5-2017

FORESIGHT Benchmark Data 2015-2016

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Project FORESIGHT Annual Report, 2015-2016

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FORESIGHT Laboratory Participant—Example (US$)

Table of Contents

Table of Tables

Table of Figures

FORESIGHT Benchmark Data 2015-2016

Project FORESIGHT is a business-guided self-evaluation of forensic science laboratories across the globe. The participating laboratories represent local, regional, state, and national agencies. Economics, accounting, finance, and forensic faculty provide assistance, guidance, and analysis. Laboratories participating in Project FORESIGHT have developed standardized definitions for metrics to evaluate work processes, linking financial information to work tasks, and functions. Laboratory managers can then assess resource allocations, efficiencies, and value of services—the mission of Project FORESIGHT is to measure, preserve what works, and change what does not.

The benchmark data for the 2015-2016 performance period includes laboratory submissions for a variety of fiscal year definitions. However, all submissions have December 31, 2015 as part of their fiscal year accounting. The majority of submissions follow a July 1, 2015 through June 30, 2016 convention. Others follow a year that begins as early as January 1, 2015 (ending December 31, 2015) while the other extreme includes laboratories with a fiscal year originating October 1, 2015 and ending September 30, 2016.

Consider the summary statistics for several of the key performance indicators. Because of outliers in several of the investigative areas, the most meaningful comparisons might best be made with respect to median as a representation of "typical" laboratory performance. To lend perspective to the spread of these metrics, each of the quartile metrics are reported along with the specific comparison to the laboratory highlighted in this report.

As of this writing, one hundred thirty-nine laboratories contributed data to the project in 2015-2016. For most areas of investigation, the submitted data offers a large enough sample to elicit good statistical properties. However for Digital Evidence & Processing, and Forensic Pathology, the number of reporting laboratories in these areas is small and fewer inferences may be drawn from the data.

For more information on Project FORESIGHT, visit the Project web site at www.be.wvu.edu/forensic/foresight.htm. Questions regarding this report or other matters pertaining to Project FORESIGHT should be directed to the Principal Investigator Paul Speaker (paul.speaker@mail.wvu.edu).

FORESIGHT 20/20

The American Society of Crime Laboratory Directors (ASCLD) was successful in securing a grant from the Laura and John Arnold Foundation (LJAF) to assist laboratories in the extraction of data from their Laboratory Information Management Systems (LIMS),

including data for submission to Project FORESIGHT. The executive summary of FORESIGHT 20/20 project follows.

FORESIGHT 20/20 Executive Summary

The proliferation of television shows featuring CSI titles has both glamorized and cursed crime laboratories in America as expectations of laboratory performance have dramatically increased the demand for forensic science services. This increase in demand, coupled with laboratory funding cuts from the Great Recession, has created a bottleneck in the justice system as laboratory backlogs have risen, slowing down the entire system. The National Institute of Justice (NIJ) recognized this problem and funded a solution via two grants for Project FORESIGHT for the years 2009 through 2015. The Project FORESIGHT team was tasked with studying the forensic science industry and developing business metrics for forensic laboratories that would enable them to gain efficiencies and become more cost effective, thus addressing the bottleneck in the justice system. While Project FORESIGHT has had a pronounced effect on the participating laboratories, less than 20% of U.S. laboratories submit data to the project. The main reason for the lack of participation has been the difficulty in extracting the necessary data on laboratory casework and coupling that information with laboratory expenditures and personnel detail, which come from separate information management systems.

This proposal seeks funding to overcome this participation hurdle through the creation of software that provides the interface between the testing and casework information maintained in a Laboratory Information Management System (LIMS) and the separate financial and personnel systems. This software will be developed under ASCLD's leadership to connect the NIJ's FORESIGHT measurement standards with laboratories nationwide to permit broader forensic science industry perspectives and to enhance the business metrics available to individual laboratory directors for daily decision-making. Organizing software development through the four major LIMS providers offers a permanent software solution to all crime laboratories for access to business metrics and does so at no cost to the individual laboratories. For laboratories participating in FORESIGHT, these business metrics have permitted dramatic increases in efficiency and saved hundreds of millions of dollars. Extending participation fivefold is expected to have similarly magnified gains. Once initiated across the leading LIMS providers, this offers a permanent, broad-based system for monitoring performance of the individual laboratory and details on the performance across all forensic science.

PROJECT DESCRIPTION

The American Society of Crime Laboratory Directors (ASCLD) is a nonprofit professional society of crime laboratory directors and forensic science managers dedicated to

providing excellence in forensic science through leadership and innovation. The purpose of the organization is to foster professional interests, assist the development of laboratory management principles and techniques; acquire, preserve and disseminate forensic based information; maintain and improve communications among crime laboratory directors; and to promote, encourage and maintain the highest standards of practice in the field. With this mandate, ASCLD proposed to the Laura and John Arnold Foundation an investment to dramatically increase the efficiency and effectiveness of crime laboratories nationwide through the creation of financial intelligence software.

With ever increasing demands for services and shrinking budgets, a crime laboratory must have a thorough understanding of their operations from a business perspective and a means to compare that performance to the standards of the "forensic science industry." The National Institute of Justice (NIJ) has led efforts to improve laboratory business practices through the creation of Project FORESIGHT. Project FORESIGHT is a performance benchmarking model that enables crime laboratories to perform an internal business assessment and external comparison by standardizing terminology and performance metrics across local, state, and federal laboratories.

The FORESIGHT Project began as a funding award from the National Institute of Justice to the West Virginia University Forensic Science Initiative to develop a system that would enable laboratories to understand and assess the relationship between their casework, personnel, and budgetary expenditures. Forensic laboratory managers use these functions to assess resource allocations, human capital development, drive efficiencies, and evaluate the value of services—the mission is to measure, preserve what works, and change what does not. FORESIGHT is intended to support significant and enduring systematic reforms in accountability and decision-making in public forensic laboratories.

Participation in FORESIGHT is free, voluntary, and open to forensic science laboratories worldwide. FORESIGHT has led to significant improvement at the individual laboratory level and for the forensic industry. Evaluation of efficiency and effectiveness of a crime laboratory was virtually impossible without a common industry language and corresponding performance benchmarks. Individual annual reports to contributing laboratories detail the laboratory's metrics with emphasis on productivity, risk management, analytical process, and economic market forces. These annual evaluations are equivalent to a consultant's report, highlighting performance over time and across the industry. Even though participation is costless, less than 20% of U.S. laboratories enroll in the project. This low participation is not a comment on value of the project; rather a product of the difficulty of data extraction from multiple computer systems. Casework data is extracted from the LIMS, while personnel data and expenditures are extracted from one or more computer systems of the laboratory's parent organization (generally, a policing organization). To bridge the firewalls protecting the data in each system, laboratory management must manually extract data from these multiple systems to report their performance to project FORESIGHT. For many laboratories, the

cost in time and resources is deemed too high to participate. NIJ recognizes this burden and their Forensic Science Technology Working Group Operation Requirements highlight the need for increased IT knowledge and software for management to improve productivity.

FORESIGHT has led to a macro view of the provision of forensic science services. The common measurements have permitted a review of fundamental economic hypotheses and the delivery of crime laboratory services for economic regions. The results have shown that individual laboratories are highly efficient in the provision of services, but rarely cost effective because of the reliance on political jurisdictions, rather than economic markets, for the provision of services.

Although many laboratories have adopted this program to guide their operations, a major obstacle for implementation has been the "hands on" time required by laboratory staff to manually gather and input the required data. This data is composed of both laboratory and financial metrics, each of which is stored in separate locations or in systems that do not communicate. This then requires significant time dedicated to downloading this information and transferring it to the FORESIGHT program. The FORESIGHT program is not integrated with any of the existing vendor LIMS systems. As the LIMS systems have evolved, their capabilities have advanced to allow a more detailed monitoring of evidence samples as they move through the laboratory system. The crime laboratory user can detect problems and/or issues with samples before a report is issued and provides for a greater transparency to the criminal justice system as to the analysis history and quality assurance of that item of evidence.

The development of such freeware then permits simple extraction and submission of FORESIGHT data. That allows 100% participation for all U.S. laboratories. Such a census, rather than the current voluntary sample, will benefit both the new participants as well as those laboratories currently in the program as a more complete picture of the forensic industry emerges. With the combination of casework, expenditures, and personnel data in a single database, the freeware will also permit easier reporting for federal grant purposes. For laboratory leadership, the freeware also permits the construction of a manager's data dashboard with up-to-the-minute productivity metrics. The American Society of Crime Laboratory Directors is requesting funding to support the development of freeware software, FORESIGHT 20/20, enabling the seamless data collection of core business metrics from Laboratory Information Management Systems (LIMS) commonly employed by laboratories. Once implemented into the major LIMS providers, this legacy program requires no expenditures for individual laboratories beyond the normal updating of their LIMS.

Cost Metrics

Cost per Case

The **cost** includes allocations for capital, wages & salary, benefits, overtime & temporary hires, chemicals, reagents, consumables, gases, travel, quality assurance and accreditation, subcontracting, service of instruments, advertisements, non-instrument repairs and maintenance, equipment leasing, utilities, telecommunications, overhead, and other expenses.

A **case** in an investigative area refers to a request from a crime laboratory customer that includes forensic investigation in that investigative area. Note that a customer request may lead to a case in multiple investigative areas.

Table 1: Cost per Case by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	$90	$123	$230
Crime Scene Investigation	$792	$3,984	$6,765
Digital evidence - Audio & Video	$1,567	$3,188	$5,851
DNA Casework	$943	$1,335	$1,926
DNA Database	$59	$74	$166
Document Examination	$2,213	$3,451	$6,441
Drugs - Controlled Substances	$226	$313	$424
Evidence Screening & Processing	$485	$1,178	$1,777
Explosives	$6,489	$11,940	$20,550
Fingerprints	$490	$692	$975
Fire analysis	$1,054	$1,853	$2,905
Firearms and Ballistics	$920	$1,755	$3,066
Forensic Pathology	$1,602	$2,010	$3,053
Gun Shot Residue (GSR)	$1,560	$2,307	$3,628
Marks and Impressions	$2,751	$6,243	$8,907
Serology/Biology	$810	$1,479	$2,315
Toxicology ante mortem (excluding BAC)	$465	$571	$825
Toxicology post mortem (excluding BAC)	$514	$678	$933
Trace Evidence	$2,802	$3,637	$5,836

Project FORESIGHT submissions have increased annually. Although laboratory participation is voluntary, the summary statistics have been relatively consistent across time, particularly for areas of investigation that have large numbers of submissions. For those areas with fewer observations, there has been a fair amount of fluctuation, indicative of the smaller sample and the voluntary nature of the submissions. To illustrate the time series behaviour of the median performance, the following table provides a comparison of the cost/case over time after correcting for inflation. These measures are termed "real cost/case" where real refers to inflation-adjusted measures. Prior year's metrics have been converted to 2015-2016 prices.

Table 2: Real* Cost per Case across Time

Area of Investigation	2011 - 2012	2012 - 2013	2013 - 2014	2014 - 2015	2015 - 2016
Blood Alcohol	$127	$123	$134	$130	$123
Crime Scene Investigation	$5,662	$5,436	$1,972	$3,327	$3,984
Digital evidence - Audio & Video	$5,049	$6,936	$2,455	$2,720	$3,188
DNA Casework	$1,828	$2,053	$1,591	$1,825	$1,335
DNA Database	$57	$67	$86	$70	$74
Document Examination	$4,080	$6,960	$2,778	$3,969	$3,451
Drugs - Controlled Substances	$196	$282	$331	$318	$313
Evidence Screening & Processing	$550	$1,705	$550	$1,160	$1,178
Explosives	$5,448	$14,526	$7,412	$11,618	$11,940
Fingerprints	$341	$543	$590	$797	$692
Fire analysis	$1,001	$1,409	$2,213	$1,837	$1,853
Firearms and Ballistics	$858	$744	$1,200	$2,022	$1,755
Forensic Pathology	$3,444	$2,283	$2,105	$2,027	$2,010
Gun Shot Residue (GSR)	$1,272	$2,326	$1,757	$2,466	$2,307
Marks and Impressions	$4,175	$9,704	$3,158	$6,614	$6,243
Serology/Biology	$619	$2,248	$695	$1,610	$1,479
Toxicology ante mortem (excluding BAC)	$635	$516	$493	$567	$571
Toxicology post mortem (excluding BAC)	$666	$662	$863	$673	$678
Trace Evidence	$2,976	$4,128	$5,024	$3,761	$3,637
*2015-2016 = 100					

Cost per Item

Differences in case detail and differences in case complexity across laboratories (and across time) suggest that other relative cost measures may offer more meaningful comparison. FORESIGHT data collection includes measures for items, samples, and tests in each investigative area.

An **item** refers to a single object for examination submitted to the laboratory. Note that one item may be investigated and counted in several investigation areas. As noted above, the **cost** includes allocations for capital, wages & salary, benefits, overtime & temporary hires, chemicals, reagents, consumables, gases, travel, quality assurance and accreditation, subcontracting, service of instruments, advertisements, non-instrument repairs and maintenance, equipment leasing, utilities, telecommunications, overhead, and other expenses.

Table 3: Cost per Item by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	$86	$115	$229
Crime Scene Investigation	$128	$710	$4,925
Digital evidence - Audio & Video	$348	$1,268	$3,946
DNA Casework	$316	$434	$730
DNA Database	$62	$75	$109
Document Examination	$509	$998	$1,894
Drugs - Controlled Substances	$124	$181	$232
Evidence Screening & Processing	$90	$419	$780
Explosives	$2,104	$6,051	$8,211
Fingerprints	$227	$303	$471
Fire analysis	$401	$596	$1,043
Firearms and Ballistics	$391	$634	$1,042
Forensic Pathology	$1,817	$2,127	$2,650
Gun Shot Residue (GSR)	$858	$1,065	$1,516
Marks and Impressions	$972	$2,268	$3,213
Serology/Biology	$205	$420	$692
Toxicology ante mortem (excluding BAC)	$366	$446	$644
Toxicology post mortem (excluding BAC)	$206	$379	$474
Trace Evidence	$966	$1,589	$3,058

Cost per Sample

A **sample** refers to an item of evidence or a portion of an item of evidence that generates a reported result.

As noted above, the **cost** includes allocations for capital, wages & salary, benefits, overtime & temporary hires, chemicals, reagents, consumables, gases, travel, quality assurance and accreditation, subcontracting, service of instruments, advertisements, non-instrument repairs and maintenance, equipment leasing, utilities, telecommunications, overhead, and other expenses.

The sample offers a consistently applied metric across laboratories and suggests an average cost measure that is intuitively comparable in cross sectional commentary.

Table 4: Cost per Sample by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	$67	$102	$158
Crime Scene Investigation	$12	$71	$1,803
Digital evidence - Audio & Video	$606	$977	$2,633
DNA Casework	$195	$277	$420
DNA Database	$58	$75	$140
Document Examination	$521	$707	$910
Drugs - Controlled Substances	$78	$112	$178
Evidence Screening & Processing	$86	$122	$322
Explosives	$1,803	$2,157	$3,487
Fingerprints	$111	$166	$293
Fire analysis	$228	$392	$938
Firearms and Ballistics	$335	$507	$908
Forensic Pathology	$858	$2,053	$2,465
Gun Shot Residue (GSR)	$234	$412	$817
Marks and Impressions	$708	$1,014	$2,461
Serology/Biology	$83	$126	$237
Toxicology ante mortem (excluding BAC)	$216	$306	$448
Toxicology post mortem (excluding BAC)	$172	$212	$380
Trace Evidence	$763	$1,148	$2,198

Cost per Test

A **test** refers to an analytical process, including but not limited to visual examination, instrumental analysis, presumptive evaluations, enhancement techniques, extractions, quantifications, microscopic techniques, and comparative examinations. This does not include technical or administrative reviews.

As noted above, the **cost** includes allocations for capital, wages & salary, benefits, overtime & temporary hires, chemicals, reagents, consumables, gases, travel, quality assurance and accreditation, subcontracting, service of instruments, advertisements, non-instrument repairs and maintenance, equipment leasing, utilities, telecommunications, overhead, and other expenses.

Table 5: Cost per Test by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	$39	$57	$101
Crime Scene Investigation	$6	$56	$2,211
Digital evidence - Audio & Video	$137	$213	$1,127
DNA Casework	$43	$59	$97
DNA Database	$49	$62	$117
Document Examination	$173	$477	$712
Drugs - Controlled Substances	$37	$47	$66
Evidence Screening & Processing	$40	$96	$201
Explosives	$417	$790	$1,075
Fingerprints	$59	$88	$140
Fire analysis	$154	$248	$555
Firearms and Ballistics	$144	$247	$439
Forensic Pathology	$223	$1,237	$1,998
Gun Shot Residue (GSR)	$258	$349	$498
Marks and Impressions	$351	$781	$1,145
Serology/Biology	$68	$96	$137
Toxicology ante mortem (excluding BAC)	$66	$85	$123
Toxicology post mortem (excluding BAC)	$48	$70	$121
Trace Evidence	$236	$377	$626

Cost per Report

A **report** refers to a formal statement of the results of an investigation, or of any matter on which definite information is required, made by some person or body instructed or required to do so.

As noted above, the **cost** includes allocations for capital, wages & salary, benefits, overtime & temporary hires, chemicals, reagents, consumables, gases, travel, quality assurance and accreditation, subcontracting, service of instruments, advertisements, non-instrument repairs and maintenance, equipment leasing, utilities, telecommunications, overhead, and other expenses.

Table 6: Cost per Report by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	$86	$125	$260
Crime Scene Investigation	$737	$4,136	$6,260
Digital evidence - Audio & Video	$2,235	$3,531	$9,265
DNA Casework	$935	$1,294	$1,913
DNA Database	$56	$74	$714
Document Examination	$1,867	$2,808	$4,109
Drugs - Controlled Substances	$170	$244	$390
Evidence Screening & Processing	$283	$478	$779
Explosives	$2,780	$3,413	$10,143
Fingerprints	$293	$615	$984
Fire analysis	$870	$1,615	$2,596
Firearms and Ballistics	$1,078	$1,865	$3,127
Forensic Pathology	$1,652	$2,023	$2,694
Gun Shot Residue (GSR)	$806	$1,347	$3,525
Marks and Impressions	$2,697	$3,670	$7,125
Serology/Biology	$463	$729	$1,292
Toxicology ante mortem (excluding BAC)	$411	$501	$816
Toxicology post mortem (excluding BAC)	$445	$564	$792
Trace Evidence	$2,490	$3,240	$4,523

Metric Interpretation

The various unit cost metrics may be interpreted using the technique highlighted in The Decomposition of Return on Investment for Forensic Laboratories, *Forensic Science Policy & Management: An International Journal* Volume 1, Issue 2, 2009, Paul J. Speaker, pages 96-102. Consider the Cost/Case metric which may be decomposed into:

$$\frac{Cost}{Case} = \frac{Average\ Compensation\ x\ Testing\ Intensity}{Personnel\ Productivity\ x\ Personnel\ Expense\ Ratio}$$

From the decomposition expression for the Cost/Case, an increase in the numerator components, Average Compensation or Testing (or Sampling) Intensity, will increase the cost per case. Similarly, a decrease in denominator component will increase the cost per case. This may occur from either a drop in productivity, as measured by cases processed per FTE, or from an increase in capital investment for future productivity but financed via a drop in personnel expenses relative to total expenses.

Although the metric breakdown illustrated above offers a decomposition of the Cost/Case metric, a similar procedure may be applied to other cost metrics. Likewise, the Testing Intensity metric may be replaced by a Sampling Intensity metric (e.g., Samples/Case) or similar decomposition which offers the most meaning to the individual laboratory.

Market Metrics

A substantial portion of the cost to the laboratory comes through personal services budget for salary and benefits. (The section below on Analytical Process Metrics highlights the percentage of total costs attributable to personnel expenditures.) Laboratories across the globe and across a particular country face very different labor markets and cost of living conditions. As such, accounting for the salary and benefit pressures in each market is beyond the direct control of the individual laboratory and is subject to the market forces in a laboratory's political jurisdiction.

It may be helpful for a laboratory to replace their specific average compensation with that of the reported sample median to gain insight into how they compare to other laboratories once market forces have been neutralized.

Average Compensation

Note that **compensation** includes all personnel expenditures. This includes wages, salary, and benefits operating staff, support staff, and administrative staff. Centrally assigned compensation is apportioned to each investigative area according to the percentage of full-time equivalent employees assigned to a particular investigative area.

Note that values reported in this table and other tables with budgetary metrics have been converted to the currency of the reporting laboratory using the exchange rate for December 31 of the measured year as reported at www.xe.com.

