CLIMATE & SUSTAINABILITY
INSIGHTS | DECEMBER 2023

HOW TO MEASURE GREEN TRANSITION RISKS: A FOUR-STEP GUIDE

NAVIGATING THE COMPLEXITIES OF THE GREEN TRANSITION: OUR CONSIDERED APPROACH TO RISK ANALYSIS

To meet the Paris Agreement and reduce greenhouse gas emissions, we must transform the world's energy systems over the coming decades. This will require substantial investments in fossil fuel-free technologies and solutions. Such a situation poses serious risks for investors, as assets with long lifetimes may lose value due to evolving climate policies and technological shifts. For example, a newly built ship running on bunker oil or liquefied natural gas (LNG) may see its profitability decline permanently under a CO_2 tax.

Furthermore, companies located in regions with more ambitious climate policies may see a significant decline in demand as they attempt to pass on costs to customers, who are in turn looking towards imports. We label these "transition risks".

The ability to identify and measure transition risks has caught the attention of financial regulators. For example, a network of central banks, "Network for Greening the Financial System" (NGFS), is developing model-based scenarios that banks and regulators are using to assess climate risks.

In the EU, the European Central Bank (ECB), the European Banking Authority (EBA), and the European Commission are working on several initiatives, and legal proposals already on the table or in process. For example, in 2021 and 2022, the EBA and the ECB conducted their first set of large-scale climate stress tests on European banks. However, a unified approach to how financial institutions should analyse, report and address transition risks has yet to be established.

In this brief, we outline our perspective on how to approach measuring transition risks, drawing on results and insights from our global and multi-sector climate-economic model, INTERSECT℠, co-developed with Bain & Company. This model is designed specifically to analyse how climate policies and technological developments will determine the path and speed of the green transition.

FOUR STEPS TO MEASURE TRANSITION RISKS

Our approach to dealing with transition risks involves the following four steps

STEP 1
Define the relevant scenarios

STEP 2
Evaluate the impact on different industries

STEP 3
Integrate assessments of asset impairments in financial sector risk management

STEP 4
Take a dialogue-based approach for high-risk firms

1 DEFINE THE RELEVANT SCENARIOS

Policies that reduce CO_2 emissions imply transition risks. However, the magnitude and scope of these risks will depend on how, when, and where these policies are implemented.

Policy-makers will need to choose **how** to reach their climate targets. They can do so using a wide range of instruments at their disposal, including carbon trading, carbon taxes, energy taxes, mandates for low-carbon content, and subsidies for specific low-carbon technologies. Each instrument influences the incentives to move from black to green technology options in slightly different ways by effectively putting a price on carbon emissions (hence this is often referred to as Effective Carbon Rates, ECR). More comprehensive emissions cuts have to be implemented by a higher carbon price, hence increasing transition risks.

When also matters for transition risks, as a faster decarbonisation path will lead to increased transition risks.

If the green transition is delayed it may be necessary to increase the pace at a later stage, hence raising the likelihood of a disorderly transition with heavy financial and real economic losses.

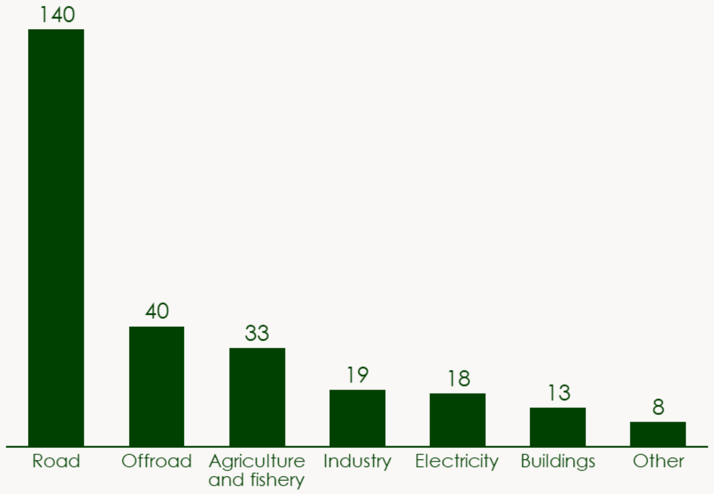
As to the **where**, a more synchronised decarbonisation path across regions will lower region-specific transition risks such as leakage risks, where production and thereby emissions move to regions with lower carbon prices, resulting in carbon leakage. However, a scenario where many regions transition simultaneously would result in more comprehensive emission cuts which increases risk. Scenarios where policy-makers fail to cooperate on an international level result in increased region-specific transition risks.

