corporate Filings
1400
1200
1000
800
600
400
200
0
01/2015
02/2015
03/2015
04/2015
05/2015
06/2015
07/2015
08/2015
09/2015
10/2015
11/2015
12/2015
Month


Comparison of Employee Productivity Rates
Monthy Average Claims Processed
1200
1000
800
600
400
1
1
1 2 3 4 5 6 7 8 9 10 11 12 13
Employee ID
UCL=1076.5
X̿=760.5
LCL=444.6
Monthy Average Claims Processed
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13
Employee ID
UCL=462.4
S̄=221.4
LCL=0
Tests are performed with unequal sample sizes.


Histogram of Productivity, Employee Adjusted Productivity
Variable
Productivity
Employee Adjusted Productivity
Frequency
0
5
10
15
20
25
30
300
600
900
1200
1500
Number of Corporate Filings

How is Performance Improved?