Episode 190. Climate change, floods, and the future of auto supply chains

Episode webpage

July 30, 2023

Transcript

(lightly edited)

Chad Bown: Climate change is coming. For the global automobile industry, some of the effects of climate change are already here. First were the floods in Thailand in 2011:

HNK: *This aerial footage was taken on Saturday. It shows that flood waters in the Rojana Industrial Park in Ayutthaya, north of Bangkok, have not receded since flooding began on October 8. There are about 150 Japanese firms operating in the park. At a Honda factory in the park, about 1000 vehicles are vaguely visible under the water…*

Chad Bown: Then, in 2014, in Detroit, the heaviest rains in 89 years caused a flood that disrupted auto plants belonging to General Motors and Chrysler:

WSJ: *Detroit gets hammered with its heaviest rain in almost a century, flooding roads and stalling auto production, and even more nasty weather could be coming…*

Chad Bown: More recent was a 2022 flood in South Africa that shut down production at a Toyota plant for 4 months:

KZN: *South Africa's automobile industry is warning that the impact of the KwaZulu Natal floods on business will be felt for some time. Near Durban the Toyota factory remains closed after suffering extensive water damage, brand new cars will have to be scrapped.*

Chad Bown: In a world of bigger and more frequent storms and floods, policymakers want resilience. They want companies to make their supply chains more diverse. More flexible. Sometimes, policymakers are even creating incentives for companies to do so.

But what are the implications of companies becoming more resilient? What costs should society expect to have to pay? Are there lessons from manufacturers already making tradeoffs needed to become more resilient to climate shocks?

Juanma Castro-Vincenzi: Car manufacturers are going to hold more plants in the future, which allows them to diversify their production to these shocks. However, these plants are going to become smaller which is bad because they're losing scale. On top of that, these firms are going to be holding more spare capacity in these plants. But of course, holding spare capacity is very costly.

Chad Bown: This episode looks at the impact of climate change on the global automobile industry. Automobiles is a sector that is both massively important economically and one that has really complicated supply chains. Automakers also have a lot of experience being hit with extreme weather events – and having to adjust their supply chains because of it.

To learn about all this, I will be joined by a very special guest:

Juanma Castro-Vincenzi: Juanma Castro-Vincenzi, Harvard University.

Chad Bown: Juanma Castro-Vincenzi is a post-doctoral fellow at Harvard University and will soon be an assistant professor at the University of Chicago. Juanma has some brand new research into the global car industry, and today he will explain how car companies react to floods, what supply chain resilience means for the industry, and what the implications of all that are for car-buying people like you and me.

Chad Bown: Hi, Juanma.

Juanma Castro-Vincenzi: Hi, Chad.

Chad Bown: You are listening to an episode of *Trade Talks*, a podcast about the economics of trade and policy. I'm your host, Chad Bown, the Reginald Jones Senior Fellow at the Peterson Institute for International Economics in Washington.

THE EPISODE

Chad Bown: Juanma, to start us off, how do companies make a car? What kind of inputs are needed and what does the typical supply chain for a car look like?

Juanma Castro-Vincenzi: Basically, cars are very complicated products.

There are many different parts that are being combined into a single product. They're combining engines, transmissions, tires, chips, windows, and seat belts. And most of them, since these are big and bulky items, are difficult to transport.

But on top of that, these are supply chains that are very geographically concentrated. There is this statistic that the average engine and transmission that goes into a car is produced at a median distance of 170 kilometers away from the final assembly plant. To make a car, around 60 percent of inputs are local.

Local shocks becoming more important might have important ramifications into the way that the car industry is organized.

Chad Bown: Sixty percent of car parts coming from nearby the final assembly plant suggests supply chains to produce a single model of a car are pretty concentrated geographically.

But at the same time, the car company churning out a model at that final assembly plant is almost always part of some giant global corporation – maybe it is Honda, Ford, General Motors, Volkswagen, or Toyota.

Why does that matter?

Juanma Castro-Vincenzi: The car industry, as a whole, is characterized by having these large firms, that are multinational, producing their cars in many countries and also multi-plant.

One important characteristic is that these firms are first coordinating a potentially very complicated supply chain.

But on top of that these firms have a flexible production structure that allows them to move production around in response to business interruptions, due to geopolitical factors, climate change or climate shocks, strikes, et cetera.

Chad Bown: While any particular car model may be heavily reliant on a local supply chain, these multinational car companies are coordinating production of these models at lots of plants

located all over the world. They often have flexibility to shift production from one plant to another in response to business interruptions.

What about the location of these final assembly plants and their supply chains – where do those plants typically end up and why?

