NEUBERGER BERMAN

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Data Science Through the Crisis

Judicious use of data has provided key insights into the pandemic, the economy and businesses.

"Big data" was already a growing force at the outset of the pandemic more than a year ago. The explosion of digital information tied to mobility and the spread of online commerce was increasingly being leveraged by businesses and investors, aided by advances in computing and artificial intelligence. During the crisis, these trends showed extraordinary new momentum. For one thing, the use of data gained a new and powerful application in tracking the trajectory of COVID-19 and the effectiveness of methods to curtail its spread. More broadly, lockdowns and social distancing measures led to widespread adoption of remote business practices and new acceptance of online transactions, vastly expanding the "playing field" for data analysis and the array of insights it could generate.

Here at Neuberger Berman, we have made extensive use of our data science capabilities in this unprecedented time. This included tracking the virus, analyzing broad economic and sector data, and studying the performance of particular companies in navigating a landscape in which large macro numbers have often obscured specific, varied impacts on operations and demand. Companies' ability to grow online business models, make progress on market share, finesse supply chain disruptions and address reputational pitfalls tied to labor policies were among issues we considered over the past year. In this article, we provide some examples of our analysis that illustrate the significance of "looking to the data" at a volatile time.

Tracking the Disease

At the outset of the pandemic, data to track COVID-19 was relatively scarce and "dirty." There were only a few models and most were inaccurate. We used data science to integrate and interpret data of various types and sources, and developed a proprietary epidemiological model to generate insights on the pandemic's trajectory. A variety of data sets proved useful in this process, including the COVID tracking project, the Centers for Disease Control and Prevention website and various state public health websites that improved over time as we paced through the pandemic.

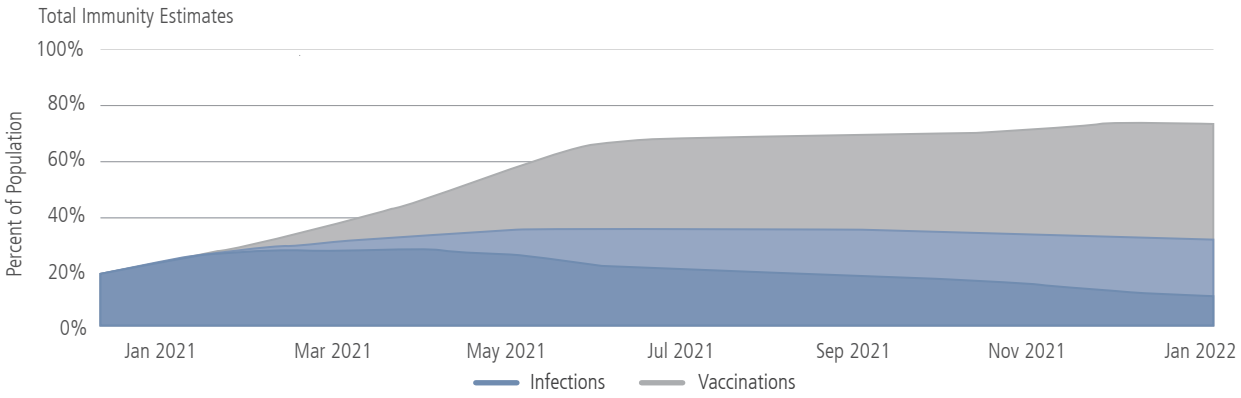
Over a year into the crisis, we've seen great progress in the availability of quality data and modeling. Effective dashboards are now available through research institutes and media, while the CDC has added dozens of models to their webpage. While maintaining an eye on overall virus trends, our focus in tracking has gradually shifted to vaccination progress and potential effectiveness.

One question on the minds of many is the potential timing of "herd immunity." While we would not presume to answer such a difficult question through one modeling tool, the issue does illustrate the use of large data sets in assessing the related questions of virus spread and potential vaccine success. **In our case, we have found our collaboration between the Data Science team and internal health care analysts around data to be particularly beneficial in focusing our efforts and refining our observations**.

