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Prepared for
the Texas
Higher Education
Coordinating Board

RAND
CORPORATION

Using Workforce Information for **Degree Program Planning** in Texas

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Preface

In May 2013, the Texas Legislature passed House Bill 1296, requiring the Texas Education Agency to distribute information to public school students about higher education institutions and workforce needs in the state. Specifically, the bill calls for comparisons on higher education institutions in terms of tuition costs, student debt, retention and graduation rates, and employment outcomes. The bill also requires disseminating the Texas Workforce Commission (TWC) projections of future occupational demands and annual wages for the jobs in highest demand.

The bill further requires the Texas Higher Education Coordinating Board (THECB), in conjunction with TWC, to prepare a report on Texas's future workforce needs that would help inform decisions to develop or expand postsecondary education programs. This portion of the bill is the motivation for the present report.

Educators and policymakers in Texas and elsewhere have a wide variety of quantitative and qualitative workforce information available for planning degree and certificate programs in colleges and universities. To help guide use of such resources, The College for All Texans Foundation, which works to further the objectives of THECB, asked RAND Education, a unit of the RAND Corporation, to conduct this study. It examines the quantitative and qualitative sources of information on workforce needs. It reviews common techniques for quantitative modeling using workforce data, as well as how institutions and states may use these data to inform decisions about degree programs. It also develops some data tools and recommends ways to use workforce information in degree program planning.

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Summary

In May 2013, the Texas Legislature passed House Bill 1296, requiring a report on Texas's future workforce needs that would help inform decisions to develop or expand postsecondary education programs. Educators and policymakers in Texas and elsewhere have a wide variety of quantitative and qualitative workforce information available for planning degree and certificate programs in colleges and universities. Such information can serve at least three major purposes: (1) strategic review of program alignment at the state or institutional level; (2) a broader strategic scan of occupations and fields of study where new programs may be needed; and (3) institutional proposal development for the opening and closing of programs, and the subsequent review of these proposals by the state.

To guide the use of these data resources and to respond to the legislative requirement, the Texas Higher Education Coordinating Board (THECB) asked the RAND Corporation to:

- describe current practices in using workforce information for degree program planning in Texas and elsewhere;
- analyze options for using workforce information and recommend promising practices;
- develop data tools, where feasible; and
- apply these tools and describe findings.

This report is based on a literature review, interviews with state officials and institutional representatives, and quantitative analysis of workforce data.

Data Sources and Services

Data sources available for planning and modeling purposes include those on individuals, on jobs, and on insights from employers, as well as combinations of these. This project reviews the following commonly used data sources and services:

- The **American Community Survey (ACS),** which allows detailed estimates of workers by occupation and region.
- **Bureau of Labor Statistics (BLS)** and **Texas Workforce Commission (TWC)** data, which provide estimates of current employment and future demand by occupation and region.
- **THECB** statistics on degree and certificates awarded by Texas higher education institutions, by field of study and degree/certificate level.
- Commercial services that allow analysis of online **job listings.** These services can show trends in demand for occupations and can often provide data much more rapidly than the BLS and the TWC. Content analysis tools allow examination of the education and skill requirements for positions.
- Statistical data capture only certain features of the labor market, so discussions with **employers** and other **experts** (e.g., professional leaders) play an essential role in further understanding workforce needs both in terms of quantity and the qualities or skills required to fill these needs.

To use workforce data for program planning, it is essential to link occupations to fields of study. The U.S. Department of Education provides a tool to match occupations to closely related fields of study, but it typically matches only a few fields to each occupation, which is especially limiting for bachelor's and graduate programs, which can lead to preparation for multiple occupations.

Key Findings and Recommendations

All of the data sources in the previous section can contribute to understanding workforce needs and hence planning for higher education programs. But each data source has important limitations, so none of the sources should be used on its own. It is important to use data from a range of sources, including quantitative data and conversations with the business community, before making decisions to open and close new degree and certificate programs or to change existing programs to align them with labor market needs.

Workforce information should be used in Texas not only to manage new and ongoing degree programs, but also for periodic strategic planning at the state, regional, and institutional levels.

Workforce information should be used in Texas not only to manage new and ongoing degree programs, but also for periodic strategic planning at the state, regional, and institutional levels. In preparing proposals, Texas institutions would benefit from clear guidance on the sources of data to use and easier methods of accessing them. In particular, more systematic means of engaging employers would help both the state and institutions to align degree programs with workforce needs.

Approaches

In this report, we identify and describe a number of methods to analyze workforce data. Workforces can be analyzed using stock or flow concepts. Stocks represent the total quantity of workers or jobs at a point in time (past, present, or future). Flows represent changes over time (often annually).

A typical flow model compares the annual need for new workers, stemming from both occupational growth and replacement of workers who leave the occupation, with the annual production of degrees and certificates within the state or region. A typical stock model compares the current and projected stock of employed workers to the total and projected supply of workers in the same occupation. Both stock and flow models then must translate gaps in supply into demand for academic programs, in terms of degree level and field of study. The models must finally compare the current and projected capacity of postsecondary programs for these degree levels and fields of study to meet the occupational demands.

Flow models generally cannot represent important mobility in the labor market, where workers move geographically and from one occupation to another. While stock models incorporate these adjustments, until recently, it was infeasible to model stocks with detail in occupations, so these models were generally much less detailed than flow models. As we discuss on the following pages, a new data source allows us to overcome this limitation.

Much of the practical use of workforce data does not follow formal stock or flow models. Instead, users generally rely on specific indicators that are related to growth in demand or imbalances between supply and demand. Commonly used indicators are "hot jobs" or rapidly growing occupations, wage changes, or vacancy rates. All of these indicators may point to unmet needs in the workforce.

Current Practices in Using Workforce Data

At the state and regional level, there is a significant amount of data available. Workforce data are being used for planning and program development at the state, regional, and institutional levels in a variety of ways.

Institutional Planning

Institutions rely on public data sources, paid services, and interactions with employers and individuals to provide evidence of workforce demand.

Institutions rely on public data sources, paid services, and interactions with employers and individuals to provide evidence of workforce demand. Institutional representatives report that, with a few exceptions (e.g., need for more current data and for data on emerging industries and occupations), available data are sufficient for their planning needs. However, our interviews and our review of the workforce evidence submitted in postsecondary education program proposals suggests that the rigor of workforce analysis varies widely and that institutions may benefit from some additional guidance on the availability and use of workforce data. Institutions may also benefit from improved information on postsecondary programs across the state and their capacity to meet workforce needs.

Strategic Review and Priority Setting

THECB staff use workforce data to validate institutional data in program proposals and create biannual regional reports that provide workforce data to support regional and institutional planning, but they do not actively use workforce data to support strategic planning. Some regions provide high-quality, region-specific data and analysis, but there are generally no processes to systematically incorporate this evidence into higher education planning. Our interviews suggest that the data provided by the TWC is extremely helpful but that the state might also provide data on larger trends in the workforce. On a somewhat different note, some interviewees also suggest that the state should standardize degree program offerings more to meet employer needs consistently across the state. A review of other state practices indicates that it is common for states to simply provide workforce data. It is much less common for states to provide analytical reports that translate these data for higher education planning.

Data Tools and Results

Flow modeling has been widely used for many years, and our analysis did not uncover any major practical improvements we could make in these techniques. Stock modeling, however, offers some new opportunities. While stock models have been restricted to quite general analysis because detailed data on employed workers were not available, the ACS generates data that can now be used to estimate historical (and future) supply of workers in each occupation group for the state as a whole and within each region. We develop a new matrix tool to compare these supply estimates to existing TWC estimates of demand.

To implement this idea, we begin by selecting the occupations that have postsecondary needs and group them into somewhat larger occupational groups. Our basic approach is to compare the growth rates in existing TWC demand projections for these occupational groups to the growth rates of supply derived from available ACS data. Because it is infeasible to compare the demand and supply growth rates directly, we classify annual rates of growth in demand into equal-sized groups of high-, medium-, and low-growing occupation groups. We also classify the annual growth rates in supply into three equal-sized groups.

Because the estimates of supply growth are uncertain, we also classify some of the supply growth values as "uncertain" if the estimates are of low precision. We do not have information on precision for the demand-growth estimates, so we report them only as high, medium, or low. We compare these growth rates in a three-by-four matrix, as shown in Table S.1. We produce matrices at the state level and for each of the ten THECB regions.

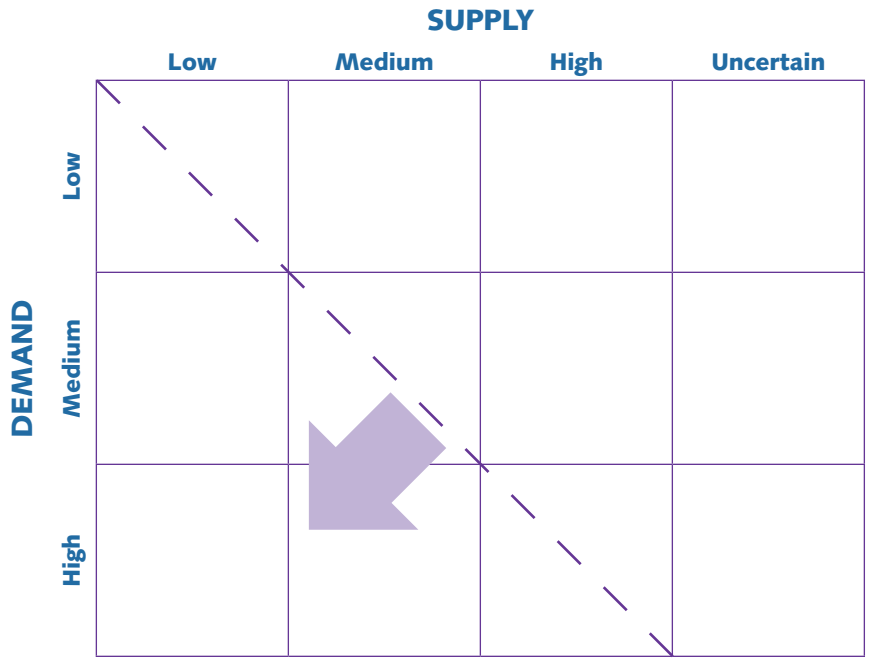
Occupation groups that fall below the diagonal, such as those in the high-demand, low-supply cell, are good candidates to explore further to identify unmet workforce needs. The following groups are in the statewide matrix:

- Religious workers
- Other construction-related workers
- Air transportation workers

The high-demand, medium-supply cell also sits below the diagonal and includes the following:

- Financial specialists
- Computer specialists
- Engineers
- Primary, secondary, and special education school teachers
- Health technologists and technicians

Table S.1. *Supply and Demand Growth Matrix Structure*



Because of the uncertainty, it is also necessary to examine the high-demand, uncertain-supply cell, which includes the following:

- Mathematical science occupations
- Architects, surveyors, and cartographers
- Physical scientists
- Legal support workers
- Occupational therapy and physical therapist assistants and aides

Supplementary files provide matrices for each of the 10 THECB regions in Texas to guide regional planning.

We also prepare other tools using the ACS data that can be used to improve both stock and flow modeling. Specifically, these tools provide the following data for Texans working in each occupation:

- Current distribution of education level
- Fields of degree for bachelor's degree holders
- Median annual earnings

These tools work in conjunction with the supply and demand matrices to identify postsecondary programs appropriate to meet the needs shown in the matrix. These tools can help identify occupational groups and regions for further exploration. In these cases, it is essential to engage institutions, employers, and other knowledgeable observers to collect local and regional perspectives on workforce needs and the appropriate postsecondary programs to meet them.

Limitations of the Tools

As with all statistical measures of the labor market, the supply and demand matrices depend on a number of assumptions, which may cause the estimates of future supply and demand to differ from actual experience. As a result, it is essential to use these tools in conjunction with the perspectives of institutions, employers, and other experts.

Recommendations

Improve Planning Processes

Workforce data can be used to improve higher education planning at the state, regional, and institutional levels. Our assessment of the ways that data are currently used in Texas higher education planning suggests that more could be done to systematically integrate workforce analysis to improve planning. We provide several recommendations on ways that planning processes can better incorporate workforce data.

Use Workforce Data for Regular Strategic Planning. We recommend that the state and institutions shift some efforts toward proactive data use through regular strategic planning. By more systematically and regularly analyzing workforce data, the state and institutions may be able to identify unmet needs earlier and mobilize resources to meet those needs. For example, the THECB could develop a priority-setting process based on fields of study with critical statewide or regional shortages. The supply and demand matrices may be useful for setting priorities. But these tools must be complemented by discussions with industry representatives, and potentially additional sources of statistical data, to validate their indicators.

Provide Guidance to Institutions on Appropriate Data Use. Institutions may benefit from a website designed to provide access to a wide range of data resources, important information on these resources, and examples of promising practices in using workforce data for program planning. In some cases, the state may need to set requirements for using workforce data. For example, in the program-approval process, requiring institutions to provide data from a common set of resources may guard against selectively including only data that support the proposal. This approach will also allow the THECB to build expertise with specific data resources in order to validate the evidence provided in proposals.

Enhance Data Resources

While workforce analysis can provide important evidence for the planning process, none of the data sources we identified provide a complete picture of the workforce. Each has strengths and weaknesses. So it is important to consider data from a range of sources, including quantitative data and conversations with the business community, before making decisions to open and close new degree and certificate programs. We provide several recommendations on ways to enhance data resources for planning.

Develop Approaches to Systematically Engage Employers. Institutional representatives we interviewed, particularly those from community colleges, are regularly and systematically engaging employers and industry experts, but they suggest that a more routine and systematic approach is needed to foster input from employers efficiently. The state may want to explore tools that have been designed to elicit regular employer input (e.g., those developed by the Center for Employability Outcomes at Texas State Technical College) and determine whether these tools can inform program development across the state.

Identify Strategies to Explore Emerging Trends. Large-scale public data sources take time to update. Institutions worry that these sources cannot inform them about current trends, especially for applied programs that would link closely to local employers with changing occupations or in emerging industries. Job posting data, available through commercial services, may provide the most efficient method of getting data on these emerging industries and occupations. Direct engagement with employers and tools to systematically solicit employer input may also be useful in identifying emerging trends.