Even though there are many policy instruments available to start the green transition, the vast majority of global emissions are currently exempt from any significantly effective carbon prices.

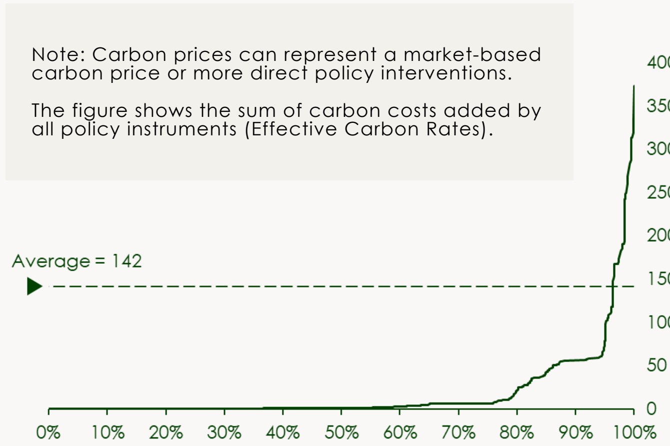
Essentially, current global policies are focusing carbon pricing on domestic energy consumption, such as heating and light-duty vehicles for personal transportation and support for renewable electricity production.

The real challenge lies in heavy industry and long-distance transport. In these sectors, few policy measures have been implemented to incentivise decarbonisation. The main reason for this is likely the political consequences of job losses.

Figure 1
Panel A: Average carbon price by sector
USD (2021 prices)



Panel B: Share of emissions subject to different levels of carbon prices
USD (2021 prices)



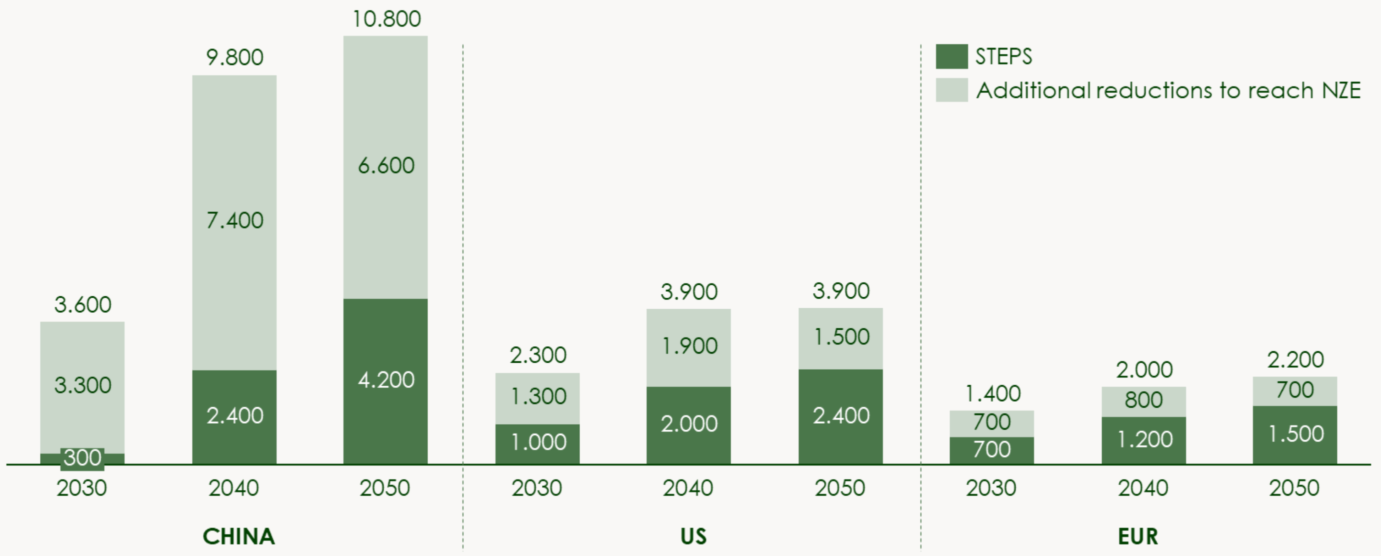
As a result, the economic incentives to decarbonise are highly diverse across industries and countries, and they are likely to remain so. Furthermore, the extent of the efforts to reduce emissions will vary among countries depending on the policy scenario in question.