Juanma Castro-Vincenzi: These final assembly plants are mostly located in big, advanced countries. There are lots of plants, as we know, close to the Great Lakes, right where this industry first developed. In the US, there are more and more plants in the Southeast. Also, there are clusters of production in Canada, in central Mexico, in western Europe, in Japan, and increasingly in developing countries such as China and in India.

And these final assembly plants are usually located close to where demand is. Because these cars are heavy, bulky items that are difficult to transport. And then these firms have that desire to be close to their customers are in order to reduce costs.

Chad Bown: Your research is going to examine really detailed information on car models produced at specific final assembly plants and where you know the exact geographic locations of those plants. Tell us more.

Juanma Castro-Vincenzi: For my research, I use a dataset of global car production that contains information on production, at the specific model level, for more than 1000 plants in 54 countries all around the world.

And I'm going to assume that the model is a brand (say, Ford), a name plate (say, Focus), and a body type, which could be either a sedan, if it has four doors, or a hatchback if it has two doors.

Chad Bown: Super interesting – so how many different models are produced at the average car plant, and at how many different plants are these models being produced?

Juanma Castro-Vincenzi: In an average plant, about 5-6 models are being produced. And these models, on average, are produced in around three plants. However, as you might imagine, the Ford 150s and the Toyota Corollas of the world are produced in about 15 plants. On the other hand, there are very luxurious customized Rolls Royce or Lamborghinis that are single plant models.

Chad Bown: Juanma has put together an incredible database mapping all of the world's car models to their specific final assembly plants. Super popular consumer models – like the Toyota Corolla are produced at lots plants. More specialized models like a fancy Rolls Royce are made

at only one plant. And the supply chains making inputs for each plant typically have an important part that is local.

OK. Next I want to turn to climate change. Or more precisely, extreme weather events.

In the opening, we heard about examples of massive floods hitting automakers in Thailand, Detroit, and South Africa. But is there one particular storm that you think really shows how the car companies' plants and supply chains can be affected?

Juanma Castro-Vincenzi: In 2018, there was a massive storm in Celaya, Mexico.

There was an extreme precipitation event. The local river burst its banks and essentially it flooded a 100-hectare industrial park that was built next to the river. And among the facilities in the industrial park, there was a Honda plant that was state of the art (inaugurated in 2015) that was completely flooded.

In this plant, Honda was producing its Honda Fit and the HR-V models. Production had to be interrupted until the month of November. This flood happened on June 28th. It was a formal closure of the plant in order to be cleaned up and repaired.

Chad Bown: This one Honda plant – making the Honda Fit and HR-V models – was hit by a flood and had to shut down for 4 months, or basically a quarter of economic activity. How did Honda respond?

Juanma Castro-Vincenzi: Luckily for Honda, they were also producing the Honda HR-V in another plant in Mexico that was about 160 miles west of Celaya, which was the place that was actually flooded. This other plant wasn't flooded and therefore they could pick up some of the lost production (in the Celaya plant) into this other plant just outside Guadalajara. Now, of course, this other plant was smaller and didn't have a lot of capacity to increase its production.

And just to give you an idea of the magnitude of this decline, this plant in Celaya was producing about 50,000 cars per quarter. And it had to completely be shut down. And in that other plant, they could raise the production of the HR-V by only around 10,000 cars. In this other plant, they were able to pick up around 20 percent of the lost production.

Chad Bown: Wow. So in this example, when the flood hit one plant, Honda had flexibility to increase production of that same model at a completely different plant that was not hit by the flood. But Honda could only recover about 20 percent of lost production at the first plant.

Did the 2018 flood at the plant in Celaya, Mexico have other impacts on Honda's operations?

Juanma Castro-Vincenzi: This Honda plant was special because it was mixed in the sense that it was an assembly plant, but it was also producing inputs that were used in production in other places in the world. They were producing a component of the engine that was critical for the production of another model, a Honda Insight that was being assembled, not in Mexico, but in Indiana. Production of this car in Indiana had to be shut down for a whole month in response to this flooding event.

This gives us an idea of how interconnected production is in these very big multinational firms.

Chad Bown: This connection between Mexico and Indiana is therefore one exception to the idea that engine factories are usually located within 170 kilometers of the final assembly plant. Here, even a far-away flood in Mexico affected Honda's production in Indiana.

More generally, this big flood hitting Honda motivate your research into how car companies systematically respond to floods.

Now let's turn to the floods. Where do you get information on the timing and location of the huge flows of water that result from these severe weather events?

Juanma Castro-Vincenzi: The Dartmouth Flood Observatory has compiled this great dataset on historical severe floods all over the world. For each of these floods, they have characterized the precise location of the flood (i.e., what was the geographical extent).

Scientists at the DFO have essentially measured what is the severity of this flood – i.e., whether it's a flood that happens in every single year or it's a flood that it's very extreme and happens only once in a lifetime, and things like that.