Table 7: Average Compensation by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	$69,232	$83,524	$97,942
Crime Scene Investigation	$67,830	$85,784	$100,541
Digital evidence - Audio & Video	$59,845	$73,087	$88,111
DNA Casework	$81,981	$91,943	$101,900
DNA Database	$57,685	$74,389	$85,042
Document Examination	$61,119	$72,972	$83,008
Drugs - Controlled Substances	$76,240	$89,338	$103,177
Evidence Screening & Processing	$41,081	$60,152	$88,377
Explosives	$52,081	$69,508	$79,125
Fingerprints	$64,077	$81,554	$97,887
Fire analysis	$59,563	$75,322	$89,662
Firearms and Ballistics	$72,743	$84,646	$94,602
Forensic Pathology	$71,321	$97,623	$116,101
Gun Shot Residue (GSR)	$45,236	$69,238	$86,367
Marks and Impressions	$50,050	$63,532	$80,243
Serology/Biology	$60,556	$71,199	$81,982
Toxicology ante mortem (excluding BAC)	$54,665	$64,132	$83,886
Toxicology post mortem (excluding BAC)	$50,724	$63,717	$75,764
Trace Evidence	$53,629	$68,661	$81,408

Risk Management Metrics

There are a variety of metrics that may be used in the decomposition of average cost to suggest quality and/or risk. Three of these metrics follow to highlight the level of testing, sampling, and items examined internally per case.

Items per Case

An **item** refers to a single object for examination submitted to the laboratory. Note that one item may be investigated and counted in several investigation areas.

A **case** in an investigative area refers to a request from a crime laboratory customer that includes forensic investigation in that investigative area. Note that a customer request may lead to a case in multiple investigative areas.

Table 8: Items per Case by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	0.94	1.01	1.24
Crime Scene Investigation	0.99	2.66	7.45
Digital evidence - Audio & Video	1.65	3.05	4.62
DNA Casework	2.80	2.95	3.14
DNA Database	0.90	0.92	1.00
Document Examination	2.80	3.64	5.98
Drugs - Controlled Substances	1.43	1.75	2.10
Evidence Screening & Processing	2.07	3.33	3.63
Explosives	1.50	1.92	4.11
Fingerprints	1.54	2.17	2.97
Fire analysis	2.16	2.55	3.23
Firearms and Ballistics	1.89	2.54	4.32
Forensic Pathology	0.92	0.95	1.00
Gun Shot Residue (GSR)	1.57	2.16	2.44
Marks and Impressions	1.98	3.00	3.81
Serology/Biology	2.79	3.59	4.63
Toxicology ante mortem (excluding BAC)	1.10	1.33	1.48
Toxicology post mortem (excluding BAC)	1.88	2.33	3.08
Trace Evidence	1.89	2.26	3.00

Samples per Case

A **sample** refers to an item of evidence or a portion of an item of evidence that generates a reported result.

A **case** in an investigative area refers to a request from a crime laboratory customer that includes forensic investigation in that investigative area. Note that a customer request may lead to a case in multiple investigative areas.

Table 9: Samples per Case by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	1.03	1.46	1.95
Crime Scene Investigation	2.51	14.76	31.85
Digital evidence - Audio & Video	1.80	3.21	4.51
DNA Casework	4.64	4.90	5.11
DNA Database	0.92	0.99	1.10
Document Examination	4.20	8.19	10.37
Drugs - Controlled Substances	1.83	2.80	4.15
Evidence Screening & Processing	3.34	5.36	12.78
Explosives	2.31	5.99	10.20
Fingerprints	2.48	4.48	5.61
Fire analysis	2.49	3.80	6.92
Firearms and Ballistics	2.16	3.98	6.15
Forensic Pathology	0.98	1.00	2.47
Gun Shot Residue (GSR)	2.60	4.84	8.86
Marks and Impressions	1.92	3.73	9.92
Serology/Biology	4.26	7.17	28.35
Toxicology ante mortem (excluding BAC)	1.26	1.99	2.29
Toxicology post mortem (excluding BAC)	1.82	3.83	4.83
Trace Evidence	1.98	3.98	4.98

Tests per Case

A **test** refers to an analytical process, including but not limited to visual examination, instrumental analysis, presumptive evaluations, enhancement techniques, extractions, quantifications, microscopic techniques, and comparative examinations. This does not include technical or administrative reviews.

A **case** in an investigative area refers to a request from a crime laboratory customer that includes forensic investigation in that investigative area. Note that a customer request may lead to a case in multiple investigative areas.

Table 10: Tests per Case by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	1.94	2.13	2.72
Crime Scene Investigation	3.39	73.77	125.29
Digital evidence - Audio & Video	6.12	8.30	23.85
DNA Casework	21.26	22.06	22.71
DNA Database	0.94	1.02	1.37
Document Examination	6.48	11.33	26.63
Drugs - Controlled Substances	5.01	6.12	9.04
Evidence Screening & Processing	8.94	9.90	23.49
Explosives	9.33	14.80	63.13
Fingerprints	5.88	7.11	11.67
Fire analysis	5.08	6.24	10.27
Firearms and Ballistics	3.72	7.29	16.37
Forensic Pathology	1.01	2.83	5.92
Gun Shot Residue (GSR)	4.70	6.20	7.93
Marks and Impressions	4.44	9.65	13.45
Serology/Biology	10.04	17.92	22.63
Toxicology ante mortem (excluding BAC)	4.31	7.84	9.56
Toxicology post mortem (excluding BAC)	8.31	11.50	13.54
Trace Evidence	8.92	10.71	14.59

Reports per Case

A **report** refers to a formal statement of the results of an investigation, or of any matter on which definite information is required, made by some person or body instructed or required to do so.

A **case** in an investigative area refers to a request from a crime laboratory customer that includes forensic investigation in that investigative area. Note that a customer request may lead to a case in multiple investigative areas.

Table 11: Reports per Case by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	0.95	1.01	1.07
Crime Scene Investigation	0.98	1.10	1.28
Digital evidence - Audio & Video	0.86	1.00	1.09
DNA Casework	1.00	1.02	1.03
DNA Database	0.88	0.97	1.07
Document Examination	1.02	1.13	2.43
Drugs - Controlled Substances	0.99	1.10	1.57
Evidence Screening & Processing	1.03	1.09	3.47
Explosives	1.00	1.27	4.41
Fingerprints	0.95	1.03	1.48
Fire analysis	0.98	1.05	1.37
Firearms and Ballistics	0.90	1.00	1.06
Forensic Pathology	0.99	1.02	1.06
Gun Shot Residue (GSR)	1.02	1.14	2.54
Marks and Impressions	0.92	1.03	2.13
Serology/Biology	1.00	1.08	4.89
Toxicology ante mortem (excluding BAC)	0.99	1.06	1.18
Toxicology post mortem (excluding BAC)	1.00	1.11	1.41
Trace Evidence	0.97	1.09	1.60

Samples per Item

A **sample** refers to an item of evidence or a portion of an item of evidence that generates a reported result.

An **item** refers to a single object for examination submitted to the laboratory. Note that one item may be investigated and counted in several investigation areas.

Table 12: Samples per Item examined internally by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	1.02	1.14	1.64
Crime Scene Investigation	1.03	1.07	1.33
Digital evidence - Audio & Video	0.63	1.06	1.41
DNA Casework	1.58	1.65	1.73
DNA Database	0.92	1.06	1.10
Document Examination	1.03	1.29	2.67
Drugs - Controlled Substances	1.04	1.44	2.22
Evidence Screening & Processing	1.28	2.18	3.29
Explosives	1.08	2.91	3.88
Fingerprints	1.25	1.83	2.47
Fire analysis	1.03	1.09	2.56
Firearms and Ballistics	1.03	1.28	1.76
Forensic Pathology	1.05	1.06	1.73
Gun Shot Residue (GSR)	1.13	2.83	4.32
Marks and Impressions	1.02	1.12	2.90
Serology/Biology	1.08	2.07	7.40
Toxicology ante mortem (excluding BAC)	1.07	1.43	1.78
Toxicology post mortem (excluding BAC)	1.09	1.41	2.12
Trace Evidence	1.07	1.87	2.20

Tests per Item

A **test** refers to an analytical process, including but not limited to visual examination, instrumental analysis, presumptive evaluations, enhancement techniques, extractions, quantifications, microscopic techniques, and comparative examinations. This does not include technical or administrative reviews.

An **item** refers to a single object for examination submitted to the laboratory. Note that one item may be investigated and counted in several investigation areas.

Table 13: Tests per Item examined internally by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	2.00	2.17	2.52
Crime Scene Investigation	4.13	7.76	19.29
Digital evidence - Audio & Video	1.55	2.03	19.56
DNA Casework	7.05	7.43	7.81
DNA Database	0.98	1.10	1.24
Document Examination	1.13	3.16	3.71
Drugs - Controlled Substances	2.53	3.15	5.60
Evidence Screening & Processing	2.41	4.07	8.19
Explosives	4.67	7.22	9.64
Fingerprints	2.44	3.22	5.37
Fire analysis	2.02	2.46	3.47
Firearms and Ballistics	1.51	2.59	6.15
Forensic Pathology	1.07	1.62	4.75
Gun Shot Residue (GSR)	2.53	3.17	3.68
Marks and Impressions	1.86	3.09	3.94
Serology/Biology	3.30	4.95	6.17
Toxicology ante mortem (excluding BAC)	3.47	5.86	7.21
Toxicology post mortem (excluding BAC)	3.45	4.97	6.09
Trace Evidence	4.10	5.18	6.35

Reports per Item

A **report** refers to a formal statement of the results of an investigation, or of any matter on which definite information is required, made by some person or body instructed or required to do so.

An **item** refers to a single object for examination submitted to the laboratory. Note that one item may be investigated and counted in several investigation areas.

Table 14: Reports per Item examined internally by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	0.81	1.00	1.07
Crime Scene Investigation	0.14	0.38	1.14
Digital evidence - Audio & Video	0.18	0.39	0.65
DNA Casework	0.33	0.34	0.36
DNA Database	0.40	1.03	1.16
Document Examination	0.18	0.30	0.83
Drugs - Controlled Substances	0.55	0.71	0.92
Evidence Screening & Processing	0.29	0.33	0.87
Explosives	0.36	0.59	2.34
Fingerprints	0.32	0.60	1.11
Fire analysis	0.32	0.45	0.58
Firearms and Ballistics	0.20	0.37	0.51
Forensic Pathology	1.02	1.09	1.12
Gun Shot Residue (GSR)	0.43	0.90	1.28
Marks and Impressions	0.23	0.38	0.93
Serology/Biology	0.19	0.38	1.27
Toxicology ante mortem (excluding BAC)	0.70	0.83	1.04
Toxicology post mortem (excluding BAC)	0.33	0.53	0.84
Trace Evidence	0.31	0.49	0.82

Tests per Sample

A **test** refers to an analytical process, including but not limited to visual examination, instrumental analysis, presumptive evaluations, enhancement techniques, extractions, quantifications, microscopic techniques, and comparative examinations. This does not include technical or administrative reviews.

A **sample** refers to an item of evidence or a portion of an item of evidence that generates a reported result.

Table 15: Tests per Sample by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	1.23	1.90	2.00
Crime Scene Investigation	1.03	1.53	5.61
Digital evidence - Audio & Video	1.92	3.94	7.38
DNA Casework	4.34	4.49	4.70
DNA Database	1.00	1.05	3.83
Document Examination	1.12	1.45	2.15
Drugs - Controlled Substances	1.35	2.65	3.64
Evidence Screening & Processing	0.67	2.81	4.49
Explosives	2.11	2.55	5.84
Fingerprints	1.26	1.65	3.77
Fire analysis	0.98	1.47	3.05
Firearms and Ballistics	1.23	2.38	3.01
Forensic Pathology	1.01	1.06	2.07
Gun Shot Residue (GSR)	0.73	1.00	2.57
Marks and Impressions	1.06	2.02	3.60
Serology/Biology	0.79	1.80	3.81
Toxicology ante mortem (excluding BAC)	2.55	3.48	4.56
Toxicology post mortem (excluding BAC)	2.28	2.82	3.53
Trace Evidence	2.23	2.73	5.24

Productivity Metrics

Return to the decomposition measure for the cost/case. The denominator terms have the opposite effect on average cost. That is, as ***labor productivity*** or the ***labor expense ratio*** increase, average costs will fall. This confirms that, as a representative scientist is able to process more cases per year, then the effect will be a decrease in the average cost as fixed expenditures are averaged over a higher volume of processed cases. Similarly, if a greater portion of the budget is devoted to personnel expenditures (as opposed to capital investment) *ceteris paribus*, more cases will be processed for the same expenditure at the opportunity cost of delaying investment in capital equipment for future returns.

The next five tables contain the LabRAT summary statistics for alternative personnel productivity ratio measures.

Cases per FTE

This measure is simply the number of Cases completed for each full-time equivalent (FTE) employee (the work input of a full-time employee working for one full year) retained by the laboratory. It gives an indication of the level of productivity within the average laboratory by investigative area.

Table 16: Cases per FTE by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	433	883	1,262
Crime Scene Investigation	15	30	146
Digital evidence - Audio & Video	14	27	51
DNA Casework	62	96	126
DNA Database	945	2,010	2,477
Document Examination	11	25	46
Drugs - Controlled Substances	331	418	528
Evidence Screening & Processing	49	69	134
Explosives	3	7	10
Fingerprints	119	147	214
Fire analysis	30	55	101
Firearms and Ballistics	49	66	140
Forensic Pathology	45	56	61
Gun Shot Residue (GSR)	24	37	84
Marks and Impressions	8	14	32
Serology/Biology	31	69	132
Toxicology ante mortem (excluding BAC)	147	176	253
Toxicology post mortem (excluding BAC)	81	118	201
Trace Evidence	17	27	40

Items per FTE

This measure is the number of Items examined internally for each full-time equivalent (FTE) employee (the work input of a full-time employee working for one full year) retained by the laboratory. It gives an indication of the level of productivity within the average laboratory by investigative area.

Table 17: Items examined internally per FTE by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	690	1,270	1,736
Crime Scene Investigation	48	1,909	3,766
Digital evidence - Audio & Video	32	62	155
DNA Casework	301	468	616
DNA Database	743	1,883	2,389
Document Examination	77	106	197
Drugs - Controlled Substances	753	1,117	1,659
Evidence Screening & Processing	349	598	702
Explosives	20	41	55
Fingerprints	445	625	818
Fire analysis	110	204	371
Firearms and Ballistics	158	276	364
Forensic Pathology	49	59	132
Gun Shot Residue (GSR)	111	248	372
Marks and Impressions	36	68	88
Serology/Biology	471	741	882
Toxicology ante mortem (excluding BAC)	251	332	396
Toxicology post mortem (excluding BAC)	267	360	464
Trace Evidence	51	78	120

Samples per FTE

This measure is the number of samples from Items examined internally for each full-time equivalent (FTE) employee (the work input of a full-time employee working for one full year) retained by the laboratory. It gives an indication of the level of productivity within the average laboratory by investigative area.

Table 18: Samples per FTE by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	690	1,270	1,736
Crime Scene Investigation	48	1,909	3,766
Digital evidence - Audio & Video	32	62	155
DNA Casework	301	468	616
DNA Database	743	1,883	2,389
Document Examination	77	106	197
Drugs - Controlled Substances	753	1,117	1,659
Evidence Screening & Processing	349	598	702
Explosives	20	41	55
Fingerprints	445	625	818
Fire analysis	110	204	371
Firearms and Ballistics	158	276	364
Forensic Pathology	49	59	132
Gun Shot Residue (GSR)	111	248	372
Marks and Impressions	36	68	88
Serology/Biology	471	741	882
Toxicology ante mortem (excluding BAC)	251	332	396
Toxicology post mortem (excluding BAC)	267	360	464
Trace Evidence	51	78	120

Tests per FTE

This measure is the number of tests performed on samples for each full-time equivalent (FTE) employee (the work input of a full-time employee working for one full year) retained by the laboratory. It gives an indication of the level of productivity within the average laboratory by investigative area.

Table 19: Tests per FTE by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	1,286	2,026	2,797
Crime Scene Investigation	34	3,844	11,559
Digital evidence - Audio & Video	68	253	576
DNA Casework	1,321	2,089	2,826
DNA Database	940	2,357	3,151
Document Examination	98	187	637
Drugs - Controlled Substances	2,026	2,614	3,653
Evidence Screening & Processing	378	882	2,365
Explosives	70	109	256
Fingerprints	814	1,372	2,040
Fire analysis	168	351	591
Firearms and Ballistics	279	592	1,037
Forensic Pathology	59	134	383
Gun Shot Residue (GSR)	140	253	488
Marks and Impressions	63	90	277
Serology/Biology	588	887	1,530
Toxicology ante mortem (excluding BAC)	840	1,214	1,594
Toxicology post mortem (excluding BAC)	787	1,045	1,771
Trace Evidence	165	221	452

Reports per FTE

This measure is the number of reports filed per full-time equivalent (FTE) employees (the work input of a full-time employee working for one full year) retained by the laboratory. It gives an indication of the level of productivity within the average laboratory by investigative area.

Table 20: Reports per FTE by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	447	837	1,312
Crime Scene Investigation	16	32	179
Digital evidence - Audio & Video	11	21	51
DNA Casework	63	98	131
DNA Database	146	2,098	2,781
Document Examination	23	27	54
Drugs - Controlled Substances	400	520	676
Evidence Screening & Processing	108	141	156
Explosives	8	24	31
Fingerprints	120	194	338
Fire analysis	40	54	111
Firearms and Ballistics	45	63	107
Forensic Pathology	45	57	63
Gun Shot Residue (GSR)	25	70	113
Marks and Impressions	13	20	31
Serology/Biology	79	141	160
Toxicology ante mortem (excluding BAC)	160	196	253
Toxicology post mortem (excluding BAC)	117	150	213
Trace Evidence	25	32	39

Analytical Process Metrics

The next decomposition measure, **Personnel Expense/Total Expense**, serves as a proxy for the level of analytical technology chosen. This measure has a significant negative correlation with **Capital Expense/Total Expense** and serves as simpler decomposition term for the return on investment.

Below, the cost structure is detailed with a breakdown of expenses in capital, labor, consumables, versus other costs. Investigative areas that are highly automated, such as evidenced by the DNA database processing line, should show a lower Personnel Expense/Total Expense.

Personnel Expense as a proportion of Total Expense

Note that **compensation** includes all personnel expenditures. This includes wages, salary, and benefits operating staff, support staff, and administrative staff. Centrally assigned compensation is apportioned to each investigative area according to the percentage of full-time equivalent employees assigned to a particular investigative area.

Table 21: Personnel Expenditures/Total Expenditures by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	63.38%	74.70%	83.09%
Crime Scene Investigation	69.10%	80.02%	86.31%
Digital evidence - Audio & Video	67.26%	76.68%	82.71%
DNA Casework	63.69%	77.01%	84.96%
DNA Database	47.75%	57.50%	71.37%
Document Examination	73.19%	84.38%	89.57%
Drugs - Controlled Substances	63.55%	73.87%	83.23%
Evidence Screening & Processing	66.64%	83.75%	90.12%
Explosives	64.83%	78.62%	86.72%
Fingerprints	66.11%	73.90%	82.63%
Fire analysis	68.88%	75.26%	81.36%
Firearms and Ballistics	60.77%	70.05%	76.90%
Forensic Pathology	67.07%	79.98%	88.49%
Gun Shot Residue (GSR)	64.87%	75.63%	84.47%
Marks and Impressions	73.19%	81.82%	93.30%
Serology/Biology	63.15%	77.62%	90.03%
Toxicology ante mortem (excluding BAC)	55.99%	64.29%	72.37%
Toxicology post mortem (excluding BAC)	62.35%	71.55%	79.78%
Trace Evidence	60.53%	66.22%	75.18%

Capital Expense as a proportion of Total Expense

Capital expenditures reference those purchases by the laboratory for assets whose use extends across time periods. Since depreciation classifications place laboratory equipment into a five year depreciation class, the capital expenditures over a five year period are averaged in the determination of this portion of a laboratory's expenditures.

Table 22: Capital Expenditures/Total Expenditures by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	2.11%	5.74%	11.97%
Crime Scene Investigation	1.43%	4.99%	7.67%
Digital evidence - Audio & Video	5.55%	9.42%	15.06%
DNA Casework	2.46%	5.09%	9.23%
DNA Database	2.15%	5.43%	7.14%
Document Examination	0.77%	2.18%	5.39%
Drugs - Controlled Substances	3.56%	7.93%	13.93%
Evidence Screening & Processing	0.28%	3.29%	6.49%
Explosives	2.80%	5.34%	18.89%
Fingerprints	3.07%	5.78%	11.47%
Fire analysis	2.87%	5.24%	8.36%
Firearms and Ballistics	3.21%	6.76%	12.43%
Forensic Pathology	0.20%	3.47%	7.52%
Gun Shot Residue (GSR)	1.77%	5.00%	9.52%
Marks and Impressions	0.30%	2.21%	6.54%
Serology/Biology	0.94%	2.06%	4.92%
Toxicology ante mortem (excluding BAC)	4.20%	7.19%	13.43%
Toxicology post mortem (excluding BAC)	4.23%	7.19%	10.67%
Trace Evidence	6.89%	10.65%	17.53%

Consumables Expense as a proportion of Total Expense

This category includes a variety of variable cost components including chemicals, reagents, consumables, and gases.

