

# Projecting the Supply of and Demand for Middle-Skill Occupations in Local Areas:

## A Review of the Literature

Dr. James Orr  
June 4, 2017

### Abstract:

Community colleges and workforce development providers face the ongoing challenge of aligning their training efforts with the skills employers demand most. Middle-skill jobs, defined in the literature as those requiring additional education or training beyond high school but less than a bachelor's degree, are a particular focus of these providers. This review surveys the methods used in projecting supply and demand for middle-skill occupations in the aggregate and in four local areas—Wisconsin, Texas, the Greater Houston metropolitan area, and a 10-county region in Western New York State. Local area supplies of middle-skill workers are typically defined as the number of workers who recently completed appropriate education and training programs in institutions located within the geographic scope of the local labor market. Demand for middle-skill occupations at a local level are generally based on U.S. Bureau of Labor Statistics (BLS) long-run occupation demand projections and online job advertisements. The studies offer several options for characterizing middle-skill mismatches in local areas, ranging from strict numerical differences between projected supply and demand to a comparison of supply and demand growth rates.

This review is being submitted as part of the Study of the Supply of and Demand for Middle-Skill Workers in New York City, conducted by the New York City Labor Market Information Service (NYCLMIS) at the City University of New York Graduate Center. The study is due for release in the summer of 2017. The study is supported by the New York Community Trust, the New York City Workforce Funders, and the New York City Workforce Development Board. The author would like to thank Lesley Hirsch, Ofronama Biu, Kasey Zapatka, Pam Hoberman, and Alison Richardson of NYCLMIS for helpful comments. The author would also like to thank the members of the study's Technical Advisory and Stakeholder Advisory groups, and Jaison Abel, Richard Deitz, Donghoon Lee, Roy Mars, Todd Oldham and Joseph Salvo for helpful comments.

## Table of Contents

I.	Introduction .....	1
II.	Defining Middle-Skill Occupations.....	2
III.	Defining Middle-Skill Supply and Demand Imbalances.....	4
IV.	Projecting Middle-skill Occupational Demands and Supplies: Aggregate Studies .....	6
V.	Projecting Middle-skill Occupational Demand and Supplies: Local Market Studies .....	7
a.	Projections of middle-skill occupational demand and supply: <b>Wisconsin</b> .....	8
b.	Projections of middle-skill occupational shortages: <b>Texas</b> .....	9
c.	Projections of middle-skill occupational demands and supplies: <b>Western New York State</b> .....	11
d.	Projections of occupational demand and supply: <b>Houston metropolitan area</b> .....	12
VI.	Summary and Implications for the New York City Labor Market Study.....	13

---

## I. Introduction

Aligning training efforts with skills that are most in demand by employers is an ongoing challenge faced by workforce development providers. For local areas, getting the training mix right helps to ensure that job opportunities do not go unfilled and that the market is not over-supplied with too many eligible job seekers for too few jobs. Middle-skill jobs are particularly important as they typically require some education and/or training beyond a high school diploma (or its equivalent) but less than a bachelor's degree, and usually offer workers better pay and better chances for advancement within a career than low-wage jobs requiring less skill.<sup>1</sup>

Matching middle-skill occupational demand and supply in a dynamic local market requires information on how the demands of employers are growing and evolving. Middle-skill development programs need to address current demand as well as anticipate how this demand is likely to change over time. Middle-skill supply projections require information on the extent to which workers will enroll in and complete relevant training programs or migrate to take advantage of job opportunities. A number of workforce development organizations have adopted various means to help identify potential mismatches and to characterize them in a way that informs programs or funding.

The New York City Labor Market Information Service at the City University of New York Graduate Center (NYCLMIS) is studying the supply for and demand of middle-skill workers in New York City. The study intends to help the City's workforce providers, specifically secondary and postsecondary educational and training institutions, make more informed decisions regarding their use of educational and training resources. Ensuring an appropriate supply of middle-skill workers for particular occupations in demand will help more segments of the population fully participate in the local labor market.

As part of that study, this report reviews the methods that are currently used to assess demand and supply conditions for middle-skill occupations in local labor markets. The focus is on data-driven tools to measure conditions in the market for middle-skill workers both in the near-term and long-term. This review follows the outline of most studies of the middle-skill occupational market. It begins with a review of the various ways that middle-skill jobs are defined. The review then briefly discusses the concepts of skill shortages and surpluses and how they have been applied in empirical labor market studies. This review introduces the various models that project middle-skill occupational supply and demand, focusing first on aggregate projection methods and then on local area projection methods, while drawing on the experiences of four large regional labor markets: two states (Wisconsin and Texas), the Houston metropolitan area, and a 10-county area in western New York State. The methodologies underlying each set of projections are compared with an emphasis on how they address several important conceptual and measurement issues. A final section summarizes the findings and outlines the implications for the New York City middle-skill jobs study.

---

<sup>1</sup> This report uses the term "skill" in the same sense as credential.

---

## II. Defining Middle-Skill Occupations

Educational attainment of the workforce, relative occupational wage levels, and descriptions of the knowledge and skills required to perform job tasks, among other factors, are often used to delineate a set of high-, middle-, and low-skilled occupations. The adopted definitions vary and reflect the specific objectives of the studies and the availability of data.

- **Educational Attainment.** Because skills need to be learned, a starting point for considering occupations as middle-skill is a measure of the level of education or training required to perform the job. The Standard Occupational Classification (SOC) system developed by the U.S. Bureau of Labor Statistics (BLS) classifies all workers into occupations by similarity in their duties as well as by the level of educational attainment, skills, and training required to perform the job.<sup>2</sup> The methods that are used to project middle-skill occupational supply and demand are typically applied to the 890 six-digit SOC categories.<sup>3</sup>

The educational attainment of the workforce in each occupation is captured by two measures. The first measure is an assignment by the BLS to one of eight educational attainment levels required for entry into each occupation.<sup>4</sup> The second is the distribution of the observed educational attainment of the workforce in each of the occupations. That latter measure uses the American Community Survey (ACS) to identify the shares of workers both in national and in sub-national areas according to the educational attainment of workers in each occupation.<sup>5</sup> Researchers using the former measure typically define middle-skill jobs as those requiring more than a high school diploma (or its equivalent) but less than a bachelor's degree. The second measure requires that researchers first specify a level of educational attainment for workers in middle-skill jobs. Then, researchers select a minimum share of workers in the occupation with the appropriate level of educational attainment.

- **Wage levels.** Wages are presumed to reflect the return on skill. Autor et al. (2010), Abel and Deitz (2012), and Holzer (2015) have defined middle-skill occupations as those occupations making up roughly the middle third of the distribution of earnings. However, wages and earnings can vary across occupations for reasons other than differences in education or training—for example, employers may increase wages to attract workers to perform high-risk tasks or to overcome a labor shortage. Moreover, studies using relative wages or earnings to define middle-skill occupations have been concerned more

---

<sup>2</sup> See <http://www.bls.gov/soc/>.

