Labor Supply Projections for Wisconsin

2020-2040

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1) Executive Summary

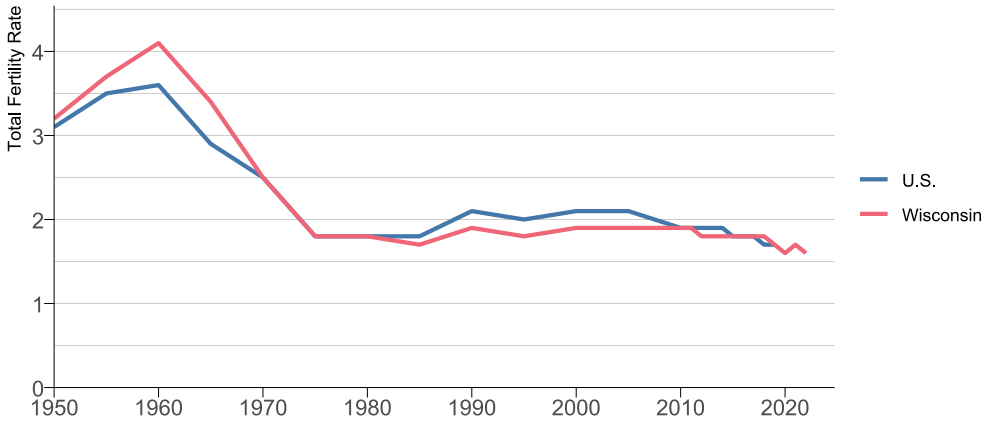
A greater concentration of Wisconsin's population will be nearing or entering retirement in the coming years, posing challenges to the workforce and economy. As Wisconsin's population ages, concerns over the state's labor force trajectory are at the forefront of economic and workforce development initiatives. The baby boomer generation entered the workforce from the 1960s through the 1980s, changing the labor force landscape in Wisconsin and the nation. As these workers continue their exit from the workforce, the challenge to sustain labor force growth is, and will continue to be, significant. This report analyzes and forecasts some of the major components of the Wisconsin labor force. These findings include:

- Wisconsin's population will continue to grow, but at a slower rate than prior to 2020.
- The average age of the labor force will be older and more people 65 and older will be in the workforce.
- For most age groups, the labor force participation rate (LFPR) has been declining and will continue to decline.
- Wisconsinites will be working longer. The labor force participation rate for those 60 and older has been increasing and will continue to increase.
- The number of jobs held per employed person is higher for women than men and does not vary across time.
- Historically, more Wisconsinites commute outside of the state to find work than vice-versa. This will remain the case, but more young out-of-state residents will commute to Wisconsin in the future.

2) Introduction

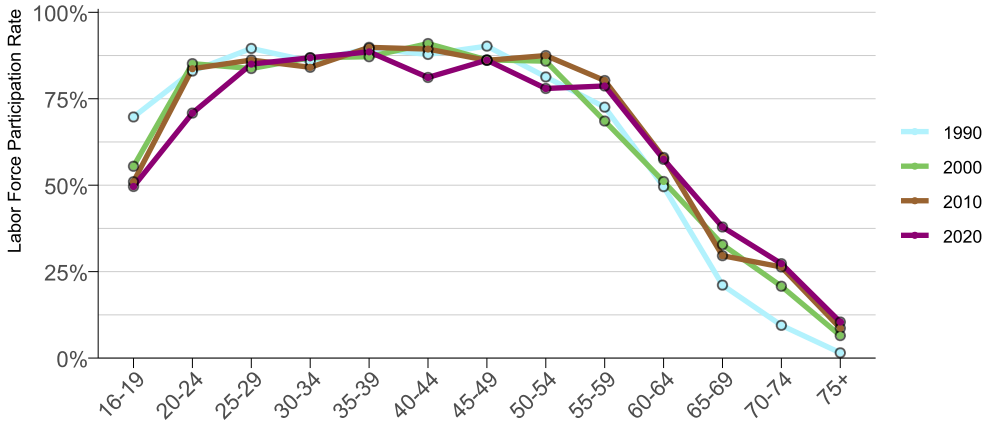
An increasingly aging population has become a concern for the United States and the developed world. Most developed economies have been witnessing this demographic shift for decades as both fertility rates have declined and longevity has increased (He et al.). The baby boomer cohort can easily be identified in Figure 1. Also illustrated are the lower birth rates for the last 45 years.

Figure 1 — Total fertility rate in Wisconsin and the U.S. (Wisconsin Department of Health Services).



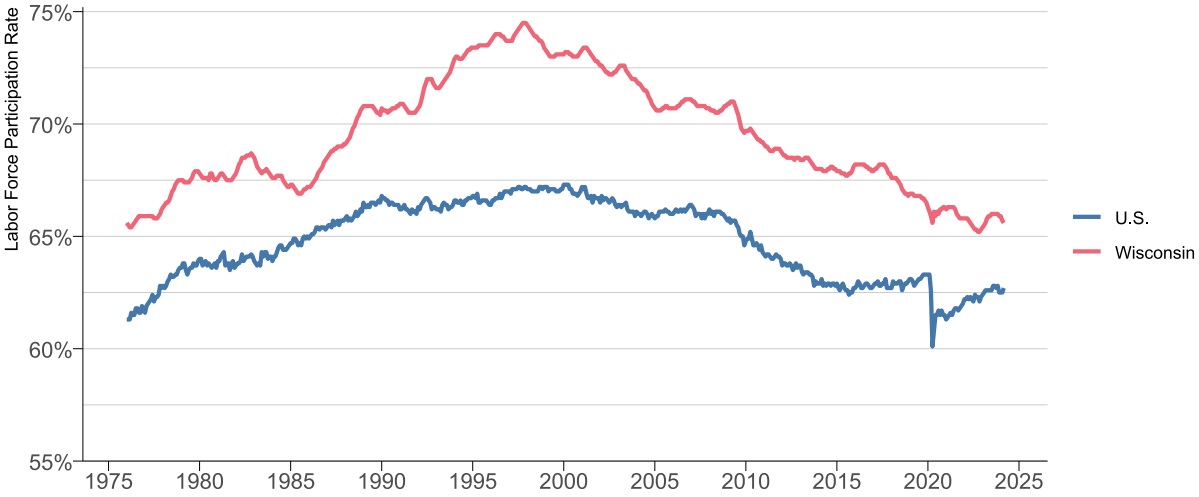
Pressing that cohort profile against the labor force participation rates by age illustrates the primary cause of the workforce quantity challenge.

Figure 2 — Age profile of Wisconsin's labor force participation rate across time.



The net result is a declining overall labor force participation rate, a workforce quantity squeeze, and an increasing dependency ratio.

Figure 3 — Overall Labor Force Participation Rate in Wisconsin and the U.S. (Bureau of Labor Statistics).



This is especially true in Wisconsin where the consequences of an aging population have long been a concern (Winters et al.). The median age in Wisconsin was 40.1 years old in 2021, higher than the median age for the United States, 38.8 years (U.S. Census Bureau).

The following report illustrates the data, methodology, and results of a demographic workforce model developed to quantify the dimensions of Wisconsin's future labor force. Projections for the overall population of Wisconsin, institutionalization rates, and labor force participation rates were used to arrive at a labor force projection, or supply of labor. Projections of the unemployment rate, jobs per employed, and interstate job flows were then used to convert the projected labor supply into the supply of jobs. Incorporating these assumptions, estimates of Wisconsin's supply of jobs to the year 2040 were projected. Evidence from current literature was used to verify that the assumptions and projections made were reasonable.

The job supply is an estimate of the capacity to fill jobs in Wisconsin. This report compares these projections to an established occupation-based, demand-based projection of filled jobs. This difference reflects the divergent trajectories between the capacity of the state's demand for jobs and its ability to fill jobs. If these current trends continue, the state will be faced with severe a labor shortage. The gap will have impacts on multiple aspects of the state's labor market, public finance, and economy.

