

Correlation Between Economic Resources and Productivity in different Industries of the U.S.

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Problem Statement

What is the correlation between the quantity of Economic Resources and Multifactor Productivity?

Quantity as primary indicator

The **more** resources the better OR the **less** resources the better?

- The quantity of resources indicates the “cost” to achieve a certain degree of productivity
- Originally, to increase productivity organizations had to invest more resources
- This research aims to identify whether this still holds true nowadays

Why is topic important and interesting?

Productivity is much more important than revenue and profit!

- Profits only reflect end results
- Productivity reflects whole business processes and policies

Economic Factors are the most basic approach to analyze Productivity!

- Traditional resources including labor, capital, and raw material
- Are useful to indicate the effect of current trends on productivity

→ Enables Businesses to find Strength and Weaknesses

Hypothesis

1. The number of employees has a negative correlation with labor productivity.
2. The number of hours has a negative correlation with labor productivity.
3. Labor productivity has the most significant impact on multifactor productivity
4. Unit labor cost has a negative correlation with multifactor productivity.
5. Capital of tangible resources invested has a positive correlation with capital productivity.

Rational: The hypothesis were chosen based on the objective to relate quantity of resources and multifactor productivity

Independent & Dependent Variables

Independent Variables	Dependent Variables
Labor Compensation Cost	Multifactor Productivity
Intermediate Purchases Cost	Labor Productivity
Number of Employee	Intermediate Purchases Productivity
Number of Hours	Capital Productivity
Capital of tangible Resources	Value of Production
Unit Labor Cost	

Data Description

1. Data Size: 20 years * 12 variables * 1870 rows = 448,800
2. The time range covers 21 years from 1995-2015
3. Complete web link to data:
https://www.bls.gov/mfp/mfp_by_industry_and_measure.xlsx
4. The whole dataset is of quantitative nature
5. There was no data merge required for this research
6. Data transformation: transposition of rows and columns, elimination of rows with missing values (year 2017)

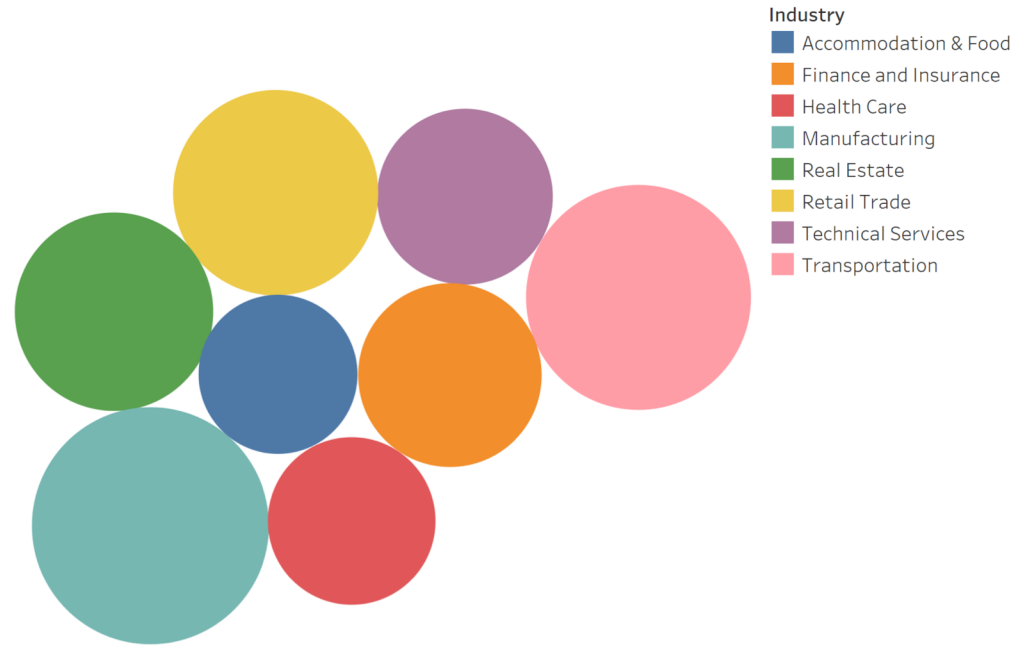


Figure1: Industry Productivity Distribution

- Representation of overall productivity divided by aggregated industries over 20 year time period
- Manufacturing and Transportation have the highest, while Health Care and Accommodation & Food have the lowest overall productivity
- Service Industries have started later to improve productivity and it is more difficult to measure