Table 23: Consumables Expenditures/Total Expenditures by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	6.01%	7.12%	9.46%
Crime Scene Investigation	0.36%	1.58%	6.14%
Digital evidence - Audio & Video	0.00%	2.27%	6.10%
DNA Casework	5.46%	8.92%	12.56%
DNA Database	5.57%	10.43%	20.84%
Document Examination	0.34%	1.41%	3.95%
Drugs - Controlled Substances	4.26%	7.17%	10.28%
Evidence Screening & Processing	0.30%	2.01%	4.71%
Explosives	1.57%	2.61%	4.64%
Fingerprints	1.21%	5.32%	9.39%
Fire analysis	1.91%	4.42%	7.28%
Firearms and Ballistics	4.57%	10.52%	14.73%
Forensic Pathology	2.39%	2.83%	3.90%
Gun Shot Residue (GSR)	2.10%	3.61%	8.48%
Marks and Impressions	0.96%	3.31%	7.40%
Serology/Biology	2.06%	7.91%	15.07%
Toxicology ante mortem (excluding BAC)	7.74%	10.72%	14.14%
Toxicology post mortem (excluding BAC)	6.38%	8.40%	11.72%
Trace Evidence	2.48%	5.37%	10.45%

Turn-around Time

Note that turn-around time is offered in two forms. The first is a measure that begins when the last item of evidence in an investigative area has been submitted to the laboratory. The second measure begins the turn-around time count with the submission of the first piece of evidence in an investigative area. Because most laboratories only record one or the other of these measures, there is some seeming inconsistency which is attributed to the limited sample. The metric has been slightly altered from previous years to correspond to recommendations from Project FORESIGHT participants. The change in the metric reflects the time from each request for analysis to issuance of a report. As such, a case in one investigative area may have multiple turn-around times that correspond to separate requests.

Median Turn-around Time (Timed in days from last submission of evidence to Report submission)

Table 24: Turnaround Time from Last Item Received by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	8	13	23
Crime Scene Investigation	9	11	90
Digital evidence - Audio & Video	38	59	175
DNA Casework	58	67	87
DNA Database	16	75	99
Document Examination	33	44	60
Drugs - Controlled Substances	21	39	54
Evidence Screening & Processing	25	33	38
Explosives	29	40	56
Fingerprints	23	35	57
Fire analysis	26	43	57
Firearms and Ballistics	21	51	131
Forensic Pathology	48	86	89
Gun Shot Residue (GSR)	22	35	54
Marks and Impressions	38	45	78
Serology/Biology	28	40	55
Toxicology ante mortem (excluding BAC)	24	31	50
Toxicology post mortem (excluding BAC)	21	29	47
Trace Evidence	57	72	87

Median Turn-around Time (Timed in days from first submission of evidence to Report submission)

Table 25: Turnaround Time from First Item Received by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	8	14	27
Crime Scene Investigation	9	15	87
Digital evidence - Audio & Video	38	135	282
DNA Casework	83	108	138
DNA Database	16	56	169
Document Examination	48	71	99
Drugs - Controlled Substances	22	46	75
Evidence Screening & Processing	25	30	47
Explosives	31	81	117
Fingerprints	22	42	69
Fire analysis	26	51	95
Firearms and Ballistics	30	79	143
Forensic Pathology	32	45	73
Gun Shot Residue (GSR)	19	39	89
Marks and Impressions	29	64	147
Serology/Biology	45	62	107
Toxicology ante mortem (excluding BAC)	27	44	66
Toxicology post mortem (excluding BAC)	33	38	49
Trace Evidence	49	85	141

Backlog

Another area of concern involves the increased demand for laboratory services and the level of backlog. For data collection purposes, the definition of backlog has been defined as open cases at the end of the fiscal year that have been open for more than thirty days. As a relative comparative measure, the ratio of open cases to total cases for the year is presented in the following table.

Cases Open over 30 Days/Annual Caseload

Table 26: Backlog Cases as a Percent of Total Cases by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	0.33%	0.66%	1.74%
Crime Scene Investigation	0.59%	7.95%	24.32%
Digital evidence - Audio & Video	10.34%	18.52%	81.25%
DNA Casework	5.92%	10.07%	21.21%
DNA Database	3.86%	20.14%	41.38%
Document Examination	10.78%	22.70%	30.04%
Drugs - Controlled Substances	2.24%	5.46%	11.29%
Evidence Screening & Processing	12.57%	23.05%	44.98%
Explosives	23.83%	38.24%	58.28%
Fingerprints	5.00%	8.63%	27.64%
Fire analysis	4.67%	10.00%	14.70%
Firearms and Ballistics	7.04%	18.68%	46.43%
Forensic Pathology	6.02%	13.14%	30.84%
Gun Shot Residue (GSR)	6.38%	8.07%	20.13%
Marks and Impressions	26.38%	44.44%	65.08%
Serology/Biology	4.79%	10.45%	22.75%
Toxicology ante mortem (excluding BAC)	2.50%	5.73%	9.40%
Toxicology post mortem (excluding BAC)	4.96%	6.94%	12.93%
Trace Evidence	15.06%	23.28%	38.98%

Efficiency and Cost Effectiveness of Forensic Science Services—FORESIGHT 2015-2016 Benchmark Data

The summary statistics offer a one-dimensional view of performance. In this section, that view is expanded through a consideration of cost effectiveness and efficiency. Economic theory indicates that any industry, including forensic science laboratories, will have average costs (Cost/Case) that decline as caseload is increased until reaching a point of perfect economies of scale. Thereafter, diseconomies of scale will be realized and average costs will rise as caseload increases. This behavior is exemplified via U-shaped average cost curves.

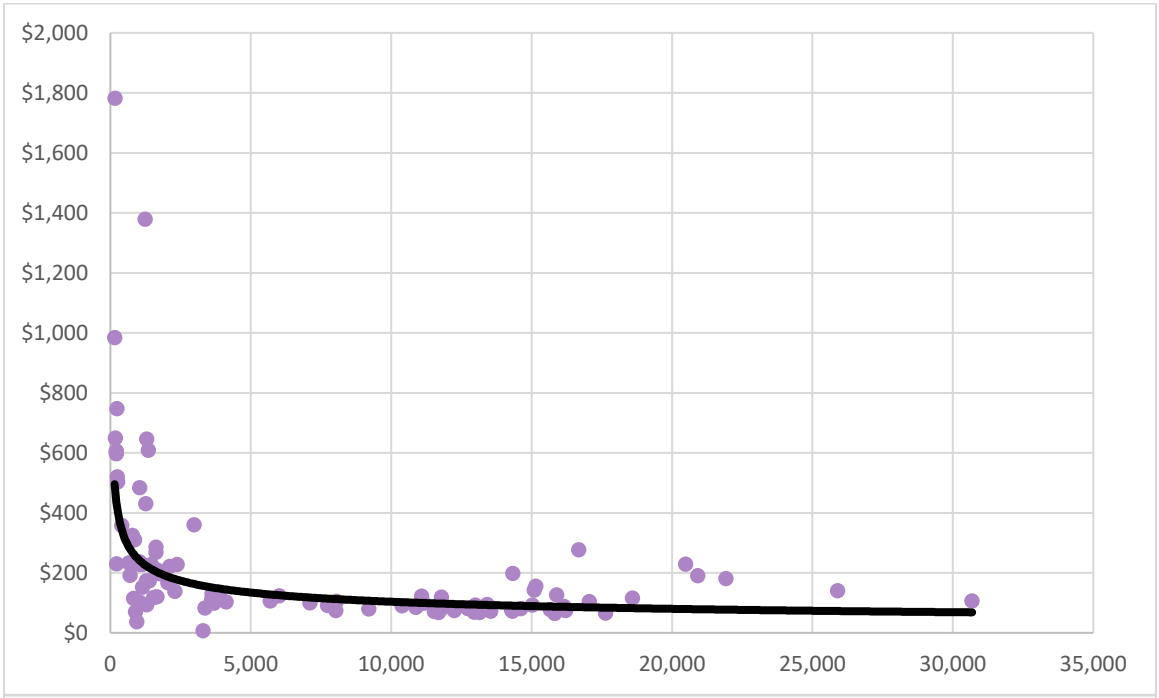
For each investigative area, the industry average total cost curve has been estimated by a series of non-linear regressions. When a laboratory performs on or near the curve, it is an indication of efficiency for the corresponding caseload. For an efficient performance that is near the bottom of the U-shaped curve, the laboratory exhibits cost effective performance as it approaches perfect economies of scale.

Each of the average cost curves is illustrated with the corresponding mapping of productivity in the form of Cases/FTE versus the corresponding caseload. Research to-date suggests that the level of productivity for any caseload is the most critical component in the DuPont breakdown to explain efficiency in the laboratory. That is, a laboratory which exemplifies high productivity for their caseload is likely to be operating near peak efficient average cost for that level of casework.

In addition to this cross–sectional comparison, average cost and productivity are illustrated for all past FORESIGHT submissions. The term “real” indicates that costs have been adjusted for inflation and converted to the most recent year’s price index.

Blood Alcohol Analysis

Figure 1: Blood Alcohol Analysis Average Total Cost v. Caseload



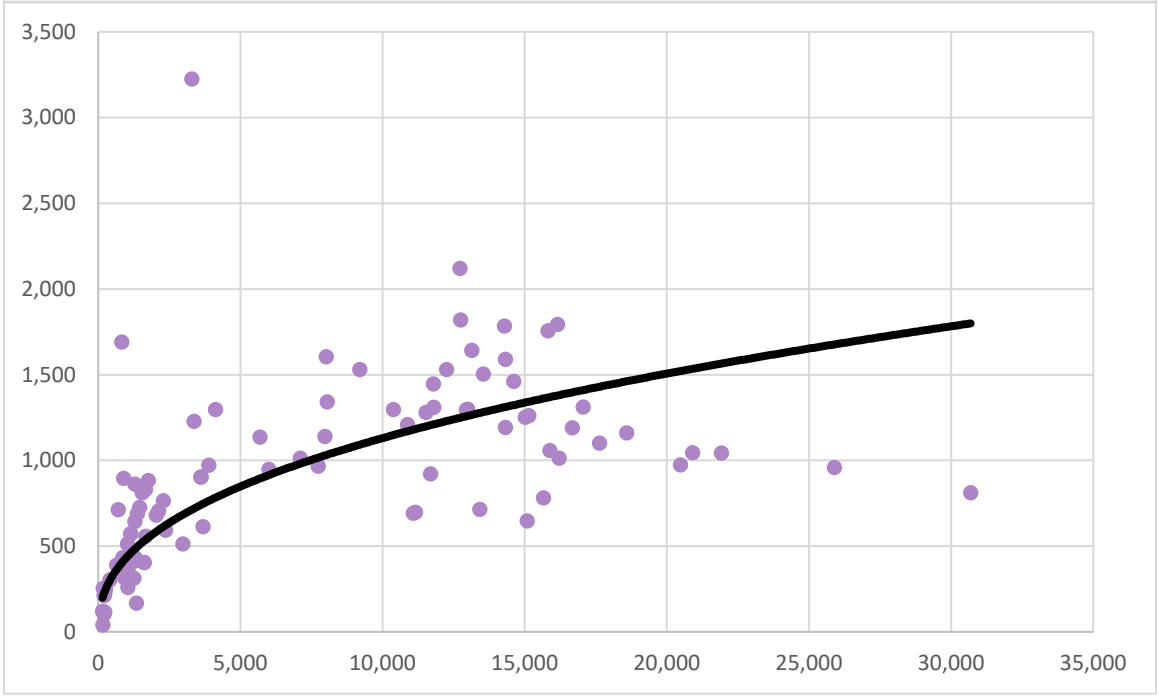
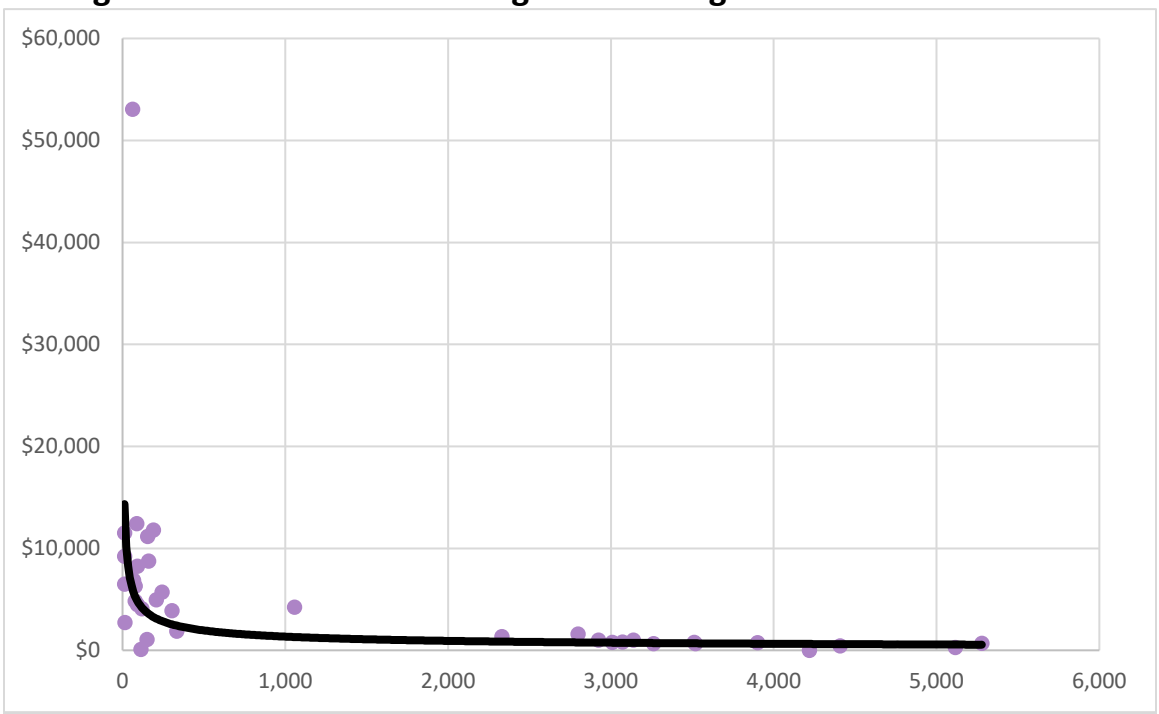


Figure 2: Blood Alcohol Analysis Productivity (Cases/FTE v. Caseload)

Crime Scene Investigation

Figure 3: Crime Scene Investigation Average Total Cost v. Caseload



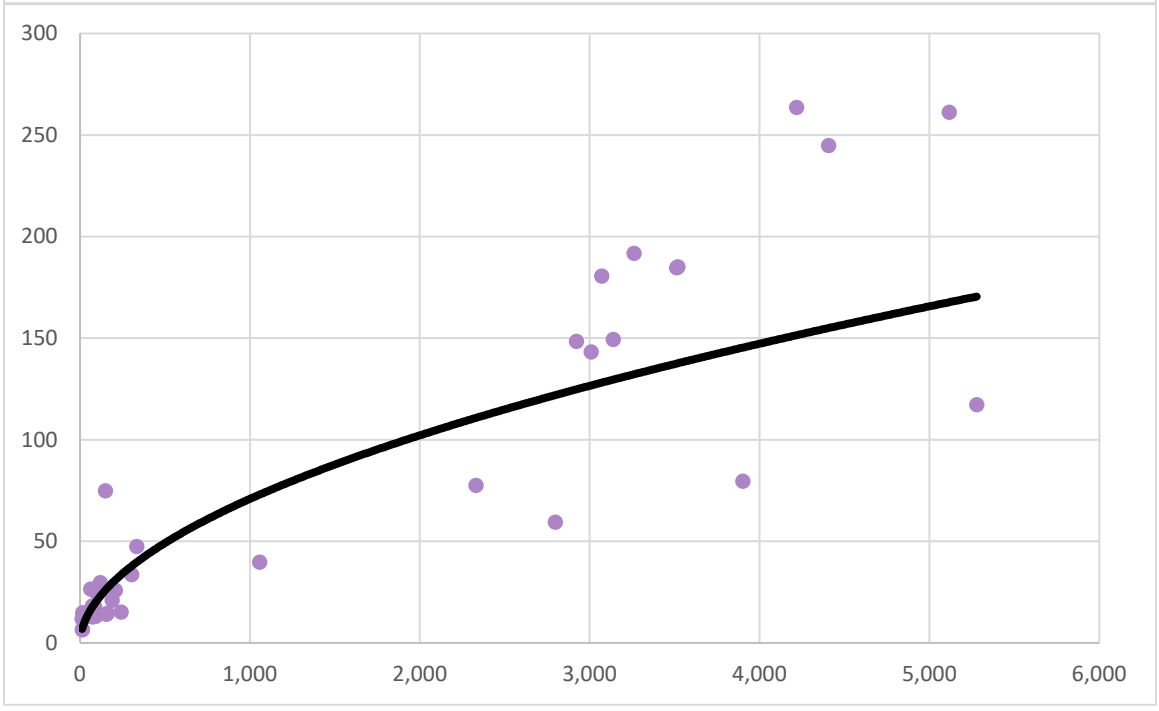
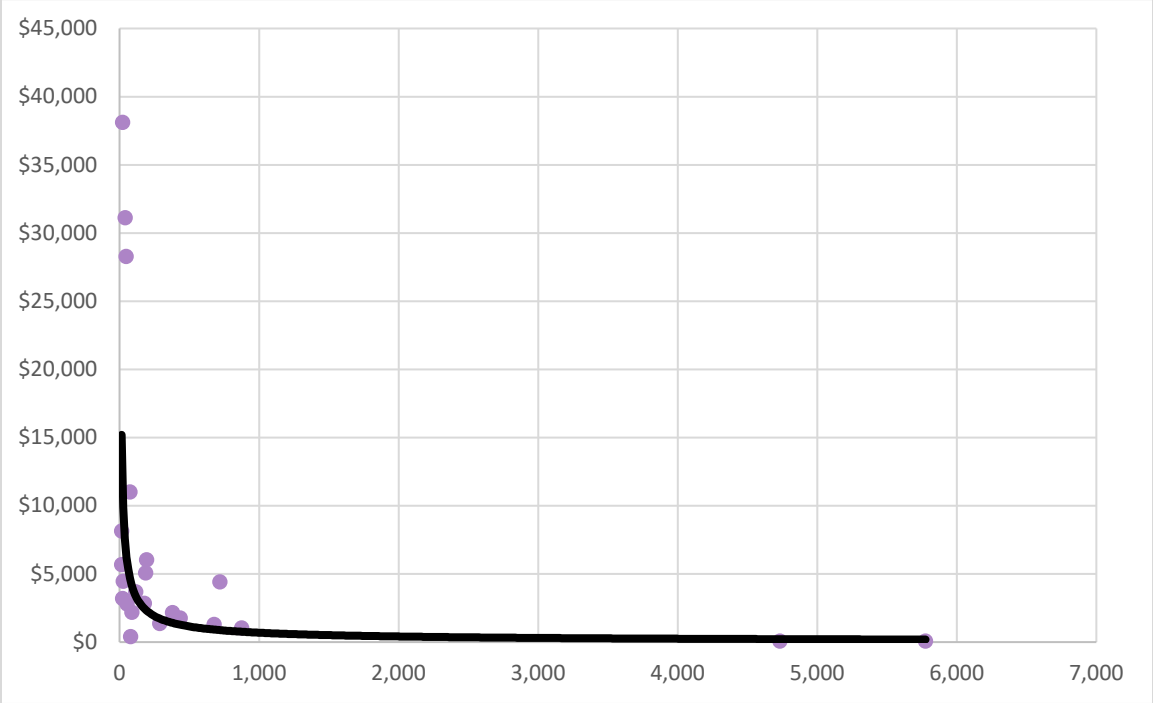


Figure 4: Crime Scene Investigation Productivity (Cases/FTE v. Caseload)

