Forensic Science Policy & Management, 3: 62–69, 2012

ISSN: 1940-9044 print / 1940-9036 online
DOI: 10.1080/19409044.2012.734546

Efficiency and the Cost-Effective Delivery of Forensic Science Services: Insourcing, Outsourcing, and Privatization

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Abstract *Budgets for forensic science laboratories have always been meager relative to the caseload demands on their services, but the pressure to do more with less has been growing at a more rapid pace recently for laboratories around the world. Much of this pressure is related to the stress on government budgets from global recession. During any fiscal crisis, governments look to areas in which public budgets can cut costs to move toward greater fiscal responsibility; in the most recent global recession those cuts, some draconian, have affected forensic science laboratories with some notable reductions in force. Rather than passively await the decisions of officials from outside the laboratory environment, laboratories may have a greater hand in their destiny through preemptive action before unwanted changes are thrust upon them. To do so it is essential that laboratory directors have a firm grasp on foundational economic realities. With that knowledge, directors can begin to use those realities to increase cost-effectiveness while maintaining efficiency. In many situations the optimal response may be to make cross-jurisdictional agreements to insource or outsource casework. In other situations the response may lead to reorganizing existing or opening new facilities to spread a heavy caseload among multiple laboratories for a more effective division of services. In some circumstances a private sector solution may be optimal as excess caseloads are outsourced to private laboratories or entire investigative areas diverted to the for-profit market.*

Keywords Cost-efficiency, financial management, forensic laboratory, outsourcing, privatization

Introduction

The 2012 closure of the Forensic Science Service (FSS) in the United Kingdom sent a shock wave through forensic science laboratories around the world (Dougan 2012). If the continued existence and operation of one the world's great forensic science innovators was not safe from government cuts in a severe economic climate, then no institution could consider itself immune from the austerity measures under consideration across the globe (Lawless 2011). Such austerity measures may have unintended consequences upon the ability to carry out the mission previously championed by the public sector laboratory (Houck 2011).

Rather than argue whether the FSS should have anticipated the changed economic conditions that put it out of business, we consider some of the realities that exist for all forensic laboratories and suggest some actions that other laboratories might take before being faced with such an undesirable *fait accompli*. The alternative strategies are rooted in the fundamental laws of economics. Economics has been branded the dismal science (Carlyle 1849), but unlike other social sciences it does share some characteristics with the hard sciences. Economics is the only social science able to confidently propose laws of behavior, and these laws pertain to private and public sectors alike. Notable among the laws of economics are the law of demand and the law of diminishing marginal returns. The former law deals with the desires of a customer for goods and services, given the limitations of

Received 28 May 2012; accepted 23 September 2012.
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their ability to purchase from their income and wealth and given their willingness to purchase as defined by their tastes and preferences. The latter, the law of diminishing marginal returns, guides the realities of the productivity of resources and the affiliated costs as goods or services are made available for customers. Failure to understand the implications of these laws could make a laboratory victim to the harsh realities of economic life (Kobus et al. 2011).

To monitor its performance in the economic world, a laboratory must have something to measure that it connects in a meaningful way to its decision making. Ideally, the laboratory will have metrics that connect its performance to its goals and strategies. Such metrics should allow comparison to the laboratory's internal performance over time and permit external comparison in a given time period to other laboratories that provide the same forensic science services. These comparisons should extend to both the public and private provision of these services with recognition of the different motives of each type of organization.

Once armed with the knowledge of its position in the economic world, a laboratory opens itself up to more meaningful evaluations of the cost-effectiveness and efficiency of its operations. Such evaluations offer better opportunities to develop strategies to enhance efficiency and achieve more cost-effective use of its resources (Speaker & Fleming 2010). These strategic decisions include opportunities to expand, contract, or eliminate the provision of existing services and evaluate opportunities to expand operations into new investigative areas. The application of quality forensic science coupled with equally strong economic science offers an opportunity for laboratories to continually monitor their operational strategies and to preempt or at least mitigate the austerity measures of their funding bodies.