<sup>3</sup> The BLS also aggregates these 890 occupations into 461 broad occupations and 23 major occupational groups. For example, in the healthcare field, radiation therapists are classified in SOC 29-1124, in broad group 29-1120 Therapists, and in major group 29 Healthcare Practitioners. See <http://www.bls.gov/soc/>.

<sup>4</sup> The eight degree levels are Doctorate or Professional degree, Master's degree, Bachelor's degree, Associate degree, Post-secondary non-degree, Some College, High School diploma (or its equivalent) and no formal educational requirement.

<sup>5</sup> The ACS educational attainment data are reported for 530 occupational categories which can be concorded to the occupational categories in the BLS data. See: <https://www.census.gov/programs-surveys/acs/>.

---

with how employment and wages in this group of occupations have shifted over time rather than linking middle-skill occupations to specific education or training programs.

- **Knowledge, skills, and abilities.** A third focus of middle-skill occupational studies focuses on the knowledge, skills, and abilities that are required to perform on-the-job tasks. This approach avoids relying solely on the educational background of the current workforce within an occupation. Autor et al. (2003), in a detailed study of how the computer has changed the nature of work, used task descriptions in the Dictionary of Occupational Titles (DOT) to categorize occupations as made up of routine or non-routine tasks and of cognitive or non-cognitive skills. Middle-skill occupations were defined as those requiring the performance of a large share of routine tasks, both “non-cognitive” and “cognitive.” While this approach has the merit of looking at what workers actually do on the job, it does not lend itself readily to identifying specific education or training programs at a local level.

Data from the Department of Labor sponsored Occupational Information Network (O\*NET) builds on the DOT data and specify the required entry-level educational attainment and preparation; the mix of knowledge, skills, and abilities required on the job; as well as the variety of activities and tasks performed on the job.<sup>6</sup> For example, there are six categories of required skills—basic, complex problem solving, resource management, social, systems, and technical. Analysts rate these skills for specific occupations in accordance with the required level and importance. O\*NET data have been used in several recent studies. Handel (2009) uses O\*NET data on a highly aggregated group of occupations to describe the process of skill upgrading across 24 Organization for Economic Co-operation and Development (OECD) countries. His results point to the growing importance of educational, cognitive, and interpersonal skills across occupations and the general decreasing importance of craft skills. Rothwell (2015) defines a group of advanced technical occupations by combining a workforce’s educational attainment within an occupation with detailed O\*NET data on several areas of scientific and technical knowledge that are required to perform their job. While O\*NET data allow for a complex, multi-dimensional approach to occupational skill classifications, an important step would be a more systematic integration of the O\*NET database into definitions of middle-skill occupations.

Recent studies have noted two dynamic features associated with middle-skill occupations. First, education and experience requirements change over time, and the evidence suggests that *upskilling* has been taking place within many occupations. Predicting how these requirements will change is difficult; however, and most studies that project demand for and supply of labor to middle-skill occupations do not address changing skill requirements.<sup>7</sup> A study by Neumark et al. (2012) looks for evidence of changing skill requirements by comparing the distribution of educational attainment in the current workforce as described by the ACS to the distribution in prior years and to requirements of newly listed jobs.

---

<sup>6</sup> <http://www.onetcenter.org/overview.html>.

<sup>7</sup> In addition to secular trends, Modestino (2014) describes some significant cyclical features of this occupational upskilling.

---

Second, the recent discussions of job polarization show a decline in the share of middle-skill occupations in total employment over the past few decades due to outsourcing and the automation of routine tasks.<sup>8</sup> Nevertheless, using definitions based on educational attainment, Modestino (2015) estimates that about one-third of all jobs can still be considered middle-skill. A useful classification of these middle-skill occupations by Holzer (2015) distinguishes between those jobs that are *older middle*—or jobs in clerical, support, or assembly work that have seen demand reduced over the past few decades—and jobs in the *newer middle*—or those occupations that are experiencing relatively rapid growth such as healthcare and installation, and maintenance and repair. These latter jobs require relatively more postsecondary education and technical skills as well as face-to-face interaction. This distinction points to occupations in important segments of the middle-skill labor market where ongoing increases in the supply of trained workers is needed to keep pace with demand.

### III. Defining Middle-Skill Supply and Demand Imbalances

Although a number of meanings have been attached to the term *skill imbalances*, the standard textbook definition refers to a market in disequilibrium at a particular point in time, that is, when the demand by firms for workers with particular skills is not matched by an equivalent supply of trained individuals available to work at the current market wage.<sup>9</sup> Shortages refer to market situations where the quantity of skills demanded is significantly above the quantity supplied. Markets with shortages are characterized by high job vacancies and low unemployment; markets with surpluses are characterized by low job vacancies and high unemployment. In a more dynamic view, a shortage (or surplus) occurs where the growth in the demand for a particular skill increases (or declines) over time at a rate above (or below) the growth in the supply of the skill. Arrow and Capron (1959) used this definition to define market shortages for scientists and engineers. This dynamic shortage concept describes a market where supply has to continually adjust to meet demand.

Market conditions are assumed to be temporary, and markets are assumed to eliminate these imbalances. While wage adjustments are emphasized as the main equilibrating mechanism, Froeschle (2014) and Barnow et al. (2013) outline a broader set of adjustments in local area middle-skill occupational markets, including firms expanding the geographic scope of recruiting efforts, increasing overtime hours, investing in new equipment, providing on-the-job training, and reducing minimum entry level qualifications. The supply of workers can also change with in-migration, increases in labor force participation, and transfers from occupations utilizing similar skills. These adjustments provide a potentially rich set of indicators of actual or impending shortages though the relatively severe data requirements have limited the extent to which studies have estimated a full range of impacts.<sup>10</sup>

A second class of models presented in recent labor market studies by Sahin et al. (2014), Elsby et al. (2014), and Daly et al. (2012) use the term *skill mismatches* to emphasize the job search

---

8 See Autor, Levy and Murnane (2003) and Abel and Deitz (2012).

9 Several uses of the term skill shortage are discussed in Vineri (1999).

10 See Lane and Gohmann (1995) and Hanel, Kalb and Scott (2012) for models of the role of wages in the adjustment of skill supply and demand in the market for nurses.

---

behavior of workers and firms. Not all unemployed workers readily find suitable jobs and not all firms readily find qualified workers; therefore, at any time, both unemployed workers and job vacancies will be observed. Historically there has been a stable inverse relationship between the unemployment rate (U) and the job vacancy rate (V) over the business cycle, described as the Beveridge Curve. Evidence of a shortage of appropriately trained workers is the shifting in the V/U ratio for particular skills, or a higher vacancy rate for any given unemployment rate. This shifting can be the result of either a mismatch between supply and demand for skills or a mismatch between the geographic location of the demand for skills and the location of the available supply of skills. Data to implement this approach for a highly disaggregated set of occupations in a local labor market are generally not available. However, the data on job postings in local areas go some way to capture the number of vacancies and could be combined with information on the occupations of the unemployed as one measure of mismatch at the broad occupational group level.