Digital Evidence

Figure 5: Digital Evidence Average Total Cost v. Caseload



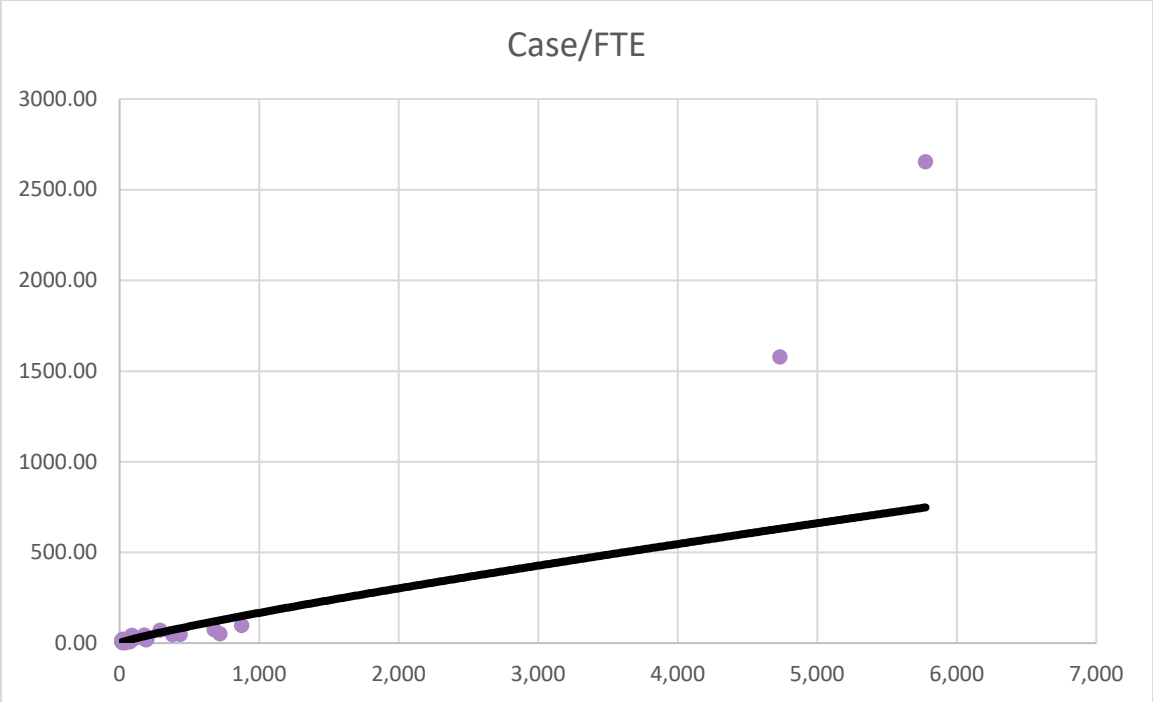
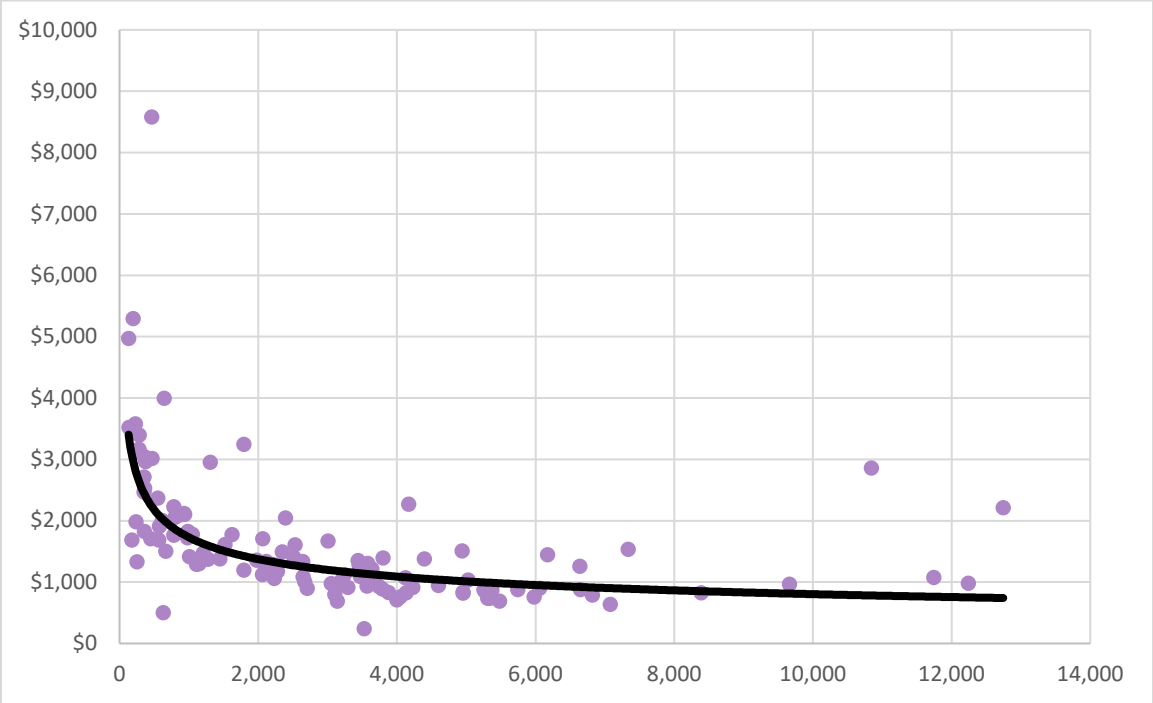


Figure 6: Digital Evidence Productivity (Cases/FTE v. Caseload)

Foresight Project 2015-2016, West Virginia University, Morgantown, WV, USA

DNA Casework Analysis

Figure 7: DNA Casework Average Total Cost v. Caseload



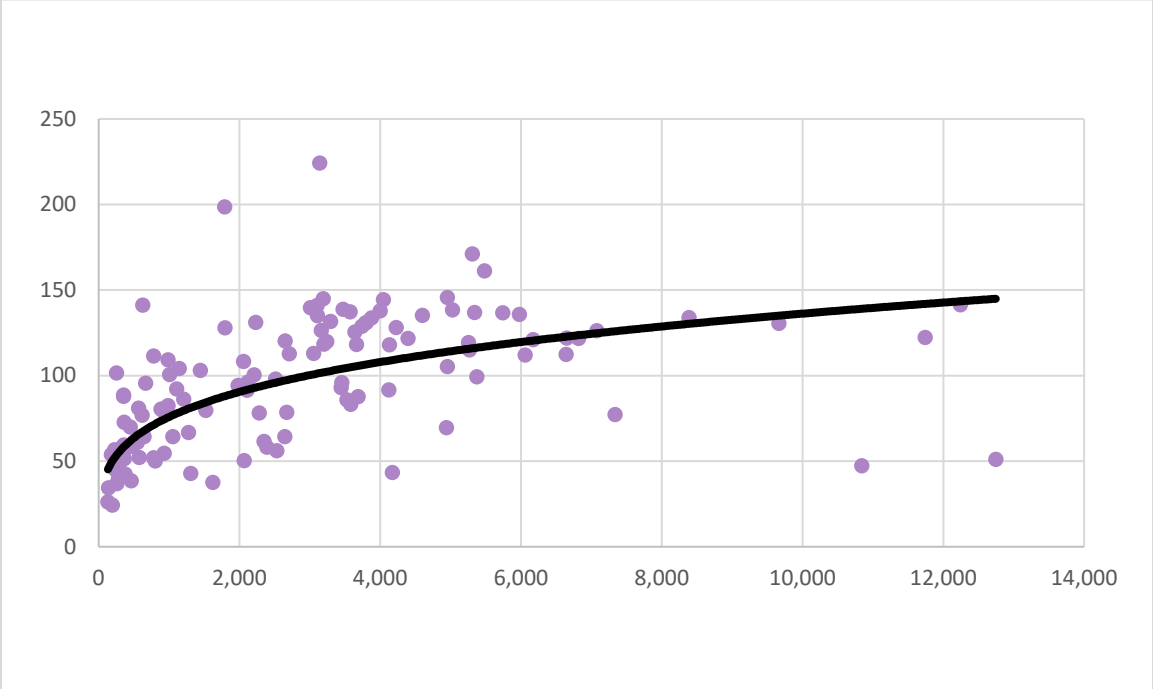
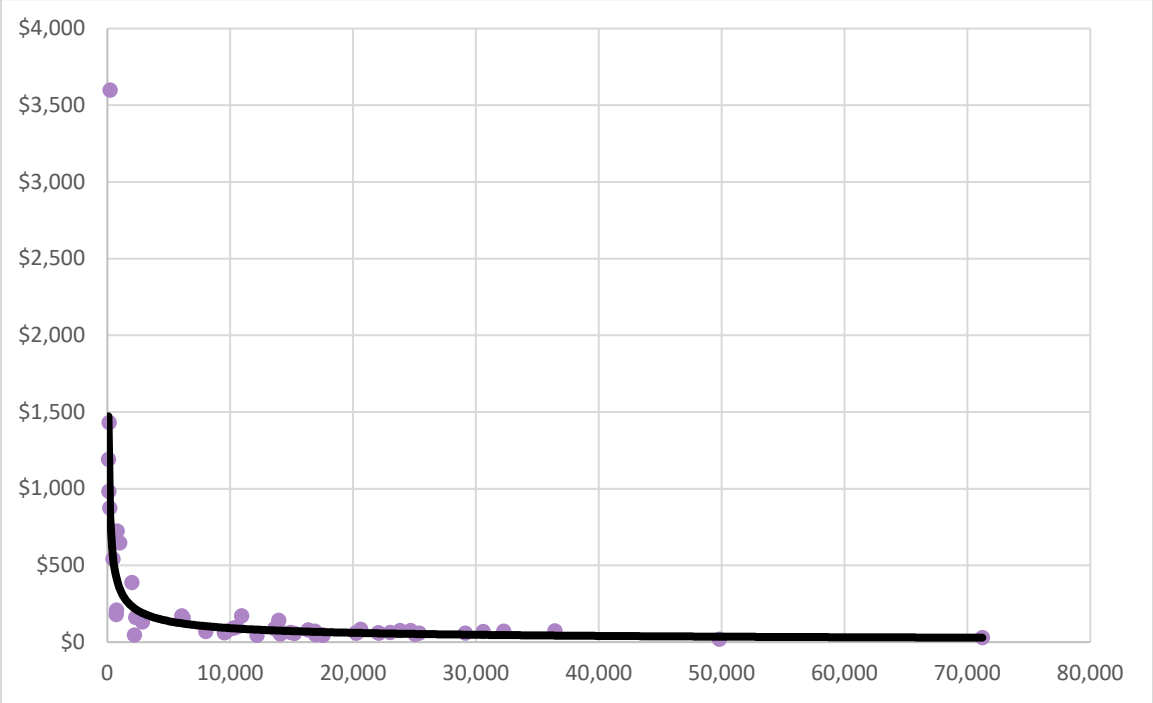


Figure 8: DNA Casework Productivity (Cases/FTE v. Caseload)

Foresight Project 2015-2016, West Virginia University, Morgantown, WV, USA

DNA Database

Figure 9: DNA Database Average Total Cost v. Caseload



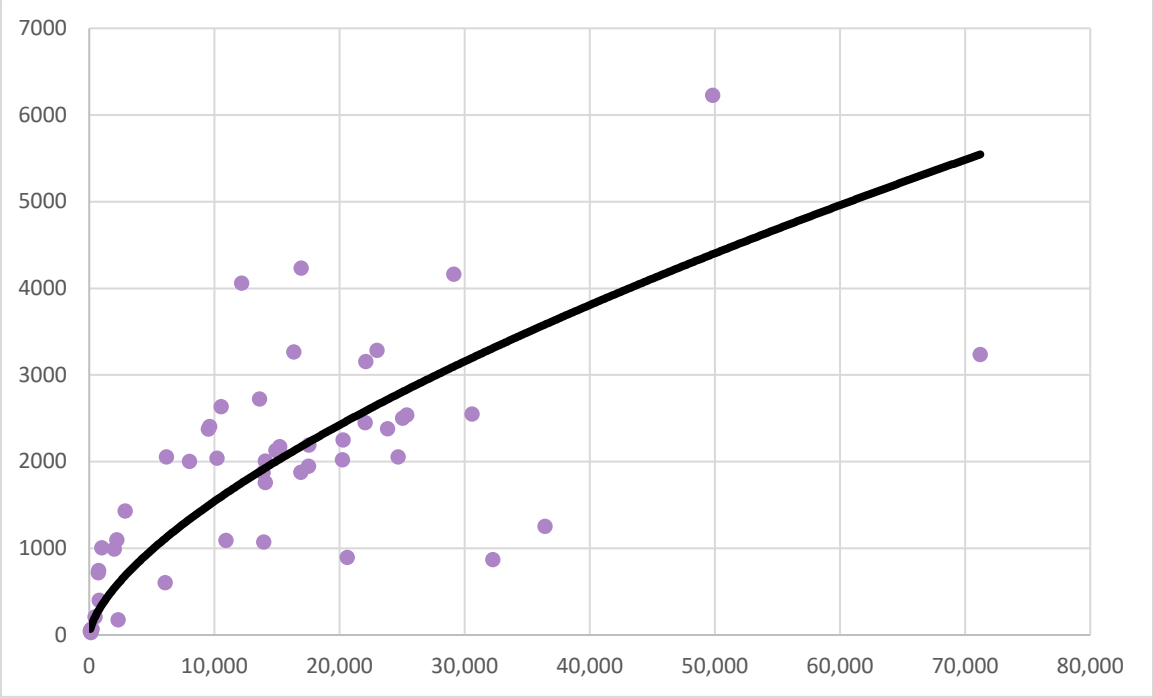
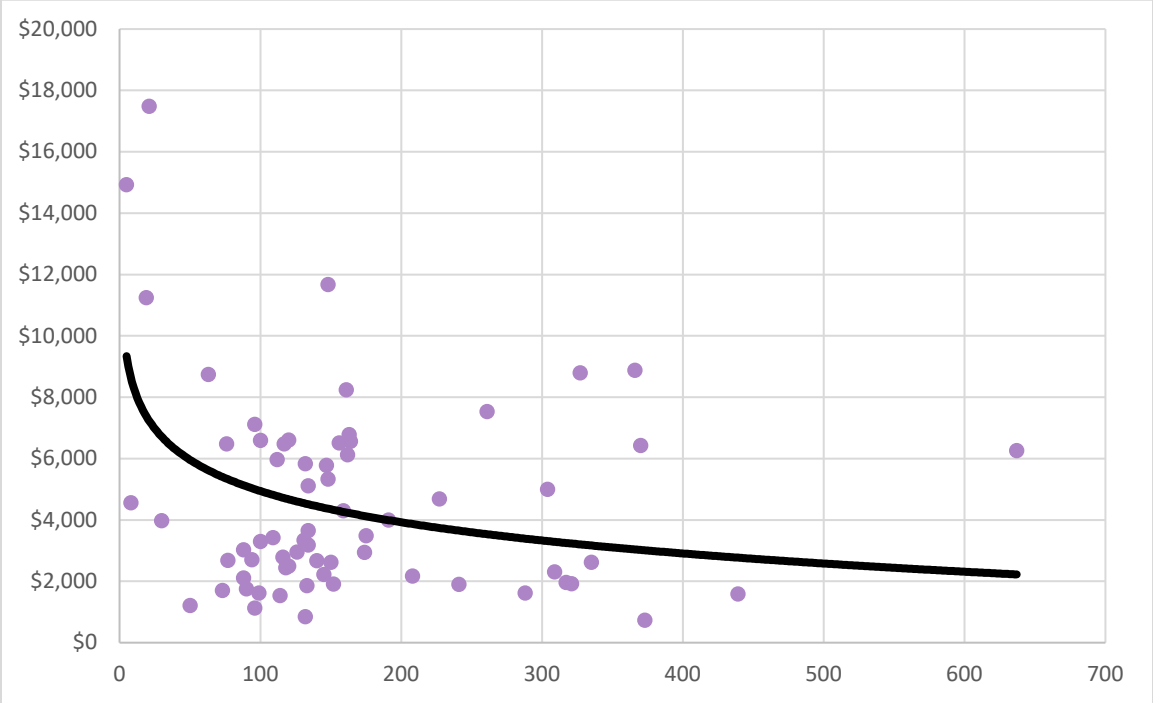


Figure 10: DNA Database Productivity (Cases/FTE v. Caseload)

Document Examination

Figure 11: Document Examination Average Total Cost v. Caseload



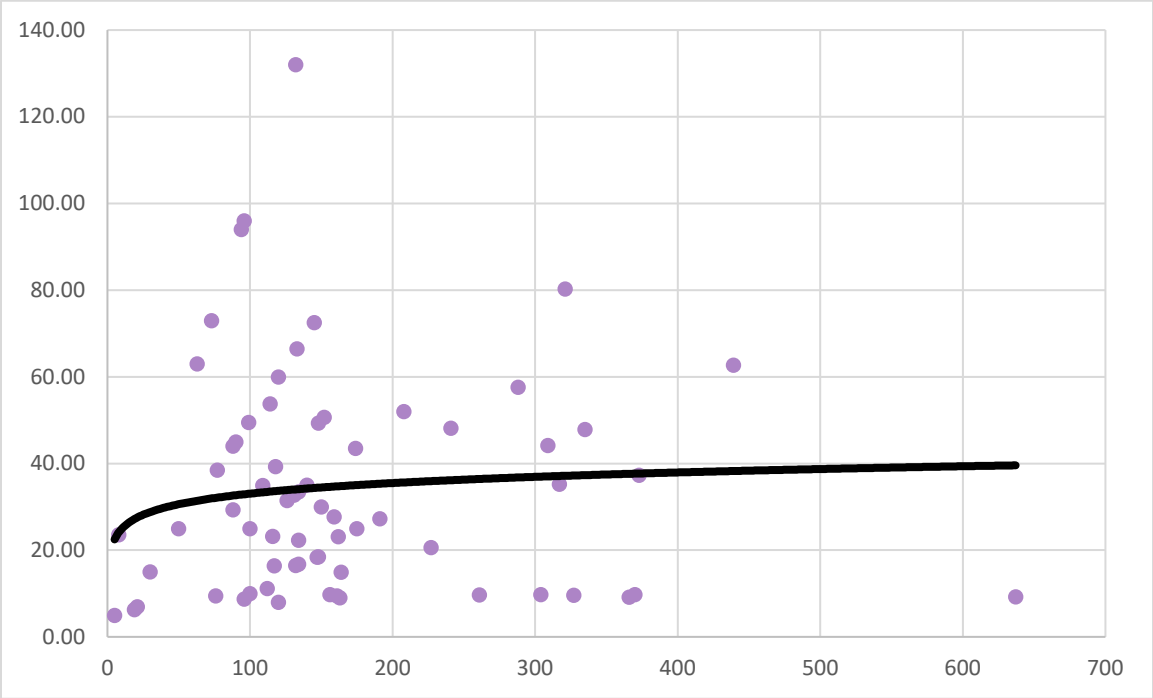
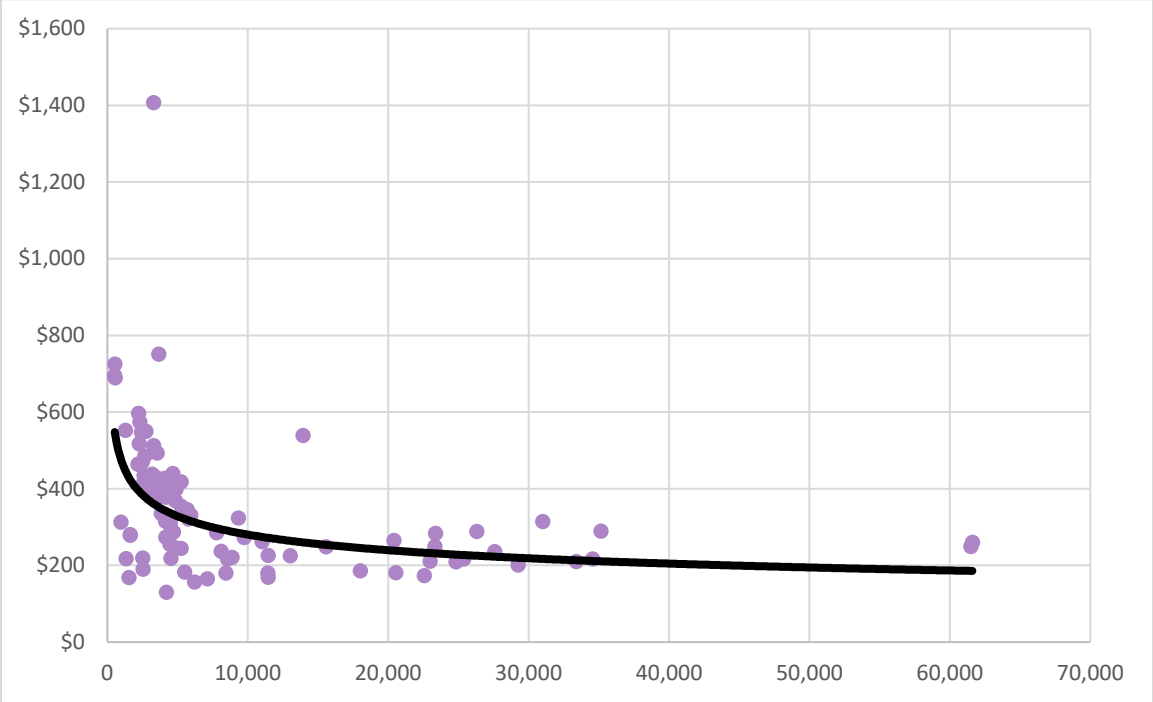


Figure 12: Document Examination Productivity (Cases/FTE v. Caseload)