This article begins with an initial discussion of tools for the measurement and monitoring of performance, both scientific output and corresponding accounting costs. This includes a look at the data available across the forensic science industry that might be used for comparison. Next, a brief presentation of two laws in economics and their implications for every laboratory is offered. These laws govern the provision of every good and service across all industries. An application of the economic laws through a demonstration of the metrics for a large sample of forensic laboratories in the provision of one investigative area, DNA casework, is provided.[1] For DNA casework, the data suggests that a large number of laboratories are conducting analysis at too small of a scale to be cost-effective. While they may be highly efficient in the conduct of their internal tasks, crime rates and subsequent submissions within the jurisdiction are insufficient to permit the most cost-effective delivery of services. The strategic alternatives that a laboratory might consider when faced with the realities of the data are then examined. As a point of reference, one laboratory from the sample was selected for a demonstration of how a laboratory might react to the data and its position in the economy.

Measuring and Monitoring Laboratory Performance

To identify appropriate metrics, it is first necessary to connect goals with measurable outcomes that directly or indirectly provide evidence of the degree of success in meeting those goals. For forensic laboratories, there are a host of viable options available from measurement in the laboratory for successful determination of scientific tests to traditional business metrics on productivity, efficiency, risk, and return. Many of these business metrics involve ratios that permit performance comparison for an entity across time and comparison with respect to others in the industry. Speaker (2009a) provides a description of some of these alternatives for forensic science laboratories.

However, for successful comparison between laboratories, it is essential that each laboratory consistently defines measurement; otherwise, comparisons will be meaningless. Forensic science currently lacks a universally accepted nomenclature from which this consistent measure may be derived. Fortunately, recent efforts have been launched to overcome this lack of a common language between laboratories (Houck et al. 2009). From their Project FORESIGHT, forensic scientists from laboratories across North America developed and defined a process for measurement that includes consistent metrics on casework, expenditures, and personnel allocation across a range of areas of forensic science analysis and investigation. FORESIGHT data from 64 forensic laboratories worldwide has now been collected and is being analyzed.

Some metrics may be directly linked to the mission, goals, and strategies of the laboratory. For the private laboratory, a metric such as return on equity (defined as profit/shareholder contribution) provides a direct link to the profit motive of the business operating the laboratory. For the public laboratory, alternative metrics for the return on investment are available. Consistent with maximizing the public laboratory's return on investment is the minimization of the average cost of successfully processing cases. And while it is convenient to relate goals to one metric, it is also true that no single metric tells the whole story. There are well-known processes available to look at a series of metrics as they are related to the return on investment through a decomposition of the return on investment ratio into a series of performance metrics that help to tell the entire story (Speaker 2009b).

For the analysis presented in the following sections, the metrics developed from the FORESIGHT Project will be used. Additionally, examples use the data from submissions using the LabRAT tool.[2] Note that the LabRAT tool includes the automatic calculation of the metrics for return on investment and the decomposition metrics that highlight market conditions, productivity, local economic conditions, and proxy measures for risk.

There is a linkage between these performance metrics and the development of strategies to increase cost-effectiveness and efficiency. Newman, Dawley, and Speaker (2012) provide a demonstration of how one laboratory, Ontario's Centre of Forensic Sciences, managed to implement a strategic planning cycle in which the metrics were regularly monitored and coordinated with project goals. Houck et al. (2012) offer a broader perspective in which cost-efficiency is evaluated alongside other laboratory goals. This allows the assessment of the impact across broader missions in a balanced scorecard approach.

Among the metrics common to these studies is the direct measure of the cost minimization goal. For any investigative area, the metric COST/CASE (defined as total expenditures/cases processed) offers a ratio that adjusts to the scale of operations and is therefore useful for comparisons across time and across laboratories. The total expenditure component is extensive in its coverage of costs. It includes all personnel expenditures from direct wages and salaries to benefits, all capital expenditures (allocated across time following Internal Revenue guidelines for laboratory equipment), consumables, utilities, and all forms of overhead.

In the analysis below, another aspect of the COST/CASE metric is examined as it relates to caseload and cost theory. Economic theory has demonstrated that there is range of output that is optimal for a good or service provider in any industry. In the next section, that aspect of economic theory is introduced and it is demonstrated how this relates to forensic science laboratories is introduced.