This is important, as the carbon price (or tax) needed to support the more ambitious scenarios increases significantly (see next section). There is not an objectively "correct" climate policy scenario that investors can rely on as being the only expected scenario. Measuring transition risks is therefore a forward-looking exercise that is highly sensitive to the how, when, and where of different policy scenarios.

There is a wide gap between the expected emissions following the policies that the global community has committed to, such as the Stated Policies Scenario (STEPS), and an emission path consistent with the 1.5-degree limit increase in long-run average temperatures, the Net Zero (NZE). In the STEPS scenario, advanced economies such as the US and Europe would need to make substantial reductions in emissions over the next decade (see Figure 2).

China, as a developing economy, would only need to make smaller CO_2 reductions. However, to reach NZE by 2050, China and other large economies would need to cut emissions significantly as they are currently the largest global emitters of CO_2.

Figure 2
Implied CO_2 reductions in the STEPS and NZE scenarios | Selected regions
Mt CO_2 required emission reductions



2 EVALUATE THE IMPACT ON DIFFERENT INDUSTRIES

The more ambitious the scenario is in terms of reducing emissions, the more radical the required changes in energy and economic systems will be. A measure that is often used is the so-called marginal abatement cost (MAC). This measures the cost (typically in USD) of reducing emissions on the margin, typically by an additional ton of CO_2. The MAC will increase as emissions cuts become more comprehensive. This occurs as ever more expensive technologies are needed to reach policy targets.

The implication here is that the profitability of existing energy carbon-intensive assets declines as the cost base increases through higher carbon prices. In addition, profitability will decline more if the scenarios are more ambitious.

One critical question is therefore: how costly are the technologies required to deliver on emission targets?

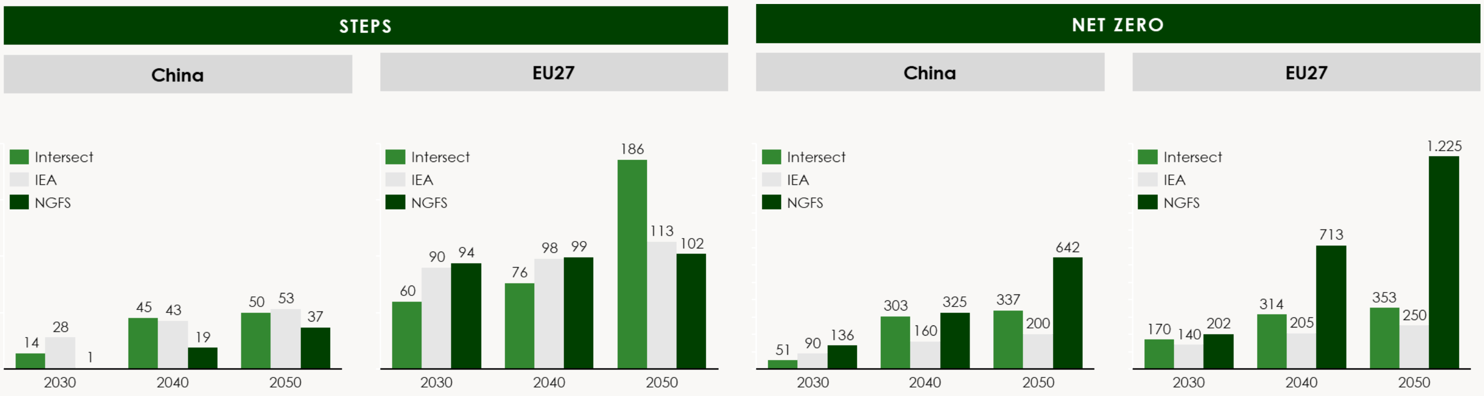
Put differently, how high do carbon prices need to be to deliver on objectives?

Under STEPS, our INTERSECT℠ model predicts slightly higher carbon prices for developing economies than the Network for Greening the Financial System (NGFS) and somewhat similar carbon prices of around $100-110 in 2050 for advanced economies. These estimates are broadly in line with the International Energy Agency (IEA) and NGFS.