The state should explore whether there are more cost-effective ways to achieve statewide access to data tools in an effort to ensure that institutions are using a common set of data resources.

Assess Existing Capacity. Several institutions cite difficulties in assessing the level of capacity at other institutions in their region to address a particular workforce need. It might be worthwhile to collect information on program capacity periodically to simplify institutional planning and discourage duplicative efforts.

Provide Access to Major Data Resources. Vendor tools that could be useful to institutions and the state are used unevenly across institutions. In some cases, the cost of licenses to use these tools may prevent institutions from accessing them. The state should explore whether there are more cost-effective ways to achieve statewide access to these tools in an effort to ensure that institutions are using a common set of data resources.

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We also thank the participants in our interviews. Although we generally agreed not to name them or their institutions, we deeply appreciate their cooperation and the important information they shared with our research team.

Abbreviations

ACS	American Community Survey
BLS	Bureau of Labor Statistics
C4EO	Center for Employability Outcomes
CIP	Classification of Instructional Programs
CPS	Current Population Survey
EMSI	Economic Modeling Specialists International
FOD	field of degree
FTSE	full-time student equivalent
JOLTS	Job Openings and Labor Turnover System
KSAs	knowledge, skills, and abilities
LMCI	Labor Market and Career Information
LMI	labor-market information
PUMA	Public Use Microdata Area
SOC	Standard Occupational Classification
SOCRATES	Standardized Occupational Components for Research and Analysis of Trends in Employment System
STEM	science, technology, engineering, and mathematics
SWAP	Strategic Workforce Assessment Program
TAWB	Texas Association of Workforce Boards
TCNWS	Texas Center for Nursing Workforce Studies
TEPS	Training and Education Planning System
TRACER	Texas Rapid Access to Career and Economic Services
THECB	Texas Higher Education Coordinating Board
TWC	Texas Workforce Commission
WDA	Workforce Development Area
WIOA	Workforce Innovation and Opportunity Act

1 Introduction

Government, employers, and other key stakeholders have raised concerns that the current pool of graduates are not meeting workforce needs and have emphasized a need for greater alignment between workforce needs and education (ACICS, 2014; GAO, 2013; NGA, 2014; TAWB, 2014). The 2014 federal Workforce Innovation and Opportunity Act (WIOA) places renewed emphasis on education and training for workforce needs. In particular, the WIOA requires states accepting its funds to streamline programs and pathways for workforce education and training and to evaluate and adjust these programs in response to measured outcomes. Others also recommend that we use workforce data to a greater degree and encourage more partnerships with employers to improve higher education planning (ACICS, 2014; NGA, 2014).

In an effort to improve the alignment between workforce needs and higher education in Texas, the Texas Legislature approved House Bill 1296 on May 20, 2013, requiring a report on Texas's future workforce needs to inform decisions to develop or expand postsecondary education programs to meet these needs. In support of this requirement, the Texas Higher Education Coordinating Board (THECB) asked the RAND Corporation to conduct this study to:

- describe current practices in using workforce information for degree program planning in Texas and elsewhere;
- analyze options for using workforce information and recommend promising practices;
- develop data tools where feasible; and
- apply these tools and describe findings.

Educators and policymakers have available a wide variety of quantitative and qualitative workforce information for planning degree and certificate programs in colleges and universities. The use of workforce data to identify unmet workforce needs—where the demand for individuals by employers is greater than the supply of qualified workers—can help states, regions, and institutions ensure that new degree programs are being created in areas with high levels of unmet workforce need. They also can help in decisions to close programs that are not needed. The data can be used in at least three ways: (1) strategic review of program alignment at the state or institutional level; (2) a broader strategic scan of occupations and fields of study[1] where new programs may be needed; and (3) institutional proposal development for the opening and closing of programs and the subsequent review of these proposals by the state. In this report, we document current use of workforce data in Texas and the nation and suggest improvements to existing state and institutional practices for using such data.

There are a number of challenges to using workforce analysis for degree- and certificate-program decisions. Each data source used to estimate workforce demand provides a different snapshot of the workforce, and each has substantial limitations. Efforts to map occupations and industries onto specific degree types are challenging

1 In this report, we use "field of study" in the general sense of academic fields, not to denote the Texas-specific Field of Study Curriculum, which specifies common courses that fulfill lower-division requirements.

because most occupations have individuals with a range of educational credentials, making the linkages complex and constantly changing. In this report, we document the range of challenges that stakeholders should be aware of when using workforce analysis for higher education planning. We also introduce a new tool that can address some of the limitations of existing data sources and may be able to support statewide strategic planning.

Chapter 2 describes the commonly used approaches and data sources for estimating workforce needs and linking those needs to degree programs, and describes the benefits and limitations of various approaches and data sources. Chapter 3 examines how these data are currently being used by institutions and states to inform decisions about degree programs. Chapter 4 presents a new data tool that was created to address limitations of other data sources and may be useful in strategic planning and program development. Chapter 5 concludes the report with recommendations on ways that workforce information, including the new tool that is presented, can be used to better inform degree program planning. Appendix A provides some additional review of approaches to quantitative modeling in the literature, and Appendix B explains the standard error computations used in the tool development.

2 Approaches to Workforce Modeling and Data Sources

In this chapter, we review data sources and technical considerations relevant to measuring workforce needs. We begin by exploring three common techniques: (1) modeling workforce needs in terms of flows; (2) modeling needs in terms of stocks; and (3) using specific indicators rather than models. We then discuss standard classification systems for educational programs, occupations, and Texas geography, which are used in many data sources. Following the discussion of major data sources, we discuss some issues in matching occupations to fields of study and explore two commercial services that try to address these issues and make the data sources easier to use.

Appendix A provides some additional review of the literature in workforce modeling. Here, we offer a streamlined overview of the most relevant points.

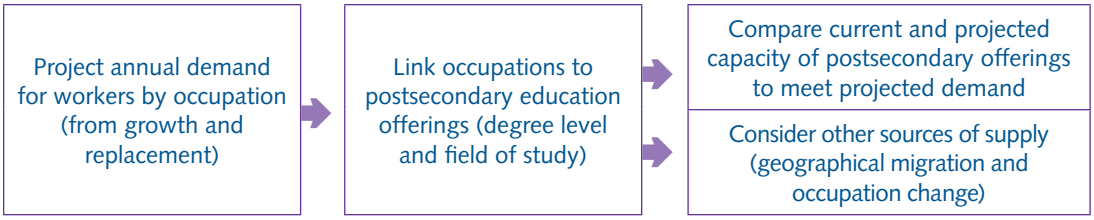
Approaches to Modeling Workforce Needs

Identifying Gaps between Demand and Supply: Stock and Flow Models

Workforce needs are often identified by comparing measures of demand for workers to measures of the supply of workers. This analysis can be done using stock modeling (i.e., comparing the total supply and demand of workers or jobs) or through flow modeling (i.e., comparing new supply of workers or jobs to new demand for them).

Figure 2.1 shows the structure of a typical flow model. These models compare the annual requirement for occupational growth and replacement with the annual production of degrees and certificates within the state or region. The model starts with projections of the demand for workers and then translates this demand into academic programs, in terms of degree level and field of study. The model then compares the current and projected capacity of postsecondary programs for these degree levels and fields of study to meet the occupational demands.

Figure 2.1. *Flow Model Structure*



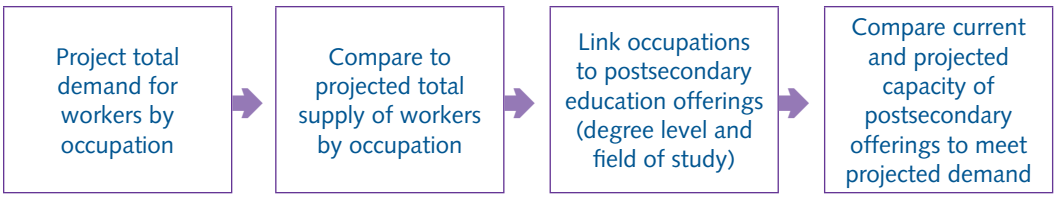
These models can be very detailed in terms of occupations and fields of study, but they face a major challenge: They typically use data that focus on sources of workers within a state or region, while newly credentialed workers may come from elsewhere. Put another way, there are many sources of new credentials for the Texas

workforce beyond those produced by Texas colleges. An accurate comparison requires modeling in- and out-migration, entry and exit from the labor force, and movement among the presently employed from one occupation to another (given that a degree may qualify a worker for more than one occupation, and a single occupation may draw workers from multiple fields of study). This is particularly problematic when modeling flows of credentials at the regional level, as graduates are likely to move across regions for study, work, or other reasons. Although we explored ways to extend flow models to take account of geographic mobility and movement from one occupation to another, we were unable to identify any broadly applicable techniques that could be used in Texas for this purpose. As a result, flow models necessarily represent only part of the supply that may be available to meet employer demands, limiting their accuracy in many circumstances.

Because stock models capture all sources of demand and supply in making comparisons, they have a major advantage over flow models, which are forced to ignore many potential sources of supply.

The other major modeling approach is based on stocks. Figure 2.2 shows the structure of a typical stock model, which compares the current and projected stock of employed workers to the total supply of workers in the same occupation. As with the flow model, the model then must translate gaps in supply into demand for academic programs, in terms of degree level and field of study. The model then compares the current and projected capacity of postsecondary programs for these degree levels and fields of study to meet the occupational demands.

Figure 2.2. *Stock Model Structure*



Because stock models capture all sources of demand and supply in making comparisons, they have a major advantage over flow models, which are forced to ignore many potential sources of supply. There is no need in stock models to isolate in- and out-migration at the state or regional level or the entry to and exit from the labor force, which are all likely to respond to simple measures of gaps identified by flow models. Until recently, however, it was infeasible to model stocks with detail in occupations, so these models were generally much less detailed than flow models. As we discuss later in this report, a new data source allows us to overcome this limitation.

Using Indicators of Workforce Need

Much of the practical use of workforce data does not follow formal stock or flow models. Instead, users generally rely on specific indicators that are related to growth in demand or imbalances between supply and demand. For example, many states and institutions focus on "hot jobs," or rapidly growing occupations, to identify areas of potential need, with the assumption that there is more likely to be unmet need when demand is growing rapidly. Others may look at wage changes over time, as economic theory suggests that in a labor market responding to changes in prices, a shortage should push relative compensation up as the market adjusts (Mortenson, 1986; Rogerson, Shimer, and Wright, 2005). Stakeholders may also look to job vacancy rates and the time it takes to fill a position, in addition to indicators such as unemployment, employment, and job vacancies.

Qualitative Analysis of Employer and Expert Perceptions

As we will describe in greater detail in the following section, there are substantial challenges to using quantitative workforce modeling, including limitations to data sources. Qualitative data from employers and industry experts are important for providing an alternate look at the workforce. These conversations may help the state and institutions prioritize fields for deeper quantitative analysis.

Depending on the purpose, there are different individuals from whom to collect qualitative information. For example, human-resource managers, high-level leadership, and industry experts may be better positioned to provide information on local employment and trends in demand, while first-line supervisors and employees in the positions can better speak to skill needs for occupations.

Challenges with Workforce Modeling

Matching Workforce Needs to Degrees

Using workforce data for higher education planning requires a way to link workforce needs to degrees. In the examples of stock and flow modeling in the previous section, both modeling strategies require occupations to be linked to degrees to determine how workforce needs translate into needs for higher education, although the matching takes place at different points in the process. Similarly, if indicators of workforce need or qualitative data from employers are used to identify workforce shortages, there must be a way to translate these workforce needs into higher education demands.

There are substantial challenges to face in translating workforce need to degree needs.

There are substantial challenges to face in translating workforce need to degree needs. In some professional occupations, such as nursing, the degree-holders-to-jobs match is straightforward: To work as a nurse, an individual must hold a nursing degree, and most individuals who graduate from nursing programs are likely to go into nursing or one of a few nursing-related occupations. While registered nurses in Texas are not required to hold a bachelor's degree, about 55 percent of them do. Of the registered nurses with bachelor's degrees, 81 percent hold those degrees in nursing and 19 percent hold a bachelor's degree in another field (2010–11 data from the U.S. Census Bureau, 2014).

In other occupations, such as those involving computer and information technology, the pathways are much more varied. Many individuals enter these occupations without any postsecondary education. Others have certificates, associate degrees, or baccalaureate degrees. The field of study for degrees feeding into computer and information technology-related occupations varies widely. Table 2.1 shows the most common baccalaureate degree fields among computer systems analysts in Texas. Clearly, many types of degrees feed into this occupation. It is challenging, therefore, to identify whether existing programs are meeting the workforce needs, because existing programs may represent a wide range of fields.

Table 2.1. *Degrees Held by Computer Systems Analysts with a Baccalaureate Degree in Texas, 2010–11*

In CIP-to-SOC Crosswalk	Degree Field	Percentage of Degrees
	Computer Science	12.1
	Business Management and Administration	7.4
•	Computer and Information Systems—General	6.3
	Finance	5.7
	Electrical Engineering	5.5
	General Business	5.1
	Mathematics	4.4
	Computer Engineering	4.0
	General Engineering	3.8
	Management Information Systems and Statistics	3.7
	Accounting	3.2
	Biology	2.8
	Mechanical Engineering	2.7
•	Information Sciences	2.7
	Economics	2.3
	Psychology	2.0
	Other	26.3
	Total	**100**

SOURCE: Data from the U.S. Census Bureau, 2014.

The federal government has provided a crosswalk that is commonly used in workforce modeling. This crosswalk relies on two government classification systems, the **Standard Occupational Classification (SOC)** and the **Classification of Instructional Programs (CIP).**

The SOC is a taxonomy system to group workers into occupation categories and is used by many federal statistical agencies, such as the Census Bureau and the Bureau of Labor Statistics (BLS). SOCs are six-digit codes in which the first two digits are recognized as the "major" occupational group, the first four digits are recognized as the "minor" occupational group, and the full six-digit code is the "detailed" occupation. For example, agricultural engineering workers, whose SOC code is 172020, work within the "Architecture and Engineering Occupations" major group, whose two-digit code is 17, and are "Engineers" whose minor-group code is 1720. The complete list of SOCs is reviewed and updated frequently to stay current as new jobs emerge and as other jobs become obsolete. In 2010, there were 23 major groups, 97 minor groups, and 860 detailed occupations (BLS, "Standard Occupational Classification," n.d.).