According to most epidemiological experts, herd immunity will likely be reached when 70% – 80% of the population develops immunity through a combination of vaccination and natural infection. Although vaccine distribution is gaining momentum in the U.S., we believe it may be challenging for the U.S. to reach the 80% threshold during the summer, considering that currently only about 78% of the U.S. population is eligible for vaccination while understandable apprehension about safety in light of rapid development is widespread. Additionally, the emergence of COVID-19 viral variants could affect the timing of herd immunity and needs to be carefully monitored. Clinical data to date suggests lower vaccine efficacy against the South African and Brazilian variants, although protection against severe COVID appears to have been maintained across all strains identified to date.

We have been tracking U.S. and global vaccination progress using data and models from the CDC, Johns Hopkins University, ourworldindata.org and covid19-projections.com. The display below (data as of March 5) is an example of modeling current and projected immunity levels in the U.S. With the likely acceleration of vaccine delivery over the spring and summer, it projects 69% immunity by September, with the majority of that coming from vaccinations of about half the population. Obviously, much can change, but given the broader impact of the virus and related lockdowns on the economy, having some position on the possible timing of herd immunity is likely an important element of economic growth projections, and thus opinions on earnings and market performance.

POTENTIAL PATH TO U.S. HERD IMMUNITY



Source: covid19-projections.com. Data as of March 5, 2021.

Investment Insights

In asset management, data science and large-scale data engineering make it possible to understand and evaluate businesses both at a high level and in minute detail. In our view, this has never been more important than in the current business environment, which is undergoing an unprecedented rate of change driven by the pandemic. Indeed, over the past year, high-level economic trends have often obscured the varied trajectories of specific businesses. Along these lines, we have worked to develop insights through multiple lenses and applied them to various commercial sectors and market/economic themes.

Travel and COVID

The travel industry has been among the sectors most affected by the pandemic. International and long-distance travel, as well as hotel stays, have suffered major declines, even as regional travel (for example, trips by car to national parks and other attractions) has recently showed substantial recovery. In the U.S. and Europe, we've found travel intent to be highly correlated with COVID-19 case numbers. When cases dipped at times over the past year, consumer travel showed sharp upticks, reflecting the release of pent-up demand.

The trajectory of the pandemic is thus a crucial variable for the travel industry. If the virus is quickly contained through vaccines and effective social distancing, we would expect to see a travel resurgence. However, renewed virus spread and a prolonged pandemic could create a longer-term impact on business travel, especially if virtual meetings become standard practice over time and companies become more hesitant to spend on travel. Eventually, we could see a return closer to pre-pandemic norms, but that could take a while.

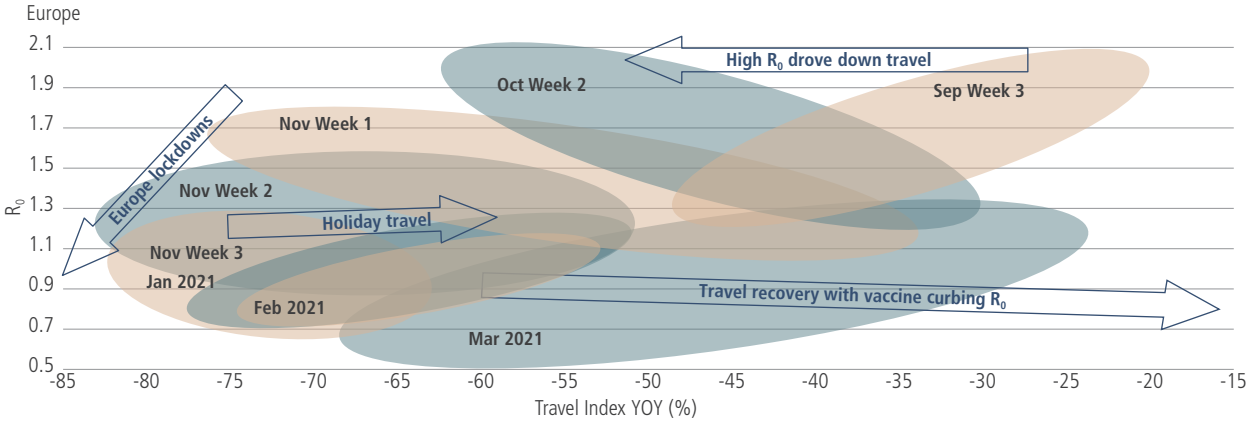
One way to assess the potential timing of a travel recovery is through an assessment of travel search levels in relation to the COVID reproduction rate ("R_0"—the number of individuals to which an infected person is transmitting the virus). Back in September, our proprietary Travel Index[1] hit relatively high levels in Europe, with its movement largely correlated with an increase in R_0, suggesting greater virus spread due to elevated mobility. Subsequent surging case levels prompted fresh lockdowns and behavioral change that in turn dampened travel activity and R_0, which then recovered modestly during the holidays. This is shown graphically at the top of page 4, with high levels of travel and transmission at the upper right, and low levels of these variables at the bottom left. (Each balloon shows the relationship between the Travel Index and R_0 of six major European countries at a given time.) The trick, based on our assessment, is to expand travel with a limited effect on R_0, thus moving values to the bottom right. This is something we think could be accomplished gradually over the spring and summer as vaccination hopefully keeps transmission at manageable levels.

