The research question is what impact does machine learning have on economics, and how future impacts may develop? The author does adequately define the research question in Introduction part (Athey, 2018: p.1). The author begins to describe the definition of machine learning, its advantages and disadvantages, and the difference between it and the traditional economic methods. Then, the author gives us some analysis of what aspects of machine learning can be applied to economics. (Athey, 2018: p.1)

I think the author compellingly answers the research question. Firstly, the author gives us the definition of machine learning "from a perspective that can be distinguished from other economic measurement methods (Athey, 2018: p.3)". From the author's point of view, those tools are very useful because it could provide a data-driven way to find more similar models and create more variables in economic analysis. The author also introduces some methods for supervised learning with the comparison of disadvantages in traditional economic approaches (Athey, 2018: p.4). The author also introduces other categories of machine learning models like "anomaly detection focuses on looking for outliers or unusual behavior (Athey, 2018: p.7)". Secondly, the author introduces the applications of prediction methods in ML in policy analysis. Basically, the author introduces some applications that use ML algorithms to make predictions in different social environments. Then, the author discusses the problems that economists have long faced with some misinterpretation of models. Hopefully, ML algorithms can help us make more efficient resource allocation and interpret the economic models more objectively than human beings (Athey, 2018: p.9). Besides, the author also talks about "how to constrain ML models to make them less prone to manipulability (Athey, 2018: p.9)". Thirdly, the author predicts that there will be new methods combining ML and causal inference to "harness the strengths of ML algorithms to solve causal inference problems (Athey, 2018: p.10)". Then, the author talks about several strategies on the casual inference combined with ML, like "Average Treatment Effects (Athey, 2018: p.12)", "Heterogeneous Treatment Effects and Optimal Policies (Athey, 2018: p.13)", "Contextual Bandits (Estimating Optimal Policies using Adaptive Experimentation) (Athey, 2018: p.16)", "Robustness and Supplementary Analysis (Athey, 2018: p.16)", "Panel Data and Difference-in-Difference Models (Athey, 2018: p.18)", and "Factor Models and Structural Models (Athey, 2018: p.19)". Lastly, the author gives us a general prediction on the future impact of machine learning on Economics. The author listed and well explained all the predictions. Basically, from the author's point of view, the research and methods the researchers are doing now will be changed by ML. In the future, we will have newer and more robust research methods because of combining with ML.

I think the methods used in this paper to answer the research question are appropriate and sufficient. After introducing the basic definition of ML, the author

mentions the application of ML in Economics research methods and theory, such as the extensions and modifications of the prediction methods using in Economics and the development of new methods. At the same time, the author cites a lot of literature on ML and economics to illustrate the adoption of ML in Economics and gives us her opinion on the future impacts of ML.

In this paper, the author uses a lot of literature on ML and Economics to prove his point of view and the development of the two disciplines. But I also think the author needs to explain these places more clearly: Firstly, the author described "one common feature of many ML methods is using data-driven model selection (Athey, 2018: p.4)". Then, the author simply explains that it is constantly improving the functional form of the model with new data. I think here the author can cite some literature on ML methods to prove his point of view. Secondly, the author mentioned "we will see a lot more research into the societal impacts of machine learning (Athey, 2018: p.26)". Then the author mentioned a few points why he made such a prediction, such as "the potential to create enormous efficiency (Athey, 2018: p.26)". I think here the author should cite relevant frontier literature for her illustration, which will be more convincing. Lastly, I don't think there are unnecessary references in this paper. Although some documents are cited more than 1 time in the paper, the author explains in detail the reasons for the citation and the page number. Therefore, I don't think there is a problem with over-quoting

There are some grammar and spelling errors in this article. For example, the author says, "where the probabiity of selecting an arm is chosen to balance exploration and exploitation) (Athey, 2018: p.7)". Here, "probabiity" should be corrected as "probability". On page 18, the author says, "since we dont observe the counterfactual outcomes of those units in the absence of the treatment (Athey, 2018: p.18)". I think there should be a " ' " in the middle of the word "dont". I also find it is a little confused to me when the author says "This article has al discussed the first three predictions in some detail (Athey, 2018: p.22)". From my perspective, the author should use more formal expressions in her paper, like "already" instead of "al". Also, I think this sentence in the paper is too long to be understood substantially. "Some examples of these have already been highlighted, such as the ability to measure economic outcomes at a granular level over a longer period of time, through, e.g. imagery. Glaeser et al. (2018) provides a nice overview of how big data and ML will affect urban economics as a field as well as the operational efficiency of cities. (Athey, 2018: p.23)" And I think the word should not be "through", the author probably wants to use "though" here, which also causes difficulty in reading. I think the references are correctly listed.

Machine Learning is an algorithm continuously optimizing itself based on the large data. Mullainathan and Spiess (2017) mentions, in face recognition algorithms, "ML algorithms use a large dataset of photos labeled as having a face and estimate a function $f(x)$ that predicts the presencey of a face from pixels x instead of based

on human understanding of what constitutes of face. (Mullainathan and Spiess, 2017: p.87)" In Athey (2018), the author mentions a lot of machine learning applications in economics and other social science fields. However, in this article, the author mainly focuses on the framework, theory basis and related literature of machine learning changing economics research methods. Form my perspective, the extension of this should prove the author's argument with detailed data and models. For example, one method the author uses in this paper is to predict the outcome based on supervised machine learning (Athey, 2018: p.4). The author explains in detail on how to predict the outcome according to the observed variables, like "the goal is to construct $\hat{\mu}(x)$, which is an estimator of $\mu(\mathrm{x}) = \mathrm{E}[\mathrm{Y}|\mathrm{X} = \mathrm{x}]$. (Athey, 2018: p.4)" It will be more clearly to me if the author could provide the real dataset and compare her prediction with the real result.

References:

1. **Athey, Susan**, "The Impact of Machine Learning on Economics," in Joshua Gans Ajay K. Agrawal and Avi Goldfarb, eds., *The Economics of Artificial Intelligence*: *An Agenda*, National Bureau of Economic Research
2. **Sendhil Mullainathan and Jann Spiess**, "Machine Learning: An Applied Econometric Approach", *Journal of Economic Perspectives*, Volume 31, , Pages 87–106, (2017)