How to Predict the Progress of Technology

David L. Chandler, MIT News Office

MIT researcher finds Moore's Law and Wright's Law best predict how technology improves.

Researchers at MIT [1] and the Santa Fe Institute have found that some widely used formulas for predicting how rapidly technology will advance — notably, Moore's Law and Wright's Law — offer superior approximations of the pace of technological progress. The new research is the first to directly compare the different approaches in a quantitative way, using an extensive database of past performance from many different industries.

Some of the results were surprising, says Jessika Trancik, an assistant professor of engineering systems at MIT. The findings could help industries to assess where to focus their research efforts, investors to pick high-growth sectors, and regulators to more accurately predict the economic impacts of policy changes.

The report is published in the online open-access journal PLOS ONE. Its other authors are Bela Nagy of the Santa Fe Institute, J. Doyne Farmer of the University of Oxford and the Santa Fe Institute, and Quan Bui of St. John's College in Santa Fe, N.M.

The best-known of the formulas is Moore's Law, originally formulated by Intel co-founder Gordon Moore in 1965 to describe the rate of improvement in the power of computer chips. That law, which predicts that the number of components in integrated circuit chips will double every 18 months, has since been generalized as a principle that can be applied to any technology; in its general form, it simply states that rates of improvement will increase exponentially over time. The actual rate of improvement — the exponent in the equation — varies depending on the technology.

The analysis indicates that Moore's Law is one of two formulas that best match actual technological progress over past decades. The top performer, called Wright's Law, was first formulated in 1936: It holds that progress increases with experience

— specifically, that each percent increase in cumulative production in a given industry results in a fixed percentage improvement in production efficiency.

To carry out the analysis, the researchers amassed an extensive set of data on actual costs and production levels over time for 62 different industry sectors; these ranged from commodities such as aluminum, manganese and beer to more advanced products like computers, communications systems, solar cells, aircraft and cars.

“There are lots of proposals out there,” Trancik says, for predicting the rate of advances in technologies. “But the data to test the hypotheses is hard to come by.”

The research team scoured government reports, market-research publications, research reports and other published sources to compile their database. They only used sources for which at least a decade’s worth of consistent data was available, and which contained metrics for both the rate of production and for some measure of improvement. They then analyzed the data by using the different formulas in “hindcasting”: assessing which of the formulas best fit the actual pace of technological advances in past decades.

“We didn’t know what to expect when we looked at the performance of these equations relative to one another,” Trancik says, but “some of the proposals do markedly better than others.”

Knowing which models work best in forecasting technological change can be very important for business leaders and policymakers. “It could be useful in things like climate-change mitigation,” Trancik says, “where you want to know what you’ll get out of your investment.”

The rates of change vary greatly among different technologies, the team found.

“Information technologies improve the fastest,” Trancik says, “but you also see the sustained exponential improvement in many energy technologies. Photovoltaics improve very quickly. … One of our main interests is in examining the data to gain insight into how we can accelerate the improvement of technology.”

Erin Baker, an associate professor of mechanical and industrial engineering at the University of Massachusetts who was not connected with this work, says, “This is a very nice paper. The result that Wright’s Law and Moore’s Law both fit past data equally well is surprising and useful.”

For more information visit www.mit.edu [1].

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