Laws of Economics

The demands for forensic science support through police investigations, the subsequent development of a prosecution case, and the adversarial criminal justice system often outstrips the availability of such support from forensic science laboratories, leading to delays, backlogs, and adverse judicial comment (Associated Press 2011; Michigan State Police Forensic Science Division 2011; Ministry of Community Safety and Correctional Services 2009; Nelson 2011; National Institute of Justice 2003).

There are two laws in economics that are particularly important for understanding what is meant by efficiency for forensic science laboratories and how that sense of efficiency may differ from cost-effectiveness. The first of these economic laws, the law of demand, governs the behavior of the customer for any good or service, including forensic science services. The second, the law of diminishing marginal returns (LDMR), governs the production of goods and services and has direct implications for the cost of forensic science services. Understanding the implications of both of these laws is critical for the management of a successful laboratory. The old adage has particular relevance here: Ignorance of the law is no excuse.

The law of demand is a direct consequence of what is termed the "economic problem" (Kobus et al. 2011). That is, society has unlimited wants, but only limited resources to meet those wants. As a result, economic agents must find some mechanism to ration those scarce resources and attempt to put them to their highest valued use. In a capitalist economy, that rationing mechanism is price, where the relative price of one good versus another reflects the relative value to consumers, given the scarcity of the good or service in question. The law of demand indicates how consumer preferences for a good or service will be expressed with respect to the price, given fixed levels of income, wealth, tastes and preferences, and the prices of other goods and services. The law of demand tells us that as price is increased, eventually the quantity demanded of that good or service falls. Figure 1 shows a typical downward-sloped demand schedule, D_0, along which we highlight two prices: P_0 and P_1. If the initial price is P_0 and the corresponding quantity of cases demanded at that prices is Q_0, then given the budget restrictions of consumers of casework (e.g., police and prosecutors), a higher quantity demanded, such as Q_1, will be the result only when the price of casework falls to a level such as P_1.

The alternative way in which a higher quantity demanded might emerge is through the relaxation of the assumptions regarding the factors held constant in the construction of the demand schedule. That is, if there were an increase in income or wealth, a change in attitude

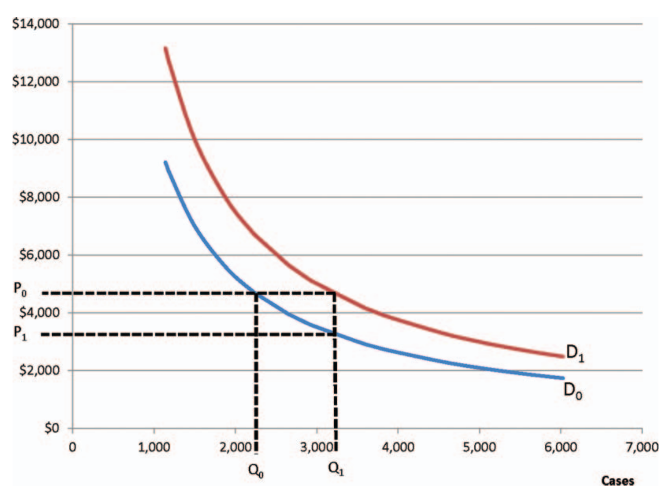

Figure 1. Demand schedule for cases (color figure available online).

(tastes and preferences) toward a particular investigative area, or a change in the price of alternative services, then demand could change at every price level. Consider the second demand curve D_1 in Figure 1. Suppose there had been an increase in the budget for this investigative area (e.g., receipt of a grant), then the quantity demanded is higher at every price level. In that situation, at the initial price P_0 the higher quantity demanded Q_1 is the result of a shift in demand from D_0 to D_1.

For the public sector forensic laboratory, the law of demand has important implications (Gronberg & Hwang 1992). Public sector budgets, once established, limit the laboratory, police, or prosecutor to a fixed amount of spending within any fiscal period. Any increase in demand (a rightward shift of the demand schedule in Figure 1) can only be met via a reduction in the demand for some other good or service. The economic cost of increasing demand can be stated in terms of the drop in demand for some other service. For example, the cost of one DNA case might be expressed as a reflection of its actual accounting cost of $1,900, or it might be recognized by its economic cost—say four fingerprint identification cases. The fixed budget forces decision makers to choose between services.

