

Use of Predictive Analytic Tools to Assess Technological Emergences and Acquisition Targets

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The competitive technological edge that the Department of the Air Force (DAF) has historically possessed is today under constant pressure, due in part to the globalization of scientific research and technology development, foreign control of sources of critical materials and components, and foreign acquisition of U.S. industrial base entities. DAF needs to understand where the United States maintains technological leadership and where that leadership is being challenged and possibly overtaken, as well as which U.S. companies possess leading technological capabilities that may be attractive for foreign investment or acquisition.



APPROACH

RAND used its patent analysis methods to detect and characterize emerging technologies through rapid growth in cumulative patent applications filed in specific technical areas within a hierarchy recognized by national and international patent offices. Patent filing data were derived from a global patent database that includes full text as well as year of filing, inventor and assignee information, claims, and drawings for applications, continuations, and issued patents. RAND identified emerging technologies through their signature rapid growth in cumulative patent applications—representing a surge in new inventions, which we call an “emergence”—and their applications in six technology areas: additive manufacturing (AM), artificial intelligence (AI), ceramics, quantum, sensors, and space. The countries and companies where these emergences first occur as well as the patent applications that fall closest to the start of emergences may represent technological leadership. We identified when technological emergences (surges of patent applications in specific technologies) occurred, in which countries they first appeared (leaders), and when they appeared later in other countries (followers). We analyzed these leader-follower relationships, and in the case of close (within three years) emergences between the United States and China, we identified and analyzed patent portfolios of U.S. companies that were early filers. We focused on U.S. companies that were of small or medium size and were not already owned or controlled by foreign entities. We analyzed their patent portfolios and identified their specific leading technological capabilities that could make them attractive for possible foreign acquisition.



CONCLUSIONS

Our proof-of-principle demonstration allowed us to draw conclusions in two different categories: (1) the status of U.S. technological leadership (as judged by being first to file) in the six technological areas analyzed and (2) the leading capabilities (as judged by being early filers in multiple technologies) of U.S. companies in the six technological areas analyzed.

U.S. Technological Leadership

We performed a statistical analysis of leader-follower relationships between the United States and China. Our findings are as follows:

- For the entire time period studied (1990–2017), the United States was the technological leader, i.e., the first to file in areas of technological emergence, far more often than other countries. Moreover, when China followed the United States, the elapsed time difference for its emergence is significantly greater than in the reverse case.
- For close emergences occurring from 2001 on, there was a significant time-dependent shift in the early filing of patent applications in the United States compared with those in China.
 - From 2001 to 2008, a large majority of the early patent applications were filed in the United States.
 - From 2009 to 2017, while the United States was still the first to file in an overwhelming majority of all emergences, for “close” emergences in which the United States and China first filed within three years of each other, the number of emergent technologies for which China had the greater number of early applications exceeded those for which the United States had the greater number of early applications in all six technology areas.
 - The above findings based on count of patent applications require a caveat: The quality as well as the number of patent applications must be taken into account when comparing technological capabilities.

Leading Capabilities of U.S. Companies

We established two criteria for identifying companies that may be industry leaders and possess capabilities that are broadly applicable in emergent technological areas:

- filing of *several* patent applications that are early (before or no more than four years after emergence detection) in areas with technological emergences
- the existence of these early patent applications (as indicated by patent examiner co-assignment) in *several areas* with technological emergences.

We applied these criteria to the patent portfolios of 36 companies that were early filers in at least one of the close and recent emergences of the leader-follower analysis. This analysis identified 21 U.S. companies with leading capabilities in the technology areas covered by this report, which could make them attractive to foreign investment or acquisition. The leading capabilities of these U.S. companies cover a wide range of technological areas, including unmanned aerial vehicles (UAVs), cold atom devices, cold ion and photonic computing, quantum integrated circuits and algorithms, program control, robotics, AM, pictorial communications, imaging, metal working, scanning probe microscopy, and ultrasensitive magnetometers.



NEXT STEPS

While the methodologies and analyses documented in this report can flag areas of possible concern to U.S. decisionmakers, only a more detailed analysis of the quality of patent applications and products on the world market can provide actionable insight. Therefore, we recommend the following next steps:

- To assess the extent to which China is approaching parity with or surpassing the United States in areas of recent close emergence, U.S. technological leadership should perform a detailed comparison of early filers in the United States and China and assess the relative quality of patent applications and products on the world market from early filers in each country. This type of detailed analysis is necessary to determine which country is the technological leader in specific technologies. This analysis need not be restricted to the six technological areas covered in this report.
- To identify the technology areas in which the United States has leading capabilities with broad applications, U.S. technological leadership should analyze the development of the U.S. technology network inferred from patent examiner co-assignments over time to identify connections between emergent technological areas (as indicated by these co-assignments) and the companies that are early filers in these connected emergent areas. This will allow the simultaneous identification of the connected emergent technology areas and the U.S. companies with leading capabilities that may be attractive for possible foreign acquisition.



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