Abstract

Skills shortages and skills mismatches are worrying issues for businesses. According to the Hays Global Skills Index 2016, a study designed to assess the dynamics of the global skill labor market, labour markets have tightened, largely due to the strengthening in the demand. This has increased talent mismatch and wage pressures (Hays plc, 2016). In U.S., the increasing talent dismatch is manifested by simultaneous growth in both unemployment and job vacancies. In addition, the overall shortage of skilled workers shows no sign of improving, especially as more baby boomers retire every year without enough experienced professionals available to replace them (Udland, 2016).

One way that companies can overcome the skills deficit is to internally manage workforce development. Importantly, workforce management provides companies an opportunity to better use their expensive and limited labor resources to their greatest potential. Accounting for each individual employee's ability to learn helps company develop skills where they are needed and will solve the increasing talent dismatch. Further, it allows companies to take advantage of the capacity that is gained as employee learns by experience. Therefore, incorporating employees' learning in companies' workforce management does not only help a company meet its current needs, but also build capacity for meeting future demand growth as well as build the flexibility needed to buffer against demand uncertainty.

In this work, we explore how companies can incorporate both employee learning and future information into their immediate routing and scheduling plan so as to meet current demand and build capacity for the future. We study a variant of the technician routing and scheduling problem (TRSP). Similar to the classic TRSP, we consider a set of technicians serving a set of customers by finishing certain tasks and different tasks have different skills associated with them. In our problem, we consider the multi-period technician routing and scheduling problem that accounts for the fact that productivity increases (or service time decreases) as technicians gain experience. We measure experience in the number of times that the technician has performed a particular type of task. How quickly a technician learns is known as the technician's learning rate. We assume that we have a set of heterogeneous technicians whose learning rates and initial experience are known. The service time depends on the amount of experience the worker has with the skill required by the task and his/her learning rate. Each day, the technicians serve the day's demand, which is not revealed until the day of service. In this work, we seek

to minimize the expected sum of service times and routing costs over a finite horizon. Choosing this objective eliminates other factors' effect such as line balance and allows us to compare the performance of different approaches.

To solve the problem, we propose an approximate dynamic programming method that uses a parameterized linear model to approximate the value function at each time period. The linear model uses a basis function that maps the state into a small number of features. Importantly, the basis function reduces the large number of state variables into a smaller number.

To achieve a good approximation of the cost-to-go, we face two challenges. The first challenge is the construction of basis functions that reflect important elements of the state variable and capture essential information about the cost-to-go. Our basis function reduces the state to a value for each technician's aggregate experience levels over all task types. The second challenge is to determine the appropriate values of the coefficients of the basis functions. To determine the coefficients, we use approximate value iteration coupled with iterative regression.

In this study, we will make the following research contributions. First, we will develop a tractable ADP approach that uses a parameterized linear model to approximate the value function for the Multi-Period Technician Routing and Scheduling with Experience-based Service Times and Stochastic Customers. Our approach integrates future information over the whole planning horizon into current period decision-making. Second, we will provide computational experiments illustrating the value of integrating information from the whole horizon. To do so, we will compare the proposed ADP solution approach to a myopic approach.