3) Methods

3.1) General

The data compiled for this analysis comes from publicly available sources. The assumptions, model construction, coefficient selections, results, and conclusions are those of the authors.

In general, historical values were from publicly available data from the United States Census Bureau. The Current Population Survey (CPS) and American Community Survey (ACS) were used for institutionalization rates, labor force participation rates, unemployment rates, and jobs per employed. The Census's LEHD Origin-Destination Employment Statistics (LODES) data were used for commuting patterns.

Statistical software packages SAS and R were used to generate time series forecasts. Time was the only independent variable used in forecasting. Different transformations of the LFPRs were assessed: linear, logarithmic, logistic, and exponential. The damped trend exponential smoothing model was used for most of the forecasts. Other researchers (McKenzie and Gardner) have noted that the "damped trend method of exponential smoothing is a benchmark that has been difficult to beat in empirical studies of forecast accuracy." The damped trend exponential smoothing model is also especially accurate over long lead times (Gardner and McKenzie). Trend and series damping smoothing weight parameters were constrained to the zero to one additive invertible region. Depending on the underlying data, other forecasting models were also used, including mean, linear as well as other exponential smoothing models.

3.2) Population

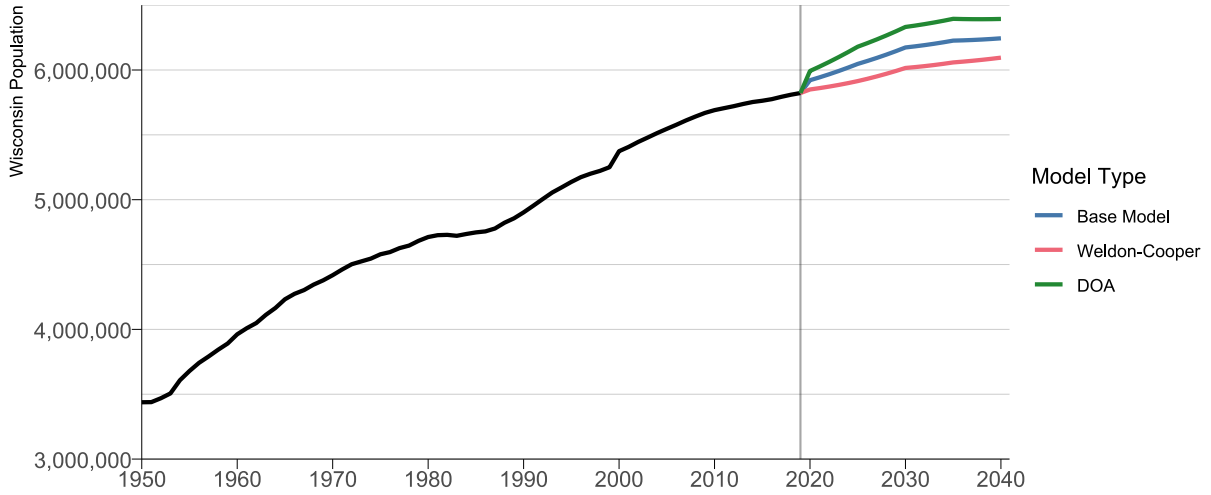
Two projections of the population of Wisconsin were considered: one produced by the State of Wisconsin's Department of Administration (DOA) Demographic Services Center, and the other by the University of Virginia's Weldon Cooper Center (WC) Demographics Research Group (*National Population Projections*; Wisconsin Department of Administration). The DOA population projection was completed in 2013. WC projections were published in 2018.

DOA predicted a higher overall population for Wisconsin compared to Weldon Cooper, as seen in Figure 4.[1] The base case projections used the average of the two.

For this analysis, an individual must be non-institutionalized and of working age (age 16 and older). The DOA and WC projections use an age grouping of 15- to 19-year-old residents. For the estimate of the 16- to 19-year-old age grouping, the 15- to 19-year-old grouping was multiplied by a factor of 0.8, assuming the population cohort was equally distributed in all years of the 15-19 age group. Modifications were also needed for the time scale. DOA uses five-year increments for its projections while Weldon Cooper Projections uses ten-year increments. To generate annual projections of the total population, the intervening years were linearly interpolated.

[1]The DOA projections were published in 2013; the results were consistent with trends at the time. New population estimates from DOA Demographic Services Center are expected in the near future.

Figure 4 — Historical population and future estimates.



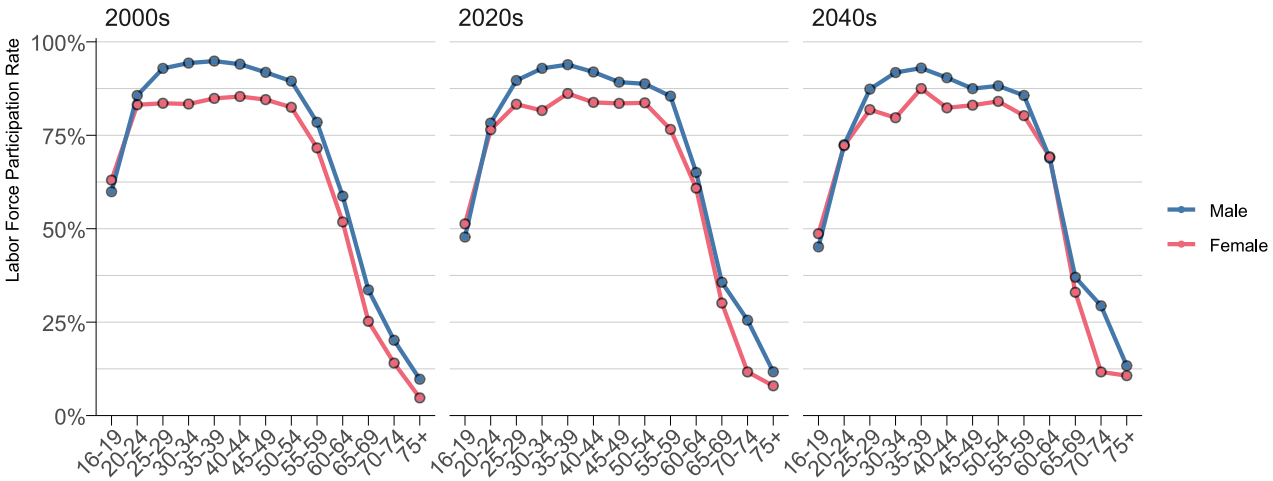
3.3) Military Service / Institutionalization Rates

The first step in identifying the labor force is excluding ineligible individuals: those who are either active duty military or institutionalized. For this purpose, the Census Bureau's American Community Survey (ACS) microdata was used to find the rates of military service or institutionalization by gender and age group (Ruggles et al.). Institutionalized individuals are those who live in an institutional facility which provides supervised care, like correctional facilities or nursing homes (Panel on Statistical Methods for Measuring the Group Quarters Population in the American Community Survey). A proportion of the Wisconsin population, either institutionalized serving in the military, is subtracted from the total population to yield the civilian non-institutionalized population (CNIP).

3.4) Labor Force Participation Rates

Labor force participation rates (LFPR) were calculated consistent with the Bureau of Labor Statistics' (BLS) definition. LFPR counts the people who participate in the labor force (working or looking for work) as a percentage of people who are eligible to participate in the labor force (civilian, non-institutionalized, age 16 and older). Microdata from the Census Bureau's Current Population Survey (CPS) was used to calculate this rate for Wisconsin (Flood et al.). The CPS microdata allows LFPRs to be delineated by gender and age cohort.

Figure 5 — Labor force participation rates.



Projections were based on historical trends, assuming current trends to continue. No assumptions about policy or other circumstantial changes which could affect these projections were made. Data from 1996 to 2019 were used to avoid the effect of the COVID-19 pandemic on labor market trends. The year 1996 is used as the starting point as it reflects an inflection point in LFPR patterns.

The volatility in the LFPR of both males and females aged 16 to 19 resulted in wide divergence in projected trends. Historically, the two groups trended in the same direction and stayed within a few percentage points of each other. To reduce this volatility, the forecast for the 16 to 19 female group is based on the predicted values of the 16-19 male group. The average historical difference in rates was added to the male 16-19 forecast. This method maintains the historically close relationship between the LFPRs of these two groups.