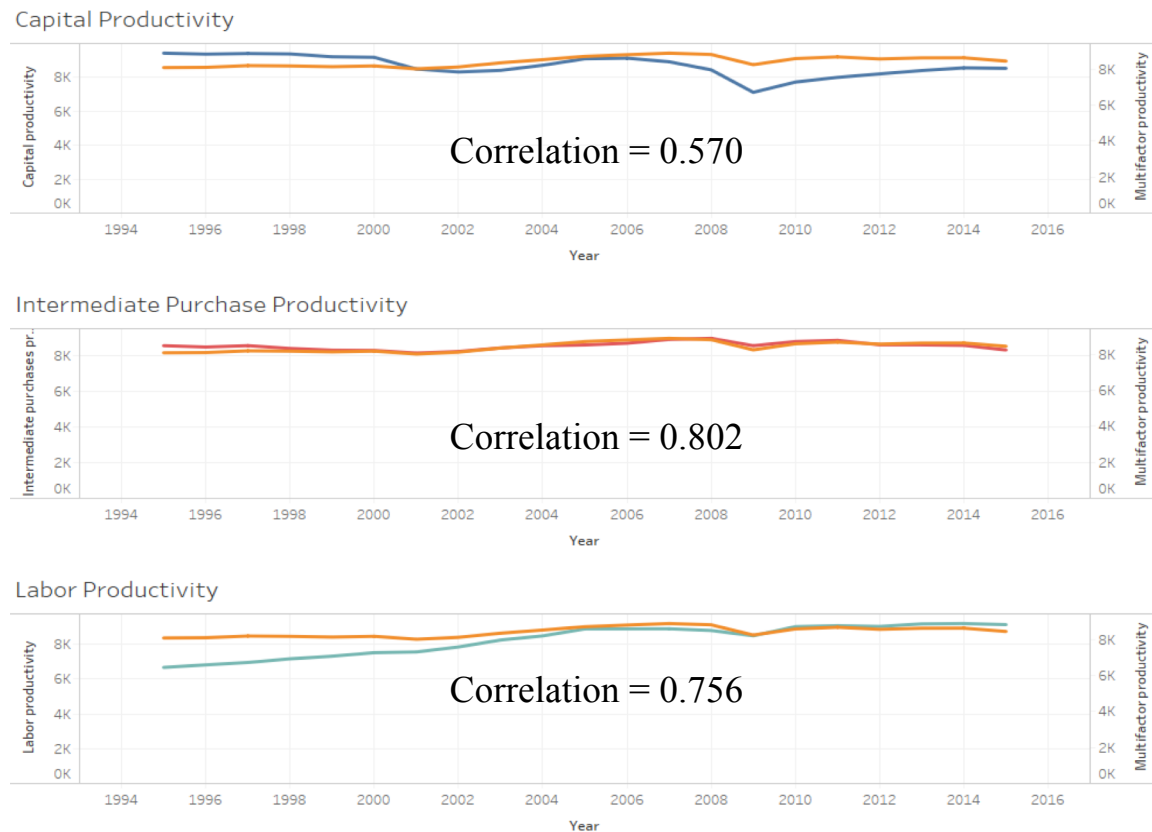


Figure 2: Components of Multifactor Productivity

- Correlation of absolute productivity of capital, intermediate purchases, and labor with multifactor productivity
- All elements have a positive correlation with Multifactor Productivity but Intermediate Purchase Productivity has the most significant
- The best leverage for companies to increase productivity is labor and intermediate purchases