The second law, LDMR, indicates the level of output expected as inputs are increased, holding all other conditions constant. For example, imagine the blood alcohol analysis section of a laboratory in which a fixed amount of space has been dedicated and that space has been outfitted with a fixed number of workstations, equipment, chemicals, and other supplies. As the number of scientists/analysts in that section is increased, output can be expected to increase as each additional analyst is added to the section. Output may well increase at an increasing rate initially; however, a point will be reached when the hiring of an additional person increases output, but the gain is less than was found with the previous hire. This behavior holds for all industries and for all inputs.

The implications of the LDMR for cost are important to consider. If new inputs (capital, consumables, personnel, etc.) are less productive, then at some point it will become more costly to provide additional services. Figure 2 illustrates this for a total cost curve as the quantity of services is increased. Notice that the total cost curve has a backward-bending S-shape. In the early levels of production, the greatest productivity gains are realized and thus the cost of higher levels of output rises at a slower rate. Beyond the point of diminishing marginal returns, costs begin to rise at a higher rate. The point of tangency of this S-shaped curve with a line drawn from the origin (i.e., the [0,0] point in Figure 2) represents the lowest average cost attainable.[3]

The LDMR affects the production of all goods and services and that includes all of the activities of the forensic science laboratory. So, what are the implications for the laboratory with respect to efficiency and cost-

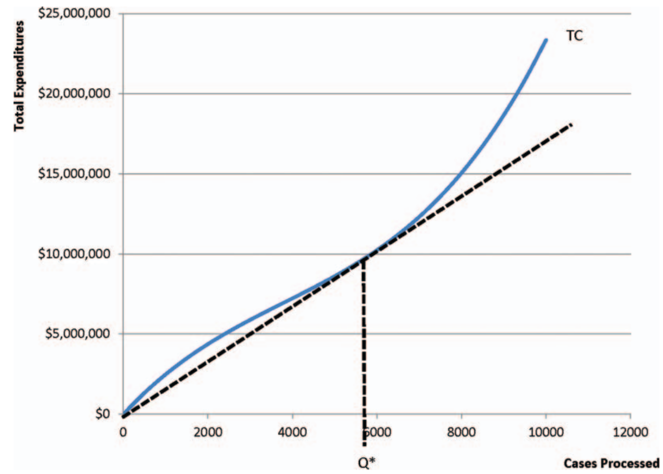

Figure 2. Total expenditures versus cases processed with minimum average total cost (color figure available online).

effectiveness? Consider a series of lines from the origin and note where they intersect the total cost curve—this will depict the average total cost curve, as shown in Figure 3. The average total cost curve (ATC) shows the efficient response to the provision of any possible quantity of output. Each and every point along the curve in Figure 3 is efficient. For example, if the caseload was level Q_0, then the corresponding COST/CASE, C_0, represents the most cost-effective way to process those Q_0 cases. Likewise, at caseload Q_1, the corresponding COST/CASE, C_1, is the efficient response.

The second curve illustrated in Figure 3 is the marginal cost curve (MC). This represents the additional cost from the production of one more unit (i.e., processing one more case). It also is a product of the total cost curve in Figure 2 where the value of the marginal cost is a reflection of

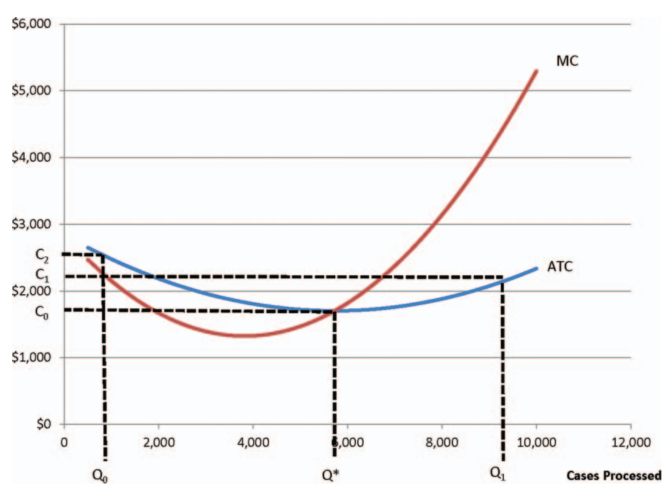

Figure 3. Average total cost and marginal cost versus cases processed and perfect economies of scale (color figure available online).

the slope of the TC curve at any level of case processing. Notice that when the MC is less than the ATC then the ATC is falling, and when the MC is above the ATC then the ATC is rising. It is when the additional cost, MC, is exactly equal to the average total cost, ATC, that the minimum ATC is achieved.