Through our Travel Index in light of R_0, combined with transactions data on actual consumer travel bookings, we are closely monitoring global travel recovery and forward expectations on travel-related names.

[1] Our proprietary Travel Index is constructed based on travel-related searches at Booking.com, Airbnb and other services.

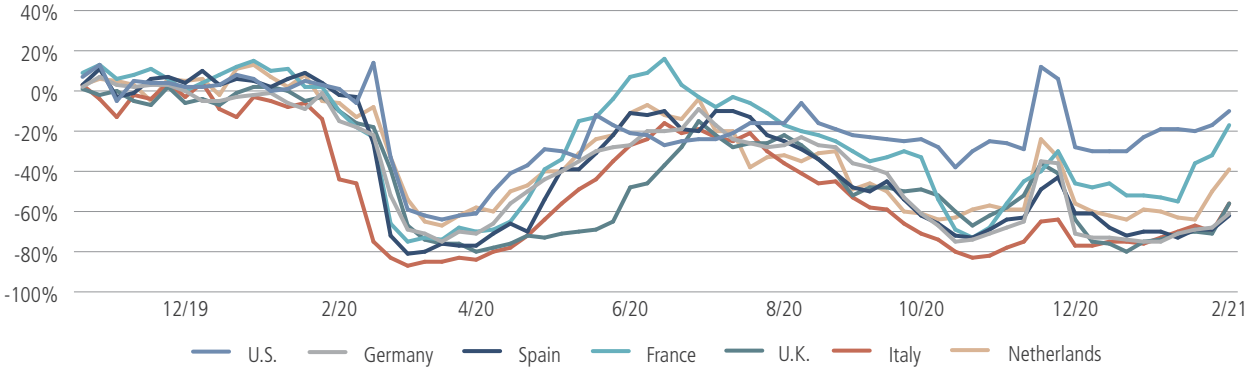
TRAVEL AND TRANSMISSION

NB Travel Index (Year-Over-Year) and COVID Reproduction Rate (R_0) in Six Major European Countries



Source: Neuberger Berman, global clickstream and web search data. Data through March 2021.

NB Travel Index by Country (Year-Over-Year)



Source: Neuberger Berman, global clickstream and web search data. Data through February 21, 2021. The NB Travel Index is constructed based on travel-related searches at Booking.com, Airbnb and other services, shown since September 2020, when the second wave of COVID in Europe started.