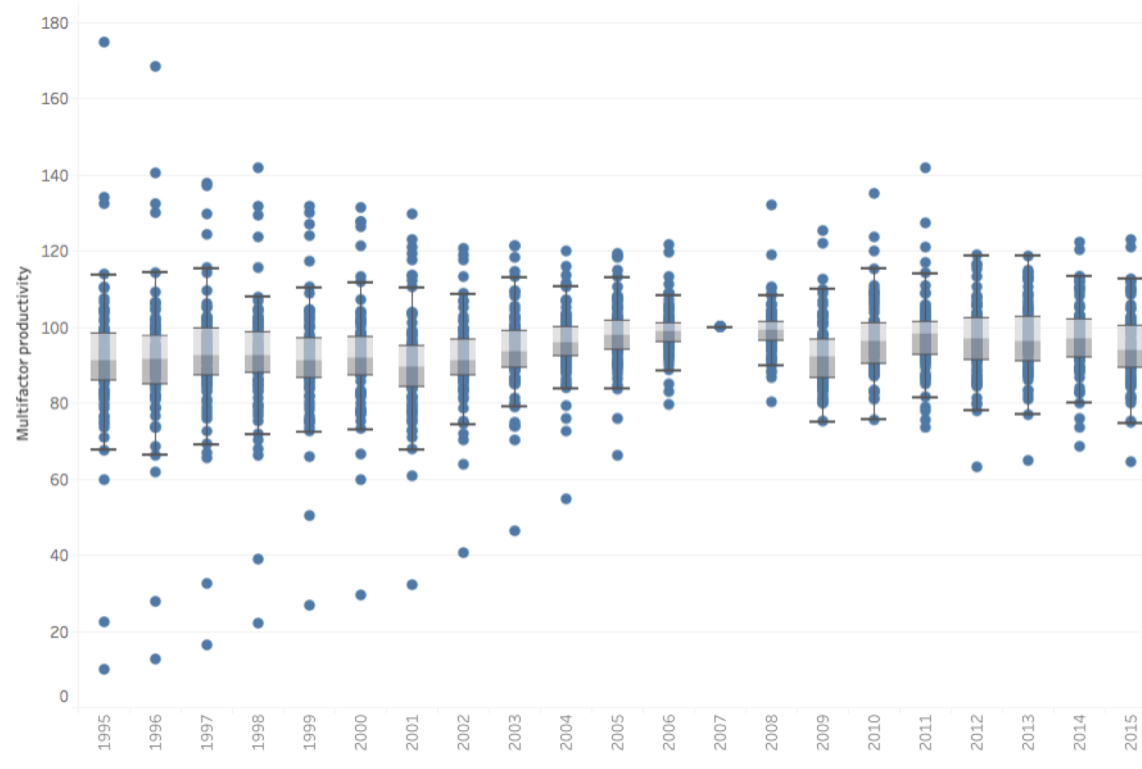


Figure 3: Difference in Productivity among Industries

- Distribution of Multifactor Productivity for each year
- The standard deviation of productivity among industries decreases over time
- Procedural and technical standards have been transferred between one industry to another (especially manufacture to service)