There are two relevant market situations where surpluses and shortages may persist despite adjustments. One example is a situation where the demand for workers in an occupation is not entirely market determined. This can be observed in cases where the demand is based on a *population's service needs*, i.e., markets where the demands for workers bears a fixed relationship to the number of people being served or to a specific feature of the population being served. One example of this is a study of the demand for physicians, conducted by Staiger et al. (2009), where population projections were combined with specific targets for physicians/population ratios in order to project the demand for physicians.<sup>11</sup> The market for special education teachers has also been analyzed using a similar service needs approach in Barnow et al. (2013). These demand measures have been used to characterize areas as being under- or over-served in some capacity.

Another model, which is most relevant to labor market shortages is that of a monopsony market, or a market with only a single buyer of skills. Unlike a “perfectly competitive” market where employers are assumed to be able to hire as many workers as they demand at a single market-determined wage, an employer in a monopsony market is assumed to have to raise the wage offered in order to attract more workers. As a result of these rising costs of expanding employment, staffing levels are below what they would be if a firm were in a perfectly competitive market. The models, discussed by Barnow et al. (2013), are typically used to characterize big firms in relatively small or isolated markets, though they could characterize markets with one buyer of a particular skill. The resulting situation is not a shortage in the textbook sense, but as noted in Modestino (2015) could lead firms to consider the constraints on hiring as a shortage.

Finally, models assume adjustment takes place in a situation of perfect information on the part of workers about occupational market developments. However, in considering supply adjustments Jacobson and LaLonde (2013) argue that the efficiency with which workers make sound investments in acquiring new skills is significantly influenced by the amount and quality of the information they have regarding market demand and the features of training programs. Accurate information about opportunities, including wages, benefits, and, importantly, what types of

---

<sup>11</sup> Some healthcare occupational demand is modeled using these indicators of services need.

---

workers have successfully transitioned into the occupation would help workers evaluate the costs and benefits of enrolling in the program and reduce the considerable risks associated with making these investments. Jacobson and LaLonde offer several ways public agencies can provide that information.

#### IV. Projecting Middle-skill Occupational Demands and Supplies: Aggregate Studies

Broad population and educational trends have motivated a number of studies examining the potential for middle-skill surpluses and shortages to develop at an aggregate level. For example, a study of the national labor market by Neumark et al. (2013) focused on the retirement of the relatively large and highly-educated baby-boom cohort. As these workers leave the labor market over the coming years the key policy question has been, “will the retirement of this relatively highly-educated cohort lead to skill shortages?” Skill imbalances have been addressed with models that use educational attainment to proxy for skill levels, and then project separately the demand for and supply of categories of workers with different skills.

Projections of the future demand for workers with different levels of education are derived from the BLS occupational employment projections.<sup>12</sup> These 10-year projected job openings are computed every two years and are calculated to account for change due both to new jobs and to retirements. Beginning in 2017, BLS will also include openings due to churn, or turnover. The share of workers with different levels of educational attainment in each occupation are then applied to the projections of occupational employment levels to arrive at the aggregate demand for workers with different levels of educational attainment.<sup>13</sup>

The supply of workers by educational attainment level is derived from a cohort-component model of population growth that essentially ages out older cohorts of workers and ages in younger cohorts. Current and future population levels are computed by age, gender, race, and nativity, with future supplies of education reflecting educational attainment trends within and among cohorts.

Both Neumark et al. (2013) and Modestino (2015) are two studies that use this methodology. The former, as noted above, examined the adequacy of the supply of educated workers through 2018 while the latter looked specifically at the future demand and supply for middle-skill workers. Both studies base their demand estimates on BLS occupational demand projections and use ACS data on the observed educational distribution of occupations to derive estimates of future educational demand and supplies. Neumark also uses ACS data to project trends in the educational demands of occupations and in the educational attainment of cohorts of workers. Adjustments in these models that are based on past trends in educational attainment, however, do not account for the full range of preferences and constraints that underlie occupational choice, schooling, immigration and migration, as well as labor force participation decisions.<sup>14</sup>

---

<sup>12</sup> See BLS (2013). A step-by-step presentation of the methodology is available in Modestino (2010).

<sup>13</sup> Both the empirically-observed distribution of educational attainment of workers in each occupation from the ACS and the educational attainment required to enter the occupation from the BLS have been used.

<sup>14</sup> Lee and Wolpin (2010) present a model of educational and occupational choice in their analysis of the rise of employment in the services sector.



---

These decisions represent a richer set of responses that would both influence and be influenced by the impending labor market imbalances.<sup>15</sup>

Comparison of educational demand and supply in Neumark et al. (2013) show little evidence of overall impending aggregate skill shortages over their projection horizons. For middle-skill workers, however, both Neumark et al. and Modestino find a large gap between the projected demand and supply. Modestino looks further into the set of occupations at the national level that utilize middle-skill workers intensively to suggest where developing imbalances might have their largest impact. Neumark et al. also point to the likelihood of high-skill shortages arising in states with relatively large proportions of less-educated workers, including California, Texas and Florida.

Variations of the cohort-component model have been used in other studies of skill supplies and demands. Modestino (2010) showed a potential for skill shortages to develop in New England and Johnson et al. (2015) projected an inadequate supply of future college-educated labor in California.

There is generally not a lot of detail in these models regarding the way in which the economy will evolve as imbalances between skill demands and supplies appear. As shortages or surpluses develop both employers and workers will make adjustments that, in theory, will work to bring markets toward equilibrium. As a result, these and other projections should be looked at as primarily identifying where imbalances between demand and supplies for particular skills are likely to develop.

## V. Projecting Middle-skill Occupational Demand and Supplies: Local Market Studies

A number of policy studies have been undertaken to help identify near-term and longer-term gaps between the demand and supply of middle-skill workers within a state or local area. The definition of the geographic scope of the local labor market is typically the state or the area for which policy makers have workforce development responsibilities. Demand is expressed as the number of current and projected job openings, defined to include new jobs and replacements of retirees. The supply of workers to those occupations is then projected and the gap between demand and supply is calculated.

The following sections present the methods used to assess demand and supply for middle-skilled occupations in two states, Wisconsin and Texas, in the Houston metropolitan area, and in a 10-county region around the City of Rochester in western New York State. Table 1, *Summary of Case Study Findings*, presents the basic approach and results of each study.

---

<sup>15</sup> Similar models of occupational demand and supply projections for the countries making up the European Union have been developed by Cedefop (2011), the European Centre for the Development of Vocational Training. These models have been augmented with modules that forecast the educational attainment and **labor force participation behavior of different cohorts of workers**.

---

a. Projections of middle-skill occupational demand and supply:  
Wisconsin

In light of concern about the potential for a skills gap to develop across the spectrum of skills in Wisconsin, a study of the demand and supply of skilled workers in the state was undertaken by Loritz et al. (2013). The study, prepared for the Wisconsin Legislative Council, an independent policy research organization, projected demand and supply conditions for selected occupations in the year 2020.