Now consider the minimum COST/CASE, C_0. It represents an efficient response to the processing of Q* cases, but as the minimum average total cost it also represents the most cost-efficient means of production and yields the "best" response to the economic problem. At Q* cases, perfect economies of scale are achieved. Along the downward-sloped portion of Figure 3, higher case processing provides economies of scale. Beyond Q*, higher case processing results in diseconomies of scale as the laboratory volume has exceeded its ideal size.

Economic Law into Practice

These two economic laws when taken together provide an indication of the nature of market solutions to the economic problem. On the one hand, the demand for any good or service may be represented by a demand schedule in which there is an inverse relationship between price and the quantity demanded for a given level of income or wealth. This relationship holds for all goods and services. For a fixed budget over any given period of time, such as that of a public laboratory for a fiscal year, this implies that decisions to conduct tests in a particular area of investigation will have the simultaneous effect of reducing the ability to conduct tests in another area of investigation for either the same case or for other cases. Couple the behavior of the demand schedule with the law of diminishing marginal returns and the implication is that the cost of additional services eventually reaches a point where costs will increase as more services are provided.

In private sector markets, the implication of the foregoing analysis is that all surviving businesses in an industry tend to produce a level of output near the quantity associated with perfect economies of scale, Q*. Any business failing to produce at that low cost level will find that market prices will be insufficient to generate a profit level for survival as competing businesses force them to either right-size their operating level or leave the industry altogether. Imagine any product or service and there will be countless examples of businesses tending toward a similar size for that industry.

The public sector, however, does not share this characteristic. Rather than economic forces determining the size of services, other factors, such as population or the crime rate in the case of the forensic laboratory, are the influencing factor on size. While the primary size-determining factors for public sector operations allow a political entity to exercise great control, they do not necessarily lead to a cost-effective approach to the provision of services (McAndrew 2012). Lacking the pressure from competitors to find more cost-effective solutions, the public laboratory may continue to operate at an efficient level. However, it runs the danger of forced change in an economic crisis, and this may have undesirable consequences, as seen with the FSS (Dougan 2012).

If a laboratory is cognizant of the cost-effective level of output—the caseload which is consistent with perfect economies of scale—then the most efficient level of public service might be provided, one that is both efficient and minimizes the average total cost. This minimum cost level is not necessarily the same for public and private laboratories. A public laboratory does have an advantage over any private laboratory that might compete to provide the same service because the public laboratory is not burdened with the economic cost of a rate of return on investment for its owners (Speaker & Fleming 2009).

Cost Curves for DNA Casework

To illustrate the alternatives for a laboratory, consider the performance of laboratories in DNA casework using a sample of laboratories. The data represent 42 voluntary submissions of self-reported data on casework, expenditures, and personnel allocation using the LabRAT tool for their performance in fiscal 2010.[4] The sample includes some submissions to Project FORESIGHT from public sector jurisdictions that operate a single laboratory facility and it includes some submissions from single-facility laboratories that do not participate in the FORESIGHT project. However, all laboratories have been certified by ASCLD/LAB or are ISO/IEC 17025 certified. Laboratories in the sample represent metropolitan, regional, provincial, and national laboratories.

Figure 4 maps the individual laboratories for cases processed and the corresponding average total cost for the provision of the DNA casework services.[5] Visual inspection of the data points is suggestive of the U-shaped curve for average total cost presented in Figure 3 and projected by economic theory (Witt & Speaker 2012). The curve presented in Figure 4 is representative of a curve fitted to the data using ordinary least squares of a quadratic function (i.e., a U-shaped second degree polynomial) relating the average total cost to cases processed. The second-degree polynomial regression permits the formation of the best unbiased estimator of the relationship between caseload and average total cost while observing the assumptions of the regression model.