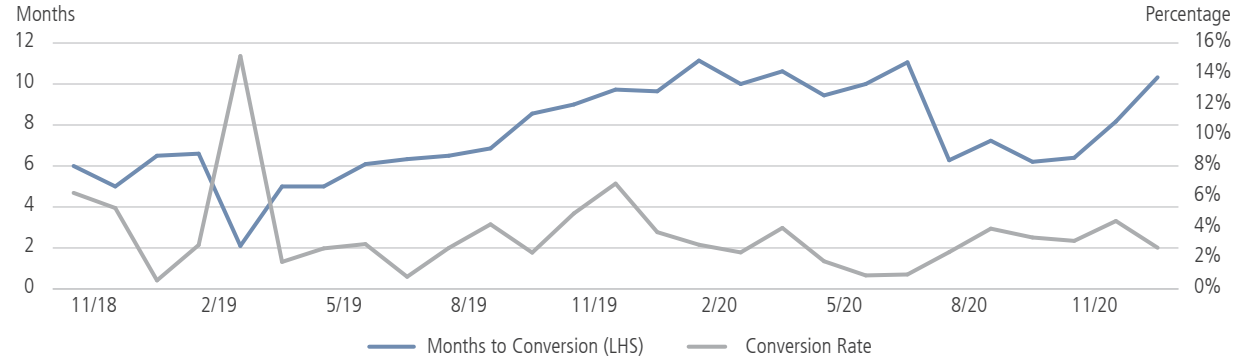
Supply Chains: Changing Under Stress

One of our firm's economic and market themes for 2021 is the adaptation of supply chains to the post-COVID landscape. The pandemic put complex global supply chains under tremendous stress and revealed their weaknesses. While geopolitical uncertainty, economic populism and simple wage and cost convergence had been shortening global supply chains for more than a decade, COVID-19 added further impetus to this trend. In our view, the ongoing transition toward lean, regionalized and digitized supply chains has the potential to improve business resiliency and reduce companies' exposure to disruption risk.

The challenges associated with supply chains is reflected in the data we analyzed. One prominent remote fitness name was an early beneficiary of lockdowns and the transition to home fitness as its digital subscriptions surged. However, a key aspect of the company's business model is that it first secures memberships and then provides the hardware that goes along with them. With the pandemic disrupting supply chains, its conversion to "all-access" subscriptions lagged due to delayed deliveries, as shown by an analysis of consumer transaction data (see the following display). Although conversion improved in the fall as pre-pandemic new members received their hardware, it worsened again later, requiring costly workarounds from management.

This is just one example of how analysis of large data sets has helped us assess ongoing impacts of COVID to corporate operations. **Our capability in tracking evolving supply chains continues to expand, both in terms of coverage and granularity, through ongoing collaboration with logistics data providers and analysis of global shipping and bills of lading data**.

HEALTH COMPANY'S DIGITAL MEMBER TO ALL-ACCESS MEMBER CONVERSION RATE AND WAIT TIME

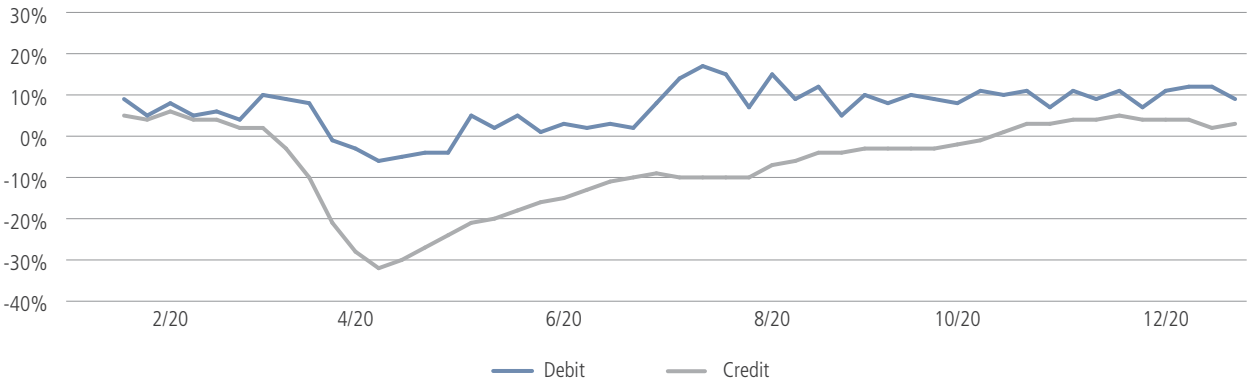


Source: Neuberger Berman, U.S. transaction data. Data through January 2021.