Chad Bown: The Dartmouth Flood Observatory provides historical weather information that you can match to the geographic location of these car assembly plants where you have production data from 2000 to 2019. Over those 20 years, were there a lot of floods nearby these plants?

Juanma Castro-Vincenzi: I was very surprised when I found out that, in this 20 years of data, around three out of every four plants were experiencing one of these very important floods nearby.

While, at any moment in time, there might not be a flood affecting a plant, in the long run, these plants are facing this risk at some point.

Chad Bown: So obviously floods don't happen every day, but 75 percent of the plants had at least one nearby flood over this 20 year period. Amazing.

This then takes us to the first thing that you examine, which is the impact of one of these floods on car production at one of these plants. What do you find?

Juanma Castro-Vincenzi: When I measure the impact that these severe floods have on car production in each plant, I was very surprised to find that the occurrence of these floods have a very negative and persistent effect in production at the plant.

By one year after, production at the average plant is down by 20 percent, and what I found really surprising is that it keeps declining. So, 10 years after the flood happens, production is still down by around 33 percent. It never gets to recover.

Chad Bown: Why? What are some reasons why a flood makes car production at a plant both decline so severely and also never completely recover?

Juanma Castro-Vincenzi: With this dataset, I cannot really pinpoint why production is not coming back. But there could be several explanations.

One explanation is that this flood is happening in an important location and the local production landscape gets worse. And then the firm doesn't want to produce there anymore because infrastructure might be bad – because transportation might be more difficult, because their local suppliers that were selling to them all of these inputs that they need for assembly of these cars went down, or they went broke. Input suppliers are not producing there anymore, and therefore firms start moving away from this region.

You could also think that firms are learning from these events. These events happen and when they happen, firms learn something about the underlying flood risk of producing in a particular location. So firms decide to move their production to other regions and start to downscale their plants there.

These car manufacturers are also always phasing out car models that become obsolete or unpopular. And they are deciding whether to start producing these models in places that are less risky and that are more productive. This flooding event may just be speeding up this process.

Regardless of the reason behind this decline, whenever these plants are affected by these floods, production is going to decline in a very negative and persistent way.

Chad Bown: Interesting – I should have asked you this before, but to clarify, how do you characterize whether a plant is affected by a particular flood? You have this amazing data on the locations of the floods and of the plants.

But how nearby does the flood need to be for a plant to be affected in your analysis? And if you change that threshold a little bit – so if you categorize a nearby flood as being slightly closer or further away from the plant – what do you learn?

Juanma Castro-Vincenzi: I'm going to categorize that the plant is being affected by these floods whenever there is a flood occurring 100 kilometers or less away from the plant.

However, I was very surprised when I found out that if I did the analysis for floods that were only 25 kilometers away, or 50 kilometers away, or 100 kilometers away, the effect was very similar.

This led me to think that – and it's something that I verified in the data – it's not only that these plants are being directly affected. These plants may be indirectly affected by damages to the infrastructure, as well as difficulties in moving and transporting goods and inputs and people in and out of the plant and, of course, by local supply chains.

It might be that this assembly plant is not being affected directly but your supplier, or the supplier of your supplier, might be. This is why I think I find this effect that it doesn't change much if I consider different distance thresholds.

Chad Bown: Plants with local supply chains exposed to these floods face a sharp decline in production, but these plants are being run by Toyota, GM, Ford – these global, multi-plant car companies. Earlier, you gave us the example of a flood in Mexico and explained how Honda reallocated some production of its HR-V model from one flooded plant to another non-flooded plant.

What do you find when you examine this issue across all of the plants and all of the floods in your 20 years of data? How much production are firms able to shift from one plant to another after a flood?

Juanma Castro-Vincenzi: In line with the Honda example, we're going to find that these firms are really going to exploit their multi-plant structure. They're going to use their other, unaffected plants to recover a little bit of production.

In fact, what I find is that whenever one plant of a particular firm is impacted by these floods, the firm is going to start reallocating car production to its other plants. And in particular, it's going to reallocate this production to its other plants that were producing the same models as in the plant that was affected.

It seems that these firms have this flexibility to move production around when one of their plants is disrupted by these extreme weather events.

Of course, I do find that this relocation is slower. Producing these cars is a complicated procedure. It involves a lot of logistics and of moving parts. Production in these unaffected plants does not increase right away. But I do see that after five years, it's about 25 percent larger.

Chad Bown: From that historical information of car plant production and global floods, so far, Juanma has provided evidence of two things.

First, he shows how the plants are affected by nearby floods – their production falls.

Second, he shows how these global car companies behave differently after floods.

At the flooded plants, they continue to produce fewer cars and fewer car models. Instead, the car companies shift production to other plants that have not been hit by floods.

The second big part of Juanma's project is to use all of that evidence to help us imagine how carmakers may respond to climate change.