Drugs—Controlled Substances

Figure 13: Drugs--Controlled Substance Analysis Average Total Cost v. Caseload



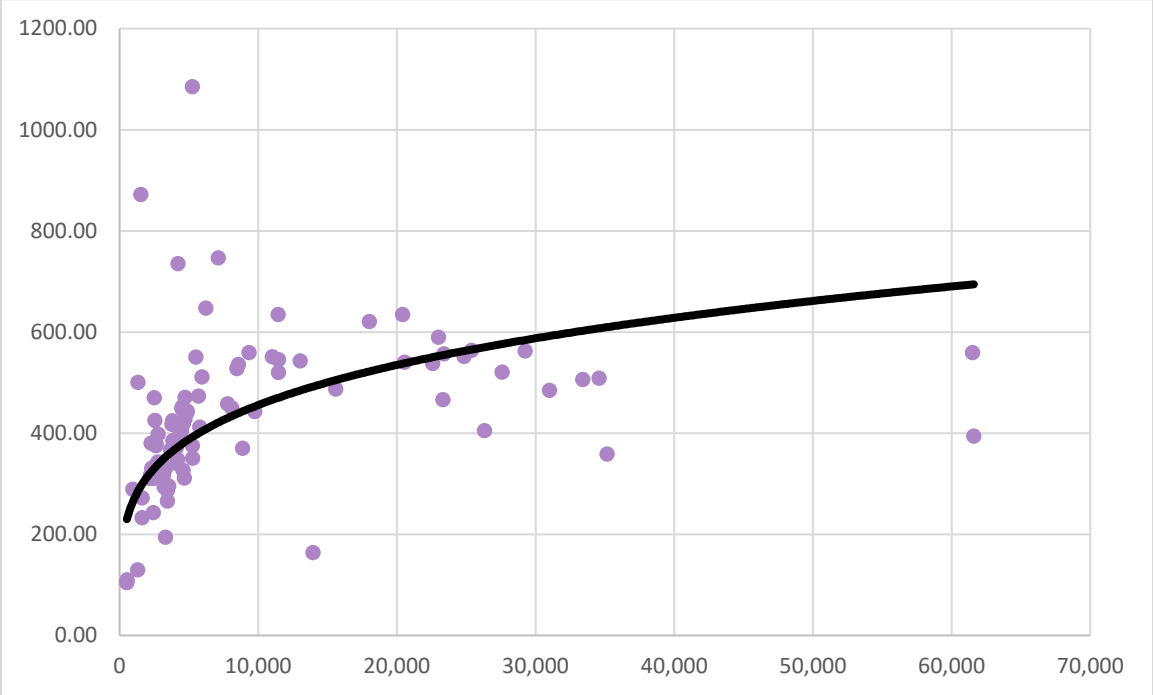


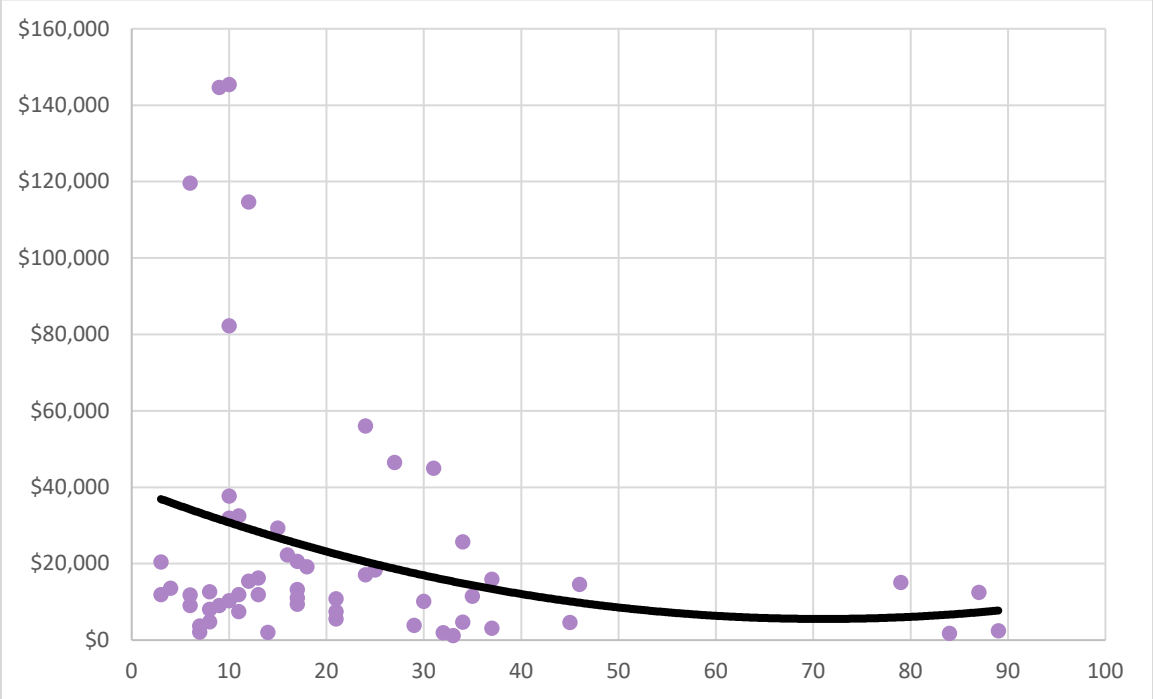
Figure 14: Drugs—Controlled Substances Productivity (Cases/FTE v. Caseload)

Evidence Screening & Processing

There was insufficient data to model this area of investigation.

Explosives Analysis

Figure 15: Explosives Analysis Average Total Cost v. Caseload



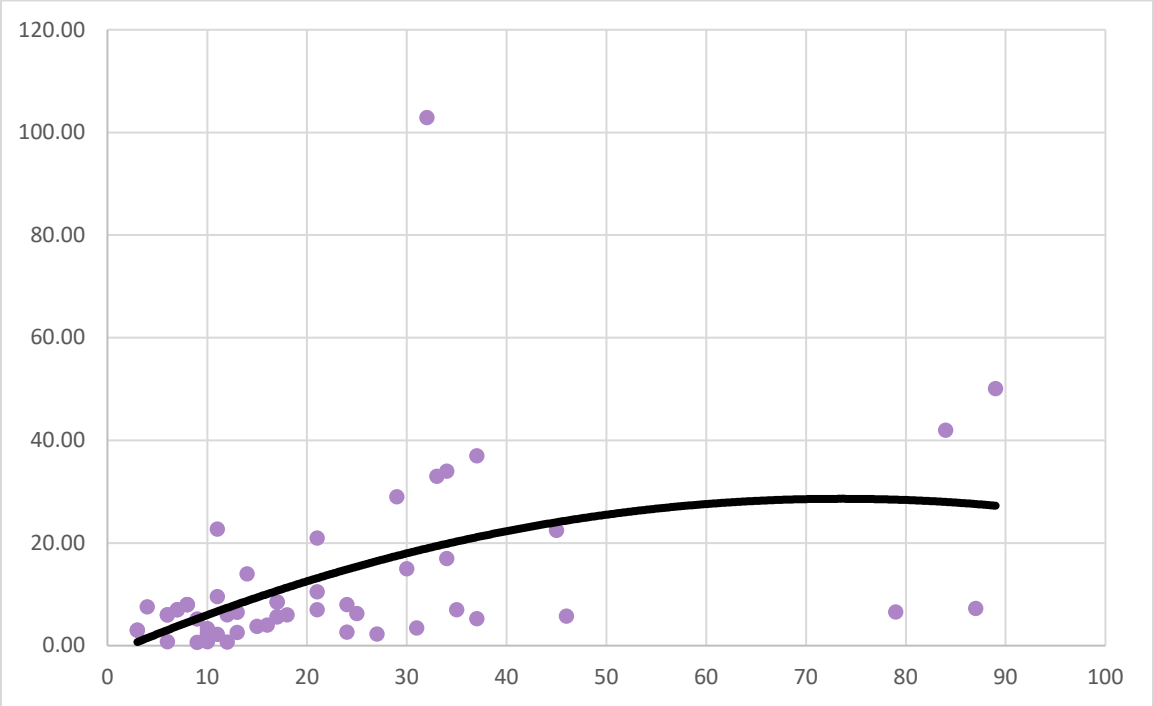
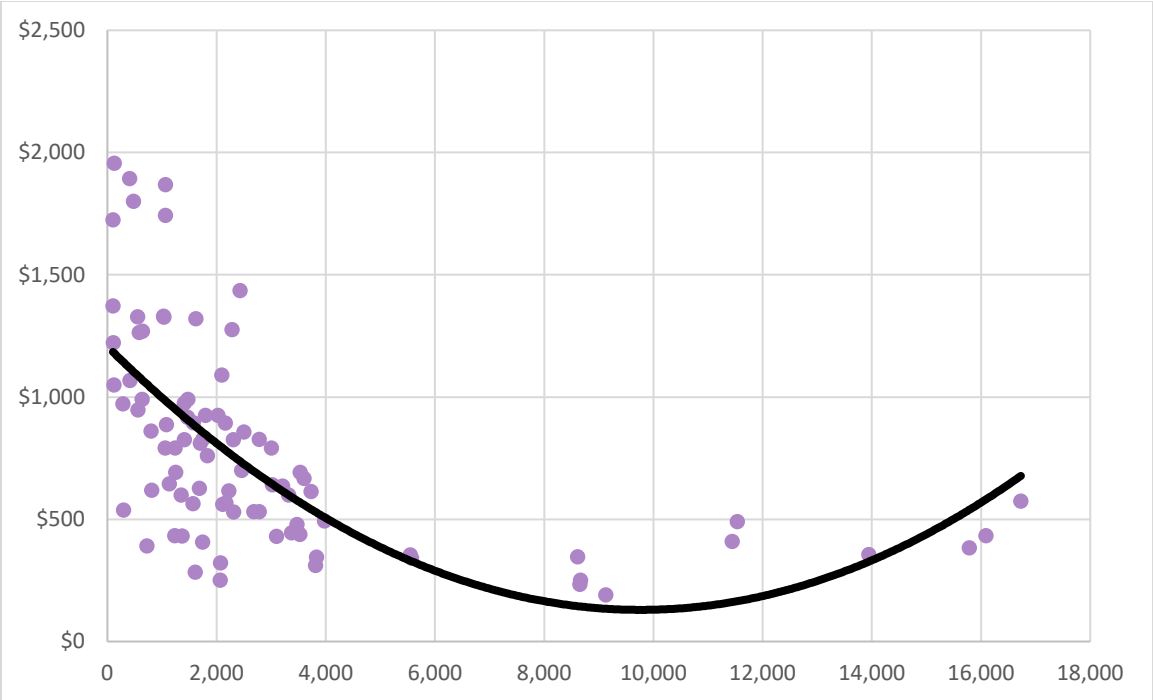


Figure 16: Explosives Analysis Productivity (Cases/FTE v. Caseload)

Fingerprint ID

Figure 17: Fingerprint Identification Average Total Cost v. Caseload



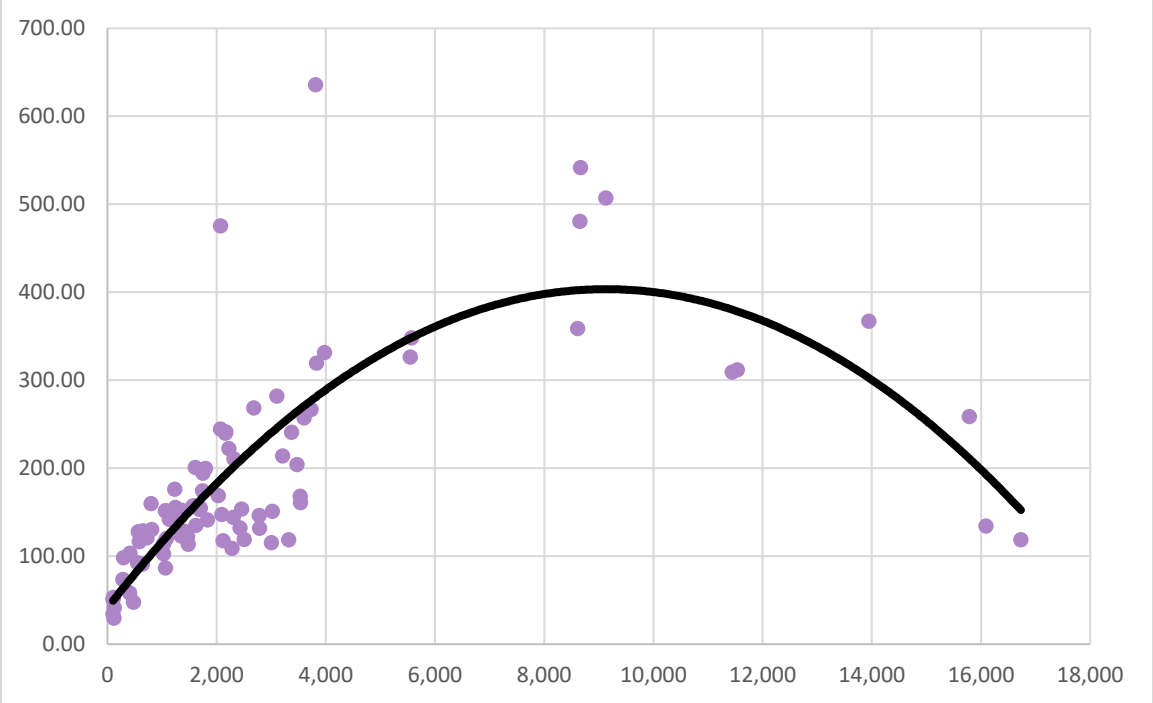


Figure 18: Fingerprint Identification Productivity (Cases/FTE v. Caseload)

Foresight Project 2015-2016, West Virginia University, Morgantown, WV, USA

Fire Analysis

Figure 19: Fire Analysis Average Total Cost v. Caseload

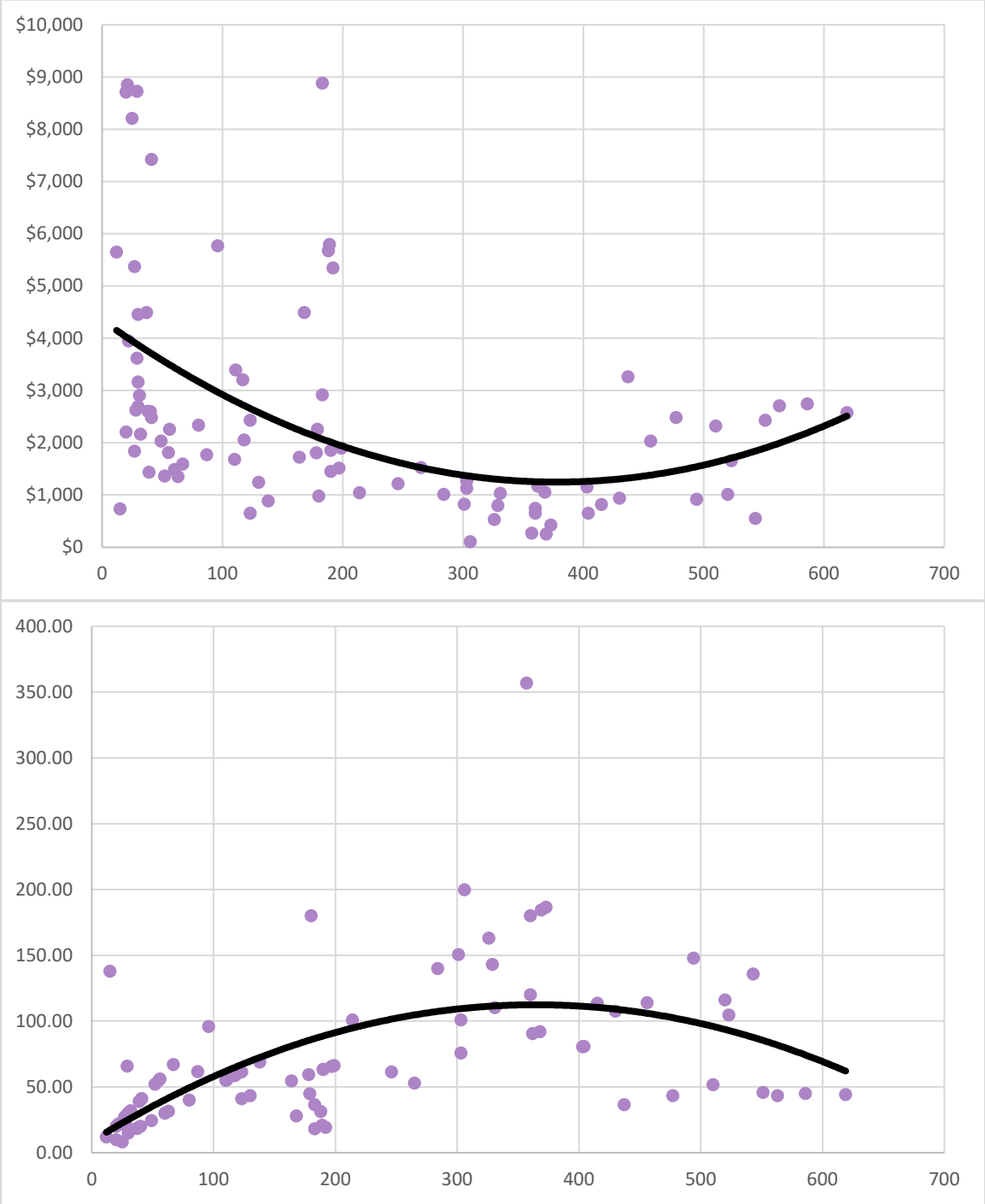
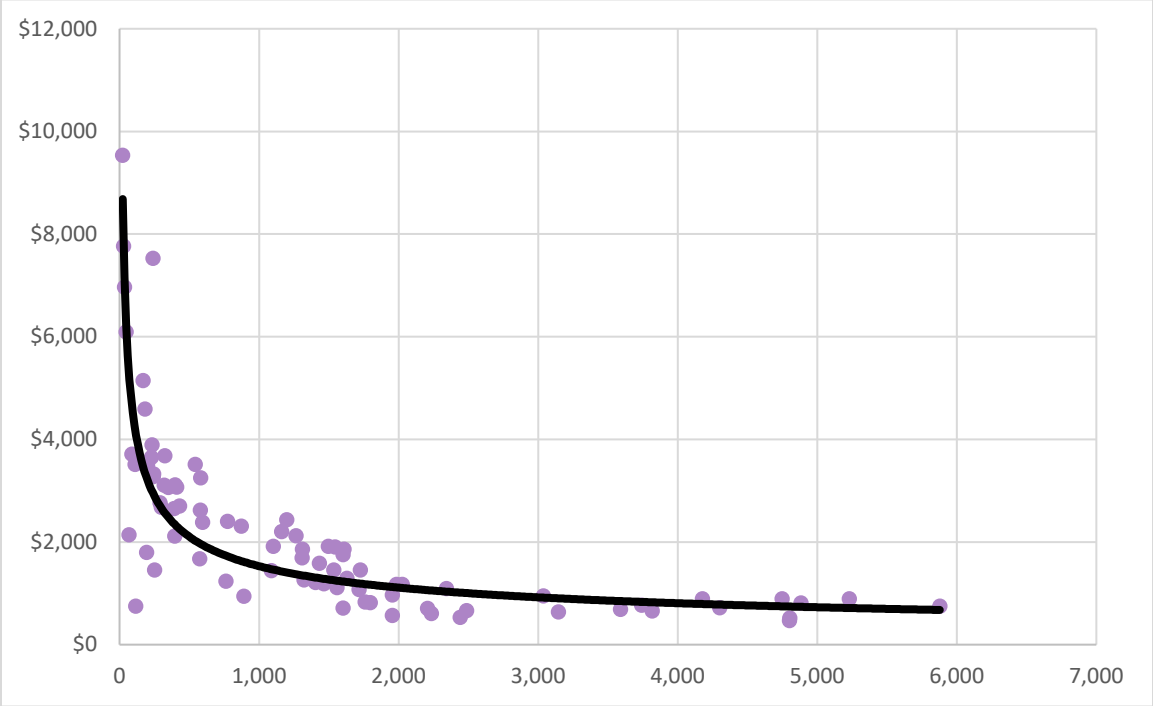


Figure 20: Fire Analysis Productivity (Cases/FTE v. Caseload)

Foresight Project 2015-2016, West Virginia University, Morgantown, WV, USA

Firearms & Ballistics Analysis

Figure 21: Firearms & Ballistics Average Total Cost v. Caseload



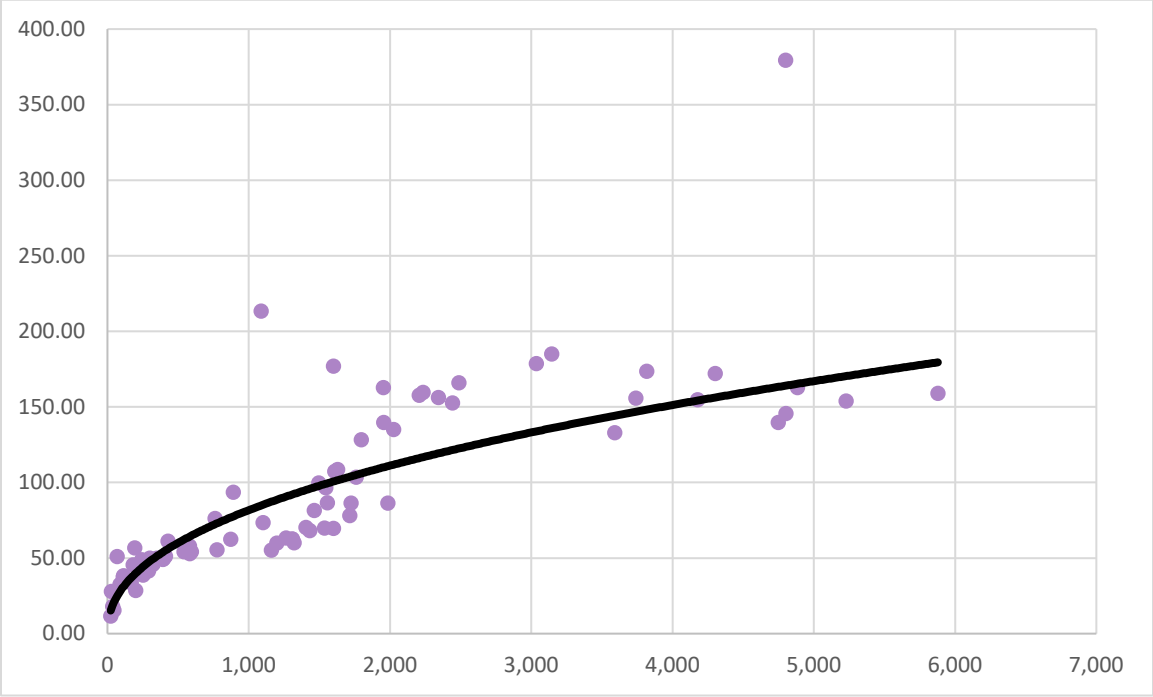


Figure 22: Firearms & Ballistics Productivity (Cases/FTE v. Caseload)