Small and Medium-Sized Business: Signs of Recovery in Card Usage

Withstanding the pandemic has been easier for some smaller companies and harder for others. Those in entertainment and restaurant sectors, for instance, have faced a particularly difficult environment given shutdowns and reluctance to congregate in enclosed settings. That said, we have seen many businesses recover from the initial shocks of COVID-19, with the confidence and financial health of many returning to pre-pandemic levels. In this case, we can obtain a timely snapshot of conditions via the spread between credit and debit card spending among small businesses. In a healthy economic environment, the two track one another closely; however, in more challenging circumstances, business owners tend to stick to debit cards to avoid overextending themselves. As shown in the display, although both dropped sharply last March, credit spending dipped further, and took considerably longer to recover than debit spending, which hit its normal range by early May. The improvement in credit spending provides some reassurance that recovery is being experienced from the bottom up. In more granular terms, it suggests that suppliers who cater to these businesses (software developers, financial providers, etc.) may have a tailwind should vaccines prove generally effective and the economic recovery accelerates. **We continue to track and monitor the health of small and medium-sized businesses in the context of offsetting dynamics of pandemic-related pressures and government stimulus**.

SMALL AND MEDIUM-SIZED BUSINESS WEEKLY SPENDING ON CREDIT AND DEBIT CARDS (YEAR-OVER-YEAR)



Source: Neuberger Berman, U.S. transaction data. Data through December 25, 2021.

The Digital Transformation

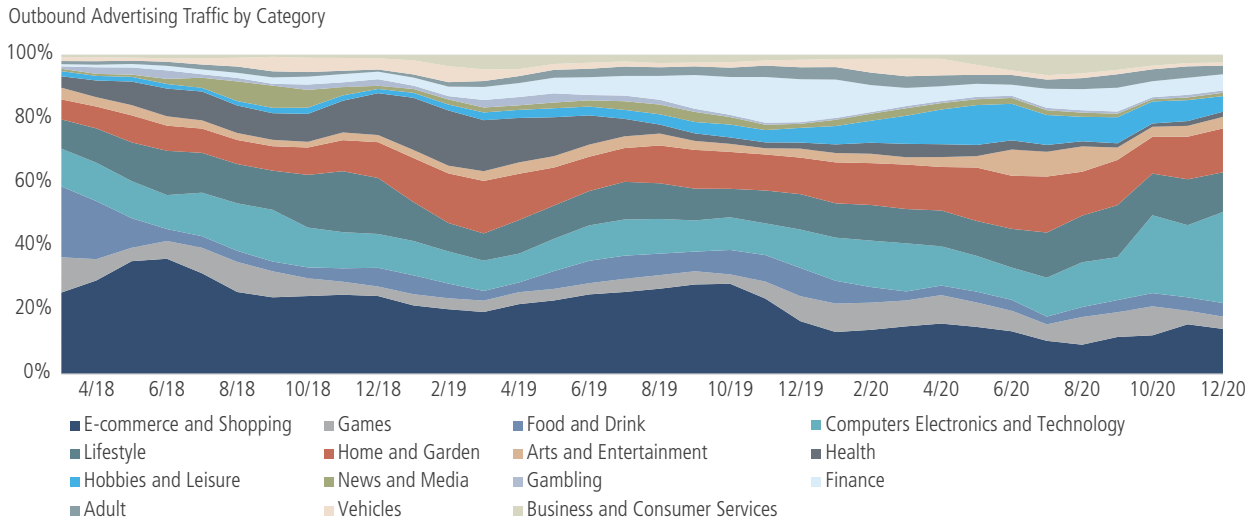
The pandemic has accelerated the trend toward the digitization of the economy, pushing businesses to expand work-from-home arrangements and driving many previously reluctant consumers to embrace online commerce. Business operations are seeing extraordinary change, as the case for automation and digital connectivity in factories, warehouses, offices and homes has gained acceptance. Some of this will likely reverse as the pandemic eases, but in general the champagne cork is out of the bottle.