The CIP is a national classification system developed by the National Center for Education Statistics to classify all postsecondary fields of study including those leading to degrees and non-degree certificates. National CIP codes are grouped by subject fields (e.g., accounting, computer science, humanities), not by level of instruction (e.g., associate, bachelor's, master's, doctorate). Similar to the SOC system, the CIP codes are structured in a hierarchy in which the first two digits are general groups, the first four digits are more specific groups, and the six-digit CIP is the detailed field. The list of CIPs is also updated periodically to reflect changes in postsecondary programs (National Center for Education Statistics, "CIP 2010," n.d.).

The federal government's CIP-to-SOC crosswalk is limited in that it accounts only for degrees and occupations that are clearly and closely linked and may not accurately represent the true distribution of educational credentials among workers in a particular occupation. For instance, only two of the instructional programs

The federal government's CIP-to-SOC crosswalk is limited in that it accounts only for degrees and occupations that are clearly and closely linked and may not accurately represent the true distribution of educational credentials among workers in a particular occupation.

listed in Table 2.1 are linked with the computer systems analyst occupation in the CIP-to-SOC crosswalk. These two instructional programs produced only 9 percent of computer systems analysts with a baccalaureate degree. Limiting the pool of supply to degrees identified in the crosswalk is likely to underestimate significantly the true number of individuals equipped to meet occupational workforce needs. Another challenge is that fields of study may be linked to multiple occupations, so it is unclear how many graduates in a field might choose one occupation over others to which the degree is linked. For example, we cannot assume that all information-sciences graduates will become computer system analysts.

The CIP-to-SOC crosswalk is commonly thought to be more accurate for certificates and associate programs, where linkages are often tighter compared to those for bachelor's and graduate programs.

Defining the Populations of Interest

To conduct workforce analysis, one must first determine what population to examine. This will vary by the purpose of the analysis. As noted previously, we are focusing on workforce analysis at the occupational level, but state and regional workforce analysis could also be conducted at the industry or the degree level (e.g., comparing how the demand for workers with B.A. degrees compares to supply). Some workforce analysts argue that the analysis should be done at an even lower level, where degrees are broken into the knowledge, skills, and abilities (KSAs) that a graduate from the field should have, and matched to the KSAs that employers desire for particular jobs. However, the public data are not amenable to KSA-level analysis, so these approaches require substantial additional data collection to supplement what is publicly available.

For occupational analysis, one must determine how occupations will be grouped; that is, what level of SOC codes to use. Institutions may target specific occupations for analysis based on conversations with employers about particular areas of need, while the state may want to analyze all occupations to ensure that the greatest areas of need are identified. We may be interested in the most detailed (narrow) occupational groups, as these correspond with how employers may think about occupations. Degree programs also may map more directly onto detailed occupations and may therefore be useful in developing new degree programs. However, there are several challenges with using six-digit SOC codes. Public datasets that do not include the full population and instead rely on a sample of individuals may not have enough data to reliably estimate demand or supply for smaller occupations. Some federal agencies use a grouping called the "broad" occupational group, in which rarer occupations are grouped together, but still at a level finer than the minor groups. Common occupations are still represented at the most detailed (six-digit) level when using these broad occupational groups.

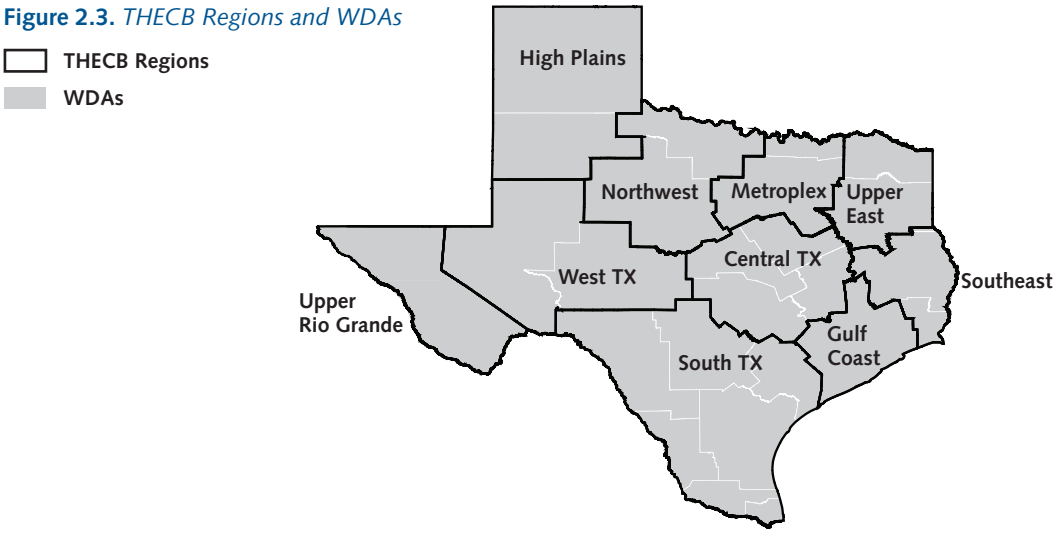
The use of SOC codes, which are intended to remain stable classifications of occupations, may not capture changes that are occurring to occupations. Newly emerging occupations may not be captured by any SOC code, at least until the next periodic revision of the codes, and some occupations may be shifting so that the appropriate classification is a hybrid of several SOC codes.

Defining Regions

Another challenge in workforce analysis is to define the region of interest. If regions are defined to be too small, there may be insufficient data from sampled surveys to generate estimates for them. Analyses of small regions also may not account for persons commuting or moving to and from such regions. If regions are defined to be too large, the analysis may incorrectly assume that individuals are willing and able to work anywhere within the region, when that may not be true. In addition, the analysis cannot be used to examine regional variation in supply and demand that is any finer than the defined regions. The appropriate scope of analysis may differ by occupation or degree type. For example, individuals with associate degrees and certificates may be less likely to move than individuals with bachelor degrees or graduate degrees, so larger regions might be appropriate when considering new bachelor's or graduate degree programs.

The Texas legislature has specified 28 official Workforce Development Areas (WDAs), which contain one or more whole counties. Collectively, these 28 WDAs cover the entire state. The WDAs are used to organize local workforce development boards and to process and report all workforce statistics in the state. The THECB has aggregated these 28 WDAs into 10 larger regions for higher education planning. Figure 2.1 shows the names and boundaries of the 10 THECB regions, along with lighter lines indicating the boundaries of the 28 WDAs that are combined.

Figure 2.3. *THECB Regions and WDAs*



Regardless of how regions are defined, there are likely to be challenges in fully capturing demand and supply within them. For example, state-level analysis may not include the many individuals who commute to work in Texas from Louisiana and Oklahoma in measures of supply, and the jobs in Louisiana and Oklahoma to which Texas residents commute will not be included in analysis of demand.

Data Sources

Data sources available for planning and modeling purposes include those on individuals, on jobs, and on insights from employers, as well as combinations of these. In this section, we review the major national and Texas-specific data sources most commonly used in measuring workforce supply and demand, as well as linking workforce needs to educational needs. In a Ray Marshall Center project funded by the Texas Workforce Investment Council, Mikelson et al. (2014) also provide a recent and thorough overview of data sources and tools for measuring workforce supply and demand.

American Community Survey (ACS)

The ACS is the largest survey—other than the decennial census—that the Census Bureau administers (U.S. Census Bureau, 2014). It was launched in 2005 to provide detailed annual data on a sample of the entire U.S. population, replacing the long form of the decennial census, which formerly provided such data but only once every 10 years. It asks approximately 1 percent of the population each year about their demographic characteristics, their household and family status, and their education and work, among other topics. It allows the examination of several important variables over both state and sub-state regions, but, of course, it is limited to the variables included on the ACS questionnaire. Thus, it is necessary to use ACS data in conjunction with other sources to measure a labor market situation.

Bureau of Labor Statistics (BLS) Data

The BLS is the authoritative source for SOC definitions and provides guidance for harmonizing SOC lists from different time points. While the SOC codes are essential descriptors for workforce data and they are updated periodically to reflect new and obsolete occupations, the list of SOC codes necessarily lags behind the emergence of new occupations in the economy.

Along with the SOC system, the BLS maintains a data file of the "typical" education required for entry into each detailed occupation that is estimated based on ACS data, data from a survey conducted by the Department of Labor, and interviews with employers and training experts. There are limitations to the usefulness of these education-level designations, as they do not reflect the full distribution of degree levels held by individuals in particular occupations, nor depict all employer needs. As Summers and Morisi (2012) note, if we assume these preferred education levels to accurately portray what is needed for occupations, it would lead to the conclusion that only a third of Americans require any college education, which is widely believed to be a significant underestimate.

The BLS coordinates a nationwide system of occupational-demand projections, largely implemented by the states. We discuss the Texas data on the following page. Based on these data, BLS produces a number of reports and data products providing the outlook for jobs by occupation or occupational group. Some BLS reports, such as those in Job Openings and Labor Turnover System (JOLTS), are reported only at the industry level and cannot be used for occupational analysis.

Current Population Survey (CPS)

The CPS is a national survey sponsored jointly by the U.S. Census Bureau and the BLS to gather data on the employment and unemployment, hours of work, earnings, and other labor-force characteristics (U.S. Census Bureau, 2012). For those interested in long-term historical trends, the CPS can provide occupation data back to the late 1960s, unlike the ACS which started in 2005. But the CPS sample is small compared to the ACS and is primarily intended to provide national estimates, not state or regional estimates within Texas.

Texas Workforce Commission (TWC) Data

The TWC is the state agency whose responsibilities include workforce development. Using methods coordinated by the BLS, the TWC—like similar agencies in other states—produces labor market projections over a 10-year period by detailed occupation for the state as a whole and for each of the 28 WDAs. Its occupational projections are for number of job positions, not workers. The current projections cover the period between 2012 and 2022. These projections are updated every few years to a new 10-year span.

These projections are based on large-scale surveys of business enterprises to establish a matrix of the frequency of occupations in each industry. The projections start with forecasts of growth by industry and then apply this industry-occupation matrix to translate the growth of industries into growth of occupations.

The TWC Labor Market and Career Information (LMCI) department provides a number of tools for accessing labor market information. Three widely used tools are Texas Rapid Access to Career and Economic Services (TRACER), Standardized Occupational Components for Research and Analysis of Trends in Employment System (SOCRATES), and Strategic Workforce Assessment Program (SWAP). Among other features, TRACER offers a web interface where users can access and download current employment and projected demand by occupation and WDA (and other geographical units), as well as average wages. SOCRATES offers a great deal of information for individual occupations. Through its web interface, users can generate a customized occupation profile including the same workforce and wage data as TRACER, as well as education levels typically required (from BLS), linked fields of study (from the CIP-to-SOC crosswalk), KSAs, and common industries employing the occupation. The common industry list allows users to search for individual employer contact information within those industries in any WDA, providing a helpful tool for institutions seeking to engage employers.

The TWC's SWAP is a tool designed to assist policymakers or employers to identify the necessary skills and training programs related to any industry cluster or sector. Users can select an industry and specific occupation to access a list of the detailed work activities that are required. For each detailed work activity, the tool identifies the level of education needed to prepare for that activity and the CIP codes for the programs that are likely to provide the KSAs required to perform a particular work activity. The tool also provides a means of comparing the needs for graduates from a particular education program to the production of graduates in that field and region, a form of flow analysis.

THECB Data

The THECB produces statistics on degree and certificates awarded by Texas higher education institutions (also called completions), organized by CIP code for fields of study and degree/certificate level. While the data can depict the supply of new graduates, they do not report the total capacity of existing programs—which is the key measure for planning any new degree program.

Job Listings

Thanks to widespread posting of job listings on websites, a number of tools are available to analyze the frequency and content of job listings. Frequency counts can show trends in demand for occupations and can often provide data much more rapidly than larger scale statistical projects developed by BLS, TWC, and other agencies. Content analysis tools allow examination of the education and skill requirements for positions. This can significantly supplement the information available from government data sources, such as the BLS typical education at entry level.

There are also limitations with job-listing data. A significant portion of jobs are never listed through the sites and services used for job-posting analysis. In addition, many job listings may not include specific data on the educational credentials required, so other approaches may still be needed to link occupations to degrees. Analysis of the data must account for duplicate listings of the same position, and there may be some employers that list positions to accumulate resumes while not actually having an open position. While the data are likely to be more timely than the datasets collected by federal and state agencies, they also are less likely

to provide a fully representative picture of workforce needs. In general, job postings data have fewer validity checks and may thus be of less certain quality compared to more traditional labor market sources.

Discussions with Employers and Experts

As mentioned previously, statistical data capture only certain features of the labor market, so discussions with employers and other experts such as professional bodies play an essential role in providing context to statistical data and improving understanding of workforce needs. Discussions with employers and industry experts can provide a more nuanced picture of workforce needs and can help to ensure that degree programs are designed so that graduates can move directly into the workforce. In particular, it is important to elicit from employers detailed information on the skills needed and standards of preparation expected of graduates. Yet it can be challenging to systematically engage employers and collect high-quality data across a range of occupations. Employers may be narrowly focused on their direct needs and may not be able to provide the higher-level picture of the entire workforce in a region and occupation that are available in quantitative data.

Statistical data capture only certain features of the labor market, so discussions with employers and other experts such as professional bodies play an essential role in providing context to statistical data and improving understanding of workforce needs.

The Texas State Technical College's Center for Employability Outcomes (C4EO) is exploring more systematic ways to collect employer input. It aims to provide colleges with online tools that increase efficiency in gathering and summarizing employer perspectives, reduce the efforts that colleges must devote to engaging employers, and streamline the process for employers to avoid duplicative engagement efforts. For example, C4EO provides a Skills Validation tool, which uses online surveys of individuals in particular occupations to assess the criticality, frequency, and proficiency level required for each skill. Respondents can also submit new skills and edit proposed skills. These tools can be used by higher education institutions to determine whether degree and certificate program curricula are aligned with workforce needs. They may be useful in identifying evolution in occupations and emerging trends in skill needs by the workforce.