Multiplying corresponding LFPR by CNIP cohorts provided estimates for the labor force for each age and gender group. Summing these labor force projections by age and gender yielded projections for the total labor force in Wisconsin out to 2040.

3.5) Natural Unemployment Rate

Moving from a supply of labor to a supply of jobs involved forecasting the natural unemployment rate. Estimating the natural rate of unemployment is an attempt to measure the underlying rate of unemployment, that which, "arises from all sources other than fluctuations in demand associated with business cycles" (Brauer). This natural rate is driven primarily by the structure of the economy as well as demographic and compositional changes of the labor force. Many estimates use some combination of demographic information, alongside occupational skill, or educational attainment (Aaronson; Brauer; Tüzemen).

The methodology in this report closely followed the methods employed by (Aaronson). This began with the share of the labor force by a combination of age and highest level of educational attainment (professional degree or doctorate, master's degree, bachelor's degree, associate degree, some college, high school, less than high school). Unlike other components of this model, this grouping was not broken out by age and gender as the source data became too thin to provide an accurate estimate when grouping by age, educational attainment as well as gender. Similarly, the age groupings used were broader, with youth (age 16 to 24), prime working age (age 25 to 54) and old age (age 55 and above).

In addition to the labor force share, the unemployment rate of each of those groups was estimated. Using 2016 as the base year for unemployment rates, the changes in composition to estimate unemployment rates by age group were used.[2] SAS's forecasting methods were used to create forecasts of the share of the labor force by educational attainment within each age grouping. Then, using the changes in the age and educational composition of the labor force, changes in the unemployment rate could be estimated from a particular starting point. For this purpose, 2016 was chosen as the base year for unemployment rate. For example, individuals with higher levels of education have historically had a lower rate of unemployment. If the share of the labor force with higher levels of education increases, then the natural rate of unemployment for the state overall will decrease.

[2]Both Aaronson et al. and Tüzemen used the widely accepted base year of 2005 for their estimates. They chose 2005 as a base year because it was the last time the observed national unemployment rate was equal to the Congressional Budget Office's estimate of the natural rate of unemployment. The year 2005 was a year in which the labor market was largely unaffected by either the "boom or bust" of the business cycle.

This method uses a base year in which unemployment was deemed to be at a natural level. The Congressional Budget Office (CBO) produces estimates of the natural unemployment rate for the nation, but no such estimates exist for the states. This model's estimate for Wisconsin's historical natural rate of unemployment relied on CBO's published estimates using the fact that Wisconsin's unemployment rate has been lower than the nation's at a consistent rate. The average difference between the United States's unemployment rate and Wisconsin's was applied to the CBO's estimate of the natural rate of unemployment, yielding an estimate of Wisconsin's historical natural rate of unemployment. Based on this, 2016 was chosen as the base year for the projections of Wisconsin's natural unemployment rate; that was the most recent year in which Wisconsin's observed unemployment rate matched the estimate of the natural rate of unemployment.

This method for estimating and forecasting the natural unemployment rate relies on two major assumptions: first, age and education are key determinants of unemployment (and their effects on unemployment will stay the same in the future); second, the Wisconsin unemployment rate in 2016 was at its natural level. To the first assumption, there is a wide body of literature that indicates a negative correlation between level of educational attainment and job loss and length of unemployment (Farber; Mincer). However, there is little research into state-specific natural unemployment rates, let alone specific to Wisconsin. Given the research and data constraints, 2016 represents a reasonable approximation of a year in which the overall unemployment rate was at its long-run trend.[3]

3.6) Multiple Job Holders

At this point, the model has yielded the number of employed Wisconsin residents. To estimate the supply of jobs from employed people, the number of jobs per employed individual was needed. Not every employed individual works just one job. CPS data was used to estimate the jobs per employed person. Due to the thinness of the data on multiple job holders, the most salient demographic grouping was gender. The mean of the number of jobs per employed person across time was used to forecast. No noticeable trends across time for the number of jobs were observed. Multiplying the average jobs per employed by the number of employed individuals produced the total number of jobs held by Wisconsin residents.

3.7) Interstate Job Flows

Net interstate job flow is another factor that impacts labor supply. Net interstate job flow is the annual number of Wisconsinites who work in other states subtracted from residents of other states who work in Wisconsin. Origin-Destination Employment Statistics data from the Census Bureau's Longitudinal Employer-Household Dynamics (LEHD) program was used to estimate the flow of jobs between Wisconsin and neighboring states (U.S. Census Bureau, *LEHD Origin-Destination Employment Statistics*). LODES data is available for Wisconsin from 2002 to 2019. LODES uses age categories 14 to 29, 30 to 54, and 55 and above. The 14 to 29 age group was not excluded under the assumption that those 14- and 15-year-old individuals make up an insignificant percentage of interstate job flows. Adding net commuters to the overall jobs from the previous step yields the final projection for the supply of jobs for Wisconsin.

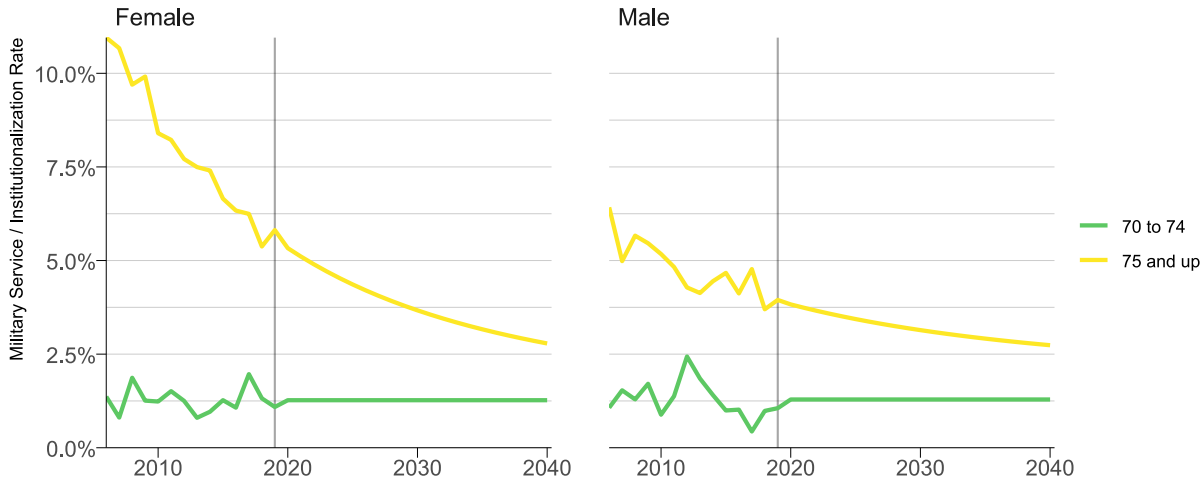
[3]In exploring alternative methods of picking a base unemployment rate, (Aaronson) used a Philips curve model that related inflationary gaps to unemployment rate. They found that such a model, while theoretically appealing, led to imprecise estimates.