Notice that a large portion of the sample involves laboratories operating at a fairly low caseload level when compared to the caseload of laboratories operating near the minimum average total cost level of the fitted curve (the observations near the perfect economies of scale are

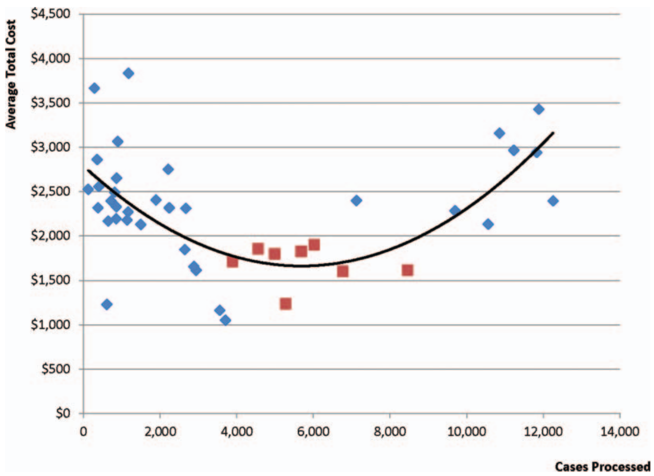

Figure 4. Average total cost versus cases processed in DNA casework (color figure available online).

highlighted by squares, while the other observations are noted by diamond-shaped points). The sample suggests that cost-minimizing analysis of DNA casework occurs somewhere in the range of roughly 4,000 to 8,000 cases per year (with a point estimate of 5,727 cases). Nearly two-thirds of the sample laboratories are operating at a level of casework below that range, and approximately 15% of the sample is operating above the upper limit of that caseload range.

What are the implications of these laboratory data when reviewed with respect to economic theory? First, consider this question as if the market for DNA casework was a private sector market. In that case, private laboratories would have to compete on price, and only those laboratories that are able to generate enough business to lower their average total cost to levels near the perfect economies of scale would survive. Those surviving businesses would have experienced an average total cost curve that was similar to the one pictured in Figure 4.[6] Any laboratories that insisted on a level of operation outside the range of perfect economies of scale would find that they would be priced out of the market. They would be forced to operate at a loss, eventually realize that long-term profit could not be earned and shut down. This would be true regardless of the size of the laboratory's caseload; high caseload facilities might adapt by either opening a second facility or by lowering their case volume and associated average total cost of servicing that lower volume, but they would have to react in some fashion or be forced into financial distress (i.e., bankruptcy).

Second, consider the scenario when forensic science services are delivered through the public sector. In that case, the freedom of entry and exit into the market faces significant barriers, and as a result of these barriers to entry the pressure to compete on price is not a direct consequence of market activity. The allocation of scarce resources is based upon other criteria where the body politic makes the decision for the general population (McAndrew 2012). In times of plentiful public coffers, the decision by a jurisdiction to maintain a forensic laboratory might not face much opposition. However, in times of economic stress, when public budgets face greater scrutiny, the ability to maintain laboratories that operate at the low-volume end of the caseload spectrum in Figure 4 comes into question.

It is these stressful economic conditions, or other political commitments to austerity, in which change is forced upon the public sector. That stress is exacerbated when coupled with an increased perception of what forensic science may be able to answer (Houck 2006). The results of desperate circumstances can have tragic consequences for the provision of these services as has been experienced in the United Kingdom with the Forensic Science Service (Dougan 2012).

However, public sector agencies can act to avoid the direct consequences of these pressures. Recognition of the significance of economic laws and the forces contained within them can empower jurisdictions of any size to take a proactive stance in the determination of their own destinies. In the situation of the public forensic laboratory, there are a variety of choices. These include the continuation of the status quo, insourcing, outsourcing, and abandonment of services. The expansion of services through insourcing could include cross-jurisdictional work in existing expertise or expansion of the types of services within an investigative area. For example, several geographically adjacent laboratories may combine resources to address a desired service that no single laboratory has the capacity to sustain—questioned documents, for example. These laboratories might parcel out tasks by types of case (misdemeanors vs. felonies), examinations (handwriting vs. ink chemistry), or unit of time (month to month, quarter to quarter, etc.). Thus, the same or a greater level of service could be achieved through a minimal realignment of existing resources to balance supply with demand.