Commercial Services for Using Workforce Data

Public agencies such as BLS and TWC make their data available in various formats and provide tools to enable public access to data. But, as we describe further in Chapter 3, institutions and states frequently use commercial services to access and manipulate these public data, as well as non-public data available only through these means. The two services mentioned most frequently in our interviews are Economic Modeling Specialists International (EMSI) and Burning Glass; both attempt to link occupations and degrees to facilitate the use of workforce data. We spoke to representatives of both companies and reviewed the tools they offered.

EMSI

EMSI offers a popular tool to access and manipulate workforce data. EMSI's Analyst tool builds on the publicly available data from the BLS, the TWC, and other state workforce commissions. These data include projected job openings, earnings, education levels, and other measures by occupation. EMSI's system allows users to specify any geographic region for analysis, to see estimates of these measures for that region, and to compare estimates with the state or nation as a whole. To support this flexible geographic analysis, EMSI distributes data that is reported at larger regions such as WDAs into any smaller sub-region using population ratios to

allocate the number of jobs. This is a decidedly approximate approach, especially at very small geographic levels such as individual ZIP codes, so users of the data should be cautious in how they use them.

EMSI has extended the CIP-to-SOC crosswalk with additional linkages based on empirical analysis to provide users with more useful links between occupations and fields of study. However, challenges remain in directly linking occupations to degree fields as is done in the EMSI tool. EMSI has also recently added frequency analysis of online job postings that allows users to explore trends in the number of positions posted by occupation and region. As noted previously, there are some important limitations to using job-postings data to measure unmet workforce need.

Burning Glass

Burning Glass also markets a popular tool for analyzing workforce data. The heart of the Burning Glass data is frequency and content analysis of millions of online job postings. The tools allow users to see changes in the rate of job postings by occupation and region. Users also can view the education levels, fields of study, and specific skills and competencies demanded by entry-level positions in each occupation. Our caution on the limitations of job postings data also holds true for the use of Burning Glass.

Summary

In this chapter, we detailed a range of modeling techniques, described some challenges with workforce modeling, and summarized the data sources that are used to estimate workforce needs. In the next chapter, we describe the ways in which these modeling techniques and data sources are currently being used for state, regional, and institutional planning. By describing the current landscape for data use, we can identify areas where the data tools and processes may be improved.

3 Describing the Current Practices for Workforce Data Use

There is a range of ways that workforce data are being used to inform higher education planning at the state, regional, and institutional levels. To create a new workforce modeling tool for higher education planning, we must first understand what is currently being done in Texas and elsewhere, including formal modeling of workforce shortages and informal use of indicators. By examining current practices, we can identify potential areas of improvement, ensure that a tool is designed to meet the needs of stakeholders, and develop recommendations to facilitate use of the tool. In this chapter, we look at the use of workforce data for state- or regional-level strategic review, as well as for institutional program planning.

Methodology

State and Regional Use of Workforce Data

We used two different methods to assess the use of workforce data for strategic planning at the state and regional level. First, we spoke with key Texas state policymakers, including staff at the THECB and the TWC. Our interviews with THECB staff helped us to determine how they use workforce data to verify the information provided in program proposals, how workforce need figures in the approval process, and what other efforts THECB undertakes that use workforce data for planning. TWC staff participated in several meetings with the research team to discuss the state's workforce data collection and analysis of state workforce needs. We also reviewed literature developed by TWC staff to assist in the research process.

In addition to examining use of workforce data in Texas, we wanted to look to other states to document the range of practices in using workforce data for higher education planning. We aimed to describe common practices and to identify promising practices that could be adopted in Texas. To determine the workforce data landscape in other states, we first examined the labor market data systems available at the state level using web searches and state agency websites, and we reviewed any recent reports on workforce needs by state agencies across the country. We reviewed modeling methods and use of workforce data for program planning. Following this broad search, we synthesized the information from each state to analyze how workforce data was used to inform decisions made in the labor market. Next, we used this information to understand how state agencies, higher education institutions, and workforce institutions used the available data. This literature review helped us determine how states use workforce data to inform planning of higher education programs.

Institutional Use of Workforce Data

To identify how institutions identify unmet workforce need and use workforce data for program planning, we first reviewed in detail the program proposals submitted over several years for both public two-year and four-year colleges in Texas. These proposals included programs leading to bachelor's degrees, master's degrees,

and doctoral degrees. We analyzed these proposals to determine how these institutions identify workforce need in their region as well as in the state. We found common themes in workforce data use from these program proposals.

In addition to analyzing program proposals, we selected a convenience sample of institutions across the state and conducted interviews to ensure a deeper understanding of the types of data institutions are using, the processes by which they are used, the purposes for which they are used, and what additional needs institutions may have to support more effective use of workforce data. We selected institutions based on work and contacts from an earlier project (Daugherty et al., 2014) for the THECB on unmet workforce needs in five occupations, supplementing these selections with recommendations from THECB staff. We interviewed eight individuals across seven institutions, including heads of institutions and other senior institutional leaders. The institutions chosen for interviews were one technical college, three community colleges, and three regional universities.

Limitations

There are several limitations in our methods. Our review of state systems and practices outside Texas is based almost entirely on web searches and examinations of state agency websites, so we may not have captured every aspect of how other states provide and use workforce information. Our analysis of program proposals is limited to those that met the criteria for THECB review, generally meaning that they were either doctoral programs or other program where startup costs exceeded $2 million. Given that they are all successful proposals, we cannot make conclusions about the relationship between the quality of workforce data and program approval. Finally, we interview a limited sample of Texas institutional representatives so we are not able to capture the entire range of practices at all state higher education institutions.

Findings on State and Regional Workforce Data Use for Planning

Use of Workforce Data in Texas

Our interviews suggest that the data provided by the TWC are extremely helpful, but that the state also might provide data on larger trends in the workforce.

The state of Texas, and in particular the TWC, provides a wide range of workforce data that can be used for strategic planning; we described these data in detail in Chapter 2. The TWC TRACER and SOCRATES tools in particular are viewed as valuable tools for accessing data on the workforce for higher education planning purposes. As described in Chapter 2, these tools provide data on the growth in various occupations and industries and project the current stock of jobs and the flow of new jobs that are expected. The tools provide data at both the state and regional levels.

Across the state, the Texas Association of Workforce Boards (TAWB) provides economic and workforce data and research for the 28 local Texas workforce boards. The goals of the TAWB are to provide information on the workforce that can help align higher education with workforce needs and to facilitate communication among the Texas business community, educational providers, and state and federal officials (TAWB, 2014). These workforce boards rely on indicators and qualitative discussions with employers to identify areas of need within particular regions and across the state.

The THECB incorporates workforce data into higher education planning in several ways. First, it provides a Regional Plan every two years. The Regional Plan focuses on the 10 higher education regions across the state. Within these regions, the THECB provides analysis on a variety of regional data on supply of and demand for individuals. The detailed analysis of workforce need by occupation or industry relies primarily on demand data from the TWC and does not attempt to model unmet need through a flow model or stock model. The report is

intended to support alignment between state and regional planning for degree programs (THECB, 2012, p. 64). The report is linked to a regional data portal on the Texas Higher Education Data website to encourage strategic use of the data (THECB, 2012, p. 64). While the report provides insight through narrative and detailed charts to readers, the THECB recommends readers also analyze the data through the regional portal and make their own strategic connections across sources (THECB, 2012, p. 2).

Institutions must submit proposals to the state for certain types of degree programs, and these proposals require institutions to provide data on workforce need. The data provided by institutions typically include indicators of unmet need and sometimes include efforts to construct simple flow models by comparing the demand estimated by the TWC with current levels of degree production. As a general rule, THECB staff review the workforce data that are submitted in these proposals and often verify the data with sources such as the TWC, BLS, or professional organizations. Proposals often also include letters from local workforce boards or industry in support of new programs.

In many cases, regional organizations provide data and commission studies to better understand the workforce needs and occupational projections. For example, after experiencing several years of extraordinary growth in the Houston region, the Greater Houston Partnership Regional Workforce Development Taskforce produced a study to address the workforce challenges and skills gap of the middle-skills workforce in the Houston region. (Middle-skills occupations are ones that require some postsecondary education but less than a bachelor's degree.) The report uses a range of indicators of unmet workforce need, including employer survey feedback, an EMSI indicator called "staffing environment" that incorporates wage data and indicators of changes in demand, and comparisons of annual openings and degree completions (an informal flow model). From this analysis, the task force develops a sector-led and employer-driven action plan to guide a regional workforce initiative over the next five years (Greater Houston Partnership, 2014, p. 20). Similarly, the Rural Workforce Network, which provides a variety of services in a 75-county area that includes Abilene, Lubbock, and Midland, assessed medical occupations in its West Texas region (Rural Workforce Network, "About," n.d.). This report seeks to understand employer needs and assess job seeker skills; its data also are included in an institutional program proposal to expand nursing programs. Interlink, a North Central Texas nonprofit, also has worked to bridge the gap between business, government, and education through workforce and economic development, providing the region with a variety of evidence on workforce trends and labor market information through workshops, presentations, and targeted occupation information for 135 secondary school districts and 33 college districts (Interlink, 2012).

Industry-focused organizations and professional associations also provide workforce data and analysis. For example, the Texas Center for Nursing Workforce Studies (TCNWS) was created by the Texas Legislature in response to the nursing shortage and serves as a resource for research and data on the nursing workforce in Texas (TCNWS, 2014). It reports data on supply and demand of the labor market, as well as reporting data on nursing education and public health, but does not attempt to formally model unmet need. The Texas Team Advancing Health through Nursing is a regional action coalition charged with transforming the health of Texans through recommendations of the Institute of Medicine report "The Future of Nursing" (2010). This organization also created a 2009 strategic plan to meet nursing workforce needs in the state.

Use of Workforce Data in Other States

Many other states also make workforce data available, and some use the data for strategic planning. Table 3.1 summarizes the number of states that we found offering three types of tools or analysis.

Similar to the TWC in Texas, labor and workforce commissions are usually the primary source of such data for policymakers, employers, and institutions seeking to learn about the economic climate in their state and to ensure better economic planning. Forty-six states provide a general labor-market information (LMI) tool,

which is typically found on a state's labor or workforce website. These systems are designed to offer access to information on a variety of industries and occupations. Depending on the state, users can find information regarding unemployment rates, industry job openings, specific occupation wage rates, and occupation economic profiles. Even though LMI tools provide a great deal of labor market and occupational information, they are typically not designed to directly inform program planning for degree programs and do not provide a means for linking occupations or industries to particular degree types.

Table 3.1. *Overview of States by Type of Tool or Analysis*

Type of Tool or Analysis	No. of States
Labor-market information web system available	46
Occupation to educational program crosswalk available	14
Reports on workforce needs and degree program planning	41

Fourteen states do provide some way to connect projections for occupations to higher education programs. These states typically rely on the CIP-to-SOC crosswalk to link workforce data to degree programs in their reports and web-based portals. For example, the State of California Employment Development Department, in conjunction with the California Community Colleges Chancellor's Office, created the job outlook data system linking community-college degree programs to current employment statistics. This data system provides community colleges with the information needed to understand job outlooks for students enrolling in occupational programs (State of California Employment Development Department, 2014). Users may search for job outlooks by selecting a geographic region and a community college field of study. The tool does not aggregate or analyze the occupational projections; it simply reports data separately for each occupation linked in the CIP-to-SOC crosswalk. The state does not have a tool that allows users to search on bachelor's and graduate degree fields, given the limitations of the CIP-to-SOC crosswalk for these levels.

Most of these states use a similar approach where the crosswalk simply indexes the occupation projections. Connecticut has gone further by developing supply/demand clusters, which group occupations that are related in the labor market and allow a broader view than simply connecting individual occupations to fields of study. The Training and Education Planning System (TEPS) is geared toward educational administrators and those involved in workforce development (Connecticut Department of Labor, 2014). TEPS gives users the ability to consider a variety of options for their particular field: reduction of programs, introduction of new programs, programs allowing students to find stronger job opportunities, and educational attainment levels needed for specific occupations.

Some states also produce reports that use workforce data to inform program planning. We found 11 states had posted reports on workforce needs aimed at higher education program planning. For instance, the Kansas Board of Regents produced a 2013 report to discuss the alignment of higher education with the state economy. The report relied on data from Kansas Long-Term Occupational Projections, Kansas Job Vacancy Surveys, and Burning Glass Online Job Postings, as well as linked occupations to degree programs through the CIP-to-SOC crosswalk (Kansas Board of Regents, 2013). To estimate unmet workforce need, the report relies on ratios of the number of graduates to the number of new positions as an informal flow model.

The University of Tennessee Center for Business and Economic Research, in conjunction with the Tennessee Higher Education Commission, created a report that used a flow model, with historical data on academic awards (supply) compared with anticipated job openings (demand). The collected data provided insight into the output of higher education programs and how well they matched the anticipated job demands for the state (Luna, Murray, and Cunningham, 2011). The data show that the largest growth of program completions

was in health care fields, while the greatest occupation demand was in science, technology, engineering, and mathematics (STEM) fields. Tennessee also hosts a new online initiative, called EdutrendsTN (2014), which offers statewide and regional data on occupational demand linked to degree fields and levels. The website compares these demands to degree program completions (using flow model logic). The website also offers information on wages as well as specifically on graduate earnings by public institution and program.

Louisiana also has closely linked workforce needs assessment to program planning. Through an interview with a state-level policymaker, we learned that the state currently has a workforce cabinet composed of a sector of the workforce commission, the state superintendent of schools, and several other key figures. The workforce cabinet meets quarterly to determine workforce priorities, using statistical workforce data and qualitative data collected from employers. The state then allocates additional resources to institutions willing to develop programs in these areas of focus. We spoke with a key stakeholder from the state who reported that the strategic use of workforce data and resources allowed Louisiana to close 500 under-enrolled or otherwise unneeded programs at community colleges while simultaneously increasing the colleges' overall enrollment by 61 percent. The stakeholder attributed the great strides that were made in graduation and job placement to prioritizing certain fields and supporting program development in these fields with additional resources.