4) Findings

4.1) Military Service and Institutionalization Rates

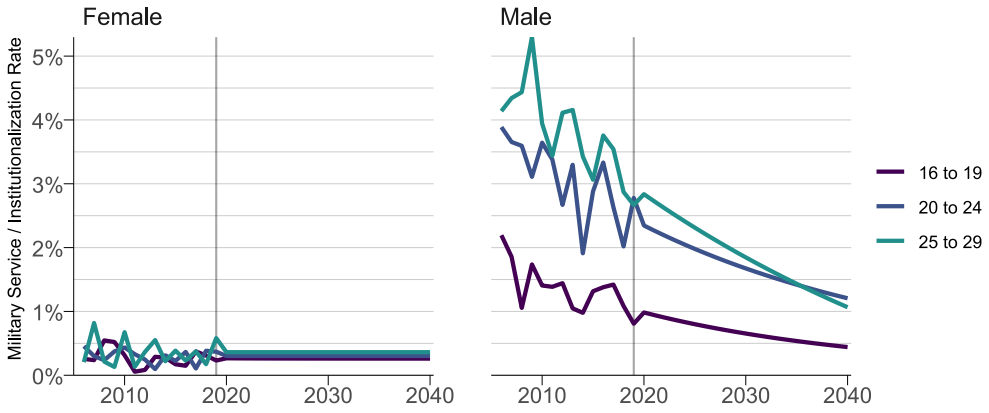
The rates of military service and institutionalization have held steady since 2006 for most age cohorts, with two notable exceptions. The rates of institutionalization among the elderly experienced a steep decline compared to the early 2000s, see Figure 6. While the ACS survey does not elaborate on the exact type of institutional group home, this decline of institutionalization is likely due to the decline of nursing homes in favor of other forms of long-term care. This trend is well noted and has been declining since the 1980s (Mathews and McGinty; Toth et al.). There are multiple reasons given for this decline, primarily costliness and comfort of accessing care from home.

Figure 6 — Rates of institutionalization or military service for older age groups.



The second notable trend is a decline in institutionalization among men aged 16 to 29. This is likely driven by declining incarceration rates in the past 15 years in Wisconsin (Wisconsin Department of Corrections). The admissions of younger individuals have decreased in the past two decades (Wisconsin Department of Corrections, *Prison Admissions 2000-2019*). Incarceration policy has been a contentious topic and public policy changes could easily change this downward trend. However, through various administrations of both political parties, Wisconsin has seen a decline in the rates of young men incarcerated.

Figure 7 — Rates of institutionalization or military service for younger age groups.

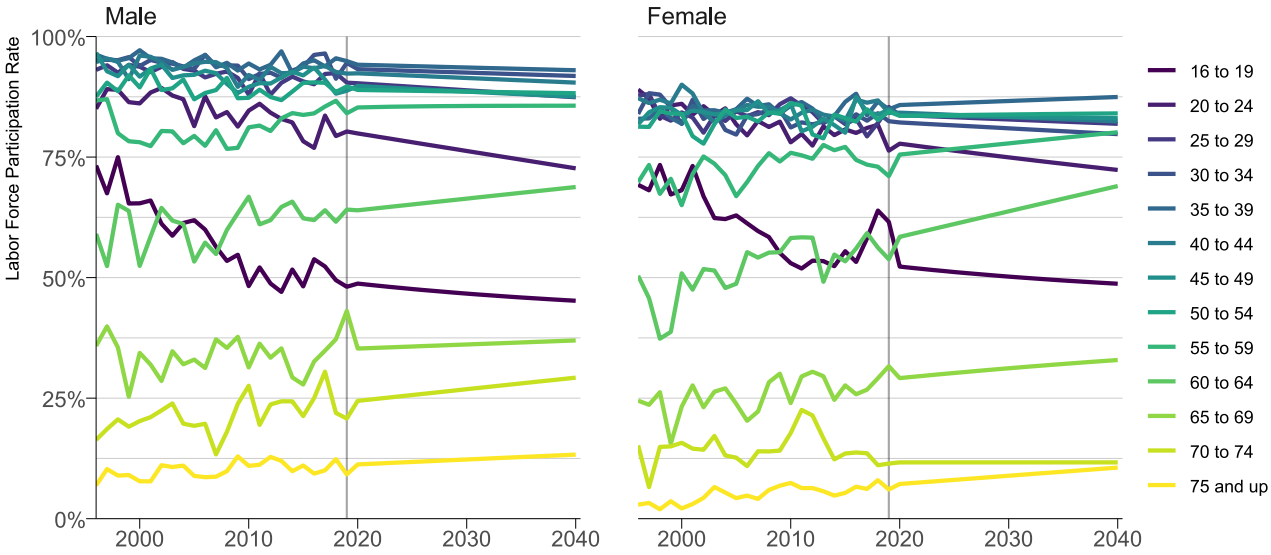


4.2) Labor Force Participation Rates

Wisconsin's LFPR has always been higher than the national rate (see Figure 3); this phenomenon is continued in these projections as well. These projections assume a decrease in the LFPR for the 16 to 19 age cohort for both genders. The male LFPR decreases from 48% to 45% from 2019 to 2040, whereas the female drops from 61% to 48%.

The predicted trend is for slight declines in most other categories. One exception is for females aged 35 to 39, where the participation rate rises slightly from 85% to 87%. In general, there is an increase in labor force participation rate for older age cohorts (age 55 to 64), regardless of gender. The LFPR for 65 to 69 females is expected to increase over the next twenty years. Among the 70-74 age group, females showed almost negligible growth whereas male LFPR rose from 21% to 29%. In the eldest age cohort, those 75 and above, there is predicted to be a slight increase in labor force participation in both genders. Interestingly, the LFPR for women is predicted to overtake men by 2040.

Figure 8 — Labor force participation rates over time by age and gender.



The dataset used for projections deliberately avoided the years following COVID-19. The years 2020 and 2021 reversed some trends in labor force participation, especially in the women of childbearing age as schools closed (Albanesi and Kim; Alon et al.). While this effect was extreme, its impact proved to be short-lived, with the national level of labor force participation to be close to its historical trend as of 2022 (Hornstein et al.).

4.3) Comparisons

A useful comparison for this report is to the Projections Management Partnership's (PMP) projections. PMP is a nationwide program that creates state and local projections, including labor force projections by state. PMP based its labor force projections on the Weldon Cooper population projections. This contributed to PMP's much lower labor force projections compared to both the previous DWD forecast and the current base forecast. Additionally, PMP assumed that the rate of active-duty military service and institutionalization would be constant at 2018 rates. In contrast, in this report, ACS data was used to project the future rates of military service and institutionalization.

4.4) Labor Force

The base case projections show Wisconsin's labor force increasing by only 0.4% from 2020 to 2040. Using job openings as a rough proxy for excess demand, there has been an increase in the ratio of job openings to the number of unemployed in the past decade (Bureau of Labor Statistics) Younger workers are not entering the workforce at the same pace as the retiring population is leaving. Currently, older aged people, particularly men, are staying in the workforce longer than before. However, many of them will ultimately exit the labor force in the near future. The concentrated distribution of the baby boomer generation will accelerate the pace of exits.

Figure 9 — Labor force projections by gender.