The study defined middle-skill occupations as those requiring an associate degree or postsecondary certificate and the set of occupations reviewed were roughly equivalent to those at the four-digit SOC level of aggregation. The authors limited their study to occupations with more than 5,000 projected new openings between 2012 and 2020. On the demand side, the Wisconsin Department of Workforce Development (DWD) provided projections of the demand by occupation in 2020.<sup>16</sup> Projected demand included both new openings and replacement for those permanently leaving the occupation. The DWD also assigned a required level of educational attainment for entry into the occupation. On the supply side, projections of the supply of middle-skill workers by occupation was based largely on the number of program completers from Wisconsin schools. Specifically, the supply of workers in 2020 was projected by assuming a continuation of the annual growth rate of the number of graduates from Wisconsin institutions in each occupation between 2000 and 2011. The Integrated Postsecondary Education Data System (IPEDS) data were used to measure the annual number of new graduates eligible to work in an occupation.<sup>17</sup> The authors used a crosswalk to link a student's major, as defined in the Classification of Instructional Programs (CIP) to the BLS SOC. As the authors note, it is possible for some educational programs to relate to multiple SOCs.

Several trend growth rates were computed in an effort to take account of the impact of the recession on employment levels resulting in upper and lower bound supply estimates for each occupation. The authors adjusted these occupational supply projections to account for outmigration and labor force participation rates of graduates. Specifically, they reduced the supply projections to account for the fact that roughly 67 percent of University of Wisconsin system graduates remain in the state after graduation, and used information from the BLS to reflect the labor force participation rates of graduates.

Overall, the results were consistent with the projection of a rough balance between demand and supply of workers in middle-skill occupations in the state in 2020.<sup>18</sup> The only reported projections of shortages for workers in high-skill occupations were for computer science, information technology, and elementary and high schoolteachers. At the middle-skill level,

---

<sup>16</sup> See Wisconsin Department of Workforce Development, Office of Economic Analysis, for the latest projections, available at: <https://dwd.wisconsin.gov/oea/>.

<sup>17</sup> IPEDS is a system of annual surveys conducted by the National Center for Education Statistics that collect data on enrollments and completions, among other information, at U.S. post-secondary educational institutions. See: <https://surveys.nces.ed.gov/ipeds/ViewContent.aspx?contentId=15>. The data have been collected since 1993 and participation is mandatory for institutions receiving federal aid under Title IV of the Higher Education Act of 2015.

<sup>18</sup> The authors note that their findings are not fully consistent with several other studies which found some evidence of impending skill shortages in some middle-skill occupations.

---

nursing aides were among the occupations projected to have a sizeable surplus of workers in the state in 2020.

Given the demand projections, the study's findings suggest only modest changes in the state's education and training agenda for producing middle-skill workers. However, the increases in supply that underlie many of the trend projections through 2020 will likely require a significant expansion in the capacity of education and training institutions statewide. Little information was reported on the ability of or cost to Wisconsin institutions of increasing that capacity to meet the projected growth in demand.

#### **b. Projections of middle-skill occupational shortages: Texas**

In May 2013, the Texas legislature passed a bill requiring the Texas Higher Education Coordinating Board (THECB), in conjunction with the Texas Workforce Commission (TWC), to report on future workforce needs in the state. As part of the requirements these organizations prepared a report that used the information on workforce needs to inform the development and expansion of the supply of post-secondary education programs. Going forward, all state program providers must use occupational demand and supply data to demonstrate the need to create new programs or to eliminate existing programs.

As discussed in Goldman et al. (2015) both near-term and longer-term models of occupational demand and supply provide relevant information for degree program planning in Texas. The near-term projections, or flow models, compare the demand for different occupations in the state and local areas with the current supply of workers receiving degrees or credentials allowing them to enter an occupation. The longer-term projections, or stock models, are similar to the models used in the Wisconsin study in that they quantify occupational demands and supplies over a longer-term horizon to identify potential imbalances.

The discussion in the report focuses on the implementation of these flow and stock models to identify gaps between the demand for and supply of middle-skill workers. For both models, the six-digit SOC occupations are grouped as high-, medium-, or low-skill based on the educational requirements reported by the BLS. Middle-skill occupations are identified as those that require postsecondary schooling or, where only a high school diploma is required, more than 65 percent of the workforce in the occupation in Texas have postsecondary schooling. The TWC also asks employers about their views on the educational requirements for middle-skill occupations, and in general are supportive of input from workforce professionals and employers throughout the process of identifying skill gaps.

Projections of current and future demand for middle-skill occupations are reported statewide and for 10 regions within the state are reported by the TWC. Demand growth is defined to include new jobs plus replacement demand. Demands at the six-digit level are aggregated into four-digit groups, and occupational groups with less than 1,000 workers in any region are excluded.

Supply projections for flow models are based on the annual number of workers completing formal training programs in Texas institutions. For each occupation, this projection is primarily computed from the annual number of degrees and certificates expected to be awarded to students currently enrolled in the different programs. Notably, the study emphasizes the need to gather data to better determine the capacity of training institutions in Texas to produce

---

additional graduates. The projections are limited to schools located in Texas and do not allow for in- or out-migration of students or possible upskilling of occupations over time.

The authors note several practical challenges in using the information on degree and certificate awards in projecting supply to an occupation. The information is typically taken either from records reported directly by post-secondary institutions in the state or from information on degrees and certifications available in IPEDS. These counts of degrees and certificates yield a quantitative estimate of the supply of workers to middle-skill occupations. However, IPEDS data only includes institutions that participate in student financial aid programs (e.g. Pell Grants), so the count may be incomplete. In addition, as was discussed in the review of the Wisconsin study, researchers must use a crosswalk to relate the major, as described in IPEDS' Classification of Instructional Programs (CIP), to the BLS Standard Occupational Classification (SOC). It is possible for educational programs to relate to multiple SOCs, i.e., a training program could prepare individuals for *multiple* occupations, not just one.

The study also cites the use of real-time job postings data as a source of occupational demand, which measure online advertisements of job vacancies and list the education, certification, and skill requirements of each position.<sup>19</sup> These data are updated daily and are available for national, state, and sub-state region; they are becoming increasingly utilized in analyses of labor demand, although this study sees their value more in linking individual occupations with postsecondary educational requirements.<sup>20</sup>

For the stock models, the number of workers supplied to different occupations is based on an extrapolation of the growth rate of the number of workers in the occupations over the prior ten years. The growth rate is taken from the ACS data on employment by detailed occupation, with the projections assuming that growth is some combination of program completers in institutions in the Texas, in-migration of qualified workers, and changes in the labor force participation. The authors note the difficulty of modeling these individual sources of supply and also note some lack of precision with these supply projections.