However, in the NZE scenario, we find significant discrepancies in estimated carbon prices between NGFS and our INTERSECT℠ model estimates.

NGFS estimates that to achieve NZE targets, carbon prices will need to reach $600 per ton of CO_2 for developing economies and $1,200 for advanced economies by 2050 (see Figure 3).

Figure 3
CO_2 prices in selected regions | STEPS and Net Zero Emissions Scenarios



Note: CO_2 prices reflect marginal abatement costs. They can represent a market-based carbon price or more direct policy interventions.

Source: INTERSECT℠, Copenhagen Economics' climate-economic model. IEA and NGFS

We argue that the NGFS's carbon prices may be substantially overestimated considering current assumptions and predictions around technology costs.

A wide range of so-called backstop technologies such as Power-to-X (PtX), Carbon Capture and Storage (CCS) and Direct Air Capture (DAC) will be profitable once carbon prices exceed $300 in the NZE scenario.

If technologies such as DAC can be deployed in a relatively unrestricted fashion for $300 per ton of CO_2, carbon prices would not need to go much above this level, even in ambitious scenarios. We see this backstop mechanism at work in the INTERSECT℠ carbon prices in Figure 3.

Carbon prices peak at $300-350, reflecting this backstop mechanism, combined with higher electricity prices (a key input cost in CCS and DAC).

For some sectors, the abatement costs would likely remain higher than this level, but instead of decarbonising themselves, they would pay for the costs that would be offset through a DAC facility.

In addition to the need for carbon prices to be substantially lower than suggested by the NGFS analysis, our analysis also indicates that risks of larger asset impairments are concentrated in a relatively limited number of industries.

Four reasons why transition risks are significant but concentrated in a few industries

- Only a few sectors are significantly exposed to high impacts (fossil fuel producers, energy-intensive industries and energy-focused infrastructure). These constitute under 10% of Europe's GDP but have significant capital assets. For less energy-intensive industries, costs would only see modest increases from rising fossil fuel prices.
- Many industries have low decarbonisation costs, as solar and wind power often match or beat fossil fuels' cost-effectiveness. Once carbon prices reach a certain point, further increases will not significantly affect long-term outcomes in the shift to green power.
- In several energy-intensive activities, key assets have short lifetimes. With short lifetimes, assets can be fully depreciated before being impacted by new policies. This means that investors will have time to phase out the use of fossil fuel-based assets before carbon policies significantly hurt their business.
- Even industries in the danger zone (high energy consumption and assets with long lifetimes) account for only a small part of overall economic activity and asset value. Considering the S&P 500 index, for most companies, the CO_2 emitted per unit of market value is minimal and the top 17 emitters represented about 3 per cent of market value in 2021.

Our conclusion is therefore to focus on industries with:

- large exposure to fossil-based solutions
- a substantial scope of assets, with a long projected remaining time of service
- high costs for adopting retrofit solutions to existing assets

One of these industries is the shipping industry. It is highly energy intensive and the lifetime of its assets is measured in decades.

Shipping, therefore, provides a good case for a deep-dive analysis (see page 6).

WHAT HAPPENS TO SHIPPING WHEN CARBON PRICING INCREASES FUEL COSTS IN TRANSPORTATION?

Carbon pricing spikes fuel costs in transportation and reduces global fossil fuel demand, affecting shipping and investors differently.

During the initial stage, the industry will aim to maintain profits and pass on increased costs to consumers. Determining the extent to which this is possible and profitable involves three key considerations regarding costs and the composition of total transportation demand:

All transport industries will incur higher fossil fuel costs

Shipping is a major source of emissions, especially for long-distance trade between global hubs. However, it has a lower carbon footprint per unit delivered than aviation transportation. Shipping costs may increase less than aviation, possibly leading to an increased market share for shipping. It is also possible that the demand for long-distance freight services is reduced.

Climate policies will affect different shipping sectors differently

In 2022, container and tanker shipping collectively constituted 50% of global shipping's CO_2 emissions, with each contributing 25%. Going forward, oil transport will likely be more impacted due to reduced fossil fuel consumption. Despite higher costs, container shipping demand is expected to grow significantly, even with a carbon price of $300-500 per ton in 2050. Changes in trading patterns as a consequence of evolving geopolitics pose the biggest challenge, not the phasing out of fossil fuels.