Finally, we discovered that some states rely on commercial services for workforce data and analysis that can be used in strategic planning efforts around higher education. In an interview with EMSI, we learned that officials in Colorado, Idaho, Kentucky, Mississippi, and West Virginia have contracted with EMSI to receive one-time reports or ongoing analysis on the greatest workforce needs in their states. EMSI data also are used for regional and state reports, such as the Houston 2014 report discussed previously. While the EMSI data tool provides a range of data that can be used to approximate flow models or used directly as indicators, EMSI also offers contracted services to conduct more formal data modeling. EMSI uses a crosswalk that it has developed internally rather than relying on the CIP-to-SOC crosswalk.

Findings on Institutional Data Use

There are two primary purposes of workforce data use by Texas institutions: (1) internal use of workforce data for program planning, including the development of new programs and the closure of existing programs; and (2) submission of workforce data as part of proposals to the THECB for approval of new programs. We describe these processes in detail in this section.

Use of Workforce Data for Internal Planning

New programs can be costly to initiate, so many institutions have a careful planning process that requires a range of evidence on the need for a program before developing a curriculum, hiring teachers, and enrolling students. Similarly, for programs that are not enrolling sufficient numbers of students, institutions may want to assess the need for the program before closing it. In our interviews with a sample of seven Texas colleges—one technical college, three community colleges, and three regional universities—we found that all institutions were using workforce data to inform program planning, although the processes for doing so varied. Some institutions have established formalized processes for program development and evidence use, while others rely primarily on informal efforts. For example, one community college has a 100-page manual detailing the processes for program proposal and development. This includes five or six different methods to assess various aspects of the workforce, including focus groups with industry leaders, consultation with subject matter experts, and approval by several internal

Institutions rely on public data sources, paid services, and interactions with employers and individuals to provide evidence of workforce demand.

bodies. Other institutions review internal data or use paid services to assess workforce needs on a case-by-case basis but have not established formalized processes for program proposals and the use of evidence.

Proposals for new programs also vary in how they are launched. Representatives at all of the institutions we selected for interviews report that programs are often initiated internally, with faculty and departments playing a driving role. Some also note external sources of initiation. For example, community college representatives report that industry will often reach out to the institution to request that a program be developed. Advisory boards may also request new programs.

Once a potential new program is identified, institutions use a variety of sources of evidence to determine whether it is needed. Institutions look both at workforce demand for the degree or certificate and student demand for the program. To build evidence around unmet workforce need, the institutions rely on both quantitative and qualitative data. Our interviewees told us that no one data source can give a complete picture of the workforce. Statistical evidence on workforce demand is typically drawn from public sources, including TWC, BLS, industries, and local job posting and salary information. As described previously, some regions provide their own data and analysis through organizations such as Interlink; institutions often use such data in program planning. Approximately half of the institutional representatives we spoke with use paid services, specifically EMSI and Burning Glass. To compare statistical data on demand to current supply, the institutions look to THECB data on program graduates from other institutions. In some cases, they call other institutions to determine what additional capacity is available in the region to meet needs in a particular area. The institutions typically rely on indicators of unmet workforce need or conduct simple comparisons of graduates and projected demand as a means of approximating a flow model, but they do not conduct formal modeling.

Our interviews and our review of the workforce evidence submitted in program proposals suggests that the quality of the data provided varies widely and that formal modeling is rarely used.

Qualitative data also play a substantial part in building evidence to determine whether a new program is needed (or whether an existing program should be closed). Our interviewees report that they rely heavily on conversations with employers and industry experts and will typically place greater weight on this information than on statistical data. The THECB requires that institutions develop a specific advisory board with industry representatives for each new workforce education program. These boards play a large role in program development at the certificate and associate levels. Some institutions also have developed their own processes to collect data from employers. For example, a representative of one institution describes a survey of employers that was conducted by a consultant. Other institutions have advisory councils of regional business leaders; focus groups; and informal interviews with employers, professional associations, and other subject matter experts. In addition to consulting with industry to identify workforce need, these interactions with employers and experts also help institutions to develop the curriculum for the new programs. Institutions rely on the perspectives of these stakeholders to provide information on the types of skills that are needed and the desired content of the degree program. This information is integrated into internal program development processes, where department staff and faculty collaborate to structure the program and finalize curricula.

In our interviews with institutions about the program planning process, we asked what additional tools or activities at the state level would be useful in targeting program planning to the areas of greatest workforce need. For the most part, institutions find that available data are sufficient to meet planning needs. Several report a need for demand data that are more current and able to capture emerging industries. Emerging industries can be a particular challenge to examine, because, as one interviewee told us, they often have occupations not yet classified in state and national labor data. While institutions find existing public data sources very useful in assessing workforce demand, the data are often too old to capture emerging trends in

the region. One interviewee notes that some additional state-level analysis identifying trends and particular workforce needs could be useful.

Institutional representatives we interviewed generally report that the data on workforce demand are sufficient, but there is wider evidence of at least some additional needs related to workforce supply. Mikelson et al. (2014) surveys users of workforce data and tools across Texas, including institutional researchers and leadership in higher education and professionals at workforce development boards and other economic development bodies. Their survey asks users about their experience with tools and their requests for additional tool development. The authors find that 96 percent of the 148 users who completed the survey would like a report that directly compares workforce supply and demand in their region.

Several institutional representatives noted to us that the THECB could perhaps help provide additional data on the supply of graduates. It can be challenging for institutions to get good data on existing capacity, so additional public data on the actual capacity of programs across the state would save the institutions substantial time and resources. The state might also help facilitate data use. One interviewee suggested a centralized website or portal to useful public data sources. Several others noted that guidance on appropriate use of workforce data resources would be helpful.

Interviewees also made recommendations about supports for program development that were not explicitly focused on data availability and use. One particular challenge reported by two community colleges is the lack of standardization across institutions in the name and content of degree programs. They argue that increased standardization across programs could help institutions more easily assess supply and identify the range of programs available across the state. In addition to providing clarity around existing programs, interviewees argue that greater consistency in programs across the state will help institutions structure their own programs and reassure employers that they can expect a common set of skills from graduates of similar programs across the state.

Use of Workforce Data for State Program Approval

All public institutions in the state must receive approval for a new program before it is opened. The workforce need for the program is an essential criterion in the approval process and a variety of workforce data are used to show evidence of need, but the THECB itself is not required to review every proposed program. The THECB does review all proposed doctoral programs. For bachelor's and master's programs, institutions submit basic information that the THECB posts for 30 days. Programs in engineering and programs where startup costs are expected to exceed $2 million are always reviewed by the THECB using a full program proposal (THECB, 2014b). Other bachelor's and master's programs can be approved by their institutions if there are no objections during the 30-day public comment period.

Many institutions begin proposals but do not submit them if they see the proposals as unlikely to be approved. In some cases, an institution will voluntarily withdraw a proposal if given an indication that it is likely to be denied by the THECB. If a program proposal does not meet the necessary standards for program approval, the THECB will work with the institution to improve the proposal quality to that needed for approval.

In Section I of a full proposal, institutions are required to specify the level of need for the proposed program in three areas: job market need, student demand, and enrollment projections. Institutions must provide short-term and long-term evidence of need for graduates in the job market and demand for the program. The THECB (2012) provides a "Standards for Bachelor's and Master's Degree Programs" guide that describes the necessary information for each section. Job market need must be demonstrated through research and documentation of recent and reliable short- and long-term job opening data. More specifically, three main types of data are to be used: "Documented vacancies in existing positions," "documented need for new

positions," and "evidence of emerging markets" (THECB, 2012, p. 1). These data may come from a variety of sources, including employer surveys and evidence from professional associations or workforce commissions. Enrollment projections are entered into a chart provided by the THECB on the form and must include the estimated head-count of full time student equivalent (FTSE) enrollment for the next five years, making these data standardized across proposals. The use of workforce data in these proposals relies exclusively on indicators of unmet need and basic flow model approximations that compare graduates to open positions.

Outside of the biannual regional reports, which provide basic data on degree completion and some aspects of workforce need, state agencies are not actively using workforce data to support strategic planning.

As of 2009, associate degrees (applied or academic) and certificate programs can be approved by an institution if its governing board certifies the program meets the required criteria and documentation is available to support the criteria. Associate of applied science programs and certificate programs must follow the "Guidelines for Instructional Programs in Workforce Education" (THECB, 2014a). Institutions must document pertinent local, statewide, or national workforce demand for the program. This documentation must also address at least two of the eight outcomes specified in the guidelines, such as preparing "students for an occupation that has been documented as needed from a strategic planning website such as EMSI" or offering "a program for which the Occupational Outlook Handbook, published by the Bureau of Labor Statistics, indicates high occupational demand for the next five to ten years" (THECB, 2014a, p. 36).

For academic associate programs, the evidence of need is less focused on workforce needs and more on graduates' ability to transfer to baccalaureate programs. Institutions are required to identify specific baccalaureate degree programs that the associate program will lead into, and these institutions must provide data from four-year institutions to support the need for a particular program and to demonstrate the way that this program will support transfer to four-year programs (THECB, n.d.).

Proposals for doctoral degree programs must include a substantial amount of additional data beyond the requirements for bachelor's and master's programs. The workforce needs analysis for doctoral-level programs must include documentation on not only local but also regional, state, and national demand for the proposed program. Proposals include five separate areas of evidence around need: job market need, existing programs, student demand, student recruitment, and enrollment projections. The THECB provides guidelines to assist institutions in completing each section. Institutions are asked to cite TWC, BLS, and professional association data as appropriate. Evidence on the ability to attract students of specific ethnicities, genders, regions, or nationalities also is requested in the doctoral-level proposal. In addition to providing detail on populations of possible students, the THECB requests evidence of reliable short- and long-term student interest.

To understand how workforce need is assessed in these proposals, we examined proposals for 10 doctoral programs and 10 bachelor's and master's programs that surpassed the $2 million start-up funds criteria. These proposals were submitted from 2010 to 2012, and all were approved by the THECB. The institutions provided similar types of information, although there was some variation in the presentation of data. The proposals all provided a workforce needs analysis that include a variety of data sources such as surveys, BLS reports, journal articles, and community data. Overall, the information we found in the proposals aligned with THECB standards and guidelines described previously, with more detailed information and a wider geographic focus required for higher level degree programs. However, there was no formal workforce modeling in these proposals; the data presented was a collection of indicators and rough approximations of flow modeling through comparisons of graduates and open positions.

The needs analysis completed at the bachelor's and master's level differed somewhat from doctoral programs. As many of these programs are expected to have a regional and statewide reach, the data focused less on

national workforce trends than the doctoral level proposals did and more on state and local data sources. Institutions often incorporated data from the BLS, U.S. Department of Labor, and the TWC. A number of institutions also included local, state, and national reports and peer-reviewed research, such as the Institute of Medicine's popular 2010 report on "The Future of Nursing" and a number of THECB reports. For programs in the health sciences, particularly nursing, research completed though state initiatives (e.g., TDHS, TCNWS) served as a foundation for the discussion of workforce need. While institutions typically provided data in a narrative form, proposals occasionally used graphs and charts to display occupational and workforce data. In the local workforce need section of the proposal, institutions typically relied on local data sources from professional organizations, the local chamber of commerce, and non-profits. For example, a rural institution included data sources from the Rural Workforce Network to confirm workforce need in the area.

Interviews with THECB staff suggest that having ways to better assess and verify data on program proposals would allow more informed decisionmaking on new proposals. The THECB does not have explicit criteria to assess the quality of workforce evidence in new program proposals, and very few program proposals are rejected or not approved based on workforce evidence. Of course, these findings may be affected by the informal processes that try to improve (or discourage) weak proposals. However, THECB staff report that the decisions to approve or reject proposals rarely hinge on the workforce evidence, because they do not feel that they have good standards by which to determine whether the workforce data provide evidence of unmet workforce need.

Summary

Workforce data are being used for planning and program development at the state, regional, and institutional levels in a variety of ways. Institutions rely on public data sources, paid services, and interactions with employers and individuals to provide evidence of workforce demand. Institutional representatives report that, with a few exceptions (e.g., need for more current data and for data on emerging industries and occupations), available data are sufficient for their planning needs. However, our interviews and our review of the workforce evidence submitted in program proposals suggest that the quality of the data provided varies widely and that formal modeling is rarely used, and when it is, institutions rely exclusively on simple flow models. This suggests that institutions may benefit from some additional guidance on the availability and use of workforce data. Institutions may also benefit from improved information on programs across the state and their capacity to meet workforce needs.

At the state and regional level, there is a significant amount of data available, but efforts to explicitly model unmet workforce need and connect to program planning are rare. THECB staff use workforce data to validate institutional data in program proposals and create biannual regional reports that provide workforce data to support regional and institutional planning. But outside of the biannual regional reports, which provide basic data on degree completion and some aspects of workforce need, state agencies are not actively using workforce data to support strategic planning. Some regions provide region-specific data and analysis that relies largely on indicators of unmet need and basic flow modeling, but there are generally no processes to systematically incorporate this evidence into higher education planning. The survey of Mikelson et al. (2014) found, as we noted, that there is a significant demand for a report that directly compares workforce supply and demand at a regional level. Our interviews suggest that the data provided by the TWC are extremely helpful, but that the state also might provide data on larger trends in the workforce. On a somewhat different note, some interviewees also suggested that the state should standardize degree program offerings more to meet employer needs consistently across the state. A review of other state practices indicates that it is common for states to simply provide workforce data. It is much less common for states to provide analytical reports that translate these data into terms suitable for higher education planning.

4 Modeling Statewide and Regional Supply and Demand

As we explained in Chapters 2 and 3, flow models and indicators derived from them are widely used. Flow modeling has been used for many years, and our analysis did not uncover any major practical improvements we could make in these techniques. Stock modeling, however, offers some new opportunities. While stock models have been restricted to quite general analysis because detailed data on employed workers were not available, the ACS generates data that can now be used to estimate supply of workers in each occupation group for the state as a whole and within each region. We compare these supply estimates to existing TWC estimates of demand in a matrix tool. Our tool aims at meeting, as far as statistical data sources allow, the need for more direct comparisons of workforce supply and demand identified by the survey of Mikelson et al. (2014).