In this report, the authors do not present point estimates of their projections of occupational demands and supplies. Rather, because the projections of demand and supply were made separately from different data sources and there was no effort to equilibrate them at a particular projection horizon, the authors do not compute the numerical size of any occupational shortages or surpluses. The tool that the authors develop and present is a matrix of occupational demand and supply growth rates. Each occupation is represented on the demand and supply axes of the matrix by one of three categories—rapid, moderate, or slow. There is an “uncertain” category that includes occupations in which the size of the error of the projected growth rate of supply makes it difficult to assign the occupation to one of the three categories.

Potential shortages are presumed to occur in those middle-skill occupations where there is rapid growth in demand and less than rapid growth in supply. The analysis shows potential shortages

---

19 For examples of real-time job ads data, see <http://burning-glass.com/> and <https://hcexchange.conference-board.org/data/helpwantedonline.cfm>.

20 For a discussion of the sources and uses of real-time labor market data, see Dorrer at <https://www.luminafoundation.org/files/resources/using-real-time-labor-market-information-full.pdf>.

---

in construction trades, air transport workers, office supervisors, and sales representatives. Potential surpluses occur where there is low growth in demand and rapid growth in supply. These occupations include a number of manufacturing production occupations.

The authors note that that this formal modeling tool relies on a continuation of past trends and argue that it ideally should be used in combination with other information on occupational demand and supply, particularly the input of employer groups. A survey of employers could indicate the occupations where they see shortages or surpluses developing, and provide a detailed outline of the expectations of the capabilities of a worker completing a degree or certification program. Further, emerging growth occupations might be better identified from recent online job postings rather than past growth rates. Wage changes, job vacancies, and unemployment rates are discussed as potential candidate series for inclusion in a broader consideration of occupational imbalances, although no data on these series are presented.

### c. Projections of middle-skill occupational demands and supplies: Western New York State

Demand and supply projections for middle-skill occupations in the ten-county Finger Lakes region in Western New York State are reported by the Monroe Community College (MCC) Economic Development and Innovative Workforce Services group.<sup>21</sup> MCC is a major provider of postsecondary training in the region and this effort supports the mission of the group to promote technical and career education and to create a middle-skills pathways system.

Ongoing concern about potential skill shortages in the region led MCC (2015) to produce a report detailing demand and supply conditions in middle-skill occupations within a pre-determined set of five industries that are key drivers of the economy of the region: Advanced Manufacturing, Skilled Trades, Information and Computer Technology, Hospitality and Tourism, and Healthcare. The analysis led to a focus on a total of twenty three clusters of occupations across the five industries.

Middle-skill occupations were identified as those requiring some postsecondary education but less than a bachelor's degree. Demand projections are presented for six-digit SOC occupational categories within each cluster in the form of the annual number of job openings. The demand projections relied on proprietary employment data and included new jobs plus openings due to the ageing out of the current workforce. Data on occupational demands were supplemented with detailed information on the job requirements as reported on online job postings, as well as the distribution of wages of current workers in the occupation. Wage, knowledge, and skill indicators yield a rich set of information to jobseekers and program providers and were reported along with the demand projections. Estimates of the value to the worker of completing the occupational training program are reported together with estimates of the economic impact, or the "bang-per-buck," of each newly-filled job on the region's economy.

The projections of the supply of workers to these occupations are the number of program completers in each individual skill from the four area colleges with training programs in the region as reported by IPEDS. Program completers from outside the region are not included in the

---

21 The counties are Genesee, Livingston, Monroe, Ontario, Orleans, Schuyler, Seneca, Wayne, Wyoming and Yates.

---

projections of supply. The report focused on annual occupational demand and supply imbalances. Middle-skill occupational gaps were reported as the strict numerical difference between projected supply and demand.<sup>22</sup>

The results point to a number of occupations where the pipeline of program graduates will be insufficient to meet projected demands. Gaps are particularly large in several healthcare occupations including health information technology and nursing, and in hotel management, computer scientists, HVAC, and tooling and machining. Excesses of supply over demand were rare, and the findings suggest the region faces significant workforce training needs to maintain and expand economic activity.

#### d. Projections of occupational demand and supply: **Houston metropolitan area**

In response to concerns of business leaders in the area, the Greater Houston Partnership (GHP) (2014) undertook an analysis of the middle-skill segment of the Houston metro area labor market to determine if the area was producing a sufficient number of middle-skill workers to meet the demands of the regions' key employers. The GHP also wanted to help ensure that local residents were being appropriately trained to take advantage of the middle-skill jobs there were being created. The project initially defined this middle-skill segment, as in the other three areas reports reviewed here, as consisting of occupations requiring a high school diploma and some postsecondary education but less than a college degree. However, the project turned its focus to the demand and supply of middle-skill occupations in the area's five key industries—energy, construction, manufacturing, transportation, and healthcare.<sup>23</sup> To reflect the composition of occupations considered middle-skill within these five industries, the definition of middle-skill occupations for this project was changed to include jobs requiring a high school diploma and some degree of training or work experience.

The first step in the project was to compute a *Staffing Environment Indicator* for each of the (six-digit) occupations within these five industries. This indicator was designed to specify if an occupation faces an actual or potential shortage. It was based on a measure of wage pressures in the occupation and a demand/supply index computed from three variables—the recent growth in demand, the share of jobs in the occupation in overall local area employment, and recent changes in the share of overall employment. The relative value of the index indicated the difficulty in meeting the demand in the occupation and resulted in a set of 53 middle-skill occupations considered as hard-to-fill.

The study projected a total of 33,000 annual job openings across these 53 middle-skill occupations over the period 2012 to 2017. The openings included both new jobs and replacement of job leavers. The report estimated that about 12,000 of these annual openings had postsecondary educational requirements; it then focused on the adequacy of the supply of workers with the requisite educational credentials. The authors acknowledged that the supply of workers to meet these demands could potentially include workers in roughly similar occupations

---

22 Goldman et al. (2015) note, however, that a strict numerical comparison over a longer horizon might overstate the precision of the projections

23 The ten counties are Austin, Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, San Jacinto and Waller.

---

in the area as well as trained workers from outside the region. However, their projections of the supply of workers to middle-skill occupations was limited to IPEDs data on for-credit degree completions of postsecondary programs at nine community colleges in the region. Notably, the supply of workers to these occupations from other workforce training providers within the region was not readily available, and the authors felt a survey was needed to obtain this essential data.

The largest demands for middle-skill occupations in the Houston area were for construction workers, installation maintenance and repair workers, and workers in the health science career cluster. A comparison of the five-year demand and supply projections showed that the region was generally producing an adequate number of graduates across all high demand occupations outside of the healthcare sector. A closer look at the healthcare occupational cluster, one of the key sectors with postsecondary educational requirements, showed the demand for licensed vocational nurses, emergency medical technicians, and nursing aides outstripped the projected supply of these workers. Moreover, the supply of healthcare information technology and medical records workers, and medical assistants exceeded the demand.