Fossil fuel versus green-powered ships

Investors with oil-driven ships will face higher costs due to evolving climate policies. So, what will happen to the return on oil-driven ships? The worst performance will be for the last ship put to service before the carbon price increases to NZE-consistent levels (e.g., a 2025 ship). With an expected lifetime of 30 years, it will not earn enough to cover its 2025 purchase cost, resulting in impaired value. Given that the global maritime transport fleet is on average around 20 years old and predominantly oil-driven, this implies an overall value impairment, reflecting a reduced expected earnings lifespan.

3 INTEGRATE ASSESSMENTS OF ASSET IMPAIRMENTS IN FINANCIAL SECTOR RISK MANAGEMENT

Integrating asset impairments into financial sector risk management is crucial to identify vulnerabilities, maintain regulatory compliance, and foster investor confidence; ultimately enhancing resilience and enabling timely intervention in case of expected losses. This involves combining static and dynamic climate stress tests in the evaluation of asset impairments and integrating them into overall risk management.

As discussed, an assessment of asset impairments entails comparing relative return performance within firms and industries under different policy scenarios and expected decarbonisation strategies. The critical question is therefore how to use such metric values to look at the balance sheets of industries and firms.

For financial institutions, it would be natural to lean into the stress test approach used in prudential regulation. The principle here is to divide the assets into equity and debt-based investments, then rely on asset impairments to estimate (i) reduced equity returns and (ii) increased default risk for debt-based instruments in various scenarios, like transitioning from STEP to NZE.

In assessing risk to balance sheets, two approaches emerge: static and dynamic. In the past, the focus has been on the static approach, which involves examining the carbon intensity of a given industry and assessing how profits would be affected by a carbon price if firms did nothing over the next 30 years. However, this method can lead to a significant overestimation of risk and losses for financial institutions which have these firms as part of their portfolio. Conversely, the dynamic approach considers changes in behaviours by firms and banks, given a higher CO_2 price. I.e., it factors in how firms respond to higher carbon prices. Using this approach is, however, more complex and more dependent on assumptions (see Figure 4).

Figure 4
Key features of static vs dynamic balance sheet approach

	STATIC APPROACH	DYNAMIC APPROACH
	• Balance sheet size and composition remain constant over the modelled horizon. • Explores the vulnerability of the current balance sheet to future shocks.	• Balance sheets can change over time as banks respond to climate risks. • Allows for actions to be undertaken by financial institutions in response to events over the horizon.
ADVANTAGES	• Ease of implementation and fewer assumptions (NGFS). • Reduced risks of understating impacts (NGFS), Conservative assessment of potential risks (FSB). • Straightforward interpretation of results and clear action focus (BoE).	• Offers more realism to the institutions' (NGFS) • Reflects the changing nature of exposures over time (NGFS). • Banks are likely to respond to climate risks and will act to mitigate projected losses (NGFS).
CHALLENGES	• Likely to overestimate losses as in reality, banks' business models will adapt (NGFS, BoE). • Significant structural changes will happen at longer horizons (IMF). • Firms will take action over the stress test time horizon to reduce risks (BoE).	• Requires adaptive behaviour to be captured accurately (NGFS). • Involves dealing with the challenge of data limitations (NGFS) and requires expertise in modelling (FSB). • Some mitigating actions may not be feasible in practice (FSB).

Note: BoE (Bank of England), FSB (Financial Stability Board), NGFS (The Network for Greening the Financial System)

Currently, the debate focuses on how to combine these two approaches. The static approach can be used to identify industries at risk and calculate the impact of higher carbon prices on profitability, assuming full cost absorption and no change in asset composition. This can be expanded on by using a semi-dynamic approach that adjusts the composition of balance sheets based on sectoral changes in the composition of the economy driven by macro-trends (e.g., declining shares of agricultural production and associated impact on business lending and assets).

However, the real assessment must be dynamic in nature and needs to be updated as its climate and energy policies are being changed, technology assessments are being updated, and industries change behaviour and asset compositions.