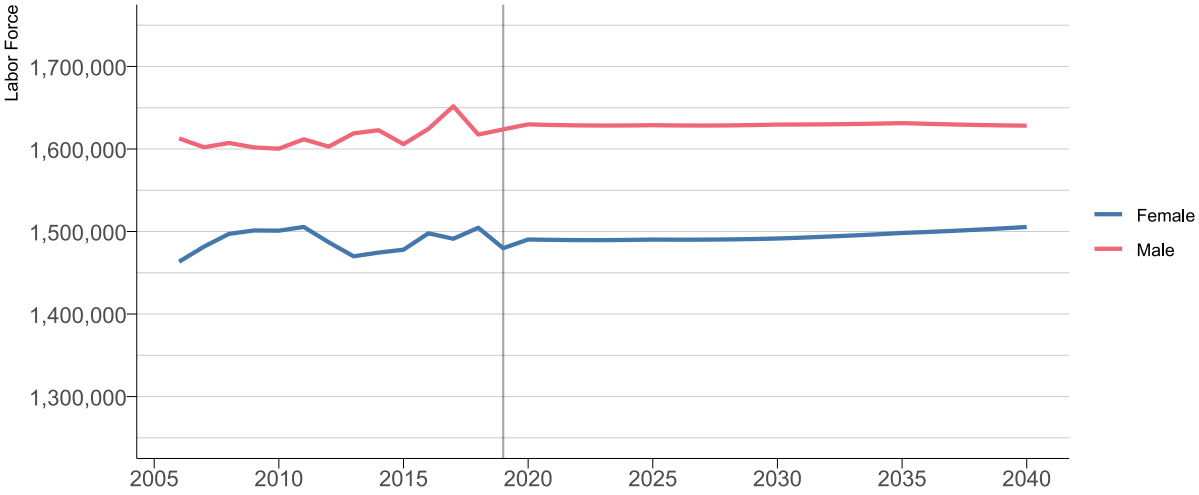
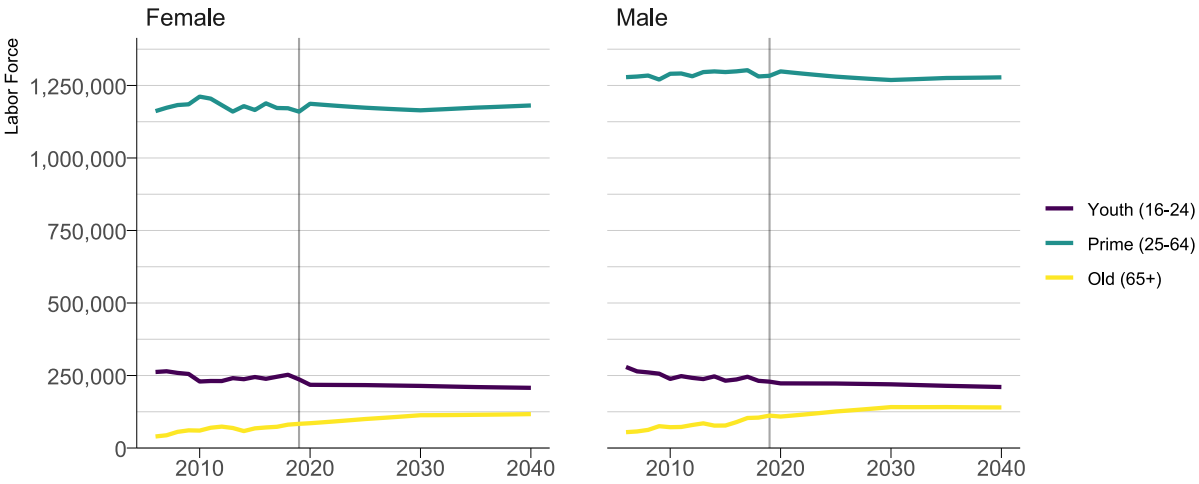


Figure 10 — Labor force by age and gender.



As seen in Figure 9, even though an increase can be observed in the 65 and above age group labor force, it becomes more constant closer to 2040. The projected labor force declines among younger age categories. Figure 10 depicts the projected labor force for the 25 to 64 age group for both genders. Table 1 highlights the net changes in labor force projected from 2020 to 2040 in different age cohorts.

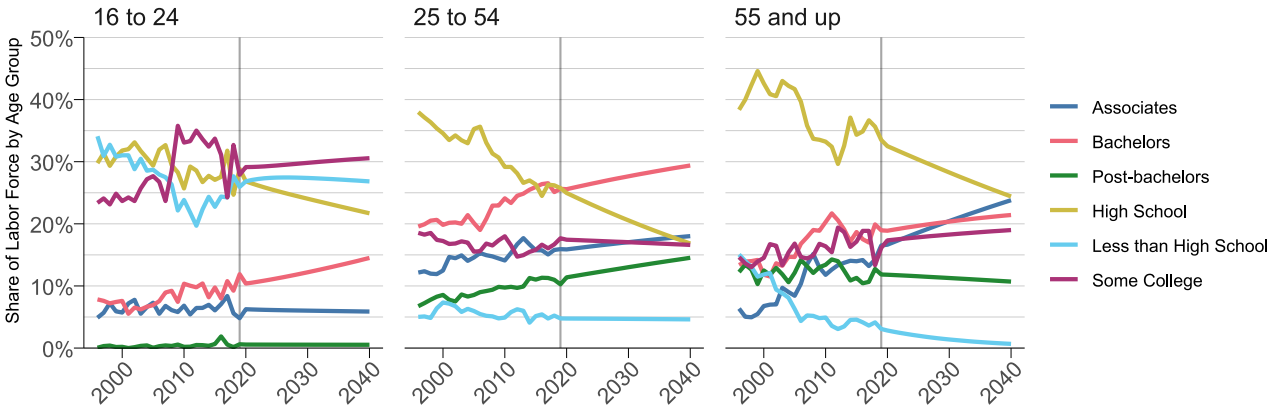
Table 1 — Changes in labor force size between 2020 and 2040.

Age Group	Gender	Labor Force Change 2020 to 2040
16 to 24	Female	−10,400
16 to 24	Male	−12,500
25 to 54	Female	7,300
25 to 54	Male	7,300
55 and up	Female	18,300
55 and up	Male	3,600

4.5) Education

The most obvious trend observed is the increase in attainment of college-level education. This is a trend that has been observed since the 2000s (Conroy et al.). This trend is assumed to continue in all broad age groups, namely youth, working age, and old age. As the share of college-level educational attainment rises, the share of those with only high school education is predicted to show the most dramatic decline. The share of those in the labor force with an associate degree is predicted to increase in working age individuals and especially among the older age cohort. These models also assume that by 2030, those with associate degrees will exceed those with only bachelor's degrees in the old age cohort.

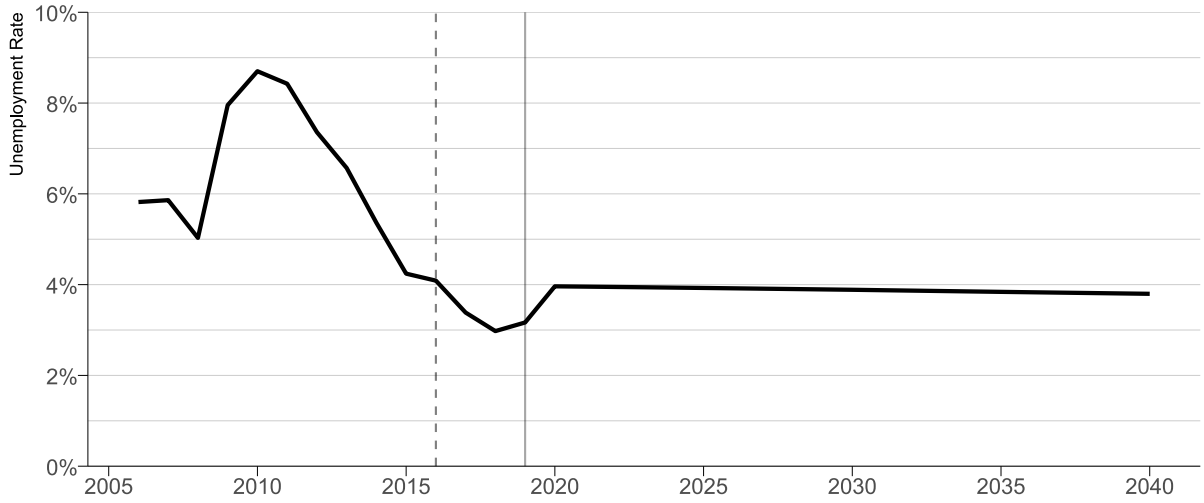
Figure 11 — Share of population by education level.