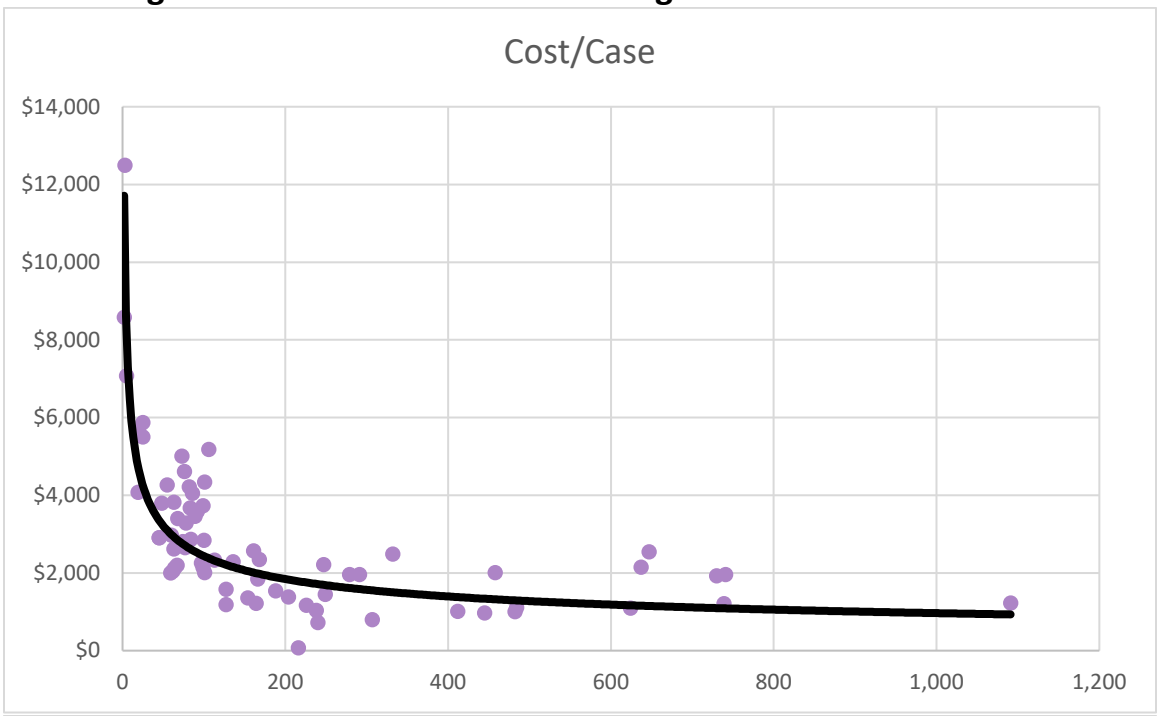
Foresight Project 2015-2016, West Virginia University, Morgantown, WV, USA

Forensic Pathology

There is insufficient data to estimate the average total cost curve for this area of investigation.

Gunshot Residue

Figure 23: Gun Shot Residue Average Total Cost v. Caseload



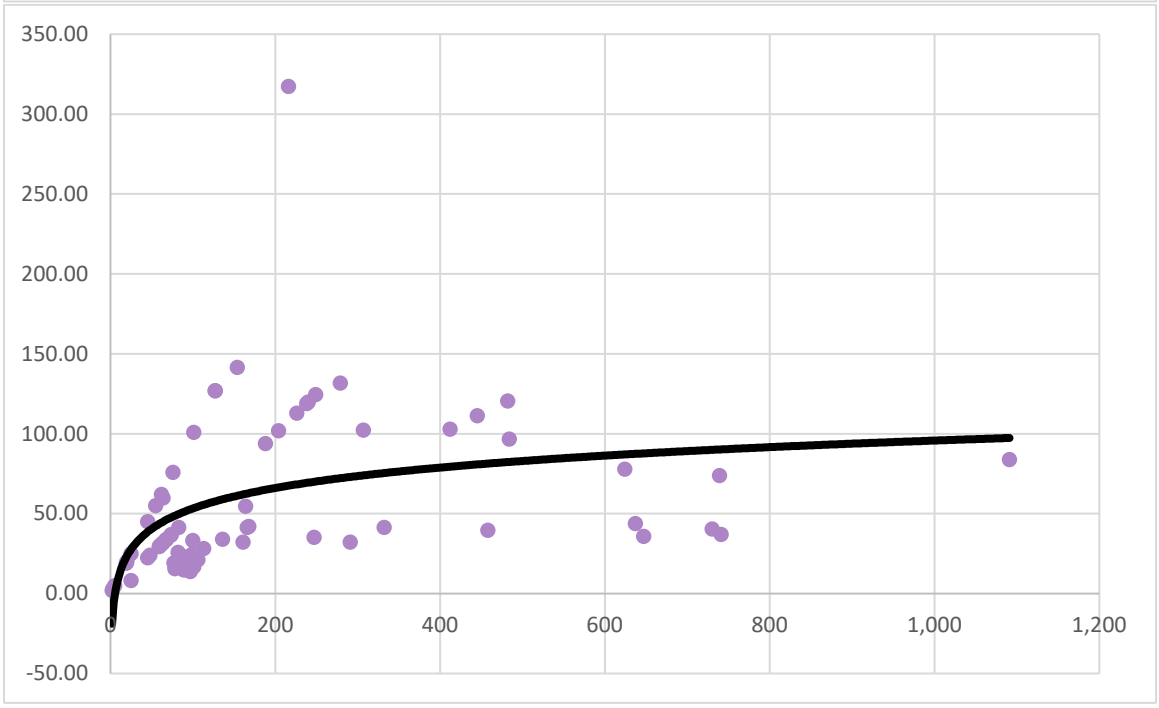
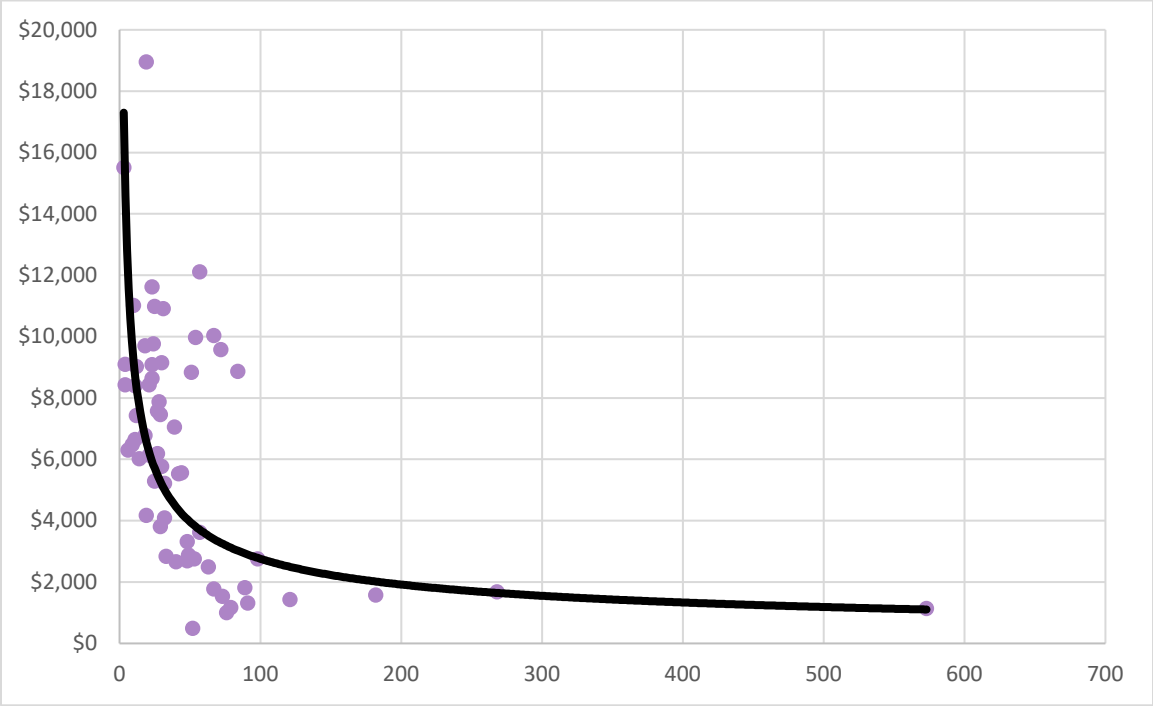


Figure 24: Gun Shot Residue Productivity (Cases/FTE v. Caseload)

Marks & Impressions Analysis

Figure 25: Marks & Impressions Average Total Cost v. Caseload



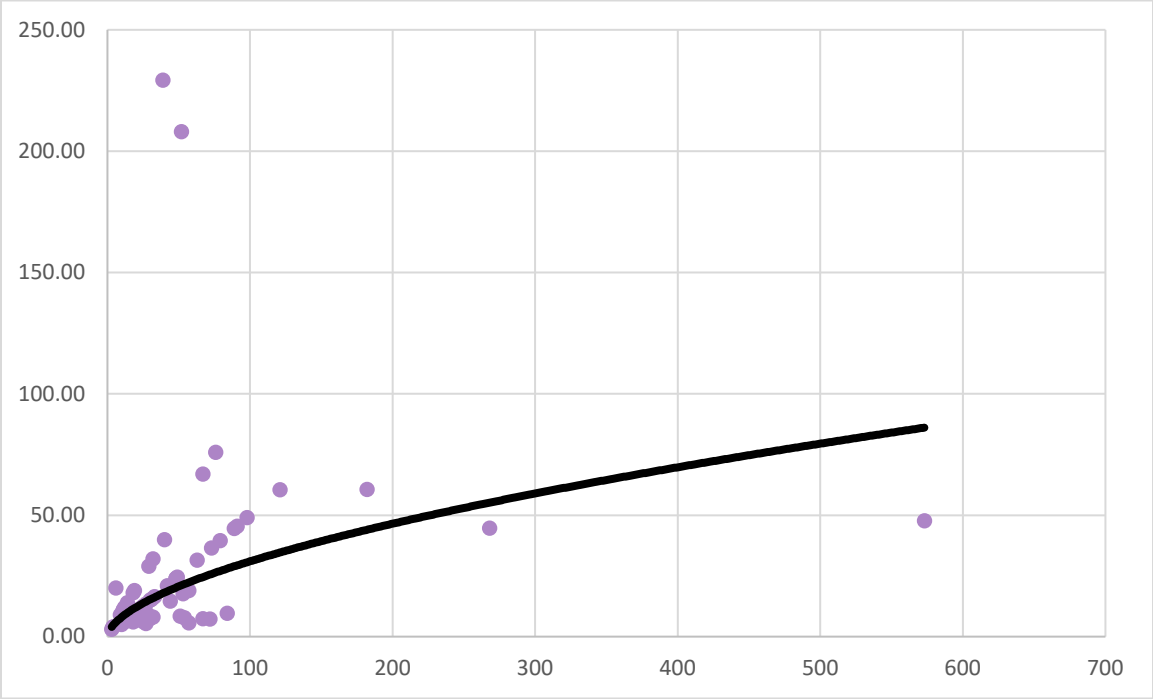
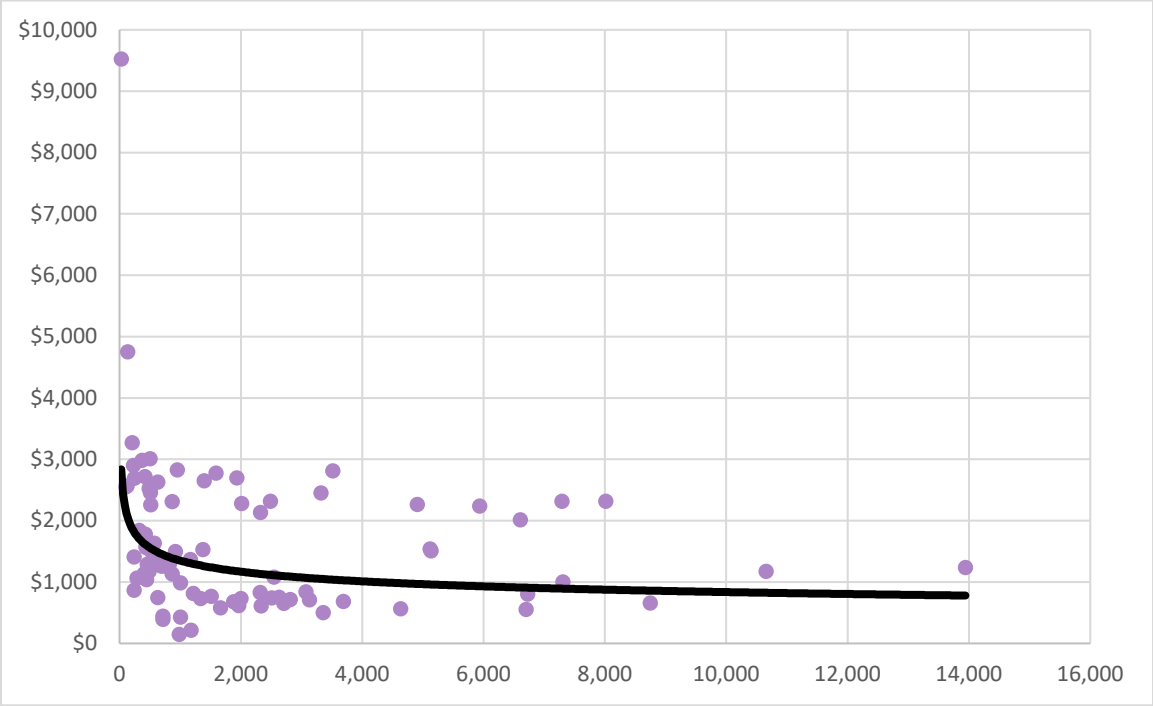


Figure 26: Marks & Impressions Productivity (Cases/FTE v. Caseload)

Foresight Project 2015-2016, West Virginia University, Morgantown, WV, USA

Serology/Biology

Figure 27: Serology/Biology Analysis Average Total Cost v. Caseload



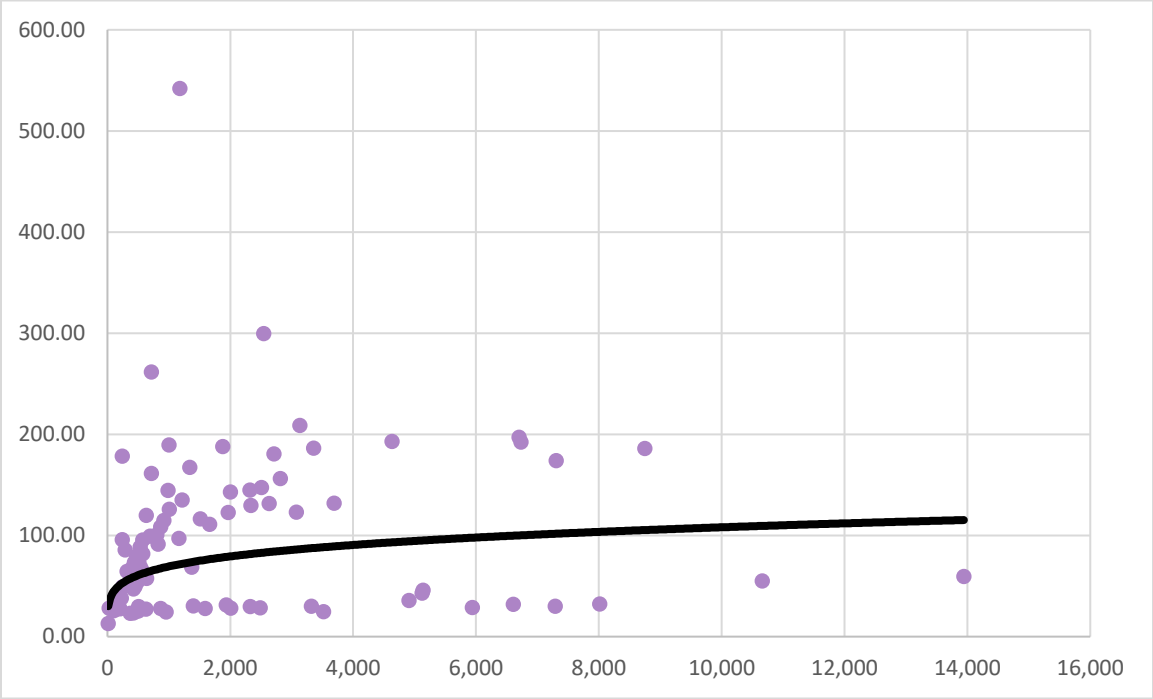
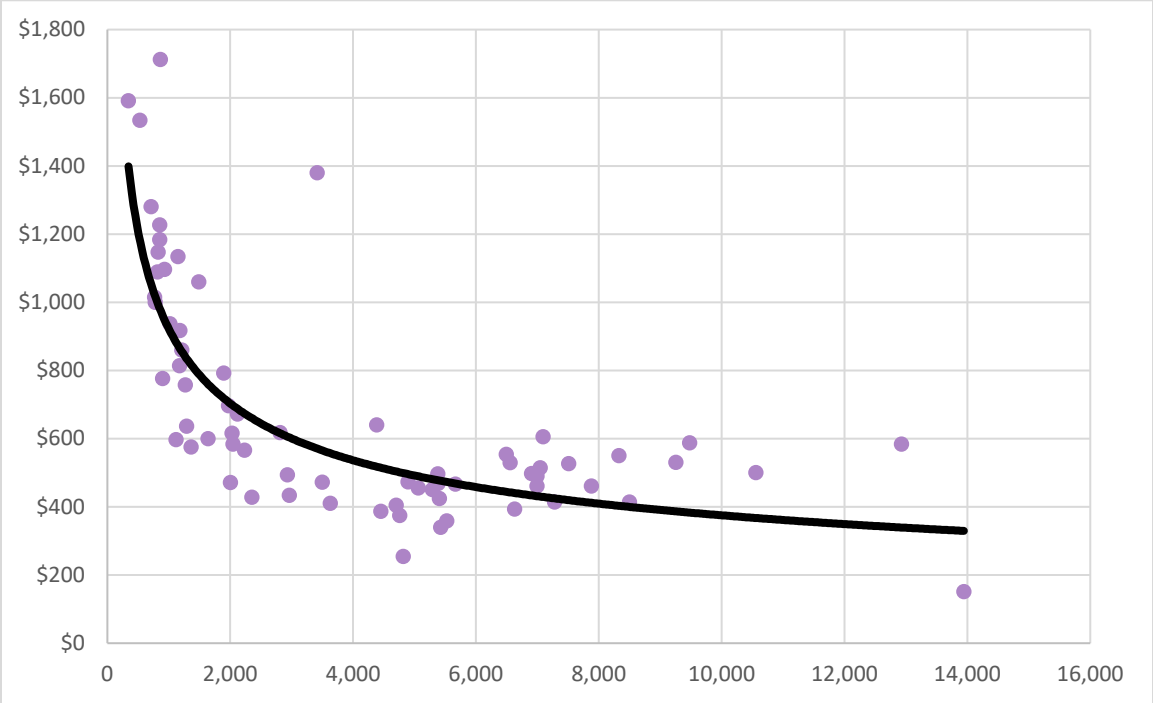


Figure 28: Serology/Biology Analysis Productivity (Cases/FTE v. Caseload)