Basic Approach

We begin by selecting the occupations that have postsecondary needs and group them into somewhat larger occupational groups.

Our basic approach is to compare the growth rates in existing TWC demand projections for these occupational groups to the growth rates of supply derived from available ACS data. Because it is infeasible to compare the demand and supply growth rates directly, we classify annual rates of growth in demand into equal-sized groups of high-, medium-, and low-growing occupation groups. We also classify the annual growth rates in supply into three equal-sized groups.

Because the estimates of supply growth are uncertain, we also classify some of the supply growth values as "uncertain" if the estimates are of low precision. We do not have information on precision for the demand growth estimates, so we report them only as high, medium, or low. We compare these growth rates in a three-by-four matrix, as shown in Table 4.1. We produce matrices at the state level and for each of the 10 THECB regions.

Our basic approach is to compare the growth rates in existing TWC demand projections for these occupational groups to the growth rates of supply derived from available ACS data.

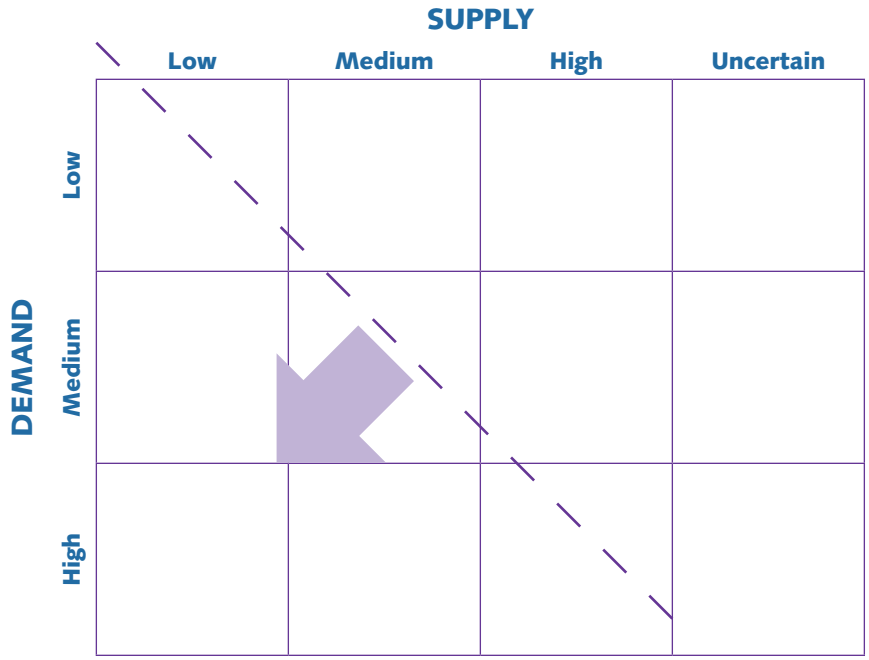
Occupations with Postsecondary Needs

To estimate supply and demand growth for the matrix in Table 4.1, we follow several steps. First, we limit our analysis to occupations that have postsecondary needs. We analyze individual occupations at the six-digit SOC level. We begin with the BLS assignment of typical education needed for entry (2010 edition), but the assignment levels are often below the qualifications seen in the labor market, so we use an additional criterion. If a SOC has any postsecondary education required according to BLS, we identify this SOC as one that has postsecondary needs. If an occupation does not require high school graduation for entry, we identify it as not having postsecondary

needs. If BLS lists high school graduation as the requirement, we identify the occupation as having postsecondary needs if more than 65 percent of Texas workers age 25 to 44 in that occupation report some postsecondary education in the ACS. We selected the 65 percent threshold in consultation with THECB staff to represent the occupations that seemed to have a substantial connection to postsecondary education, although there is no simple threshold that can accomplish this purpose exactly.

Second, we have to account for changes in SOC lists in different years and changes in groupings. There is a significant difference between SOC definitions for 2000 and 2010. We use the 2000 definitions as our standard because most of our ACS data uses the 2000 definitions and we use the BLS guidance for comparing different SOC lists. We are generally able to construct consistent series at the SOC minor group level, accounting for creation of new detailed occupations and occupations moving from one minor group to another. Of the occupations that had postsecondary needs, only one (market research analysts) is so seriously affected by changes over time that we dropped it from our analysis.

Table 4.1. *Supply and Demand Growth Matrix Structure*



Aggregation of Occupation Groups

The Census Bureau releases ACS data files that are aggregated over one-, three-, and five-year periods. The various files are refreshed each year with one year of new data. To prevent identification of respondents, cells with small counts are suppressed. So, in the one-year file, some uncommon occupations are suppressed. We find the three-year files provided sufficient data on the occupations with postsecondary needs. The first three-year file covers 2005–07, and the most recent covers 2010–12.

Reporting a matrix with every six-digit occupation would be unwieldy, so we aggregate the occupations with postsecondary needs into four-digit SOC minor groups, and calculate average growth rates in workers for each minor occupational group over time. One concern we have was that these supply growth rates are from 2005–07 to 2010–12, spanning the period around the Great Recession. Some occupations might be more sensitive to the business cycle than others. We experiment with adjusting for sensitivity to GDP growth using 40 years of CPS data and GDP growth but do not find a practical way to use this approach. To construct consistent series over this long period of time, we would have to use CPS occupational data at two-digit SOC

major group level, with unclear application to the more detailed four-digit SOC minor groups. Fortunately, it appears that some of the most economically sensitive occupations such as construction trades are removed from our analysis because they do not meet the criteria for having a postsecondary education need.

Once aggregated, the four-digit SOC minor groups only contain those occupations that have postsecondary educational needs. Of the 93 SOC minor groups, 66 have some occupations with postsecondary needs. We drop five groups that employ fewer than 5,000 workers in the state (using the 2010–12 ACS estimates).

Calculating and Classifying Growth Rates

We calculate the annual growth rates in the supply of workers by occupational group by comparing each three-year ACS file to the previous file (i.e., 2006–08 compared to 2005–07). We then average the annual growth rates. We also calculate annual growth rates of demand for jobs from the TWC projections.

Since workers can hold more than one job, it is not clear how to match estimates of supply of workers from the ACS with estimates of demand for jobs from TWC (although this concern may be small for jobs with postsecondary education needs). There also are important assumptions underlying the TWC demand projections that could affect the validity of demand estimates for occupations and regions differently.

As a result of these different approaches and units of measurement, it is very difficult to compare the demand and supply estimates directly. We address this challenge by ranking the supply and demand growth rates separately and comparing them in a general way. Specifically, we rank order the growth rates by occupational group and divide them into three equal groups (high, medium, and low), first based on their supply growth rates and then based on their demand growth rates.

Statewide, regional, or institutional planners can use a matrix to identify occupational groups where there may be a potential mismatch in the labor market by identifying those where supply and demand categories do not match.

Using the procedure for computing standard errors in Appendix B, we estimate the 90 percent confidence interval for each supply growth estimate. If the interval spans only one or two cells (high, medium, or low), we report the cell that contains the point estimate, which generally represents the most likely assignment for that occupation group. But if the confidence interval extends to cover portions of all three cells, we call that estimate "uncertain" and report it as such, rather than assigning it to any of the three main cells. While there is likely substantial error in the TWC demand estimates, we do not have access to precise information that would allow us to perform a parallel procedure on the demand estimates. So we report all demand estimates in one of the three rows: high, medium, or low. The matrices thus have four columns and three rows.

Statewide, regional, or institutional planners can use such a matrix to identify occupational groups where there may be a potential mismatch in the labor market by identifying those where supply and demand categories do not match. The meaning of "high" demand and "high" supply may differ, so even the fast-growing occupation groups that fall into the high-demand, high-supply cell should be reviewed, as there can still be shortages in these groups if growth in supply is below that for demand.

Regional Supply and Demand Growth Matrices

We repeat the same process for each of the 10 THECB regions, but this poses a complication. The regional geography used by TWC and THECB is not the same as the regional geography used by the ACS. The ACS uses a regional geography level called a Public Use Microdata Area (PUMA), each of which is a collection of census tracts with at least 100,000 people. PUMAs, just like census tracts, changed from 2000 to 2010. The THECB uses regions that are groups of WDAs, which are in turn groups of counties. Most PUMAs fall

completely within the THECB regions. For the small number of PUMAs that cross these regions, we allocate the ACS labor force data in proportion to the ratio of the total population on each side of the boundary, which is a fairly standard approach to aligning boundaries in such analyses.

In addition to the differences in geography levels used, the regional data has many SOC minor groups with small samples. We do not report results for occupation groups that we estimate to have fewer than 1,000 workers in a region. A separate Excel file reports the 10 regional matrices.

Empirical Level of Education, Field of Degree, and Earnings by Occupation

In addition to the statewide and regional supply and demand matrices, we use the ACS to construct three other data tools. Two of these tools help establish linkages between occupations and educational programs, which is an essential stage in both the stock and flow models. One of these tools estimates the actual distribution of education levels by occupation in Texas to supplement and extend the BLS typical-education-at-entry listings, which use national data. Similarly, we develop an empirical crosswalk between occupations and the field of degree for bachelor's holders to supplement and extend the CIP-to-SOC crosswalk. The third tool estimates earnings levels by occupation to provide some information that could be used to identify areas with workforce needs where there may be high economic payoff. This information is useful in making decisions about which occupations and educational programs to prioritize.

As part of our supply calculations described previously, we produce a dataset of six-digit SOC occupations showing the distribution of the education level of Texans employed in each. For educational attainment, the ACS does not capture postsecondary non-degree award/certificate holders. Rather, among persons with at least a high school diploma or its equivalent, its categories are simply high school diploma or equivalent, some college but less than 1 year, 1 or more years of college but no degree, associate degree, bachelor's degree, master's degree, professional degree, and doctoral degree.

We also produce an Occupation by Field of Degree dataset in response to the limitations of the official CIP-to-SOC crosswalk. Table 2.1 and the surrounding discussion in Chapter 2 provided an example of the empirical distribution of major fields for computer systems analysts.

Rather than CIPs, the ACS uses its own field of degree (FOD) variable for bachelor's degree holders only. It does not provide this information for associate degree holders and captures only the bachelor's degree field for holders of graduate degrees. Furthermore, the ACS added the FOD variable in 2008, so earlier ACS data files have no information on field of bachelor's degree. The FOD aggregates fields of study, especially less common and finely detailed fields, and therefore has fewer codes than the CIP classification, but the FOD and CIP are similar enough that we develop a crosswalk between FOD and CIP. In the 2010 CIP, there are 1,721 six-digit codes, whereas there are 173 FOD codes. About 70 percent of the FOD codes are equivalent to a four-digit CIP code, or a group of related four-digit CIPs. About 20 percent of the FOD codes are equivalent to a single six-digit CIP, and the rest are equivalent to the two-digit CIPs.

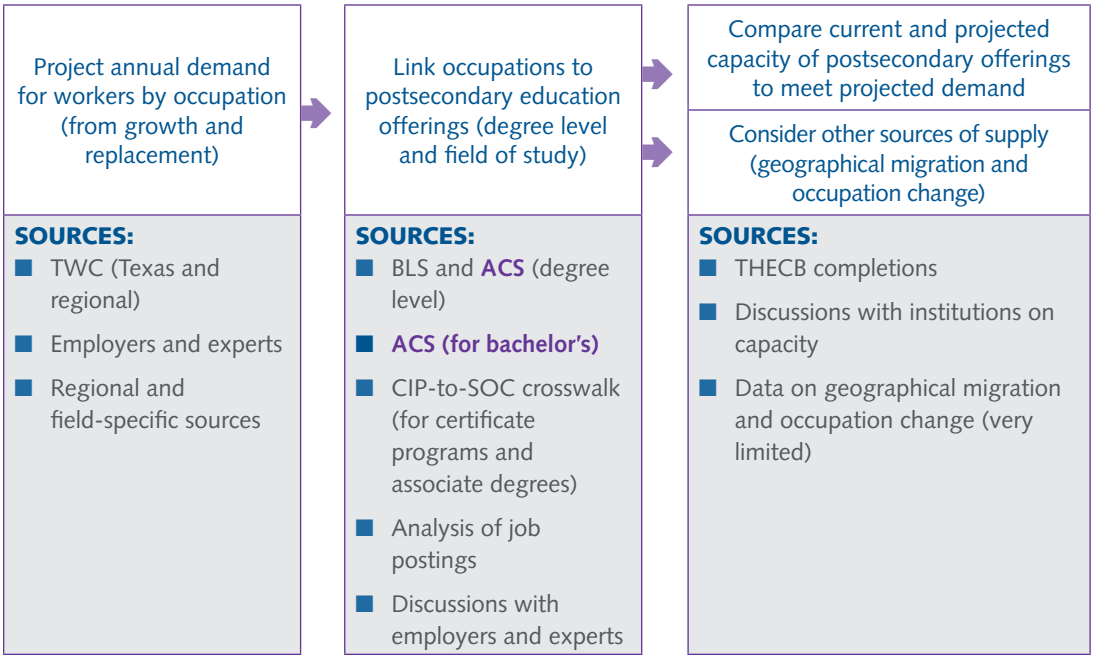
We use the most recent three-year ACS file (2010–12) to produce a dataset that displays the distribution of fields for bachelor's degree holders in each SOC minor occupational group. We also found that roughly 9 percent of bachelor's degree holders in Texas had more than one FOD listed; most likely these are individuals who double-majored. We count double majors as each contributing 0.5 instead of 1 count into various cells and produce a simple frequency matrix. This provides insight into the actual pathways taken from field of degree to occupation in Texas. We produce this data file in two directions: going from occupations to fields of degree and from fields of degree to occupations.

Finally, we use the ACS data to compute the median annual earnings in each occupation. Occupations with labor-market needs and high earnings are particularly good candidates for postsecondary programs, as students and the state can expect a reasonable return on their educational investment.

Statewide Results and Using These Tools

Figure 4.1 reviews the flow modeling approach and shows the main data sources that can be used to inform each stage.

