**Introduction**

The question this paper seeks to address is in what way, or to what extent, does technological advancement impact overall economic growth. It is important for continual growth to understand how the economic well-being of various countries develops and improves over time, and technological advancement is likely a key player in how quickly that occurs; we will try to understand to what extent, and by which advancements, that is true. Additionally, we will look at how these factors affect different countries differently, such as “developed” countries compared with “undeveloped” countries.

**Data**

We will primarily utilize two datasets; one detailing economic measurements such as GDP, employment, and population over time; and one measuring technological progress over time. The economic data comes from the Penn World Table (PWT) as provided by the University of Groningen, and the technological progress data comes from the National Bureau of Economic Research (NBER).

These are cleaned and merged into one dataset to be analyzed, with each observation containing variables on the economic and technological status of a given country in a given year; the technological data is very unbalanced, but efforts were made to pick variables to analyze that have fewer missing data points and that also give insight to the question of how technological advancement influences economic growth. The variables measuring technological advancement can be categorized into nine different sectors: Agriculture, Energy, Health, Steel, Telecommunications, Tourism, and Transportation. Variables for Textiles and Finance were omitted due to too much missing data. We will be using one variable from each of the other sections for our analysis.

The following table shows the variables that were chosen for the different sectors and the percentage for which they have data for (across all years and all countries):

|  |  |  |  |
| --- | --- | --- | --- |
| Sector | Variable Name | Description | % Missing |
| Agriculture | ag\_tractor | # of wheel and crawler tractors | 13 |
| Energy | elecprod | Gross output of electric energy in KwHr | 19 |
| Health | bed | # of beds available for patients | 63 |
| Steel | steel\_crude | Crude steel production (in metric tons) | 58 |
| Communication | cellphone | # of users of portable cell phones | 20 |
| Tourism | visitorrooms | # of visitor rooms (hotels/elsewhere) | 48 |
| Transportation | ship\_all | # of ships of all kinds in use at midyear | 69 |

We will also use several control variables to help remove bias from the regression that will be performed. One of these will be an interaction term derived by a dummy variable, “recession,” with a value of one for whether there was a recession during at least one quarter of that year and zero if there was not; the interaction term is xr \* recession (xr the exchange rate with the US dollar). Typically, a relatively worse exchange rate with the US dollar (when the US dollar isn’t impacted by US-based recessions) results when a country is in some type of recession; the exchange rate and the interaction term may help to account for this. The recession data is gathered by the Federal Reserve Bank of St. Louis; while the data is specifically about recessions in the United States, we will use it across the data set, as recessions in the US are typically felt world-wide, even if sometimes less severely. The variable “delta” is used to account for the rate of depreciation of capital; and the variable “emp\_rate” is used to measure unemployment.

Outliers in rGDP per capita were dropped; an example is Kuwait during its oil boom. Below is a graph showing the trend of rGDP per capita over time after outliers were dropped:



Something that we are interested in is how different technological sectors affect GDP growth for developed countries compared to undeveloped countries. The graphs below demonstrate that there are significant differences; most notably, capital for the Tourism sector and the Energy sector tend to experience more growth in developed countries than undeveloped. 



**Empirical Analysis**

The empirical strategy used to help tease out the effects of technological growth on economic growth resides in a robust regression model (accounting for heteroskedasticity); the explained variable, real GDPA per capita, is regressed on the following variables: employment rate, capital depreciation rate, exchange rate with US dollar, an interaction variable between exchange rate and whether there was a recession in the US that year, growth of crude steel production, growth of cellphone accessibility, growth of ships in use, growth of electrical production, growth of tractors for agricultural usage, growth in beds for ill patients, growth in rooms for tourism purposes.

The intent is that we can measure a range of technology while accounting for shocks to the economy (things that result in poor exchange rates or low unemployment). Variables were picked to maximize the number of observations that can be included in the regression, and additional measures were taken to aggregate relevant data. For example, four methods of crude steel production were aggregated into total crude steel produced; as time goes on, less advanced methods are phased out. Aggregating the data into a new totalized variable helped make the data more balanced and continuous. The same method was implemented to aggregate beds for sick patients across different types of beds (or beds for more specific purposes). We also use a Prais-Winsten regression method to account for autocorrelation over time.

Below are the numerical results of the regression analysis; verbal analysis is given after.

Regression Results:

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Coefficient | Robust Std. Err. | P-Score |
| emp\_rate | -9.8377 | 3.3554 | 0.00 |
| delta | -12.9338 | 17.0267 | 0.45 |
| xr | 0.2021 | 0.0614 | 0.00 |
| recession\_xr\_inter | -0.2008 | 0.0613 | 0.00 |
| steel\_crude\_growth | 0.0520 | 0.0219 | 0.02 |
| cellphone\_growth | 0.0024 | 0.0010 | 0.02 |
| ship\_all\_growth | -0.0039 | 0.0299 | 0.90 |
| elecprod\_growth | 0.0608 | 0.0178 | 0.00 |
| ag\_tractor\_growth | 0.0251 | 0.0825 | 0.01 |
| bed\_growth | 0.0068 | 0.0026 | 0.01 |
| visitorrooms\_growth | -0.0810 | 0.0352 | 0.03 |
| \_cons | 6.004 | 1.6789 | 0.00 |

The regression is done with 72 observations; it yields a combined F-test of 34.65 and an R-squared value of 0.4723. This means that about 47% of the variation in the data can be explained by the variables we picked. A joint F-test of all the variables related to technological advancement yields a value of 6.56, which corresponds to a 0.00 p-value.

The measures of technology that were both significant at the 5% level *and* had the greatest influence on predicting GPD growth were agricultural, tourism, electrical production, and crude steel production. Those with the least were related to communications, health, and transportation. All of these were individually significant at the 5% level except transportation.

When comparing technological growth between developed and developing countries, we see that there a number of key differences. The following variables are significantly higher in developing countries than developed: growth in crude steel production, cellphones, available ships, electrical production, and agricultural tractors. Only growth in available beds for patients and rooms for visiting tourists were higher in developed countries. Most interestingly, the number of available ships in developed countries was declining by roughly the same percentage every year on average as they are going up in developing countries. This may suggest that developed countries are growing economically more and more in the way of services rather than goods. This is supported by the long-held ideas about how a country goes from undeveloped to developed (beginning with industrialization, steel and energy production, etc.).

**Conclusion**

In short, there is certainly evidence from the data analyzed here that technological growth influence economic growth; to what extent these variables influence each other is hard to tease out. Furthermore, it is clear that technological growth occurs in different ways in developed countries and developing countries, and this is evidence to support the idea that developed countries shift away from producing goods and towards the production of services (and, perhaps, research and development). Perhaps the greatest limitation in this study was the amount of missing data; this made it difficult to have a more favorable number of observations in analysis and greatly limited the variables that could be incorporated therein. Additional analysis could be done if we had both more economic and technological data points across countries and years.