## VI. Summary and Implications for the New York City Labor Market Study

The local area middle-skill occupational studies were intended to help shape the development of the skills of the local workforce to meet the demands of employers. Workforce developers clearly recognize that skill imbalances limit opportunities for residents to enter the workforce and build successful careers. As Cleary and Van Noy (2011) noted, however, in discussing the alignment of higher education programs with market demands efforts to align workforce training with the needs of employers at this time is more of an art than a science. With this in mind, the results of the studies reviewed here are designed as guides to help workforce developers identify specific middle-skill occupations where there is potential for shortages or surpluses to occur.

The four local area studies focused on highly disaggregated (six-digit SOC) occupational classifications. Middle-skill jobs were typically defined as requiring some education or training beyond a high school diploma but less than a bachelor's degree. The sources of information on the educational attainment required to enter the occupation included the BLS, the distribution of education in the ACS, and from proprietary data supplied by commercial firms.

Researchers undertaking a study in New York City can pursue a similar set of data sources. The assignment of the level of educational attainment required to enter an occupation in New York City, as with the nation, is available from the BLS. In addition, the City's large population and labor force yields a sample size of the ACS that allows for a description of the shares of workers with different levels of postsecondary educational attainment, and thus enables a definition of middle-skill occupations based on the educational attainment of workers currently employed. Differences in the educational distribution of the workforce in an occupation between New York City and the nation highlight the regional specializations within even these highly disaggregated occupations.

FIGURE 1. CONTRIBUTIONS TO PROJECTIONS OF OCCUPATIONAL SUPPLY AND DEMAND

	Measure	Sources
SUPPLY	Current and future students, trainees, and graduates/ program completers	IPEDS, ACS, Provider Surveys
	Unemployed, current employed, in-migrants	UI Claims and ACS
DEMAND	Current vacancies	Real-Time LMI
	Projected growth, retirement, turnover, replacements	BLS, NYSDOL Occupational Employment

The figure above presents the range of factors that were noted in the literature as potentially contributing to the projections of the supply of and the demand for middle-skill workers in local areas. The most widely-used measure of the supply of workers to middle-skill occupations was the number of training and certification program completers. Pathways to these middle-skill occupations are typically through the attainment of an associate degree or certificate, and the four local area studies reviewed here generally relied on a count of the number of workers obtaining these credentials from institutions within the local area. Information on the other components of supply, such as from workers who are unemployed or out of the labor force, those employed in similar occupations in the local area or potential migrants from outside the local area under analysis, were not typically incorporated into local area labor supply projections.

In cases where local area postsecondary institutions were the principal sources of worker training and certification, IPEDS data was the basic source used to quantify the new supply of workers that were available to work in each occupation. For larger areas, however, the supply of trained workers can come from a variety of sources, not all of which are reported in IPEDS data. Notably, middle-skill workers in New York City can obtain their qualifications through a large number of training and certificate programs that fall outside the coverage of the IPEDs data, including proprietary training schools and union training programs. While data limitations make it difficult to capture all of these program completers, getting information on the number of workers certified or trained in these programs would provide a much richer set of data to understand how the demands of city employers are currently being met.

These alternative sources of middle-skill worker supply, as well as the entire range of middle-skill worker supply sources, was discussed in the greater Houston area study. The authors reported a training program infrastructure that included nine community colleges, 66 apprenticeship programs, and 70 agencies with some workforce development responsibilities. In these cases, capturing the full range of workforce developers, and the number of their program enrollees, completers and placements required a comprehensive inventory of education and training providers. The use of a common system for collecting and aggregating data was critical to insure an accurate quantification of the current and potential future supply of workers to occupations.



---

Moreover they argued that coordinating and centralizing the information on skill supplies can use limited resources more efficiently and help to avoid potential over- or under-shooting of supply to meet projected skill gaps.

The existing methods of projecting the flow of middle-skill workers to an occupation either hold the level of program completers constant at its most recent level or use estimates of the annual trends in the number of program completers to expand or contract the supply of skills over time. In the short run, particularly since the pipeline of enrollees is known, either method is likely to produce reliable indicators of the changes in the availability of different types of skills in local areas. In the longer-term, using trend projections runs some risk that the programs will not expand or contract as expected.

The basis of middle-skill occupational demand was the projected growth in occupational employment levels from both new job openings and from replacement of retirees and other permanent leavers.<sup>24</sup> Bi-annual ten-year projections of the demand for middle-skill workers by employers in New York City are available from the New York State Department of Labor.<sup>25</sup> For the areas reviewed here, the projections were typically reported by local government organizations, in some cases with substantial input from private-sector firms specializing in labor market projections, particularly for detailed occupational demand projections for geographies not reported by the BLS. In several cases state or local area agencies or private-sector firms were consulted about the occupational demand projections often to take advantage of information on demand conditions that may not yet be showing up in the data. The details of any adjustments to the occupational demand projections were typically not reported.

Real-time job posting data were used in some cases to quantify the current strength of the demand for a variety of different skills. This current, or flow demand measure, can capture the number of newly-created positions in broad sub-state regions and can be updated on a monthly basis. The data were also valued for the information they provided in two areas. One is on the link between the occupation and the postsecondary education required. By specifying what education and training are required for the position, the job postings help to reduce inaccuracies in the assignment of workers to occupations based on their course of study. Second, the data were also valued for the amount of details available on the skills required on the job. These data get at not just the education and training required but also some measure of the various aptitudes required to complete the tasks on the job.

This online source of occupational demand is widely used, but caveats apply. Real-time job ads may not reflect actual employer demand but rather the attempts by staffing agencies or employers to collect resumes as a source of labor market information. Demand could also be underestimated from this source as larger employers and higher wage jobs are more likely to advertise online rather than small employers and lower wage jobs.<sup>26</sup>

---

<sup>24</sup> Beginning in 2017, BLS projections will also include openings due to turnover.

<sup>25</sup> Data for New York State and New York City available at: <https://www.labor.ny.gov/stats/lproj.shtm>. There is an ongoing effort to incorporate differences in job turnover rates into the demand projections but these estimates are not currently available.

<sup>26</sup> See the Maher & Maher, Jobs for the Future, and The New York City Labor Market Information Service 2014 report, Real-Time Labor Market Information: An Environmental Scan of Vendors and Workforce Development Users:

---

One objective of the New York City middle-skill occupational study is to identify the particular occupations that are likely to see surpluses or shortages developing in the city. This requires that the skills gaps derived from the demand and supply projections be characterized in some way. The studies offer several options for characterizing these gaps. Using the strict numerical difference between projected supply and demand can be appropriate in some cases. Goldman et al. (2015) note, however, that often a strict comparison, especially over a longer horizon, might overstate the precision of the projections. An alternative to these numerical gaps was a comparison of demand and supply growth rates where the demand for and supply of occupations can be grouped on a spectrum from high growth to low growth. Occupations with projected high demand growth and low supply growth were candidates for potential skill shortages, and occupations in low demand growth and high supply growth were candidates for skill surpluses. A broader characterization of potential occupational imbalance was based on an index of the difficulty of filling an occupation computed from the occupation's projected demand growth rate, share of employment in the local area, and recent change in the share of overall employment in the local area. These measures could be used alone or in some combination to highlight potential skill shortages and surpluses.