Toxicology Analysis ante mortem

Figure 29: Toxicology Analysis ante mortem Average Total Cost v. Caseload



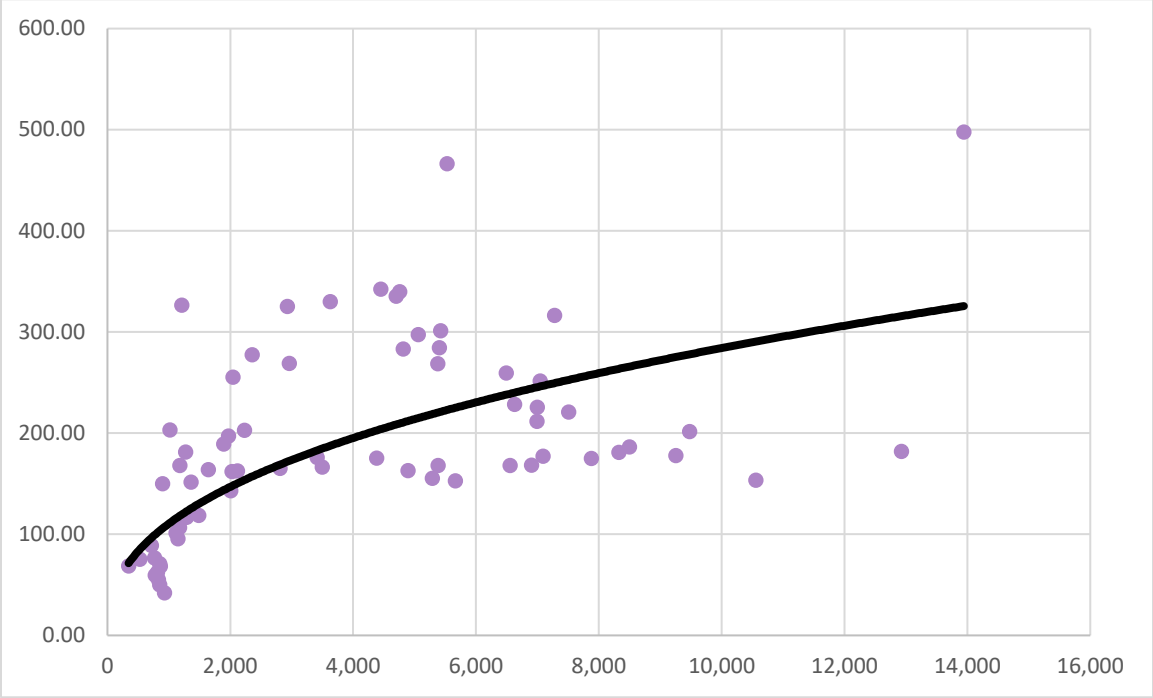
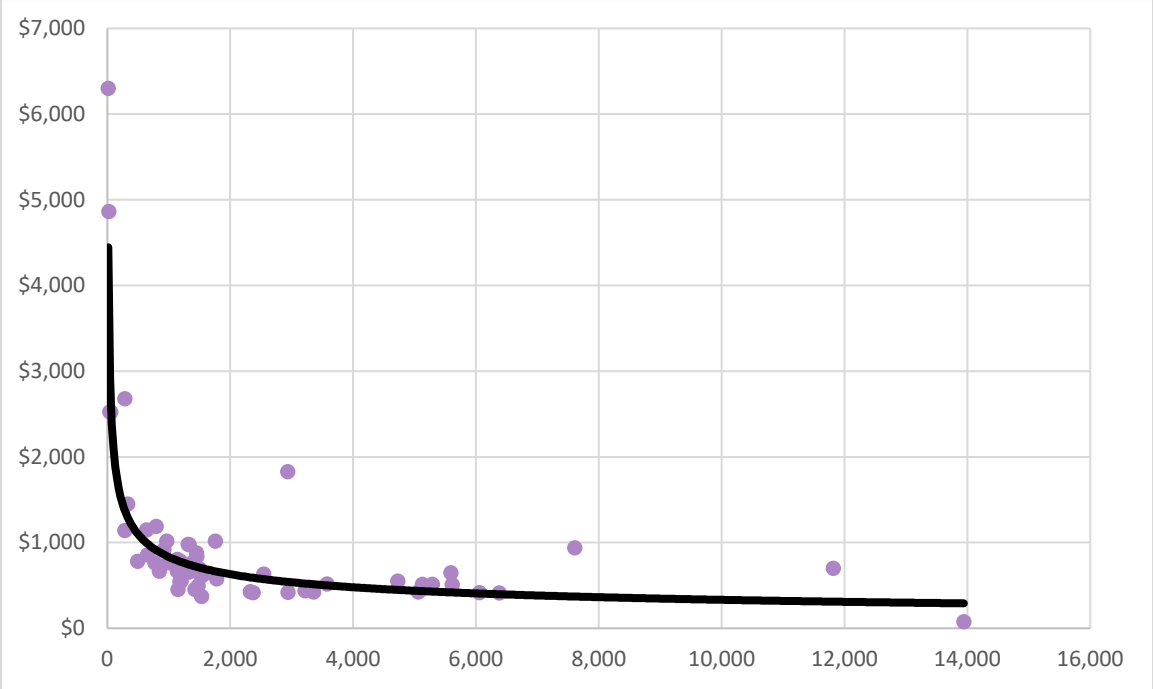


Figure 30: Toxicology Analysis ante mortem Productivity (Cases/FTE v. Caseload)

Foresight Project 2015-2016, West Virginia University, Morgantown, WV, USA

Toxicology Analysis post mortem

Figure 31: Toxicology Analysis post mortem Average Total Cost v. Caseload



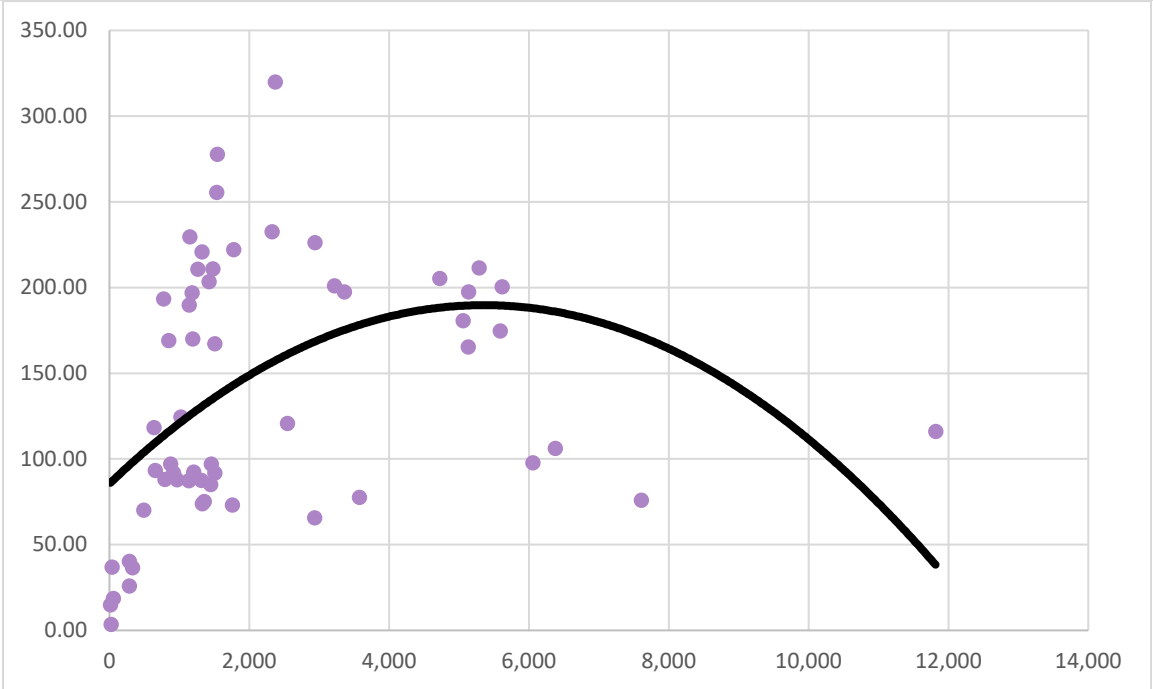
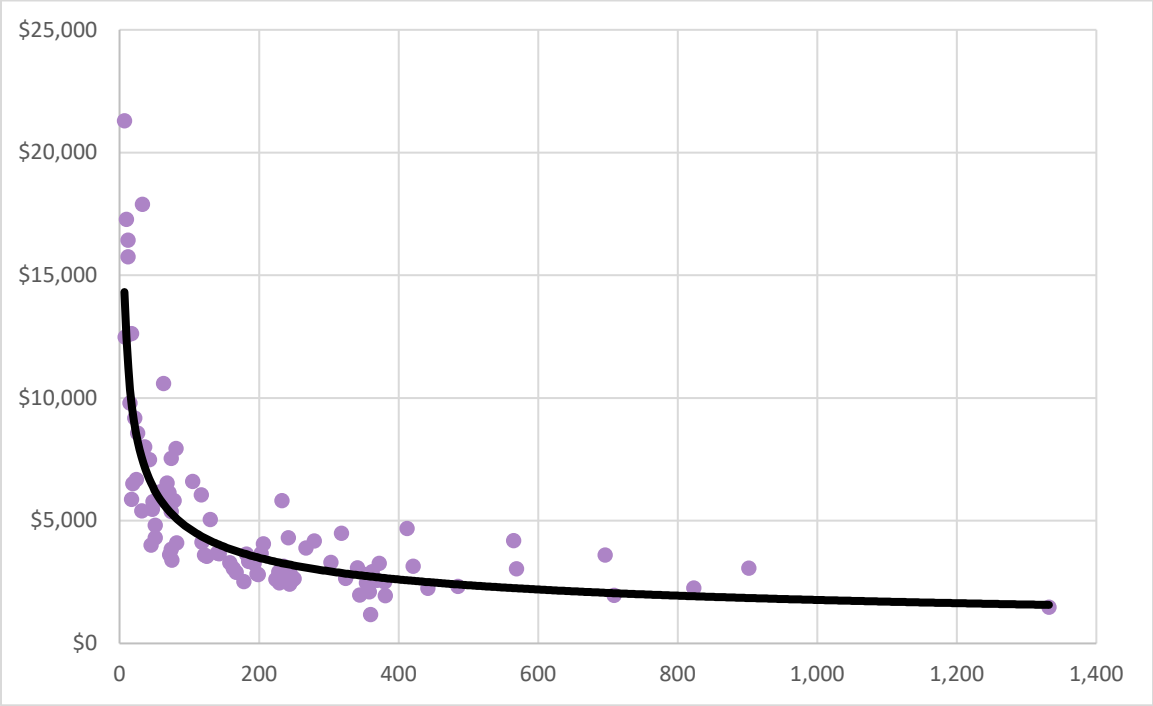


Figure 32: Toxicology Analysis post mortem Productivity (Cases/FTE v. Caseload)

Foresight Project 2015-2016, West Virginia University, Morgantown, WV, USA

Trace Evidence Analysis

Figure 33: Trace Evidence Analysis Average Total Cost v. Caseload



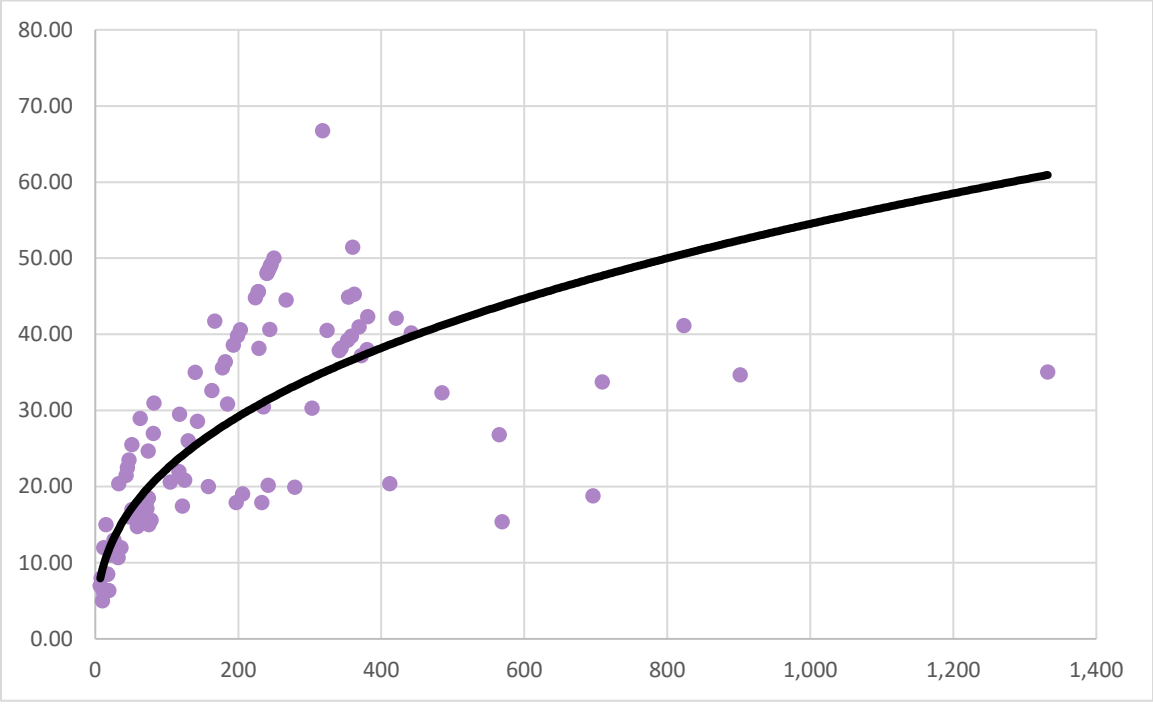


Figure 34: Trace Evidence Analysis Productivity (Cases/FTE v. Caseload)

Foresight Project 2015-2016, West Virginia University, Morgantown, WV, USA

FORESIGHT Glossary

assistant / analyst	An individual carrying out general casework examinations or analytical tests under the instruction of a Reporting Scientist or Reporting Analyst and who is able to provide information to assist with the interpretation of the tests.
backlog	Open cases that are older than 30 days.
case - institute case	A request from a crime lab "customer" that includes forensic investigations in one or more investigative areas.
case - area case	A request for examination in one forensic investigation area. An area case is a subset of an institute case.
Case – as reported in the LabRat form	Cases reported in LabRat are “area cases”
casework	All laboratory activities involved in examination of cases.
casework time	Total FTE´s for operational personnel in an investigation area (in hours) subtracted by the hours of R&D and, E&T and support and service given to external partners.
crime	Perceived violation of the law that initiates a case investigation.
direct salary	Compensation paid to employees, including salary, overtime, vacation salary, bonuses, etc.
facility expense	Sum of rents, cleaning and garbage collection, security, energy, water, communication, ICT infrastructure and facility maintenance.
floor area	Total of all floor area including office, laboratory and other.
full-time equivalent (FTE)	The work input of a full-time employee working for one full year.
full-time researcher	A forensic scientist whose primary responsibility is research and who is not taking part in casework.
investigation area	Area limited by item type and methods as they are listed in the ”definitions of investigative areas tab.
investment expense	Purchases of equipment, instruments, etc. with a lifetime longer than one year (alternatively capital expenses).
item	A single object for examination submitted to the laboratory. Note: one item may be investigated and counted in several investigation areas.
laboratory area	Floor area used for forensic investigation, including sample and consumable storage rooms.
non-reporting manager	An individual whose primary responsibilities are in managing and administering a laboratory or a unit thereof and who is not taking part in casework.

office area	Floor area of offices (square feet).
operational personnel	Personnel in operational units providing casework, research and development (R & D), education and training (E & T) and external support services. Non-reporting unit heads are included.
other floor area	Floor area of space not belonging to laboratories or offices, i.e. corridors, lunch corners, meeting rooms, etc. (square feet).
personnel expense	Sum of direct salaries, social expenses (employer contribution to FICA, Medicare, Workers Comp, and Unemployment Comp), retirement (employer contribution only towards pensions, 401K plans, etc.), personnel development and training (internal or external delivery, including travel), and occupational health service expenses (employer contribution only).
report	A formal statement of the results of an investigation, or of any matter on which definite information is required, made by some person or body instructed or required to do so.
reporting analyst	An analyst responsible in non-complicated cases (e.g. simple drugs analysis) for performing the examination of the items submitted, interpreting the analysis results, writing the analysis report and, if necessary, providing factual evidence for the court.
reporting scientist	The forensic scientist responsible in a particular case for performing or directing the examination of the items submitted, interpreting the findings, writing the report and providing evidence of fact and opinion for the court.
representation expense	The costs for hosting guests: lunches, dinners, coffees offered by the lab, and giveaway to guests or during visits abroad, etc.
sample	An item of evidence or a portion of an item of evidence that generates a reportable result.
scientist in training	An individual with no reporting rights being trained to become a reporting scientist.
support personnel	Forensic laboratory staff providing various internal support services. Management and administration personnel not belonging to the operational units are included.
test	An analytical process, including but not limited to visual examination, instrumental analysis, presumptive evaluations, enhancement techniques, extractions, quantifications, microscopic techniques, and comparative examinations. This does not include technical or administrative reviews.

Turn-around time	The number of days from a request for examination in an investigative area until issuance of a report. (Note that an area case may have multiple requests and each new request has a separate turn-around time.)
workload	Total time spent on all work related to job, including overtime.

Definitions: Investigative Areas

Blood Alcohol	The analysis of blood or breath samples to detect the presence of and quantify the amount of alcohol.
Crime Scene Investigation	The collection, analysis, and processing of locations for evidence relating to a criminal incident.
Digital evidence - Audio & Video	The analysis of multimedia audio, video, and still image materials, such as surveillance recordings and video enhancement.
DNA Casework	Analysis of biological evidence for DNA in criminal cases.
DNA Database	Analysis and entry of DNA samples from individuals for database purposes.
Document Examination	The analysis of legal, counterfeit, and questioned documents, excluding handwriting analysis.
Drugs - Controlled Substances	The analysis of solid dosage licit and illicit drugs, including pre-cursor materials.
Evidence Screening & Processing	The detection, collection, and processing of physical evidence in the laboratory for potential additional analysis.
Explosives	The analysis of energetic materials in pre- and post-blast incidents.
Fingerprint Identification	The development and analysis of friction ridge patterns.
Fire analysis	The analysis of materials from suspicious fires to include ignitable liquid residue analysis.
Firearms and Ballistics	The analysis of firearms and ammunition, to include distance determinations, shooting reconstructions, NIBIN, and toolmarks.
Forensic Pathology	Forensic pathology is a branch of medicine that deals with the determination of the cause and manner of death in cases in which death occurred under suspicious or unknown circumstances.
Gun Shot Residue (GSR)	The analysis of primer residues from discharged firearms (not distance determinations).
Marks and Impressions	The analysis of physical patterns received and retained through the interaction of objects of

	various hardness, including shoeprints and tire tracks.
Serology/Biology	The detection, collection, and non-DNA analysis of biological fluids.
Toxicology, ante-mortem	Toxicology involves the chemical analysis of body fluids and tissues to determine if a drug or poison is present in a living individual, to include blood alcohol analysis (BAC). Toxicologists are then able to determine how much and what effect, if any, the substance might have had on the person.
Toxicology, post-mortem	Toxicology involves the chemical analysis of body fluids and tissues to determine if a drug or poison is present in a deceased individual. Toxicologists are then able to determine how much and what effect, if any, the substance might have had on the person.
Trace Evidence	The analysis of materials that, because of their size or texture, transfer from one location to another and persist there for some period of time. Microscopy, either directly or as an adjunct to another instrument, is involved.

Project FORESIGHT Publications

FORESIGHT: A Business Approach to Improving Forensic Science Services, *Forensic Science Policy & Management: An International Journal* Volume 1, Issue 2, 2009, Max M. Houck, Richard A. Riley, Paul J. Speaker, & Tom S. Witt, pages 85-95

Abstract: Managers of scientific laboratories see themselves as scientists first and managers second; consequently, they tend to devalue the managerial aspects of their jobs. Forensic laboratory managers are no different, but the stakes may be much higher given the importance of quality science to the criminal justice system. The need for training and support in forensic laboratory management has been recognized for many years, but little has been done to transition the tools of business to the forensic laboratory environment. FORESIGHT is a business-guided self-evaluation of forensic science laboratories across North America. The participating laboratories represent local, regional, state, and national agencies. Economics, accounting, finance, and forensic faculty provide assistance, guidance, and analysis. The process involves standardizing definitions for metrics to evaluate work processes, linking financial information to work tasks, and functions. Laboratory managers can then assess resource allocations, efficiencies, and value of services—the mission is to measure, preserve what works, and change what does not. A project of this magnitude for forensic laboratories has not been carried out anywhere.

Key Performance Indicators and Managerial Analysis for Forensic Laboratories, *Forensic Science Policy & Management: An International Journal* Volume 1, Issue 1, 2009, Paul J. Speaker, pages 32-42

Abstract: Forensic laboratories generate a great deal of data from casework activities across investigative areas, personnel and budget allocations, and corresponding expenditures. This paper investigates ways in which laboratories can make data-driven managerial decisions through the regular extraction of key performance indicators from commonly available data sources. A laboratory's performance indicators can then be compared to peer laboratory performance to search for best practices, determine in-house trends, manage scarce resources, and provide quantitative support for the justification of additional resources.

The Decomposition of Return on Investment for Forensic Laboratories, *Forensic Science Policy & Management: An International Journal* Volume 1, Issue 2, 2009, Paul J. Speaker, pages 96-102

Abstract: For forensic laboratories, a detailed understanding of return on investment (ROI) is necessary for routine assessment, consideration of new legislative alternatives, and cost-benefit analysis for decision making. Converting performance data to ratio measures provides useful comparisons between an individual laboratory and the standards for excellence for the industry; these measures also permit an evaluation across time. Unfortunately, these same ROI measures are subject to abuse when overemphasis on a single measure leads to unintended consequences. In this paper, the ROI measure is broken down into various parts that can be tracked on a regular basis to reveal how a laboratory achieves its results. The tradeoffs between return and risk, efficiency, analytical process, and market conditions are outlined. The end product is a series of easily monitored metrics that a laboratory director may examine on a regular basis for continuous improvement.