4.6) Unemployment

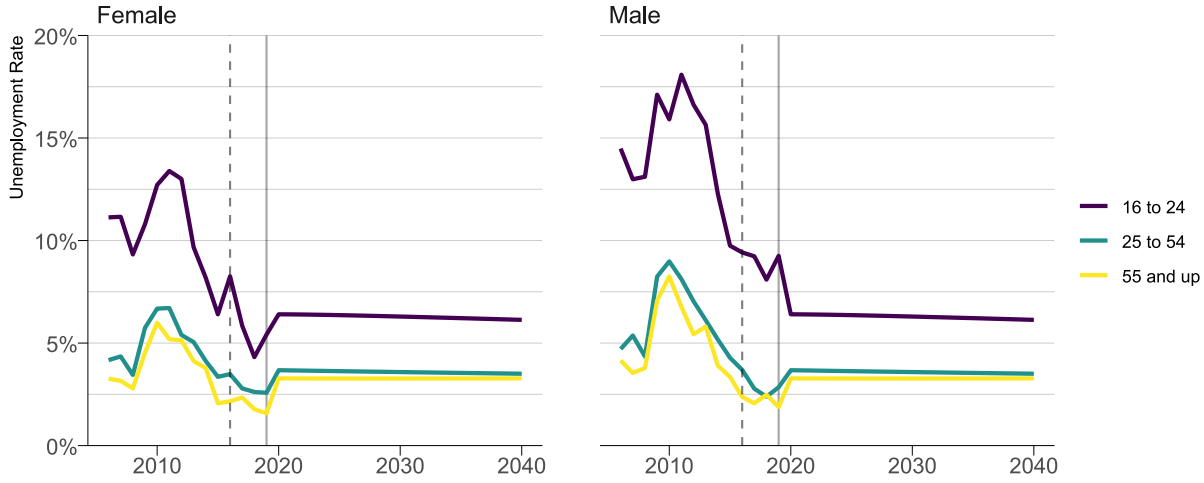
Overall, it is assumed that the natural rate of unemployment will be mostly steady at a level just under 4%, as seen in Figure 12. By 2040, the natural rate of unemployment will decline from 4.1% in 2016 to 3.8%.

Figure 12 — Historical unemployment rate and projected natural unemployment rate - the dotted line highlights 2016, the index year used for the natural unemployment rate.



A similar pattern is seen when broken out by age and gender. The unemployment rates declines are due to the prediction of increasing shares of higher levels of educational attainment within the labor force, operating under the assumption that the observed inverse relationship between educational attainment holds constant in the future. In absolute terms, this is most notable among the 16 to 24-year-old age category with a 0.6 percentage point decline from 6.9% in 2020 to 6.3% in 2040.

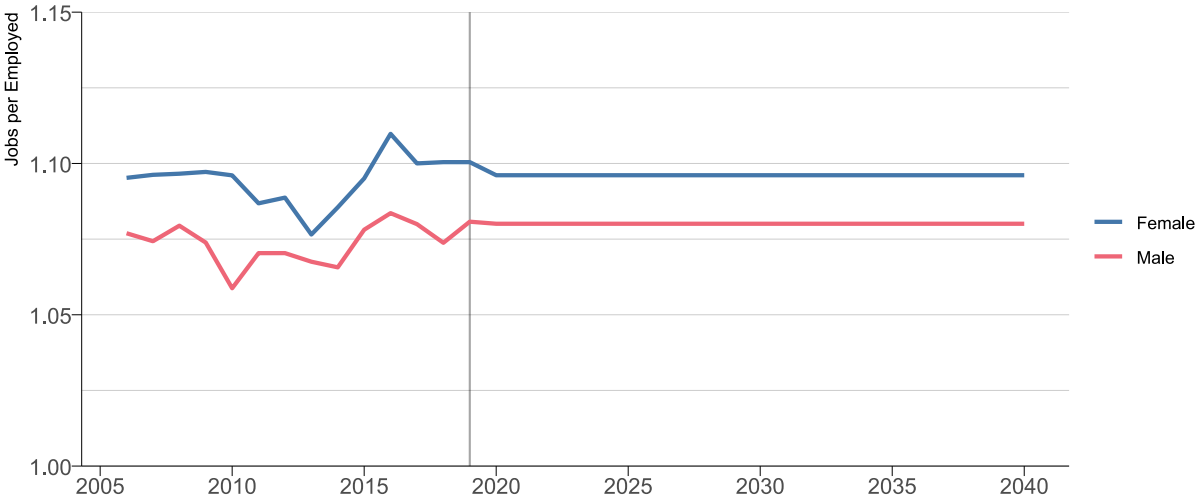
Figure 13 — Natural unemployment rate by age. The dotted line highlights 2016, the index year used for the natural unemployment rate.



4.7) Jobs Per Employed

No observable trend was found for the number of jobs per employed over time. However, the value is consistently higher for females than males. The estimated mean number of jobs per employed was 1.08 for males and 1.10 for females. An important caveat is that this methodology considers all jobs the same – therefore a part-time job is weighted the same as a full-time job.

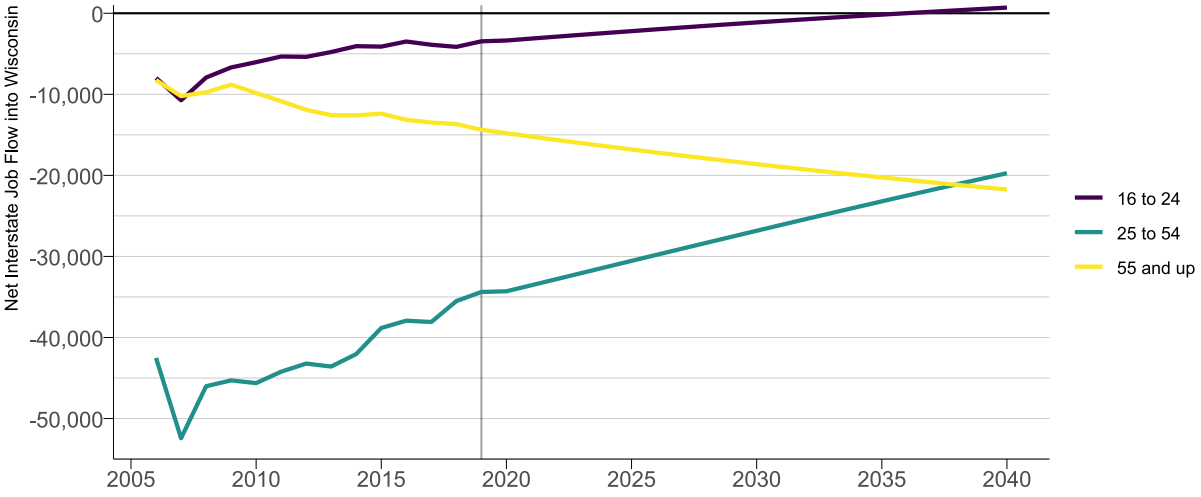
Figure 14 — Jobs per employed individual.



4.8) Net Interstate Job Flow

Trends in interstate job flow have shown that more Wisconsinites commute to work outside the state than the number of people living out of state and working in Wisconsin. In 2019, about 52,000 net jobs were held by workers commuting out of state. This makes sense given the state's proximity to the Chicago and Minneapolis metropolitan areas, which draws workers from Wisconsin. Based on past trends, projections indicate a decline in the net outflow of jobs by 2040. This is largely evident among the 14 to 29 age group, which is predicted to change from roughly a 6,000 net job outflow to an inflow of 1,200 jobs. By 2040, the total net outflow is predicted to be about 40,000 jobs.

Figure 15 — Net flow of jobs between Wisconsin and other states.



4.9) Total Job Supply versus Jobs Filled

The base model predicts growth in the total supply of jobs. It does not, however, indicate that job supply will meet job demand.[4] The quantity of both jobs supplied and demanded are

[4]DWD's employment projections were used to estimate labor demand/jobs filled. The most recent 2020-2030 projection used 2020 as the starting point, which may underestimate final demand due to suppressed labor demand in 2020 due to the COVID-19 pandemic. To compensate for this, and to maintain consistency with the pre-COVID-19 focus of our forecasts, a 10-year growth rate estimate (3.54%) was applied from DWD's 2018-2028 projections to 2021 employment numbers to create an estimate for 2031 employment projections.

contingent on one another, which complicates creating a prediction of unfilled positions. Using the Department of Workforce Development's separate, demand-side projections, this report found there to be a gap of 122,316 jobs between available workers and demand-side job projections in 2031. Applying that same analysis to 2021 shows a shortage of 20,239 jobs, as seen in Figure 16. This gap is quantified in Table 2.

Figure 16 — Jobs supply comparison.