That said, although the overall trend is largely clear, identifying actual beneficiaries is more challenging. To some degree, the winners could be purveyors of increasingly popular services such as online gaming, or existing players who can adapt or grow with changing circumstances. In some cases, seemingly advantaged businesses may suffer pitfalls because of challenges like translating order flow into successful delivery.

One technology company provides an example of apparent success in the changing landscape. Specializing in social media referrals, the company has historically generated much of its advertising income by driving users to e-commerce websites. Recently, however, it has become much more diversified as its array of users has broadened with expanded acceptance of digital transactions across commercial sectors. The next display shows the company's outbound advertising traffic, which has experienced growing penetration into areas such as computers, home and garden, and hobbies. The company has also seen a dramatic increase in overseas markets.

Given the pervasive nature of the digital transformation, we continue to seek out observations that go beyond topline trends and distinguish the potential of individual companies in managing a shifting landscape.

TECHNOLOGY COMPANY'S ADVERTISING BUSINESS SHOWS PENETRATION INTO NEW VERTICALS

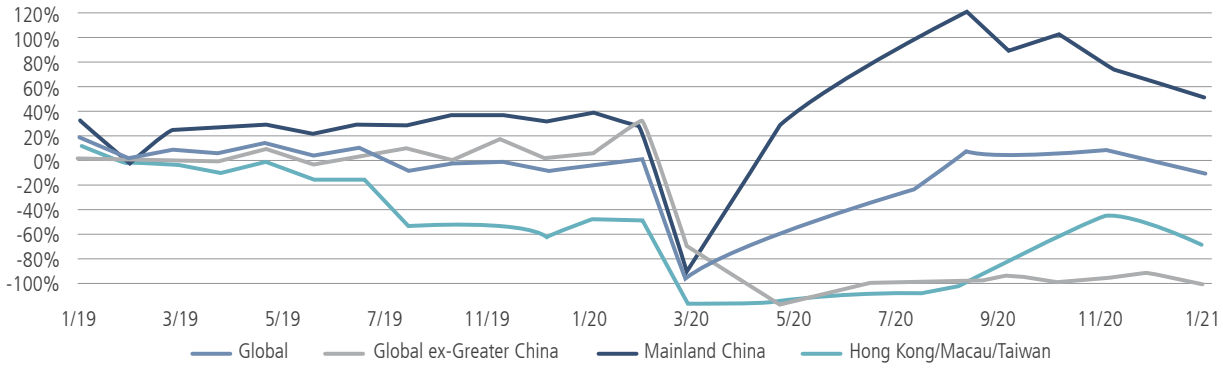


Source: Neuberger Berman, web clickstream data. Data through December 2020.

Emerging Markets and China: Data Signals Post-COVID Strength

Since China came out of lockdown in March 2020, global companies with a greater exposure to the country have generally recovered faster than those with a smaller presence. **As that recovery takes shape, we are finding that payment card data is indicating several important shifts in the commercial landscape.** For example, luxury brands are seeing renewed strength, especially in mainland China (see display). More than reflecting COVID-related pent-up demand, this is part of the ongoing trend of a rising middle class and increased disposable income, which has accelerated through the pandemic.

CHINESE LUXURY BRAND SALES VIA UNIONPAY CARDS (YEAR-OVER-YEAR)



Source: Neuberger Berman, Sandalwood Advisors. Data through January 2021.

With Data, the Future Is Now

Despite recent attention, the field of data science is still very young. As the economy becomes more digital, however, we believe that the use of large data sets for business and investing will become more commonplace and essential for success. In our view, this will require an ever-increasing level of sophistication on the part of companies to get the most out of ample electronic information, and to turn insights into drivers of revenue and earnings. For portfolio managers, the ability to understand and potentially benefit from data will likely become "table stakes" to maintain a competitive edge. In many ways, the pandemic has accelerated the pace of transformation, and has highlighted the power of data. In our view, harnessing that power will be a key focus for many in the years to come.

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