Similarly, outsourcing of services could experience similar gains as a laboratory releases its workload to another public or private laboratory in exchange for a lower cost for these services. Outsourcing is generally assumed to mean the private sector, but it is not inevitable. Much depends upon the potential gains from privatization (Schmidt 1996). These gains are lessened or eliminated by a stance that is made in response to, rather than in advance of, economic realities. The potential for cross-jurisdictional agreements is only limited by the existing infrastructure of political laws, agency policies, and the creativity of the interested parties to achieve their desired goals. Typically, the most difficult limitations to overcome are structural and not administrative. For example, one jurisdiction having a vehicle to make and receive payments with another jurisdiction can be a vital link to a successful collaboration of resources; without such a financial channel, the jurisdictions have to devise other means (such as memoranda of understanding or barter) to exchange resources.

A transition to an alternative model will not come without other costs, and these costs must also be weighed in the decision. For example, consider a small county laboratory operating at the low end of the caseload spectrum in Figure 4. Even if the small laboratory is operating efficiently (along the average total cost curve), the corresponding cost level may far exceed the cost level associated with perfect economies of scale. Suppose that one alternative for the county laboratory is to outsource its DNA casework to a larger state laboratory that currently performs at a significantly lower average total cost that is somewhere in the range where there are still some economies of scale to enjoy from a higher caseload. Both laboratories could experience a lower average cost from a combination of services into a single laboratory. However, unless the dominant state laboratory is able to offer the lower cost service with a fair queuing scheme, one that treats the county laboratory cases on equal footing with the host laboratory cases, then the potential gains to both laboratories could be lost. The county laboratory would have to weigh the gains from the average cost reduction against the backlog cost of greater wait time. At the same time, the larger state facility must evaluate the gains from insourcing cases from other laboratories and recognize the economic reality that the provider gains as a direct result of serving the needs of its customer: the better the treatment of the county customer, the greater the gains to be enjoyed by customer and provider alike. If they cannot come to some fair terms for the sharing of facilities, then each laboratory will continue to face higher costs and continue to be subject to the threat of private laboratory replacement of services.

Conclusions

The public sector is not immune from economic reality and that is true at both the macroeconomic and microeconomic levels. Macroeconomic forces, as seen through global recession, have forced dramatic changes in the modes of operation of many. In some cases, the macroeconomic forces have led to draconian policies, including the closure of public facilities in favor of privatization of many services.

Attention to the nature of economic forces at the laboratory level—the microeconomic level—offers a means for public sector laboratories to fend off unwanted change deriving from economic circumstances. Laboratories must first understand foundational economic laws in order to exploit them for their own benefit. And, as shown in the example of DNA casework, many laboratories currently are operating at levels that are far from a cost-effective delivery of services. To remedy the situation, laboratories need to understand the proactive alternatives that couple the efficient delivery of services with a cost-effective level of activity. That cost-effective level could involve cross-jurisdictional delivery of services through agreements on insourcing or outsourcing cases. It could also include outsourcing some casework to the private sector or even abandonment of some services to private providers.

Endnotes

1. The data come from a voluntary sample of laboratories using the LabRAT tool from Project FORESIGHT (Houck et al. 2009).
2. The LabRat tool and corresponding definitions are available at http://www.be.wvu.edu/forensics/LaRAT.xlsx.
3. A ray from the origin that passes through the total cost curve represents the average cost for that case level. The point of tangency represents the only ray from the origin that touches a single point, the minimum average cost. For any other steeper ray, it intersects the total cost curve at two different levels of case processing. The slope of each ray is the measure of the average cost.
4. The specific dates for the fiscal years differed across laboratories, with some laboratories reporting a fiscal year of January 1, 2010, through December 31, 2010; other laboratories reporting a fiscal year of April 1, 2010, through March 31, 2011; and a third portion of laboratories reporting a fiscal year of July 1, 2010, through June 30, 2011. The data are expressed in 2010 U.S. dollars for consistency across the measures.
5. We follow the Project FORESIGHT definition for this area of investigation, where the DNA casework investigative area is defined as "analysis of biological evidence for DNA in criminal cases" (Houck et al. 2009, p. 90).
6. The difference between the cost curve for the public sector laboratory and the for-profit laboratory comes from one portion of the cost, the profit portion required by the for-profit firm. A return on investment that is sufficient for the risk undertaken is part of the economic cost structure that would be embedded in a cost curve that is a bit higher at all levels of service.

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