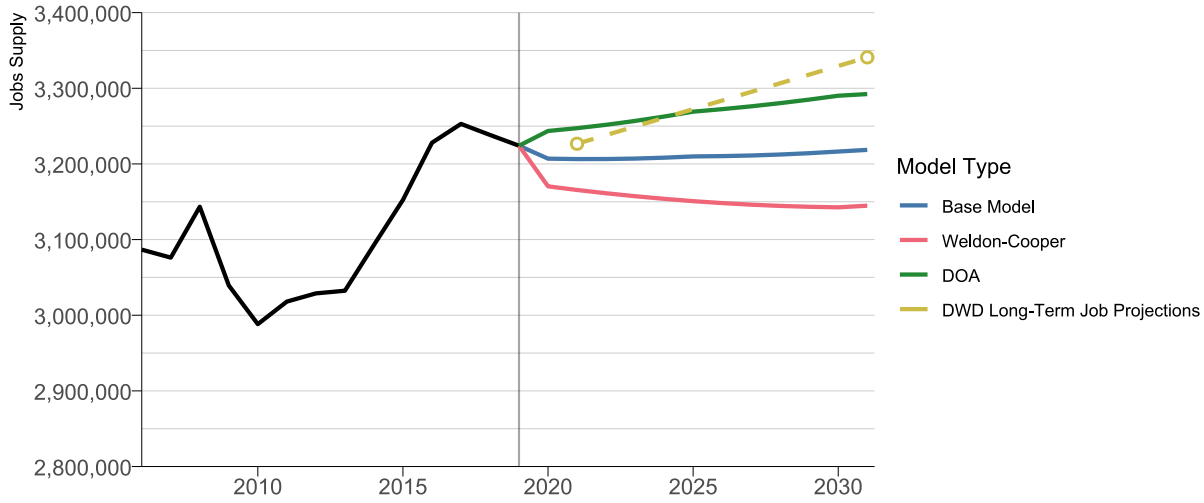


Table 2 — Gap Analysis 2031

Population Models	Supply	Jobs Filled	Gap
Base model	3,218,568	3,340,884	−122,316
Weldon Cooper	3,139,032	3,340,884	201,852
DOA WI	3,298,104	3,340,884	−42,780

A shortage of labor is difficult to quantify, as evidenced by the previously documented shortcomings of the BLS's Job Openings and Labor Turnover Survey (Ivanova; Backaitis). While this survey may seem like a natural way to validate the results of this report's labor shortage, measurement issues make this survey difficult to compare. Additionally, job openings are not necessarily a direct comparison to a labor shortage. Measurement issues aside with JOLTS, the comparison this report draws is the future difference between the capacity of the state's workforce to fill jobs and the projected number of filled jobs. This can be seen as the different trajectories between the supply and demand of jobs. If current trends for filled jobs are carried forward, there will have to be a change given the demographic shifts facing the state's capacity to fill that demand. While this discrepancy illuminates the workforce shortages in the state, future research is needed to create a more dynamic model that could incorporate the interplay and feedback between the forces of supply and demand for jobs in the state.

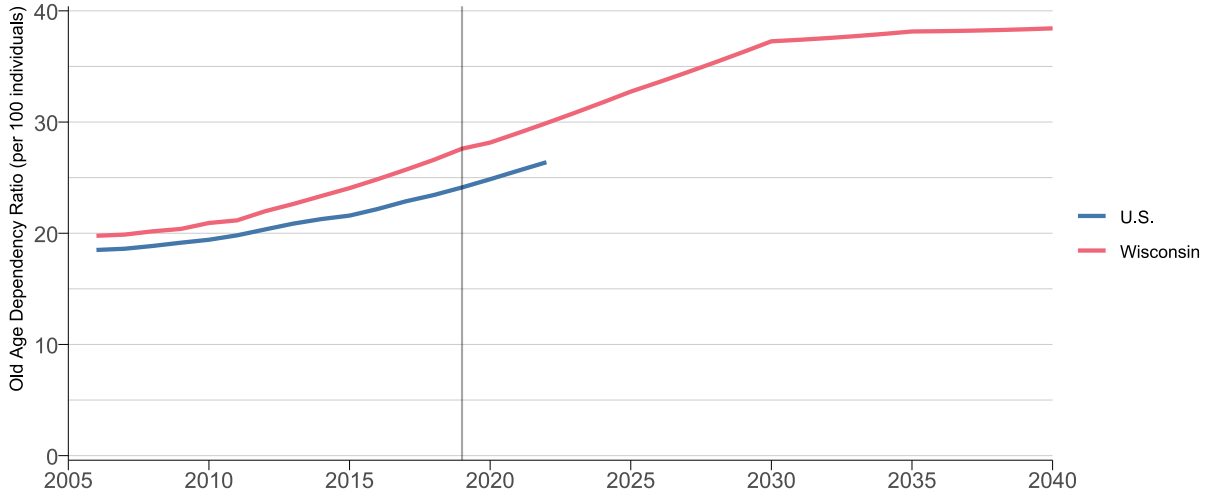
4.10) Dependency Ratios

The dependency ratio is a ratio of dependent population, such as the young and old, to the productive population, namely the working-age population. Children and the elderly often require additional care from other members of society (schooling, childcare, healthcare) that exceeds their economic contributions. Working-age individuals typically work a job with associated wages and taxes that benefit these dependent populations. Wisconsin, like many other states and nations, is facing an aging population. The old-age dependency ratio includes only

those older than 65 as dependents. As the share of Wisconsin's old-age population increases, its dependency ratio also increases.

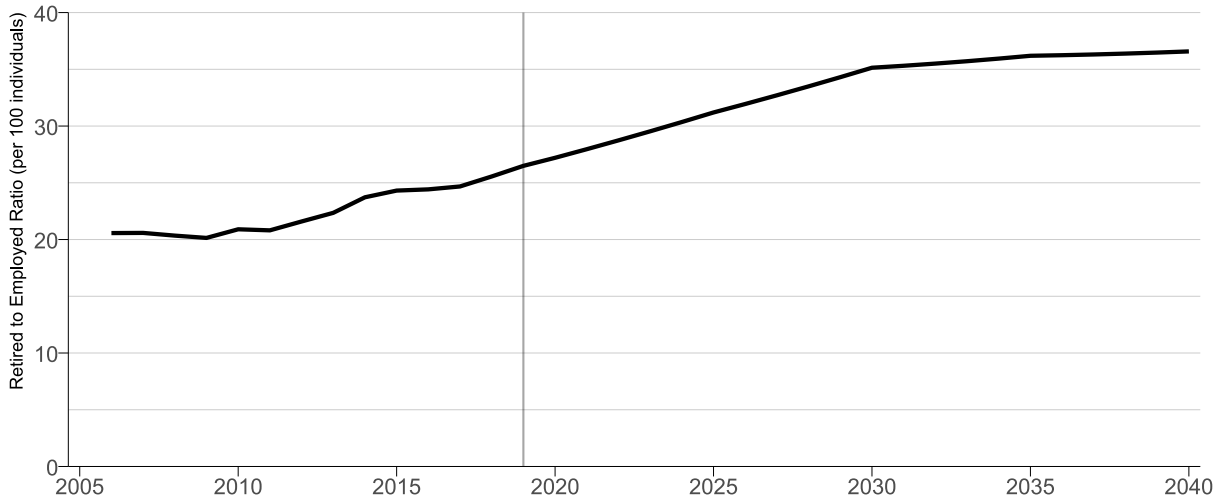
However, it is important to note that the old-age dependency ratio is a simplistic measure: not all elderly are dependent and not all working-age individuals are productive. As illustrated by Figure 17 The base population model predicts that Wisconsin's old-age dependency rate will continue its increase. By 2040, there will be 38 old-age individuals per 100 working-age individuals.

Figure 17 — Old age dependency.



A slightly more nuanced approach is to compare the retired population to the population in the labor force, as seen in Figure 18. The ratio of the retired (measured as those older than 65 not in the labor force) to the population in the labor force is also projected to increase, despite the increasing LFPRs of this older population. While slightly more nuanced than the old-age dependency ratio, this retiree-dependency ratio does not measure the actual productivity of these populations.