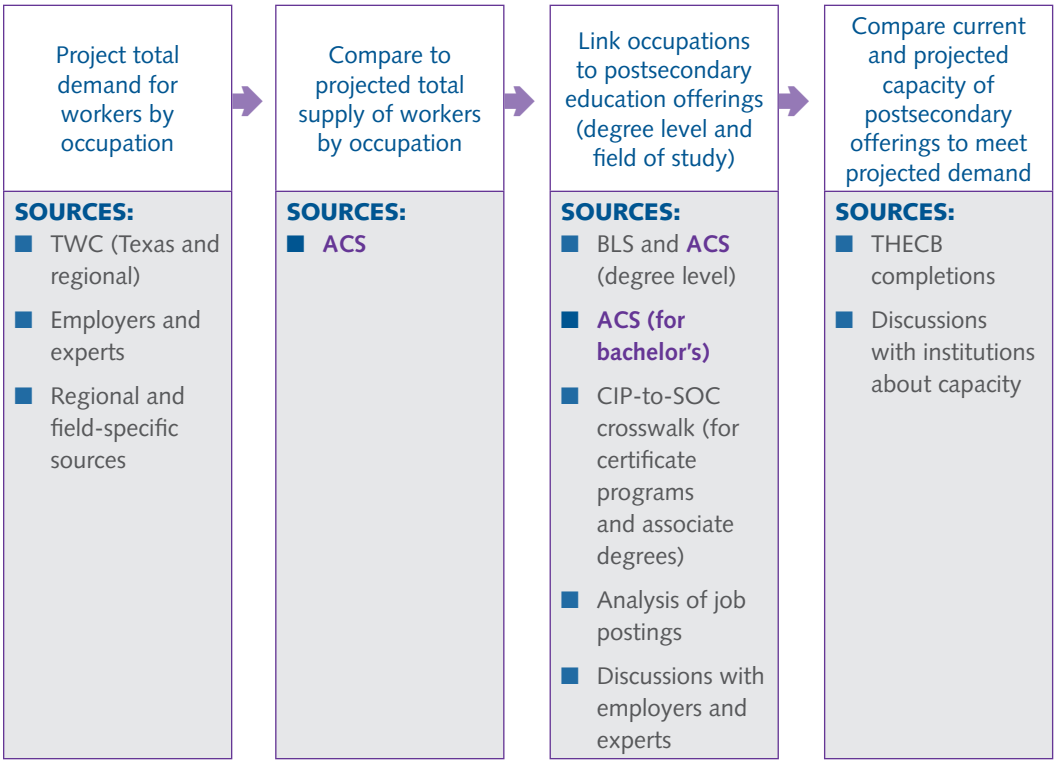
Figure 4.1. *Flow Model with Data Sources*



Note: Purple highlight indicates data sources that were used to develop new tools in this project.

Similarly, Figure 4.2 reviews the stock modeling approach and shows the main data sources that can be used to inform each stage. Our approach adds significant detail from the ACS to estimate supply of workers by occupation group and region. The supply-demand matrix allows us to examine the situation in each SOC minor group with some postsecondary education needs.

Figure 4.2. *Stock Model with Data Sources*



Note: Purple highlight indicates data sources that were used to develop new tools in this project.

Table 4.2 presents the results of our supply and demand matrix for Texas as a whole. Many occupation groups fall on the diagonal. Occupation groups that fall below the diagonal, such as those in the high-demand, low-supply cell, are good candidates to explore further to identify unmet workforce needs. The following groups are in the statewide matrix (with SOC minor group numbers in parentheses):

- Religious workers (2120)
- Other construction-related workers (4740)
- Air transportation workers (5320)

The high-demand, medium-supply cell also sits below the diagonal and includes the following:

- Financial specialists (1320)
- Computer specialists (1510)
- Engineers (1720)
- Primary, secondary, and special education school teachers (2520)
- Health technologists and technicians (2920)

Because of the uncertainty, it is also necessary to examine the high-demand, uncertain-supply cell, which includes the following:

- Mathematical science occupations (1520)
- Architects, surveyors, and cartographers (1710)
- Physical scientists (1920)
- Legal support workers (2320)
- Occupational therapy and physical therapist assistants and aides (3120)

As Figure 4.2 shows, for each of the occupation groups identified, the empirical distribution of education (derived from the ACS) provides a guide on the appropriate educational credential or degree level for an occupation, and the empirical distribution of fields for bachelor's degree holders (also derived from the ACS) can provide a sense of which bachelor's programs have relevant connections to the identified occupations. If productive conversations are not already under way, these tools can help start conversations among institutions, employers, and other knowledgeable observers to collect local and regional perspectives on workforce needs and the appropriate postsecondary programs to meet them.

Table 4.2. *Statewide Supply and Demand Growth Matrix*

DEMAND	SUPPLY: Low	SUPPLY: Medium	SUPPLY: High	SUPPLY: Uncertain
Low	Drafters, engineering, and mapping technicians (1730) First-line supervisors/ managers, protective service workers (3310) Transportation, tourism, and lodging attendants (3960) Supervisors, sales workers (4110) Communications equipment operators (4320) Material recording, scheduling, dispatching, and distributing workers (4350) Other office and administrative support workers (4390) Electrical and electronic equipment mechanics, installers, and repairers (4920) Supervisors of production workers (5110) Plant and systems operators (5180)	Art and design workers (2710)	Fire fighting and prevention workers (3320) Law enforcement workers (3330) Other production occupations (5190)	Life scientists (1910) Social scientists and related workers (1930) Media and communication workers (2730) Media and communication equipment workers (2740) Supervisors, personal care and service workers (3910) Vehicle and mobile equipment mechanics, installers, and repairers (4930)
Medium	Entertainers and performers, sports and related workers (2720) Sales representatives, services (4130) Sales representatives, wholesale and manufacturing (4140) Supervisors, office and administrative support workers (4310) Secretaries and administrative assistants (4360)	Top executives (1110) Advertising, marketing, promotions, public relations, and sales managers (1120) Other management occupations (1190) Other education, training, and library occupations (2590) Financial clerks (4330) Information and records clerks (4340)	Operations specialties managers (1130) Counselors, social workers, and other community and social service specialists (2110) Other teachers and instructors (2530) Other healthcare support occupations (3190) Entertainment attendants and related workers (3930) Other personal care and service workers (3990)	Life, physical, and social science technicians (1940) Lawyers, judges, and related workers (2310) Librarians, curators, and archivists (2540) Other sales and related workers (4190)
High	Religious workers (2120) Other construction related workers (4740) Air transportation workers (5320)	Financial specialists (1320) Computer specialists (1510) Engineers (1720) Primary, secondary, and special education school teachers (2520) Health technologists and technicians (2920)	Business operations specialists (1310) Postsecondary teachers (2510) Health diagnosing and treating practitioners (2910) Other healthcare practitioners and technical occupations (2990) Other protective service workers (3390) Personal appearance workers (3950) Other installation, maintenance, and repair occupations (4990)	Mathematical science occupations (1520) Architects, surveyors, and cartographers (1710) Physical scientists (1920) Legal support workers (2320) Occupational therapy and physical therapist assistants and aides (3120)

Note: SOC minor group numbers are in parentheses.

The empirical field-of-degree distributions are available only for bachelor's degree holders, so they cannot help with SOCs that require less postsecondary education than a bachelor's degree. For these occupations, the CIP-to-SOC crosswalk may provide a useful starting point, but talking to regional employers is essential to understand the competencies they need certificate and applied associates programs to develop in their entry-level hires. As shown in Figure 4.2, analysis of job postings and discussions with employers and other experts are useful techniques in general for matching occupations to educational credentials.

To complete the planning process, planners must assess whether existing institutional capacity is sufficient to meet the demands identified. As discussed in Chapter 3, capacity is commonly assessed by examining THECB degree completions data and asking institutions in the region of interest about their additional capacity to produce degrees. Because the stock model takes into account the historical production of institutions in Texas and other states, it is probably not necessary to consider completions data specifically. Instead, it is sufficient to determine whether institutions have capacity to expand in ways that might meet identified workforce needs.

To complete the planning process, planners must assess whether existing institutional capacity is sufficient to meet the demands identified.

As Figure 4.1 shows, some of these new tools also can improve techniques associated with flow modeling. Specifically the empirical distribution of education levels and fields of degree for bachelor's degree holders (derived from the ACS) can help improve the link between occupations and educational programs, in both flow and stock modeling.

Limitations of the Tools

As with all statistical measures of the labor market, the supply and demand growth matrices depend on a number of assumptions. As discussed previously, the data sources for supply and demand are quite different and are unlikely to be completely comparable. For this reason, we treat each source separately, using it to sort occupation groups into high, medium, and low growth. Our supply growth estimates assume that growth rates will follow recent historical patterns (specifically from 2005 to 2012). While the demand growth is officially a forecast of the future (2012 to 2022), it is also based on recent historical trends. The Great Recession likely affected some of the occupation groups' supply growth rates as well as affecting the historical data TWC used to project demand growth. In general, economic conditions could differ between the recent historical period and the future period, making both supply and demand growth estimates less accurate. The supply growth estimates as well as the values in the other tools are all based on the ACS, which is a sampled survey and thus has some error in measurement.

The demand forecasts rely heavily on static matrices of occupational employment by industry, which are applied to all occupational demand projections in the state. As a result, the projections tend to make various occupations and geographic areas move in concert, diminishing variation across occupations and regions of the state. In addition, the TWC does not provide estimates of the precision for projections.

As noted previously, the empirical field-of-degree distributions derived from the ACS are only available for bachelor's degree holders, so they cannot provide any guidance for occupations that require less postsecondary education than a bachelor's degree.

5 Main Findings, Recommendations, and Next Steps

Workforce data can improve higher education planning at the state, regional, and institutional levels. Our assessment of the ways that data are currently being used in Texas higher education planning suggests that more could be done to systematically integrate workforce analysis to improve the planning process. In this chapter, we provide some specific recommendations on how the state and institutions can improve the use of workforce data for planning purposes.

While workforce analysis can provide important evidence for the planning process, none of the data sources we identified provide a complete picture of the workforce. Each data source has strengths and weaknesses. Decisionmakers therefore should consider data from a range of sources, including quantitative data and conversations with the business community, before making decisions to open and close new degree and certificate programs. Among the existing resources, we identified several gaps. We develop a new data tool to address some of those gaps. In this chapter, we provide recommendations on improving the set of data resources available for higher education planning.

Recommendations to Improve Planning Processes

Use Workforce Data for Regular Strategic Planning

As discussed in Chapter 3, most workforce data used for higher education planning is reactive. Institutions seek evidence to explore a perceived need that is identified by faculty members, employers, or students. We recommend that the state and institutions shift some efforts toward proactive data use through regular strategic planning. By more systematically and regularly analyzing workforce data, the state and institutions may be able to identify unmet needs earlier and can mobilize resources to meet those needs. For example, the THECB could develop a priority-setting process based on fields of study with critical statewide or regional shortages. To address these shortages, it may be appropriate to provide institutions with extra support to start or expand programs. Such efforts could support requests to the state legislature for supplemental funding to defray some costs in starting or expanding programs.

The supply and demand matrices presented in Chapter 4 provide a useful strategic planning tool that can be used to identify occupation groups with unmet regional and statewide workforce needs. This tool must be complemented with discussions with industry representatives, and potentially with additional sources of statistical data, to validate their indicators.

Provide Guidance to Institutions on Appropriate Data Use

In our interviews, we found that some institutions appear to have robust and well-documented planning systems using multiple sources of workforce information. It might be useful to draft a specific practice guide drawing on institutions that have already documented their internal processes for using information sources

and reviewing proposals, or to otherwise highlight the best practices of institutions. It also is important to ensure that all institutions are aware of the data resources that are available. With a single website with links to the available data sources and descriptions of important issues in using them, all institutions would be able to more easily access the resources suggested as useful for workforce analysis.

In some cases, it may be important to extend beyond guidance, with the state setting requirements for how workforce data should be used. For example, in the program-approval process, wide variation in the data resources used has made it challenging for the THECB to validate and assess the evidence provided. If institutions were required to provide data from a common set of resources, they would be less likely to select only data that support their proposal. This approach would also help the THECB build expertise with specific data resources and validate the evidence provided in proposals.

Recommendations to Enhance Data Resources

Develop Approaches to Systematically Engage Employers

Several institutional representatives we interviewed, particularly those from community colleges, are regularly and systematically engaging employers and industry experts. Figures 4.1 and 4.2 show the importance of such discussions to inform several stages of both stock and flow models. However, several stakeholders suggested that assessing employer perspectives can be challenging, and a better system for incorporating this feedback into strategic planning around higher education is needed. In addition, while the process of employer engagement typically begins in reaction to a previously identified need and the initial development of a new program, there is value in making these interactions more regular. Texas State Technical College's C4EO and the tools it is developing are one possible approach to more systematic employer engagement. The state may want to explore how to increase the use of these tools by institutions across the state. While the center's tools do not currently provide a means to directly identifying unmet workforce needs in a particular region, their approach to gathering employer input could be adapted for these purposes.

Identify Strategies to Explore Emerging Trends

Large-scale public data sources take time to update. Institutions worry that these sources cannot inform them about current trends, especially for applied programs that would link closely to local employers with changing occupations or emerging industries. Job posting data, available through commercial services, may provide the most efficient method of getting data on these emerging industries and occupations. Direct engagement with employers and tools to systematically solicit employer input may be useful in identifying emerging trends. It also may be worthwhile for institutions to collaborate or for the state to spend some resources occasionally to describe emerging industries, with a focus on the skills and competencies that higher education institutions could deliver to meet these emerging needs.

Assess Existing Capacity

The final stage of both stock and flow modeling requires assessment of capacity to produce graduates with appropriate degrees and fields of study to meet identified occupational needs. Several institutions cited difficulties in assessing the level of capacity at other institutions in their region to address a particular workforce need. These difficulties stem from lack of information on program capacity and from variation in programs across institutions that make it hard to judge which can serve particular needs. If feasible, collecting information on program capacity periodically can help simplify institutional planning and discourage duplicative efforts. Some institutions suggested standardizing program offerings across the state, although such a policy could potentially hamper institutions' ability to meet local needs.