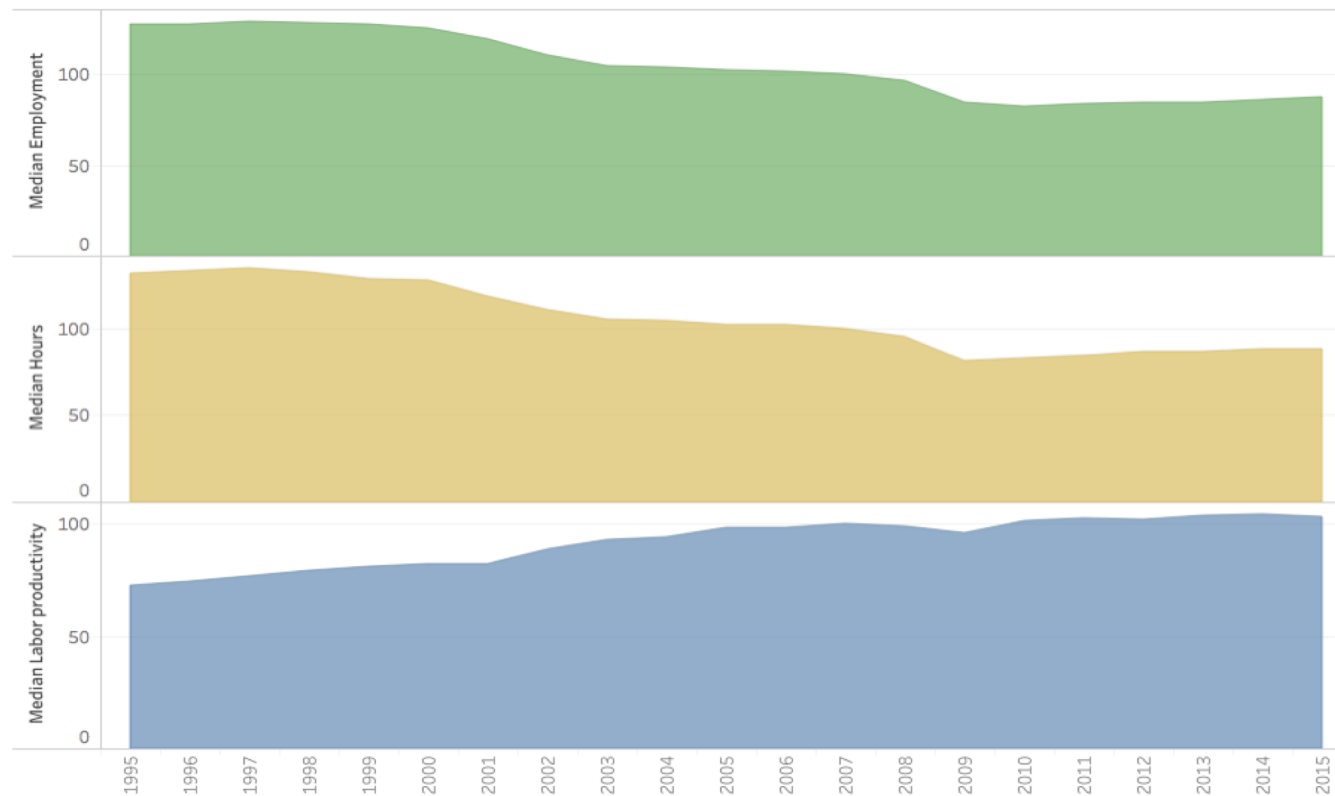


Figure 4: Quantity of Economic Resources (number of employee & number of hours)

- Area Charts to visualize the trend regarding number of employment, number of hours worked on products, and labor productivity
- While both the number of employees, as well as the hours worked decrease, labor productivity increases
- Due to automation and development in technology, less labor is needed for more productivity