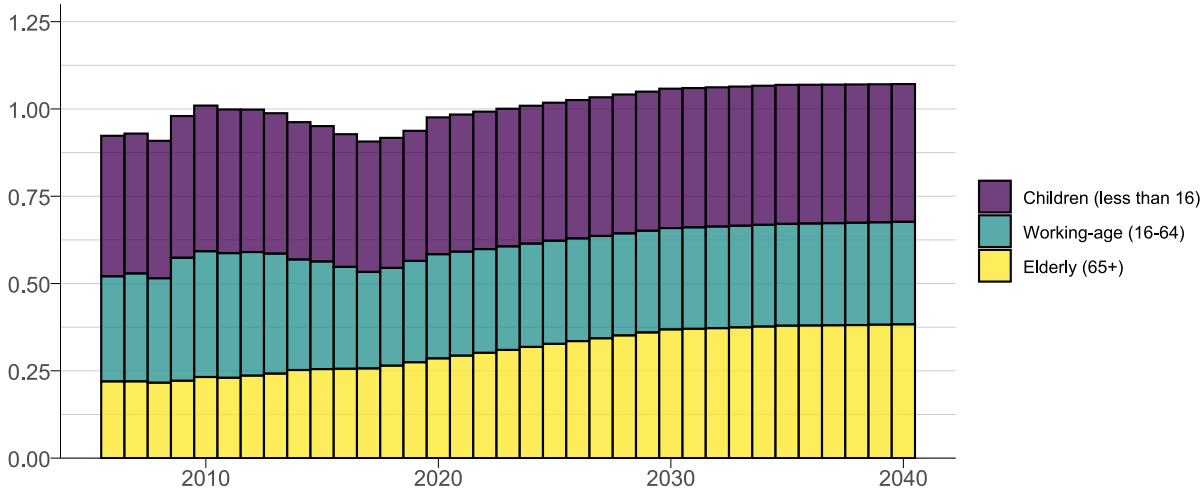
Figure 18 — Old Age Dependency Rate in Wisconsin and the U.S.



Another variation of the dependency ratio is the employment-based dependency ratio (EBDR), proposed by (Harasty and Ostermeier). The numerator of the EBDR is the sum of those not in the usual working age (population under 16 or over 65), outside the labor force (population aged 16 to 64 not in the labor force), or unemployed (population aged 16 to 64 seeking and

available for work). The denominator in the EBDR is the employed population aged 16 to 64. While this number offers advantages over other simple demographic dependency ratios by including unemployed individuals, it "does not give any indication of the job quality of those in employment and assumes them to be non-dependents" (Harasty and Ostermeier). Wisconsin's EBDR is in line with other developed countries and is projected to increase over the next two decades: from a ratio of 1.10 and 1.11 in 2010 and 2020 to 1.24 in 2030 and 1.25 in 2040. Both this level and trend matches other developed countries, which are also experiencing a demographic shift toward and older population (Harasty and Ostermeier). Figure 19 illustrates which demographic components contribute to the EBDR, highlighting the increasing percentage of the dependent population who will be elderly by year 2040. The share of the dependent population who are working-age or children will remain relatively steady.

Figure 19 — Employment-based dependency ratio.



5) Conclusion

The base case labor supply calculations indicate a current shortage and a growing gap in the balance between the demand and supply of jobs in Wisconsin. Labor force growth has been slowing and is expected to continue that trend. Predictions show a slow increase in Wisconsin's jobs supply. This indicates a need to focus on initiatives to attract talent and increase the state's capacity to fill jobs in order to counter this decline and maintain Wisconsin's economic strength. This report is a glimpse into an aspect of Wisconsin's future labor market.

These demographic and economic changes will have impacts on many aspects of the state as the needs and capacity of the state's workforce change.There could be a change in the sourcing of the state's tax revenue because relatively fewer people are earning taxable income from employment and shifting to transfer payments, which are flat in real terms.

Further research is needed to discover the implications of this shift on other aspects of the economy such as personal income, tax revenue, healthcare, and occupational changes.

6) Appendix

6.1) Definitions of Terms

- *Job Supply:* This number represents the total number of jobs held in Wisconsin. It is calculated by multiplying the number of employed workers in Wisconsin with jobs per employed and then incorporating the net number of jobs which cross Wisconsin's borders. This report estimates the future capacity to fulfill jobs in future in Wisconsin given the constraints of the state's changing demographic profile.
- *Demand for jobs*: Demand for jobs can be difficult to measure, but this report uses the Department of Workforce Development industry employment projections to project changes in occupational employment and a rough proxy for labor demand.
- *Difference between Job supply and Demand/Jobs*: There is a distinction between the capacity of the state's workforce to fill jobs and the projected number of filled jobs. This can be seen as the different trajectories between the supply and demand of jobs.
- *Institutionalization or Military Service Rate*: This rate measures the percentage who are either active-duty military or institutionalized. These individuals are typically excluded from the labor force. Institutionalized individuals are those who live in an institutional facility which provides supervised care, like correctional facilities or nursing homes. Subtracting this population from the total population yields the civilian, non-institutionalized population.
- *Labor Force Participation Rate (LFPR)*: The labor force participation rate is the percentage of people in the labor force (working or looking for work) of the total people who are eligible to participate in the labor force (civilian, non-institutionalized, and older than 15).
- *Natural Unemployment Rate*: This rate estimates the underlying rate of unemployment, accounting for all sources other than fluctuations in demand associated with business cycles.
- *Jobs Per Employed*: This represents the average number of jobs held by an employed individual. Every employed person has at least one job, but there are some who hold more than one, whether part-time or full-time.

6.2) Model Equation

$$JobsSupply_t = \sum_{ag}\left(P_{agt} \times \left(1 - \gamma_{agt}\right) \times \xi_{agt} \times \upsilon_{agt} \times \kappa_{gt}\right) + \sum_{ag}\left(C^{in}_{at} - C^{out}_{at}\right)$$

$$\gamma_{agt} = \frac{P_{agt} \in (Institution \cup Military)}{P_{agt}}$$

$$\xi_{agt} = \frac{P_{agt} \in (Employed \cup Unemployed)}{P_{agt} - P_{agt} \in (Institutionalized \cup Military)}$$

$$\upsilon_{agt} = \sum_{e}\left(\frac{P_{agte} \in (Employed \cup Unemployed)}{P_{agt} \in (Employed \cup Unemployed)} \times \frac{P_{ag2016e} \in (Unemployed)}{P_{ag2016e} \in (Employed \cup Unemployed}\right)$$

$$\kappa_{gt} = \frac{\sum_{gt} jobs}{P_{gt} \in Employed}$$

Where

a - the series of age groups. This is age cohorts in five-year increments. Beginning with age 16-19, 20-24, … until age 70 to 74. The oldest age cohort is the population over age 75. The youngest population cohort is age 0-15.

g - Gender (male or female).

e - Highest education level categories (less than high school, high school, associate degree, some college, bachelor's degree, post-bachelor's degree)

t - Year.

P - Estimate of the population ages 16 and over in Wisconsin.

γ - Rate of institutionalization or military service. Multiplying this rate by the population yields the Civilian Non-institutionalized population.

ξ - Labor for participation rate: the rate of people employed or actively looking for employment compared to the total civilian, non-institutionalized population of working age.

υ - Unemployment rate: the percentage of the labor force which does not have a job and actively looking for work.

κ - The number of jobs per employed person.

C^{in} - The number of jobs in Wisconsin where the employee resides outside of the state.

C^{out} - The opposite of the above: the number of jobs outside of Wisconsin filled by employees who reside in Wisconsin.

$Employed$ - the subset of the population who hold a job.

$Unemployed$ - the subset of the population who do not hold a job, yet are actively looking for one.

$Institutionalized$ - the population of individuals in P who live in a institutional group home, which is most commonly prisons and nursing homes. Individuals in these situations are usually unable to take part in the labor market.

$Military$ - the population of individuals in P who are actively serving in the military.

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