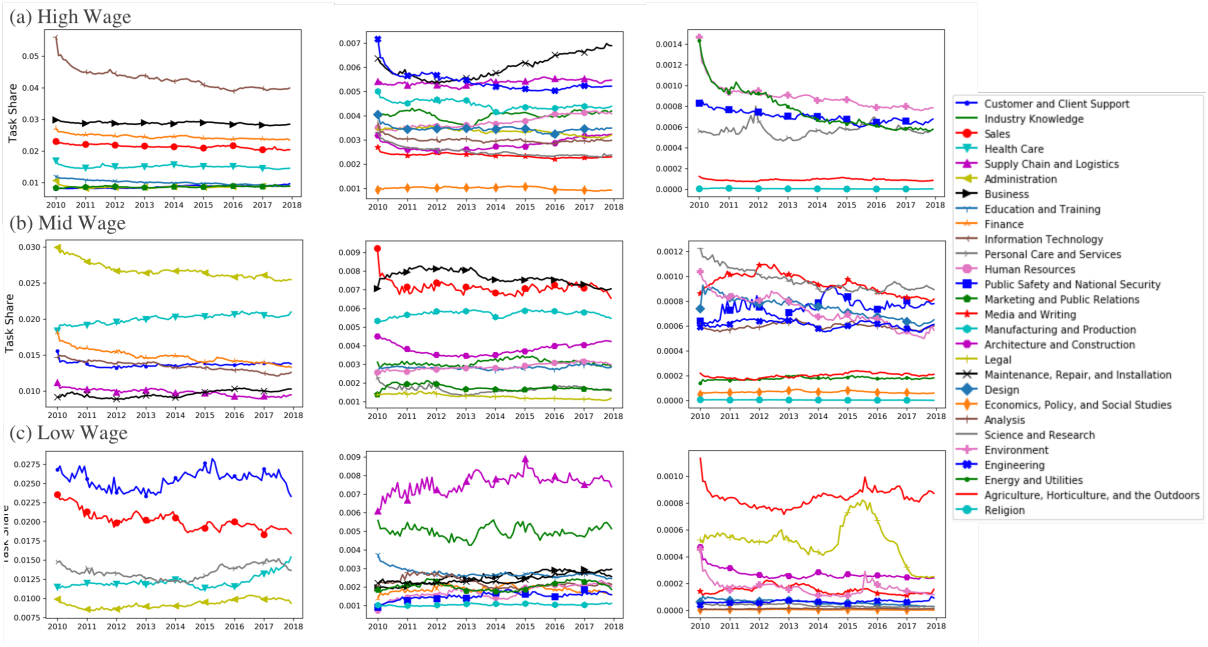

Figure 3: Task-Share dynamics of task cluster families across: (a) high, (b) medium, and, (c) low wage occupation groups.

The health care task cluster family has its highest shares in 'Healthcare Practitioners & Technical', 'Healthcare Support', 'Office & Administrative Support', 'Personal Care & Service', and, 'Community & Social Service' occupations (in order of demand). On the other end, its lowest shares are in 'Architecture & Engineering', 'Legal', 'Construction & Extraction', and 'Arts, Design, Entertainment, Sports, & Media' Occupations. These findings are in line with what one would expect and are easily extendable to other cases. Based on the regression coefficients in Table **??**, it is evident that the healthcare task-share has seen a significant growth in 'Personal Care & Service' occupation, along with considerable growths in 'Legal', 'Construction & Extraction', and 'Arts, Design, Entertainment, Sports, & Media' occupations and decline in 'Sales & Related' jobs.

In Fig. 2(b), the Information Technology (IT) task cluster family has its highest shares in 'Computer & Mathematical Operations', 'Office & Administrative Support', 'Business & Financial Operations', and 'Management' occupations, with declining demand in 'Computer & Mathematical Operations' occupations. IT has its lowest, yet steadily-growing shares in 'Personal Care & Service' and 'Construction & Extraction' occupations, as in Table **??**. These results are consistent with the anecdotal evidence of increased IT penetration of a variety of occupations as well as IT being a GPT.

High and Low Wage Jobs are Gaining Tasks

In the interest of studying how task-shares of different task cluster families have evolved across occupations with different wages levels, in Fig. 3 we display the evolution of aggregated *task-shares* $\tilde{y}_{p,q,t}$ across wage terciles (low, medium, high). The top five task-shares for high wage occupations are 'Information Technology', 'Business', 'Finance', 'Sales', and 'Health Care'; for mid-wage occupations they are 'Administration', 'Health Care', 'Finance', 'Customer & Client Support', and 'Information Technology'; and for low-wage jobs they are 'Customer & Client Support', 'Sales', 'Personal Care & Services', 'Health Care', and 'Administration'. Although the 'Maintenance, Repair, & Installation' and 'Human Resources' task cluster families had small task-shares in both high-wage and low-wage occupations, they still saw a steady and significant growth in demand. Comparable growth also happened for 'Architecture & Construction' & 'Customer & Client Support' in high-wage jobs, and, 'Business' & 'Public Safety & National Security', 'Engineering' in low-wage jobs. The regression coefficients in Table **??** provide additional details. Notably, for mid wage occupations, most task cluster families experienced declines. Such a transition in the task-shares among wage-based occupation groups indicates that mid wage occupations are losing shares overall, and that task-shares in high and low wage occupations are growing. This evidence of a more polarized workforce is consistent with the U-shaped occupational share and wage patterns found in Autor, Dorn (2013).