Provide Access to Major Data Resources

As described in Chapter 2, several vendors provide tools that could be useful to institutions and the state, as they increase the use of workforce data for planning. While these vendors are used by some institutions in the state, they are not used by all, perhaps because of their cost. The THECB may wish to explore whether there are more cost-effective ways to achieve statewide access to these tools.

APPENDIX A

Workforce Modeling Approaches

One of the goals in workforce planning is to close any gaps between the demand and supply for workers. Broadly speaking, the techniques used in workforce analysis (i.e., estimating workforce demand and workforce supply) can be categorized into economic and non-economic approaches. Economic approaches model the labor market by estimating supply, demand, and wages simultaneously. Non-economic approaches, on the other hand, estimate the supply of workers and demand for workers separately. Besides estimating the supply and demand for workers, workforce analysis for higher education program planning requires linking the results from the workforce analysis to higher education programs. It is this requirement that may drive the applicability of the various modeling techniques that are available within these two approaches.

As we discuss in Chapter 2, there are a number of publicly available data sources that provide information on the demand for positions in occupations and the supply of workers or degree holders than might fill these positions. But quantitative modeling approaches still face important challenges in measuring and forecasting relationships in the labor market. To help frame the discussion of modeling approaches, we identify five desirable characteristics of a quantitative model that would be useful for degree program planning purposes. Such an ideal model would:

- use data sources that provide detail on specific occupations;
- use data sources that provide detail on specific postsecondary education programs;
- rely on data sources that are consistently available;
- follow a standardized approach; and
- allow analyses for geographic regions within the state, potentially including regions surrounding individual higher education institutions.

Existing approaches typically cannot meet all of these ideal characteristics, but we use these five characteristics to review some of the commonly used approaches described on the following pages.

Economic Theory Approaches

Economic theory approaches are distinguished by using wage data in addition to supply and demand data. There are two commonly used methods under this approach. The first method attempts to model dynamics of the entire labor market. The second one tracks observed labor market indicators that are expected responses to certain labor market conditions.

Modeling Labor Market Dynamics

In this framework, the labor market is represented by workers (supply) and employers (demand) that respond to a set of factors such as changes in technology, attitudes toward work or population, and where the supply and demand of labor are a function of wages (the price of labor). Worker needs are identified when, at the given market wage, the number of workers that employers need or are willing to hire (quantity demanded) is greater than the number of workers available or willing to participate in the labor market (quantity supplied).

Structural models use this framework to capture supply and demand adjusting to shortages or shocks by establishing assumptions on a set of parameters (e.g., job creation, mobility of workers, substitutability among different types of workers) that are important determinants of the labor market (see, for example, Blanchard and Katz, 1992; Elsby et al., 2011; Fair and Jaffee, 1972; Heckman, Lochner, and Taber, 1998; Lane and Gohmann, 1995; Lee, 2005; Lee and Wolpin, 2006, 2010; Shimer, 2007). There are three main advantages to these models. First, they yield results based on a theory of the relationship between supply and demand. Second, they allow for rigorous and repeatable analysis of current and future shortages. Third, they are dynamic and can incorporate geographic or occupational mobility.

The econometric techniques used to estimate these models require large and detailed datasets representing individual workers. Attempting to estimate these models in terms of regional geography often results in sample sizes that are too small, so they are usually aggregated to the state or national level.

Tracking Labor Market Indicators

Another economic technique tracks certain labor market indicators for evidence of tightness or imbalance between supply and demand. Economic theory suggests that in a labor market responding to changes in prices, a gap in supply and demand should push relative compensation up as the market adjusts (Mortenson, 1986; Rogerson, Shimer, and Wright, 2005). Thus, one technique to investigate workforce needs has been to observe changes in wages over time in certain occupations or fields of study (Autor, 2010; Sirkin, Zinser, and Rose, 2013; Holzer, 2013; Levine, 2013; Sullivan, 2012). Another indicator that has been used is average weekly work hours; under tight labor market conditions, employers may increase hours for workers to compensate for the added workforce need (Levine 2013). Similarly, other studies use indicators such as unemployment, employment, job vacancies and the time it takes to fill a position, or "hot jobs" to identify areas of potential need, with the assumption that there is more likely to be workforce needs when demand is growing rapidly (Blanchard and Portugal, 2001; Benson, 2011; Bleakley, Ferris, and Fuhrer, 1999; Ghayad and Dickens, 2012; Daly et al., 2012; Davis, Faberman, and Haltinwanger, 2006; Diamond, 2013; Faberman and Mazumder, 2012; Hall, 2003 and 2005; Lazear and Spletzer, 2012; Levine, 2013; Rothstein, 2012; Sahin et al., 2012; Shimer, 2005).

The availability of labor market indicators that have been consistently captured over long periods of time makes the implementation of this technique practical for many. However, in many cases, their applicability is limited to aggregate measures—state- or country-specific—that simplify the underlying mechanism, which require careful characterization of results. Consider the case of using a low unemployment rate as an indication of a workforce need. This measure alone includes qualified and unqualified candidates that may be voluntarily or involuntarily unemployed, so it may be overestimating the true availability of the qualified workforce. Similarly, a wage measure may respond not only to supply and demand but also to other policies (e.g., family leave policies). While analysis can be conducted at an industry or metro-area level, and for certain occupations or fields of study, use of this method requires careful characterization of the results.

Non-Economic Approaches

Non-economic approaches compare measures of supply and demand. We divide these into two methods. The first, quantitative approach, use proxies of supply or demand to project workforce needs and requirements based on a set of assumptions and various sources of data. The second method, descriptive analysis, tracks indirect measures of workforce needs—typically through employer-based surveys.

Quantitative Approaches for Estimating Workforce Demand and Supply

In this section, we discuss some of the commonly used modeling techniques to estimate workforce demand and supply. These are target-setting, utilization (or demand-based), ratio analysis, and needs-based. These methodologies are commonly used in healthcare workforce planning (Dreesch et al., 2005; HHS, 2013; WHO, 2010; AAMC, 2012). Except for the ratio analysis, these methods estimate the number and types of services that are required at particular points of time. These estimates can then be converted into workforce requirements.

Generally speaking, the difference between these methods lies in how they identify workforce requirements or needs. The target-setting method estimates workforce requirements based on previously identified targets and productivity measures (e.g., Scheffler et al., 2008). The utilization method uses observed levels of service utilization in relation to future projections of population profiles (e.g., Lee et al 1998). The ratio analysis method uses a desired ratio which is then applied to population projections to estimate the workforce size required to serve the projected population (Fallacaro, 1997; Stewart et al., 2013). The needs-based approach is based on anticipated service utilization and population needs (Schmitz, Lantin, and White, 1999; Staiger, Auerbach, and Buerhaus, 2009). Some of these studies use particular primary or secondary data sources to estimate workers needed, but others rely on hypothetical scenarios, assumptions based on professional judgment, or patterns of use to estimate future need for workers.

Conceptually, these methodologies can be applied to a local setting, but doing so requires detailed data for key components that are either unavailable or not consistently captured across institutions or regions. As noted earlier, existing data sources may not capture all sources of changes in supply or demand in one region. An accurate implementation of these techniques would incorporate decisions to participate in the labor force, as well as workforce movements in and out of occupations and regions. Such data requirements mean workforce analysis often focuses on occupations (such as nursing, as noted earlier) that require specific degrees. As a result, these methods cannot be generalized to occupations where many pathways may prepare new entrants, or where there is significant mobility in and out of the occupation.

There also are other techniques that use regression analysis methods to account for unanticipated factors that affect the demand for or supply of labor. Within these, there are two major types of regression techniques: time series methods and cross-sectional methods. Cross-sectional methods model an outcome of interest as a function of other variables observed at the same time, as well as a random disturbance term (e.g., Scheffler et al., 2008, use economic indicators to control for other economic conditions that can affect demand).

Time-series methods forecast the future value of the outcome of interest (e.g., distributional occupations) based on past values of that outcome, as well as on past values of random disturbances. This method has been used by the BLS (Lacey and Wright, 2009) and others (MHEC, 2008; Freeman, 2006). It involves linking the source of education or training to each occupational level based on observed entry-level requirements. Such entry-level requirements are assumed to be constant over time, but this is often not true (Hartog, 2000; Lemieux, 2000; Vaisey, 2006; Harrington and Sum, 2010; Beaudry et al., 2013; Liu and Grusky, 2013; Vedder and Robe, 2013). Recent methodologies therefore account for changes in entry-level requirements (Carnevale

et al., 2010), as well as demographic changes (Neumark, Johnson, and Cuellar Mejia, 2013).[2] While these methodologies address changes in occupational and training requirements over time, the derived estimates are aggregated at general educational levels of attainment (e.g., bachelor's degree, high school diploma) and thus do not provide information that can be used for educational program planning in specific fields of study. There is some recent work by Zhang, Stevens, and Li (2014) on Maryland and Loritz et al. (2013) on Wisconsin that identifies workforce needs at the program level, but the work focuses only on certain occupations, whose occupational requirements the researchers assume do not change over time.

These methods often require making assumptions about the comparability of estimates of supply and demand that are derived from data sources with different measurement approaches. For instance, demand estimates may be derived from sources that measure positions, while supply estimates may come from sources that measure workers. These methods are generally implemented at state and national levels, because they do not account for occupational or geographic mobility, which is significant especially over smaller geographic regions.

Descriptive Analysis

This technique collects perspectives of employers to identify workforce needs. It asks human-resource and workforce-planning executives about their experience filling positions and their opinion on workforce preparedness. Most of these studies are surveys on the impact of skill shortages for business operations in certain industries or occupations (for example, CTIA, 2012, and Rasouli et al., 2012, focus on information technology; Deloitte Development LLC and The Manufacturing Institute, 2011, and Sirkin, Zinser, and Rose, 2013, focus on manufacturing; McGraw-Hill, 2012, focuses on construction; Atkinson, 2005, focuses on public power) or on the economic outlook in the United States and other countries (Dobbs et al., 2012; Manpower, 2014; PWC, 2012). Other studies provide employers' opinions on how well the educational system prepares workers for the job market (Harris Interactive, 2013; HRPA, 2010; CHE, 2012).

In general, these studies gather employer perspectives regarding the stock of workforce supply and demand. While their sampling methodologies limit the generalizability of their findings, some of these studies can provide insights for workforce analysis as they draw on local, institutional, industry, and more current information. They highlight core fields of study, such as mathematics, that can be developed (CHE, 2012; CTIA, 2012; Deloitte Development LLC and The Manufacturing Institute, 2011) or identify specific occupations, such as welders or engineers, for which there is workforce need in specific geographic areas (Deloitte Development LLC and The Manufacturing Institute, 2011; Sirkin, Zinser, and Rose, 2013). However, there are a few disadvantages to this approach. First, as noted, their survey methodologies are not representative of all employers, and the questions are not comparable across studies. Second, except for the *Chronicle of Higher Education's* survey (2012, p. 67) that matches majors of interest to specific industries, none of these surveys provides information on educational programs across occupations.

Summary

Although there are many public sources of data, and a number of techniques to collect and analyze specialized data, constructing accurate and useful models of workforce supply and demand is a very challenging endeavor.

Table A.1 summarizes commonly used methods for analyzing data on workforce needs and technical considerations associated with them, following the five criteria we framed in this chapter. Methods that rely on large-scale public data sources typically offer general indications about labor market needs at the state

2 Capelli (2014) provides a summary of the debate surrounding skill shortages, skill gaps, and skill mismatches.

level and by broad degree level. Methods that are suitable for analyzing regions within a state and linking to detailed degree programs largely rely on data sources specific to the field of study and may require data to be collected specifically for each occupation or field of study. There is a tradeoff between (1) more standardized methods relying on well-established datasets but producing quite general findings; and (2) customized methods that require detailed new data collections to generate insights for specific fields.

Table A.1. *Summary of Modeling Approaches*

Methods	Data Typically Available				Standardized Approach
	Occupational Details	Educational Program Details	Consistent Data	Regional or Institutional Analysis	
Labor Market Models	Usually not	Usually not	Difficult to obtain	Usually not	Yes
Labor Market Indicators	Focus on certain occupations	Only when clear link from education to occupation	Consistent, long series	Usually not	Somewhat standardized but requires careful interpretation of individual indicators
Estimating Supply and Demand Separately	Yes, but some may be limited to certain occupations	Limited to certain degrees or general educational level	Variety of data are available	Usually not	Usually specific to a field; some methods are standardized
Descriptive Analysis	Yes	Yes	Small, inconsistent samples	Yes	Not comparable across fields

APPENDIX B

Computation of Standard Errors

The ACS provides sampling information and sample weights for each observation, which we use to compute the standard error of each population estimate.

To compute the standard errors of the supply growth rates, we proceed as follows. Let $Y_1 \ldots Y_6$ be the six estimated annual total number of workers in a given occupation group, and $S_1 \ldots S_6$ be the corresponding standard errors of $Y_1 \ldots Y_6$.

The change rate between any two adjacent estimated totals is given by:

$$D_i = \frac{Y_{i+1} - Y_i}{Y_i}, i = 1 \ldots 5$$

Because the ACS three-year file refreshes only one-third of the observations each year, two adjacent files will have two-thirds of observations in common. Therefore, the correlations between adjacent estimates, $\text{cor}(Y_i, Y_{i+1}) \approx 0.6$.

By the delta method, the standard error of D_i, denoted by Q_i, is approximated as:

$$Q_i = \sqrt{\frac{S_{i+1}^2}{Y_i^2} + \frac{Y_{i+1}^2 S_i^2}{Y_i^4} - \frac{1.33 S_i S_{i+1} Y_{i+1}}{Y_i^3}}$$

The average change rate among five changes rates (all in adjacent pairs of years) is:

$$\Delta = \frac{1}{5} \sum_{i=1}^{5} D_i$$

There is no need to account for correlation among the rates of change because these rates are very weakly correlated, so the standard error of Δ can be approximated by:

$$\text{SE}(\Delta) = \frac{1}{5} \sqrt{\sum_{i=1}^{5} Q_i^2}$$

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