Once the set of occupations with imbalances was identified, an additional step taken in some studies quantify the economic impact on the local area of addressing the skill shortage through training programs. When evaluated with the cost of providing the training, these estimates offer a potential additional metric for guiding the use of limited education or training resources.

Workforce services can be most effective in connecting participants to employment when training for those occupations where local labor market demand exceeds the supply of qualified applicants. Lessons learned through this review of literature will inform the methods used in the study of the supply of and demand for middle-skill workers in New York City, due for release in the summer of 2017.

Study	Middle-Skill Definition	Geographic Scope	Time Period	Supply	Demand	Presentation of Results	Notes
Wisconsin (2013)	Occupations require an associate degree or a post-secondary non-degree award.	Statewide	2012 to 2020 period	IPEDs data on program completers from Wisconsin institutions from 2000 to 2011 used to project supply out to 2020.	Wisconsin Department of Workforce Development occupational demand projections. Focus on occupations with at least 5,000 new jobs projected by 2020.	Numerical projected gaps between supply and demand for each occupation.	Study adjusts supply projections to account for out-migration of graduates and for labor force participation rates of program completers.
Texas (2015)	Occupations require an associate degree, or 65% or more of the current workforce have an associate degree or certificate.	Statewide and 10 Texas Higher Education Community Board regions	Current year and 2012 – 2022 period	(1) IPEDs data on graduates from community colleges located in Texas. Supply growth through 2022 projected from 2005 – 2012 trend in employment from Census Bureau’s ACS.  (2) Supply growth through 2022 projected from 2005 – 2012 trend in employment from Census Bureau’s ACS.	Texas Workforce Commission projections of (1) annual number of new jobs plus replacements and (2) ten-year out projections. Focus on occupations with more than 1000 workers.	Supply-demand growth matrix tool statewide and for 10 workforce regions. Three equal-sized groups of occupations based on projected growth in demand and supply—high, medium and low. Used to identify high demand, low supply growth occupations.	Real-time job posting data used to link postsecondary education to occupations. Authors see the supply-demand matrix as one of several methods that can be effectively combined to help identify occupational supply and demand gaps.
Western New York State (2015)	Occupations require an associate degree or formal postsecondary non-degree award.	10-county region in Western New York State (Finger Lakes economy)	Annual	IPEDs data on program completions from area community colleges and the Monroe Community College student data system.	Commercially supplied proprietary employment data and projections of annual new job openings in five key industries supplemented with data on skill requirements taken from information contained in real-time job postings.	Annual numerical gap (surplus or shortage) between supply and demand.	Occupations clustered into 23 groupings based on similarity of tasks and preparation. Includes information on occupational wages and estimates the economic impact of each new job.

# Houston Metro Area (2014)

Occupations require a high school diploma plus some postsecondary schooling plus occupations that require a high school diploma and some degree of job training or work experience.	10 counties making up the Houston metro area	2012 to 2017	IPEDS data on graduates from the nine community colleges in the Houston metro area.	Commercially supplied proprietary projections of annual job openings between 2012 and 2017.	Reports (1) a Staffing Environment Indicator showing the ease of filling the occupation – neutral, hard, hardest to fill, and (2) a comparison of demand for degrees by occupation with IPEDS data on degree completers	Training providers in the area not part of an integrated network and study identified a need for better coordinator. Study also called for a survey of workforce providers to get a better handle on program enrollees and completers.
---	--	--------------	---	---	---	--

## Bibliography

- Abel, Jason R. and Richard Deitz (2012), "Job Polarization and Rising Inequality in the Nation and the New York– Northern New Jersey Region," Federal Reserve Bank of New York *Current Issues in Economics and Finance*, Volume 18 (7). Available at: [https://www.newyorkfed.org/research/current\\_issues/ci18-7.html](https://www.newyorkfed.org/research/current_issues/ci18-7.html).
- Arrow, Kenneth J. and William M. Capron (1959), "Dynamic Shortages and Price Rises: The Engineer Scientist Case," *Quarterly Journal of Economics*.
- Autor, David, Lawrence Katz and Melissa Kearney (2006), "The Polarization of the U.S. Labor Market," NBER Working Paper 11986, January. Available at: <http://www.nber.org/papers/w11986>.
- Autor, David, Frank Levy and Richard Murnane (2003), "The Skill Content of Technological Change: An Empirical Exploration," *Quarterly Journal of Economics*, 118(4), November.
- Barnow, B. S., Trutko, J., & Piatak, J. S. (2013). "Occupational labor shortages: Concepts, Causes, Consequences, and Cures," Kalamazoo, MI: W. E. Upjohn Institute for Employment Research.
- Cedefop (European Center for the Development of Vocational Training) (2011), "Skills Supply and Demand in Europe: Medium-term Forecast up to 2020. Publications Office of the European Union. Luxembourg. Available at: <http://www.cedefop.europa.eu/en/publications-and-resources/publications/3052>.
- Cleary, Jennifer and Michelle Van Noy (2014), "A Framework for Higher Education Labor Market Alignment: Lessons and Future Directions in the Development of Jobs-Driven Strategies," Heldrich Center for Workforce Development, Rutgers University, October. Available at: <http://slideplayer.com/slide/7767624/>.
- Daly, Mary C., Bart Hobijn, Aysegül Sahin, and Robert G. Valletta (2012), "A Search and Matching Approach to Labor Markets: Did the Natural Rate of Unemployment Rise?" *The Journal of Economic Perspectives*, Vol. 26, No. 3, Summer, pp. 3–26.
- Elsby, Michael W. L., Bart Hobijn, Aysegul Sahin, and Robert G. Valletta (2014), "The Labor Market in the Great Recession: An Update," Federal Reserve Bank of San Francisco Working Paper Series, No. 2011-29, October 2011. Available at: <http://www.frbsf.org/publications/economics/papers/2011/wp11-29bk.pdf>.
- Froeschle, R. (2014), Occupational supply/demand analysis: Approaches and concerns. Austin, TX: Texas Workforce Commission. Available at: [https://pdfs.semanticscholar.org/33bd/0c5f2a513d8801e08e84a4e4ea5a408a85b7.pdf?\\_ga=2.266232396.2140652272.1502316984-1269799274.1502316984\[pdfs.semanticscholar.org\]](https://pdfs.semanticscholar.org/33bd/0c5f2a513d8801e08e84a4e4ea5a408a85b7.pdf?_ga=2.266232396.2140652272.1502316984-1269799274.1502316984[pdfs.semanticscholar.org])
- Goldman, C., L. Butterfeld, D. Lavery, T. Miller, L. Daugherty, T. Beleche, and B. Han (2015), Using Workforce Information for Degree Program Planning in Texas, Santa Monica, CA: RAND Corporation, available at: [http://www.rand.org/pubs/research\\_reports/RR1011.html](http://www.rand.org/pubs/research_reports/RR1011.html).
- Greater Houston Partnership (2014), "Addressing Houston's Middle Skills Jobs Challenge," A Plan by the Greater Houston Partnership Regional Workforce Development Task Force, April. Available at: <https://www.houston.org/upskillhouston/pdf/UpSkill-Full-Report.pdf>.