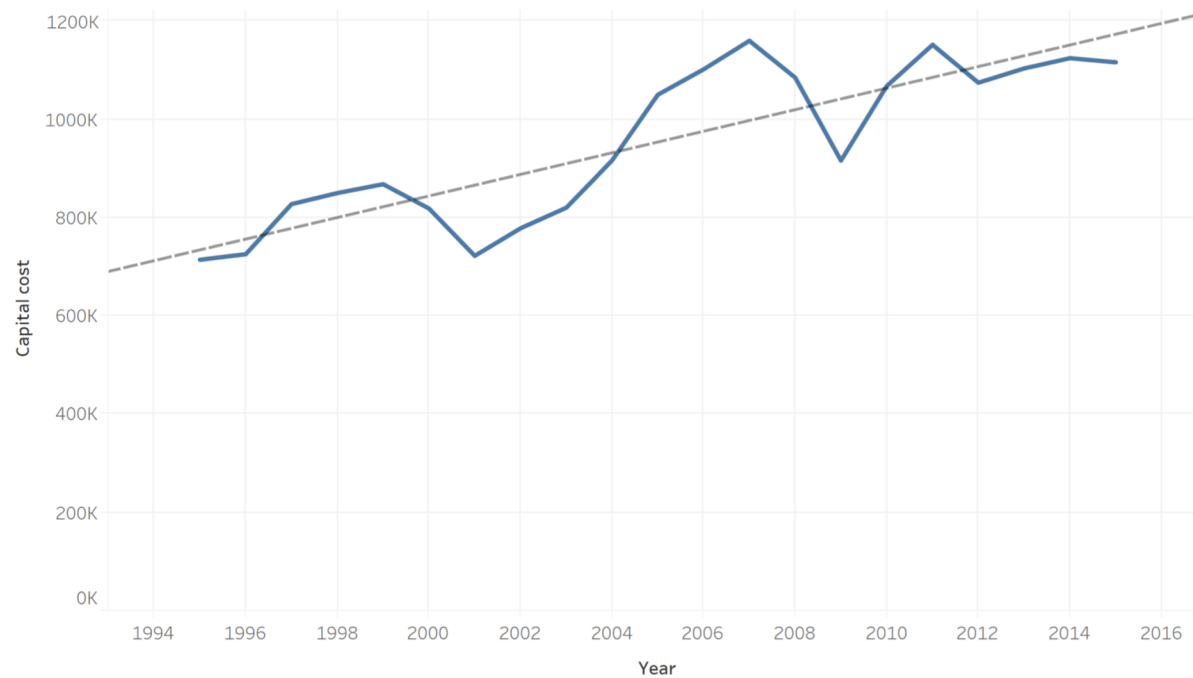
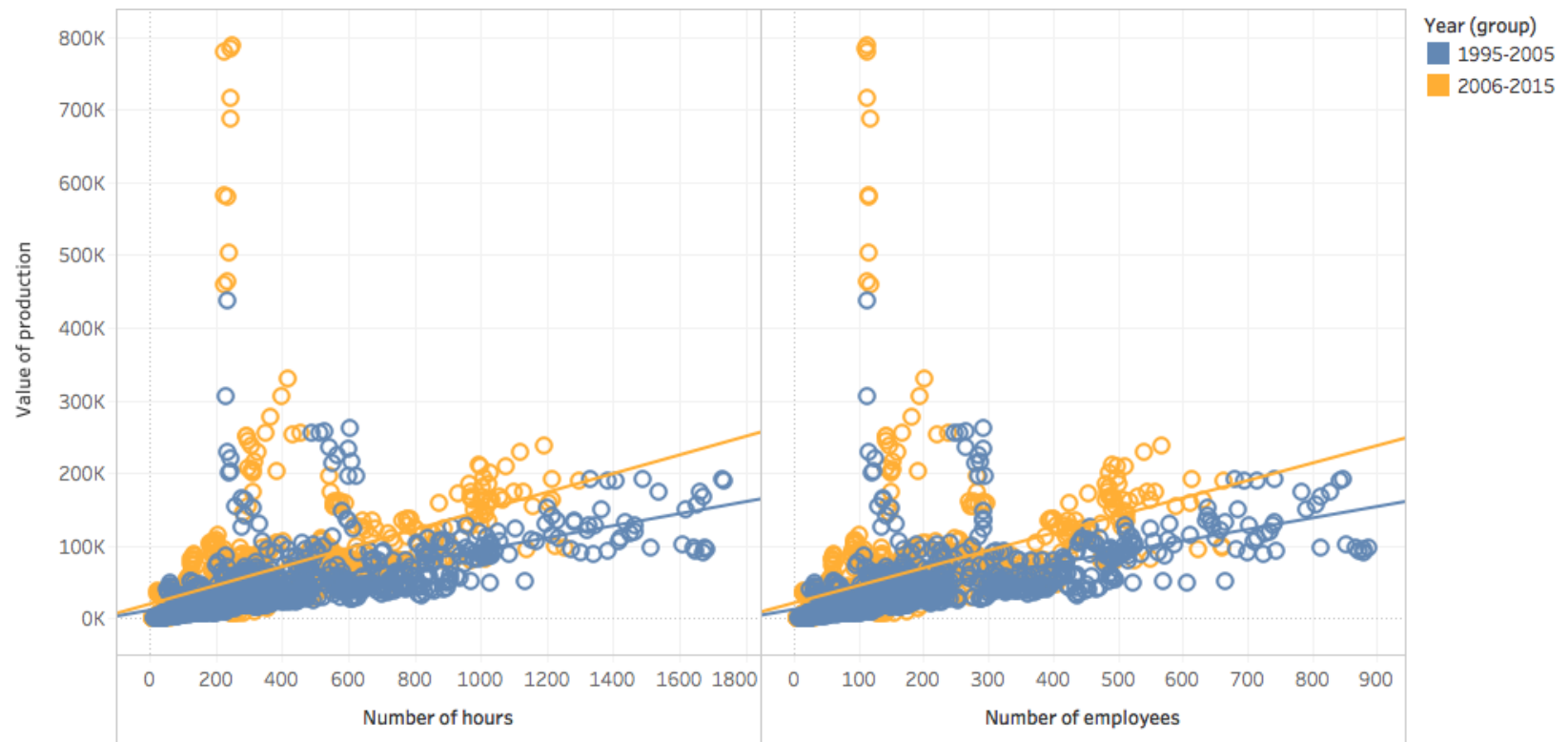