In general, climate scenarios have a much longer horizon than a business cycle, and stress testing should reflect this. To create real value, stress tests must incorporate more plausible and transparent scenarios of how climate policies affect business assets. This requires a granular formulation of the relevant climate policies that will affect business conditions, taking into account how the scale and speed dictated by these policies can affect the choice of business models for a particular industry (including upstream suppliers and downstream customers).

Such an analysis will require a technical evaluation of decarbonisation options and national/international policies which is largely absent from the current strand of analysis in this field.

4 TAKE A DIALOGUE-BASED APPROACH FOR HIGH-RISK FIRMS

Extending the risk assessment to a dialogue-based approach is especially relevant for the few industries and firms that are exposed to substantial risks of asset value impairment. Indeed, industries involved in fossil fuel exploration, production of metals, cement, fertilisers, aviation, and maritime transport are industries characterised by being both capital-intensive and globally oriented with relatively few firms in each industry.

Measuring the risk of asset impairment based on models such as our global climate model INTERSECT℠ can only get you so far. Most firms in industries at risk are moving forward with decarbonisation strategies, making crucial choices on technologies to use and transformation speed. Moreover, these firms often operate globally across diverse jurisdictions with climate policies that vary significantly. Assessing asset impairment in these industries demands a more detailed and nuanced consideration of climate policy impacts.

Hence, for the high-risk firms and industries, we need to go from a model-based assessment of risk to a more dialogue-based approach, and a more granular approach to the impact of climate policies, based on the strategic choices and specific decarbonisation plans of firms is needed. This in turn entails understanding how industries and firms themselves evaluate risk and what steps they have taken to mitigate it.

In conclusion, our recommendation is that companies facing significant green transition risks should engage in detailed discussions within forums that include management, regulators and financial institutions. Many major corporations now include extensive carbon emission reduction plans in their financial disclosures, which are vital for investors to evaluate associated risks. In cases where financial information is insufficient, investors should be able to request assessments of other aspects of the company's overall strategy.

The green transition will, over time, dramatically change energy systems at a global level. This will directly or indirectly affect all businesses.

Yet for most businesses, and the vast bulk of economic activity, the risks of asset impairments to existing assets are minimal relative to other material business risks. Costs of shifting to low-carbon solutions are relatively low, options for retrofits for existing assets are substantial, and for most firms, energy costs are only a relatively small fraction of total costs.

We recommend that tests of asset impairments should be focused on industries at high risk, such as fossil fuel producers, energy-intensive industries, and energy-focused infrastructure. Even for these activities, the devil is in the detail, and a robust analysis demands a highly granular approach regarding a number of industries and firms that often operate on a global scale.

Stress tests and risk analyses should be based on a clear formulation of the most likely climate policy scenarios, with sufficient granularity to also cover the industries at risk. Moreover, any analysis of transition risk will also require some assessment of the technical options a given industry has at its disposal to decarbonise. The likelihood of these options to materialise over time will also need to be scrutinised, as fossil fuels and low-carbon solutions will co-exist for decades. How this will affect prices, markets, and ultimately profits for different assets is the big question.

Model-based “outside-in” analysis can only take us so far in terms of understanding business risks for specific firms. For large firms that will ultimately account for the largest risks, we suggest a dialogue-based approach where investors and regulators review the assessments the firms themselves are making of their chosen decarbonisation strategies. Are they clear enough? Have they identified relevant major risks? What has been done to mitigate them? these questions and more will ensure that climate stress testing is integrated into the ongoing dialogues and processes investors and regulators are already having regarding assessing business risks and opportunities.

Hard facts. Clear stories.

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About Copenhagen Economics

Copenhagen Economics is one of the leading economics firms in Europe. Founded in 2000, the company currently employs over 100 staff operating from our offices in Brussels, Copenhagen, Helsinki, and Stockholm.

About INTERSECT℠

INTERSECT℠ is a dynamic Computable General Equilibrium (CGE) model integrating economic theory with real-world data. Covering 30 sectors and 18 regions, this innovative model enables simulations up to 2050, meticulously tracking flows, technology development, and investments. Notably, it incorporates carbon emissions at its core, offering detailed insights into decarbonisation paths.

With a market-leading approach, INTERSECT℠ combines top-down and bottom-up methodologies, ensuring a global, consistent, and comprehensive perspective on economic activities, investments, and responses to climate and energy dynamics.

The INTERSECT℠ model was co-developed by Copenhagen Economics and Bain & Company.