AI and Related IT Technologies

To study how AI and related technologies are impacting the labor market at the initial phase of adoption, we zoom into the Information Technology (IT) task cluster family to look at specific task clusters. In Fig. 4, we plot the task-shares of selected task clusters within the IT task cluster family across high, mid and low (HML) wage occupations. Although the 'SQL Databases and Programming', 'Java' and 'JavaScript & jQuery' task clusters have the highest shares in high and mid wage occupations, their demand is steadily declining, see Table **??**. In contrast, even though the 'Artificial Intelli-

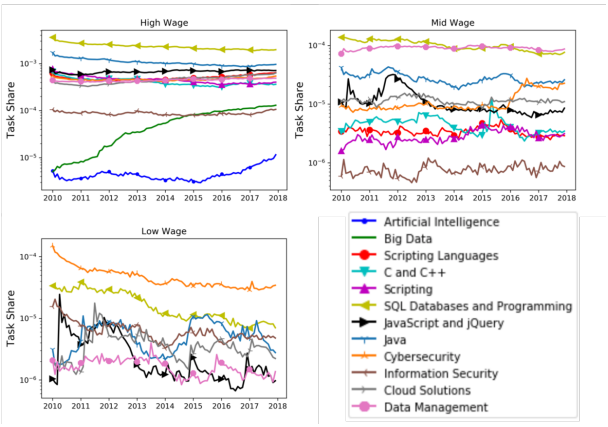

Figure 4: Task share dynamics of different Information Technology task clusters across HML wage occupations.

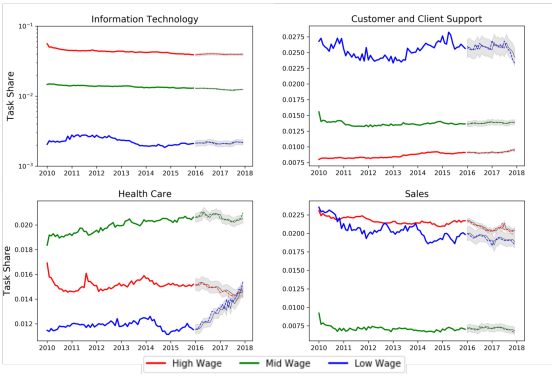

Figure 5: One-step ahead predictions of task-shares of selected task clusters families across HML wage occupations.

gence' and 'Big Data' task clusters had low task-shares in the high wage occupations, their demand increased at a very high rate during 2010-2017. These task-cluster have not seen any demand in the mid and low wage occupations. On the one hand, task clusters like 'Scripting Languages' (includes Python) and 'Cloud Solutions' are gaining task-shares in high wage occupations. On the other hand, most IT task clusters are losing task-shares in low wage occupations. This evolution of IT task demands confirms the industry trends towards developing AI-based products and services in the Cloud requiring workers to perform AI, Big Data, Scripting Languages, and Cloud Solutions based tasks while focusing less on traditional software products and services that require workers to perform SQL, Java, and Data Management oriented tasks.

Task-Share Forecasting

In addition to the insights already extracted, this study and dataset lays down the scope and foundation for detailed exploration of the evolution of occupations (and the tasks within) across different industries in the US labor market. The task-shares time-series data creates an opportunity to learn the dynamics of task and occupations, and, then quantitatively predict the task-shares for near future with confidence bounds. Such predictive capabilities on the labor market might help the workers reskill themselves, corporations retrain their employees, or, new graduates to learn the skills to be able to execute the tasks of the future.

In the first phase of this study, we have trained an autoregressive integrated moving average (ARIMA) model (**?**) to learn the representation dynamics of the task-shares of different task cluster families across HML wage occupations over the first 72 months of data (2010-2016). Using this trained ARIMA model, we make one-month ahead predictions of the task-shares. The mean absolute percentage error (MAPE) of predictions is considerably less than 5% in most cases as shown in Table **??**. In Fig. 5, we plot the task-share forecasts (black lines) with 95% confidence intervals (grey areas) to compare against the true task-shares (dotted lines) for a few selected task cluster families across high (red line), mid (green line), and low (blue line) wage occupations. The accuracy of the task-share predictions is a clear indicator towards the benefit of developing robust and more accurate forecasting models to characterize the evolution of occupations and the tasks therein.

Conclusions & Next Steps

Some of the task trends are striking. Notably, the fast rise of Big Data and Artificial Intelligence in high wage occupations since 2012 and 2016, respectively. This delayed, yet rapid development seems similar to the adoption of electricity in the 1890s as well computers in the 1970s - both started slow and labor productivity growth did not take off for over twenty years (**?**). Thus, we may have another decade or so giving workers ample time to adapt with the occupational transformation.

This empirical research sheds new light on the transformation of work by characterizing occupations in terms of task-shares dynamics. There are still many open questions remaining in the study. To extract further empirical evidence as to what is occurring in the US labor market, it would be crucial to investigate: (a) how task-share dynamics are evolving across different industries and across different geographical/Metropolitan regions within the country; (b) dynamic functional coupling between different task-shares across occupation groups; and, (c) impact of task-share dynamics on wage-dynamics and vice versa. Today, we know the change AI and new technologies will bring to the labor market is still relatively small, but real. To prepare for continued adoption and advancements in the technologies, an immediate next step will involve the development of accurate, comprehensive and robust predictive models, using Gaussian Processes or long short-term memory (LSTM) based artificial recurrent neural networks (RNN), so as to provide guidance to workers, employers, and new graduates on skills and tasks of the future.

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