Benchmarking and Budgeting Techniques for Improved Forensic Laboratory Management, *Forensic Science Policy & Management: An International Journal* Volume 1, Issue 4, 2010, Paul J. Speaker & A. Scott Fleming, pages 199-208

Abstract: Forensic laboratories are not immune from downturns in the worldwide economy. Recession and economic slowdowns, when coupled with the public's heightened sense of the capabilities of forensic science, put stress on the effectiveness of forensic laboratories. The resources available to forensic laboratories are limited, and managers are under greater pressure to improve efficiency and effectiveness. To this end, the use of internal and external financial and accounting metrics to plan, control, evaluate, and communicate performance is examined. Using data from the QUADRUPOL and FORESIGHT studies, we illustrate the use of external benchmarking through a calculation of laboratory return on investment and the internal development and use of a budget to enhance laboratory performance in light of limited resources.

Forensic Science Staffing: Creating a Working Formula, *Forensic Science Policy & Management: An International Journal* Volume 2, Issue 1, 2011, Joyce Thompson Heames & Jon Timothy Heames, pages 5-10

Abstract: The key issue facing forensic labs is "the classic economic problem—how to allocate limited resources with increasing demand for services, while maintaining high quality standards" (Speaker 2009). Employees are the biggest expense and most valuable resource that forensic labs possess, thus the question arises as to how to maximize human resource functions to best allocate resources through personnel. As the search is on to look for better practices to improve the operations as well as technical expertise of labs, human capital management is crucial to that objective. The purpose of this article is to process map some of the staffing issues facing forensic science labs, whether public or private, and to identify metrics from the FORESIGHT study (Houck et al. 2009) that might help lab directors create a working formula to better manage staffing (e.g., recruiting and selection) issues.

Managing Performance in the Forensic Sciences: Expectations in Light of Limited Budgets, *Forensic Science Policy & Management: An International Journal* Volume 2, Issue 1, 2011, Hilton Kobus, Max Houck, Paul J. Speaker & Richard Riley, pages 36-43

Abstract: For forensic service providers worldwide, the demand for high-quality services greatly outpaces available resources to meet those requests. The gap between the demand for services and the resource-restricted supply of those services has implications for managing performance: the effectiveness and efficiency of forensic science. The effectiveness of forensic science is directly related to the quality of the scientific analysis and the timeliness with which that analysis is provided, while efficiency is associated with attempts to minimize costs without negatively impacting quality. An inevitable result of the demand and supply gap is a backlog that results in downstream effects on timeliness, service, and quality. One important strategy to respond to the demand-supply imbalance is continual process improvement. Collaborative benchmarking as a basis for process improvement is another approach. This paper discusses the disjunction between perceived and actual value for forensic services and the rationale for providers to evaluate, improve, and re-tool their processes toward continual improvement given limited resources.

Strategic Management of Forensic Laboratory Resources: From Project FORESIGHT Metrics to the Development of Action Plans, *Forensic Science Policy & Management: An International Journal* Volume 2, Issue 4, 2011, Jonathan Newman, David Dawley, & Paul J. Speaker, pages 164-174

Abstract: The project FORESIGHT stated objectives begin with the development of metrics applicable to the activity of forensic science laboratories. These metrics enable a laboratory to assess how they fit within the forensic science industry and offer a glance at the levels of performance that they might be able to achieve. FORESIGHT's mission goes on to state the intent for laboratories to use those measurements to "preserve what works, and change what does not" (Houck et al. 2009, p. 85). This paper addresses the strategic implications of those additional aspects of the FORESIGHT mandate with a view of the strategic planning process for a forensic science laboratory. The keys to the development of an ongoing strategic planning and execution process are outlined, and then the actions of one laboratory, Ontario's Centre of Forensic Sciences, are examined to demonstrate the move from metrics to action. While there cannot yet be made a claim of "best practices," this Canadian example offers some guidance to "better practices" in the quest for continual improvement in the provision of forensic science services.

The Power of Information, *Forensic Magazine* April 10, 2012, Tom S. Witt & Paul J. Speaker

Abstract: When it comes to cost, the Foresight model was designed to overlook nothing. When we talk about the cost of doing something, we look at everything from equipment, telecommunications, heating, lighting, facility rent … everything. If a participant doesn't have access to the data, we can estimate those costs from other labs in our studies. We come up with an all-inclusive figure that tells participants what it costs to process a case. This leads to informed decisions. Take trace evidence cases, for example. You might find that processing one trace evidence case costs the same as processing two, three, or even four traditional DNA cases. While trace evidence is wonderful and powerful, if DNA alone will get you where you need to be, this cost factor will heavily affect your decision-making process. Foresight is not about cutting where it matters. It's about using resources wisely so that labs can do more and enhance the services they provide. Once you know the key metrics, you can make informed decisions.

Is Privatization Inevitable for Forensic Science Laboratories?, *Forensic Science Policy & Management: An International Journal* Volume 3, Issue 1, 2012, William McAndrew, pages 42-52

Abstract: Given the recent global recession, many national governments have been forced to implement austerity measures, and the forensic science industry has not been immune from such changes. Proposals to privatize some or all aspects of forensic science services have been bantered about for decades, but the recent economic climate has brought this idea back to the forefront of public debates. Although privatization has been shown to have many benefits in the provision of other goods and services, the idea of privatizing forensic services has been harshly criticized by scholars and practitioners. This paper explores some of those criticisms through the lens of economics, and arguments are offered regarding why market approaches in forensic science may be more successful than might have originally been imagined under certain conditions. On the other hand, recognition of those economic forces and reaction by forensic laboratories to address inefficiencies may provide the effective delivery of forensic services that forestalls privatization efforts.

The Balanced Scorecard: Sustainable Performance Assessment for Forensic Laboratories, *Science and Justice* Volume 52, 2012, Max Houck, Paul J. Speaker, Richard Riley, & A. Scott Fleming, pages 209-216.

Abstract: The purpose of this article is to introduce the concept of the balanced scorecard into the laboratory management environment. The balanced scorecard is a performance measurement matrix designed to capture financial and non-financial metrics that provide insight into the critical success factors for an organization, effectively aligning organization strategy to key performance objectives. The scorecard helps organizational leaders by providing balance from two perspectives. First, it ensures an appropriate mix of performance metrics from across the organization to achieve operational excellence; thereby the balanced scorecard ensures that no single or limited group of metrics dominates the assessment process, possibly leading to long-term inferior performance. Second, the balanced scorecard helps leaders offset short term performance pressures by giving recognition and weight to long-term laboratory needs that, if not properly addressed, might jeopardize future laboratory performance.

Efficiency and the Cost Effective Delivery of Forensic Science Services: In-Sourcing, Out-Sourcing, and Privatization, *Forensic Science Policy & Management: An International Journal* Volume 3, Issue 2, Chris Maguire, Max Houck, Robin Williams, & Paul J. Speaker, pages 62-69

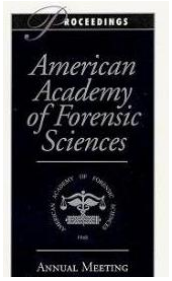
Abstract: Given the recent global recession, many national governments have been forced to implement austerity measures, and the forensic science industry has not been immune from such changes. Proposals to privatize some or all aspects of forensic science services have been bantered about for decades, but the recent economic climate has brought this idea back to the forefront of public debates. Although privatization has been shown to have many benefits in the provision of other goods and services, the idea of privatizing forensic services has been harshly criticized by scholars and practitioners. This paper explores some of those criticisms through the lens of economics, and arguments are offered regarding why market approaches in forensic science may be more successful than might have originally been imagined under certain conditions. On the other hand, recognition of those economic forces and reaction by forensic laboratories to address inefficiencies may provide the effective delivery of forensic services that forestalls privatization efforts.

Enhancing Employee Outcomes in Crime Labs: Test of a Model, *Forensic Science Policy and Management: An International Journal* Volume 3, Issue 4, 2012, David Dawley.

Abstract: This paper developed and tested a model identifying determinants of employee turnover intentions and desirable performance behaviors, including helping others and engaging in knowledge sharing. Data collected from 798 employees at ten FORESIGHT laboratories suggest that job satisfaction and embeddedness are the primary antecedents of turnover intentions and knowledge sharing, and that embeddedness is a stronger predictor variable of both outcomes. Embeddedness is driven by the employees' understanding of the lab's strategic vision. Moreover, job satisfaction and embeddedness are positively associated with helping behavior. Finally, we identified job autonomy as a primary determinant of job satisfaction. We discuss practical implications of these findings for managers.

Forensic Science Service Provider Models: Data-Driven Support for Better Delivery Options, *Australian Journal of Forensic Sciences* Volume 45, Issue 2, 2013, Paul J. Speaker.

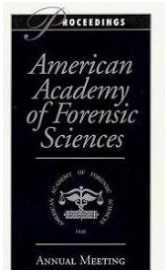
Abstract: There are a variety of models for the delivery of forensic science analysis in service to the justice system. In answer to the question as to whether there is a 'best' option for the delivery of forensic science services, New Zealand's Institute of Environmental Science and Research (ESR) has been offered as a model which demonstrates a comparative advantage over the delivery of forensic services in more traditional models. The support for that assertion rests in the ability of the ESR to react at the speed of business and avoid bureaucratic drag found too often in the public sector. This efficiency argument addresses one dimension of the search for 'best' delivery. The second dimension involves the discovery of the optimal scale of operation to take efficiency and turn it into cost effectiveness.



Improving the Effectiveness of Forensic Service: Using the Foresight Project as a Platform for Quality, *Proceedings of the American Academy of Forensic Sciences,* Volume XIX, Max M. Houck, Jay W. Henry, and Paul J. Speaker, February 2013, p.21.

Abstract: Forensic service providers are—in essence—non-profit, production-oriented organizations staffed largely by knowledge workers. Forensic scientists as knowledge workers take evidence and data and convert them into knowledge in the form of reports and testimony. They specialize in these transactions and, therefore, simplify them for the benefit of the criminal justice system; the investigators or attorneys do not need to find numerous individuals to conduct the specific examinations required for a case. As long as the costs of providing these services externally do not exceed the costs of their internal provision, for example, by a government forensic laboratory, then the organization can prosper. If the government laboratory costs are greater than the cost of finding private laboratories to provide services, then the organization may be reevaluated. Comparatively, non-profit and for-profit organizations are similar in some ways (money is an input for both) yet different (money, in the form of profits, is an output only for the private sector). Non-profits must therefore measure success in other ways, such as "low cost" or "cost effective." Forensic service providers and their parent organizations use terms such as "cost-effective" vaguely without reference to other disciplines which use these as well-defined technical terms in evaluative phrases or formulae. Despite the great concern and administrative angst over forensic service

providers' "performance" and "capacity," these metrics go undefined as industry standards.



Determinants of Turnover Intentions, Helping, and Knowledge Sharing in Crime Laboratories, *Proceedings of the American Academy of Forensic Sciences,* Volume XIX, David Dawley, February 2013, p.230.

Abstract: Forensic scientists are knowledge workers and are a laboratory's single greatest enduring expense. Therefore, it is imperative for forensic managers to find ways to retain employees, share knowledge, and create a cohesive, coherent team perspective. Based on a discussion with a group of FORESIGHT forensic laboratory directors in 2011, four major areas of research interest were identified: (1) reducing employee turnover; (2) increasing employees' helping behaviors with colleagues; (3) knowledge sharing among employees; and, (4) creating and disseminating a strategic vision to all employees.

Are Forensic Science Services Club Goods? An Analysis of the Optimal Forensic Science Service Delivery Model, *Forensic Science Policy and Management: An International Journal* Volume 3, Issue 4, 2012, William P. McAndrew, pages 151 – 158.

Abstract: Forensic science has been described as a public good by practitioners, legal professionals, and scholars, many of whom were suggesting that forensic science is simply something good for the public. It would indeed be difficult to argue otherwise. In an economic sense, the concept of a public good is defined differently from this colloquial meaning, however, leading to confusion in discussions between forensic scientists and business consultants concerning how to evaluate laboratory performance and ultimately consider strategic change from an economic or efficiency perspective. This article discusses what economists mean by a public or private good, with an application using the forensic science industry. Forensic science is likely neither a purely public or purely private good, but rather a club good that contains a degree of both the public and private. When calculated, the degree of publicness of this club good will aid in determining the appropriate institutional framework from which to provide forensic science services, as well as its optimal jurisdiction size and production level.

The Effects of Politics on Job Satisfaction in Crime Lab Employees, *Forensic Science Policy and Management: An International Journal* Volume 3, Issue 4, 2012, David Dawley & Timothy P. Munyun, pages 159 – 164.

Abstract: This study examined the effects of crime lab workers' perceptions of intra-lab politics on job satisfaction. In addition to finding that political behavior reduces employee job satisfaction, the study also identified ways in which crime lab managers can mitigate the negative effects of political behavior, increasing employee job satisfaction when political behavior is high within a given unit. Data collected from 874 employees at twelve FORESIGHT laboratories suggest that increasing crime lab worker job autonomy, job efficiency, strategic vision, and task significance are especially effective interventions that increase job satisfaction when political behavior is high. We discuss practical implications of these findings for crime lab managers. The purpose of this paper is to investigate how perceived political behavior affects the job satisfaction, or morale, of crime lab workers. The study was motivated by several interactions we had with forensic crime lab managers at the 2013 American Society of Crime Lab Directors (ASCLD) meeting. In ASCLD human resources and FORESIGHT meetings, we received consistent inquiries concerning the potential role of organizational politics as a detrimental factor on employee attitudes. These conversations highlight the unfortunate ubiquity of political behavior at work, including work in crime labs. Organizational politics often create disharmony among employees and can negatively affect employee job satisfaction and other attitudes (Breaux et al. 2009; Ferris et al. 1996). Thus, we sought to explore how political behavior affects the job satisfaction of crime lab employees, and potential managerial strategies that could be useful in mitigating for this potential negative effect.

Expanding Budgets via Strategic Use of Leasing, *Forensic Science Policy and Management: An International Journal,* Volume 3, Issue 4*, 2012,* William P. McAndrew & Paul J. Speaker, pages 169 - 179.

Abstract: An examination of the budgets of forensic laboratories reveals an unused or underused tool at the disposal of forensic laboratories. Equipment leasing offers an opportunity for a unilateral increase in the purchasing power of existing laboratory budgets and an immediate response to austerity measures. Rather than react to budget tightening with reductions in force, shared furloughs, or the forfeiture of unfilled positions, a laboratory director can forestall such measures and even see an effective increase in disposable income through a planned use of operating leases. If a public

laboratory makes an equipment purchase, the cost to the laboratory will be the full list price from the equipment supplier. However, when a private laboratory makes the same equipment purchase, it pays the supplier the full list price, but is able to deduct the expense from its income when it calculates its corporate income tax and ends up with a final expense, net of taxes, that is considerably less than the cost to the public laboratory. Leasing offers the opportunity for a private entity to purchase equipment and pass on some of the tax savings to the public laboratory through an operating lease. In this manuscript the leasing gains are explained and accompanied by a detailed example to illustrate the potential magnitudes of the gains. In this example, a representative laboratory is shown to experience nearly a twenty-five percent gain from the lease compared to the expense of a direct purchase

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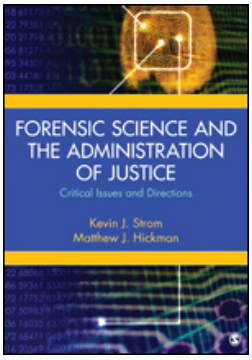

Developing New Business Models for Forensic Laboratories, Chapter 13 in *Forensic Science and the Administration of Justice*, Kevin J. Strom & Matthew J. Hickman editors, Max M. Houck & Paul J. Speaker, April 2014.

Abstract: Forensic service providers inhabit a unique, central place in the criminal justice system. Stakeholders in the forensic enterprise abound, from law enforcement to attorneys to the courts and even the public they all serve. The public orientation of these services and stakeholders necessitates forensic managers rely on providing sound performance at a reasonable cost. Certainly, the laboratory's jurisdiction will judge them on criteria such as accuracy, timeliness, and cost. Too much emphasis on quantitative outcomes, however, can create an imbalance that ignores longer-term issues, such as quality and value. Thus, efficiency, the extent to which time and effort are used to produce the desired outcome, can be mistaken for effectiveness, the attainment of that desired outcome, but they are intimately connected.

A Novel Approach to Forensic Molecular Biology Education and Training: It's Impact on the Criminal Justice System, *Australian Journal of Forensic Sciences* 47 (2), 182 – 193, 2015, Khalid M. Lodhi, Robert L. Grier, and Paul J. Speaker.

Abstract: The managers of crime laboratories face significant hurdles when preparing new hires to become productive members of the laboratory. New hires require six months of training/experience in the crime laboratory before becoming a productive member of the Biology (DNA) section. To address this deficiency in forensic DNA education, a novel forensic education curriculum was developed and tested for three consecutive years in the forensic science program at Fayetteville State University, Fayetteville, NC. The curriculum used a CTS proficiency kit which is the same kit used to validate the proficiency of forensic scientists in crime laboratories in the US. A cost benefit analysis suggests that training students in a classroom instead of in a crime laboratory provides both direct savings to the laboratory and significant societal savings as more DNA profiles are entered into the database. The societal benefit from the combined reduction in the amount of training in a crime laboratory and increasing the number of DNA database profiles entered into a database suggests a societal saving of $8.28 million for each of these months of reduced training.

鑑識科學綜論
FORENSIC SCIENCE REVIEW

A Review of Forensic Science Management Literature, *Forensic Science Review 27,* Max M. Houck, William P McAndrew & B. Daview, 2015, 53-68.

Abstract: The science in forensic science has received increased scrutiny in recent years, but interest in how forensic science is managed is a relatively new line of research. This paper summarizes the literature in forensic science management generally from 2009 to 2013, with some recent additions, to provide an overview of the growth of topics, results, and improvements in the management of forensic services in the public and private sectors. This review covers only the last three years or so and a version of this paper was originally produced for the 2013 Interpol Forensic Science Managers Symposium and is available at *interpol.int*.

Financial Management of Forensic Science Laboratories: Lessons from Project FORESIGHT 2011-2012, *Forensic Science Policy and Management: An International Journal 6(1-2),* Paul J Speaker, 2015.

Abstract: Critical to the decision-making within an individual forensic science laboratory is an understanding of their efficiency and effectiveness. The NIJ-funded project, FORESIGHT, applies financial management techniques to avowed public sector goals and offers a common starting point for the comparison of individual forensic laboratories to the established standards in the industry through a review of financial ratios. Such ratios adjust for size differences and allow insight into several aspects of the operation including evaluation of efficiency, quality, risk, market nuances, and return on investment. This study offers insight into the financial performance, productivity, efficiency, and effectiveness of forensic science laboratories. Using data from the National Institute of Justice's Project FORESIGHT for 2011-2012, a variety of benchmark performance data is presented with analytical insight into the nature of that performance. The tabular and graphic presentations offer some insight into the current status of the forensic science industry in general and provide a basis by which individual laboratories may begin to assess their own performance with respect to both analytical efficiency and cost effectiveness.

Forensic Laboratory Financial Management, *ASCLD Crime Lab Minute*, Paul J. Speaker, July 2015.

Abstract: The National Institute of Justice's Office of Justice Programs has supported laboratories for the last several years with analysis of performance via Project FORESIGHT. Project FORESIGHT has collected data from the 2006 fiscal year, growing from a handful of laboratories to over 100 participating laboratories in the most recently completed fiscal year. There is no cost to participants, and all forensic laboratories are invited to join the program. In return for data submissions, each laboratory receives a customized report comparing their performance in each forensic investigative area to the industry standards obtained from the project.

Project FORESIGHT and Return on Investment: Forensic Science Laboratories and Public Health Laboratories, *Forensic Science Policy and Management: An International Journal 8(1-2)*, Paul J Speaker, 2017.

Abstract: Project FORESIGHT developed business guided metrics for use by forensic science laboratories. Since the introduction of the project nearly a decade ago, much has been learned about the efficiency and effectiveness of the forensic laboratory industry and laboratory management has been forewarned and forearmed as they develop strategic initiatives to deal with the economic problem of limited resources available for a seemingly unlimited demand for services. The success of forensic science laboratories in the application of best practices has not gone unnoticed. Public health laboratories face similar problems and the laboratories in that industry have joined forces through the Association of Public Health Laboratories and the Centers for Disease Control and Prevention to follow the guidance of Project FORESIGHT and develop business metrics to improve the efficiency and effectiveness of this public sector service. In this paper, the project development process is highlight towards an expanded set of outcomes that offers insight into efficiency and effectiveness and connects that performance to societal outcomes through development of return on investment metrics for the industry.

National versus Local Production: Finding the Balance between Fiscal Federalism and Economies of Scale, *Public Finance Review*, pages 1-23, William P. McAndrew, 2017.

Abstract: Public finance and public choice economists have contrasting views on the determinants of public sector size. This article makes a unique contribution to this literature by exploring an integer count of output, rather than the commonly used dollar approximation of output, using data that are homogeneous across the levels of

government, where a unit of observation is not a governing body, but rather a service provider. Specifically, this article explores the counteracting effects of fiscal federalism and economies of scale using data from the National Institute of Justice with an application of data envelopment analysis and stochastic frontier analysis. I determine that provision of forensic science services at the national level rather than local level does not lead to higher relative cost, and national production may be relatively more efficient. In general, however, neither locally nor nationally operated laboratories are operating at an efficient scale, a potential argument for privatization, insourcing, or outsourcing.