- Handel, M. (2012), "Trends in Job Skill Demands in OECD Countries," OECD Social, Employment and Migration Working Papers, no. 43, OECD Publishing. Available at: <http://dx.doi.org/10.1787/5k8zk8pcq6td-en>.
- Hanel, Barbara, Guyonne Kalb and Anthony Scott (2012), "Nurses Labor Supply Elasticities: The Importance of Accounting for Extensive Margins," IZA (Institute for the Study of Labor), Discussion Paper 6573, May. Available at: [http://www.iza.org/en/webcontent/publications/papers/viewAbstract?dp\\_id=6573](http://www.iza.org/en/webcontent/publications/papers/viewAbstract?dp_id=6573).
- Hobijn, Bart (2012), "The Industry Occupation Mix of U.S. Job Openings and Hires," Federal Reserve Bank of San Francisco Working Paper 2012-09. Available at: <http://www.frbsf.org/publications/economics/papers/2012/wp12-09bk.pdf>.
- Holzer, Harry (2015), "Job Market Polarization and U.S. Worker Skills: A Tale of Two Middles," The Brookings Institution, April. Available at: <https://www.brookings.edu/research/job-market-polarization-and-u-s-worker-skills-a-tale-of-two-middles/>.
- Holzer, Harry J. (2013), "Good Workers for Good Jobs: Improving Education and Workforce Systems in the US," Madison, Wisconsin: Institute for Research on Poverty Discussion Paper 1404-13, January. Available at: <http://www.irp.wisc.edu/publications/dps/pdfs/dp140413.pdf>.
- Jacobson, L. S. & LaLonde, R. J. (2013), "Using data to improve the performance of workforce training. Washington, DC: Results for America and the Hamilton Project." Available at: [https://www.brookings.edu/wp-content/uploads/2016/06/THP\\_JacobsonLaLondePaperF2\\_413.pdf](https://www.brookings.edu/wp-content/uploads/2016/06/THP_JacobsonLaLondePaperF2_413.pdf).
- Johnson, Hans, M. C. Meija and S. Bohn (2015), "Will California Run out of College Graduates" Public Policy Institute of California, October. Available at: [http://www.ppic.org/main/publication\\_quick.asp?i=1166](http://www.ppic.org/main/publication_quick.asp?i=1166).
- Lane, Julia, and Stephan Gohmann (1995) "Shortage or Surplus: Economic and Noneconomic Approaches to the Analysis of Nursing Labor Markets," Southern Economic Journal, Vol. 61, No. 3, January, pp. 644–653.
- Lee, Donghoon, and Kenneth I. Wolpin (2010), "Accounting for Wage and Employment Changes in the US from 1968–2000: A Dynamic Model of Labor Market Equilibrium," Journal of Econometrics, Vol. 156, No. 1, May, pp. 68–85.
- Loritz, M., Nerad, B., Sletten, P., & Cunha, J. (2013). "Examining the skills gap in Wisconsin," Madison, WI: Prepared for the Wisconsin Legislative Council. Available at: [https://www.lafollette.wisc.edu/images/publications/workshops/2013-Leg\\_Council.pdf](https://www.lafollette.wisc.edu/images/publications/workshops/2013-Leg_Council.pdf).
- Modestino, Alicia Sasser (2015), "Middle Skill Workers in Today's Job Market," National Academy of Sciences Symposium on the Supply Chain for Middle-Skill Jobs: Education, Training and Certification Pathways, June 24-25. Available at: [http://sites.nationalacademies.org/PGA/step/MiddleSkillJobs/PGA\\_165733](http://sites.nationalacademies.org/PGA/step/MiddleSkillJobs/PGA_165733).
- Modestino, Alicia Sasser, Daniel Shoag and Joshua Balance (2014), "Upskilling: Do Employers Demand Greater Skills When Workers are Plentiful?" Federal Reserve Bank of Boston, Working Paper 14-17. Available at: <https://www.bostonfed.org/publications/research-department-working-paper/2014/upskilling-do-employers-demand-greater-skill-when-skilled-workers->

[are-plentiful.aspx](#).

Modestino, Alicia Sasser (2010), "Mismatch in the Labor Market: Measuring the Supply and Demand of Skilled Labor in New England," Boston: Federal Reserve Bank of Boston. Available at: <https://www.bostonfed.org/publications/new-england-public-policy-center-research-report/2010/mismatch-in-the-labor-market-measuring-the-supply-of-and-demand-for-skilled-labor-in-new-england.aspx>.

Monroe Community College (2016), "Measuring Middle-Skill Occupational Gaps: Advanced Manufacturing in Central New York," April. Available at: <http://user-tybgwup.cld.bz/Measuring-Middle-Skills-Occupational-Gaps-Advanced-Manufacturing-in-Central-New-York>.

Monroe Community College (2015), "Measuring Middle Skills Gaps within the Finger Lakes Regional Economy," Economic Development and Innovative Workforce Series #26. Available at: <http://user-tybgwup.cld.bz/Measuring-Middle-Skills-Gaps-within-the-Finger-Lakes-Regional-Economy#2>.

Monroe Community College (2013), "Rochester Area Skill Needs Assessment and Business Climate Survey," September 2015. Available at: <http://user-tybgwup.cld.bz/Rochester-Area-Skill-Needs-Assessment-and-Business-Climate-Survey-September-2013#1/z>.

Neumark, David, Hans Johnson, and Marisol Cuellar Mejia (2013), "Future Skill Shortages in the U.S. Economy," *Economics of Education Review*, Vol. 32, February, pp. 151–167.

Rothwell, Jonathan (2015), "Defining Skilled Technical Work," Prepared for National Academies Board on Science, Technology, and Economic Policy, Project on "The Supply Chain for Middle-Skilled Jobs: Education, Training and Certification Pathways" June 24-25. Available at: [http://sites.nationalacademies.org/PGA/step/MiddleSkillJobs/PGA\\_165733](http://sites.nationalacademies.org/PGA/step/MiddleSkillJobs/PGA_165733).

Şahin, Ayşegül, Joseph Song, Giorgio Topa, and Giovanni L. Violante (2014), "Mismatch Unemployment," NBER Working Paper No. 18265, August. Available at: <http://www.nber.org/papers/w18265>.

Staiger, Douglas, David Auerbach and Peter Buerhaus (2009), "Comparison of Physician Workforce Estimates and Supply Projections," *Journal of the American Medical Association*, October.

U.S. Bureau of Labor Statistics (2013), "Occupational Employment Projections to 2022," December. Available at: <http://www.bls.gov/opub/mlr/2013/article/occupational-employment-projections-to-2022.htm>.

Vineri, Carolyn M. (1999), "Can occupational labor shortages be identified using available data?" U.S. Bureau of Labor Statistics *Monthly Labor Review*, March.