Figure 5: Investments in Technology

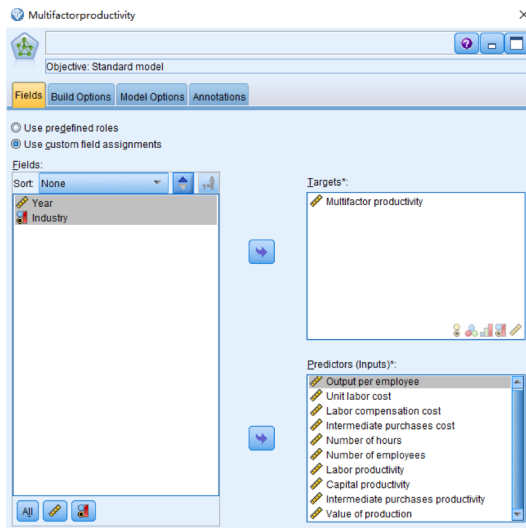
- Illustration of overall capital costs in terms of equipment, (IT-) Infrastructure, and machineries
- The investments increase over the inspected time period of 20 years as the trend line shows
- It is of paramount importance for companies to invest in technological equipment



Number of hours and Number of employees vs. Value of production. Color shows details about Year (group). The view is filtered on Year (group), which keeps 1995-2005 and 2006-2015.

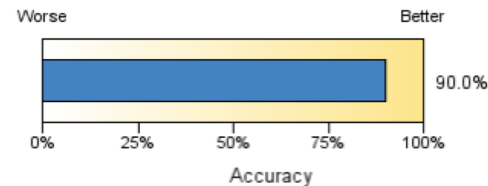
Figure 6: Statistical Model, Linear Regression

- Number of hours as well as number of employees are positively correlated with value of production;
- These trend lines prove that value of production increases more rapidly during 2006-2015 than that during 1995-2005.



Model Summary

Target	Multifactor productivity
Model	Multilayer Perceptron
Stopping Rule Used	Error cannot be further decreased
Hidden Layer 1 Neurons	6



Predictor Importance
Target: Multifactor productivity

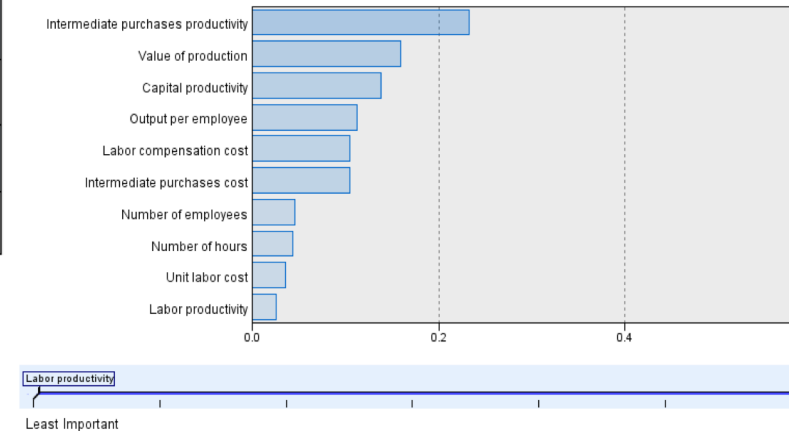


Figure 7: Machine Learning Model, Neural Network

- We generate the neural network model, and choose proper variables as inputs and target.
- The accuracy of model is 90% and the most important variable for target is intermediate purchase productivity.
- Intermediate purchase productivity may perform a important role in affecting multifactor productivity.

Results & Discussion

1. Quantity of labor has a negative correlation with productivity
2. Unit Labor Costs correlates negatively with productivity, while individual labor compensation increases (=automation)
3. Labor and intermediate purchase productivity have the most significant effect on multifactor productivity
4. The increasing capital invested in tangible resources (defined as IT-equipment and infrastructure) has a positive effect on productivity

Scope & Limitations

- Methodological
 - Sample size limited; might not include all existing industries
 - Provide trend indications rather than representation of population
- Resources
 - Data might not be consistently inflation adjusted
 - Only physical resources are taken into account (excluding knowledge, etc.)
 - Location is limited to the USA
- Researchers
 - Limited access to dataset (i.e. no login, no buying, etc.)

Conclusion & Future Research

As the results show, this research can conclude that:

There is a negative correlation between the quantity of economic resources and multifactor productivity in various industries of the U.S.

This study can be used as a trend indicator and basis for further research on the topic of productivity. Suggested areas are:

- Effects of robotics on productivity
- Effects of wearables on productivity

Policy / Managerial Implications

- Fewer traditional economical resources are needed for the same or increased degree of productivity
- This phenomena can be (partially) explained by current trends and developments in technology
- Managers should focus on smart investments rather than quantity of resources (More \neq Better)
- Higher compensation of labor does not increase productivity (intrinsic motivation $>$ extrinsic motivation)
- Investment in technology boosts productivity