He builds a framework based on all of that detailed car information to represent a pre-climate change world. That world had floods, so we also know how car companies shift production around in response to extreme weather events.

What he is going to do next is hit those car companies with climate change, which means a lot more floods. By looking at their response, he can learn about how the global auto industry might organize itself quite differently in the future.

Juanma, for this part of your research, what is the key tradeoff the car companies are thinking about when confronted with climate change?

Juanma Castro-Vincenzi: On the one hand, they want to produce their cars in the most cost-efficient place. On the other hand, they're going to balance that against the probability that

these plants might be impacted by weather disasters in the future. Therefore, this will give them incentives to make a choice that makes their production resilient to these shocks.

And the way I am going to introduce climate change into the model is essentially by taking projections from a state of the art (the most updated) climate models out there. Basically, that will give me information on how the probabilities of extreme precipitation events are going to change in the future.

Even for the location of that plant in Celaya, Mexico, what used to be a one in every yen years flood – it's going to become a one in every *eight* years flood.

If you look at 100-year events – i.e., those that were occurring with a 1 percent probability – the changes are even more striking. These are events that are, on average, passing from being 100-year events to 50-year events. The probability is almost doubling.

Chad Bown: Who should be worried? Are there certain geographic locations where currently there's a lot of car production and where these climate change models suggest that extreme weather events might be much more likely?

Juanma Castro-Vincenzi: Yes, of course, in places like Tennessee, Michigan, or Tokyo, where car production is very important, these extreme weather events are expected to become twice as likely according to these climate models.

What used to be a flood that happened in any given year with a 1 percent probability is expected to happen in, for instance, Tennessee with a 2.2 percent probability, in Michigan with a 2.3 percent probability, or in Tokyo with 1.4 percent probability.

This is just to say that these places that are very important for the global multinational car footprint today are going to be very impacted by these extreme events in the future.

Chad Bown: OK, what happens? With the extreme weather events of climate change, how do these firms set up their plants and organize themselves differently?

Do they diversify?

Juanma Castro-Vincenzi: As the probability of these extreme negative weather events that's affecting and disrupting their production is increasing, firms have more incentives to diversify their production across space.

They also want to have more plants and spare capacity just to have this option to hedge – i.e., to have this possibility to move production around once their plants are affected by these disasters.

Chad Bown: Firms diversify. They have more plants. They also want to hold spare capacity at a second plant in case the first plant gets flooded. But this all sounds costly.

Juanma Castro-Vincenzi: Of course, this is a shock that is negative. These firms are shrinking. They're becoming less productive and, on top of that, by diversifying, which will make them more resilient, they're losing productive capacity and scale in the most productive places to produce.

In terms of what I just told you, in Michigan, it's likely that if they really think that that risk in Michigan is becoming twice as large, Michigan, which is a very productive place for car manufacturing (historically and today), when they move elsewhere, they lose all the productivity that had been developed in Michigan for car production.

Chad Bown: So diversifying also means moving plants away from the most productive places where they really know how to make cars, as well as having access to all of the existing local suppliers of parts and all of those linkages.

Next I wanted to ask about the impact of all this on you and me – on the car buyers. If global car companies end up with more plants, but smaller plants, plants now in different places, and where they are keeping some capacity at these plants unused for the case of emergencies – what happens to consumers?

Juanma Castro-Vincenzi: Consumers are going to lose along two dimensions.

These firms are adapting. It's likely that their costs are going to increase and, of course, they're going to pass that increase in costs onto consumers. And this is not a one-time increase, it's a permanent increase in the cost of cars as well and in the price that consumers are facing.

The second dimension is that it's likely that consumers have less access to varieties. The fact that climate change is increasing costs for these firms is going to make them less willing to invest in new varieties and of course into their very complicated logistics and supply chains.

Chad Bown: Understanding the costs to consumers is important.

This is not a one-time hit to inflation. Here resilience means firms running more plants, but smaller plants, and choosing to keep some capacity idle. Compared to today, this is

permanently more costly. And this industry is concentrated enough that firms will likely pass along these higher costs to consumers in the form of higher prices.

The other potential loss to consumers is through access to fewer varieties. Since choice is also expensive, car companies may make fewer options available. You may be stuck with the 2-door version of the car instead of the 4-door version. Or the electric vehicle with a battery that lasts for 200 miles and not 400 miles.

OK, Juanma, this is amazing. But with a model like this, I feel like I am giving you the impossible task of predicting the future. Let me take you off the hook a little bit.

What would you say are the main caveats to your approach, and what are other things that firms might do that we should also be thinking about?

Juanma Castro-Vincenzi: On the one hand, I'm only modeling floods. Climate change is a complex phenomenon that they will have multiple implications.

Droughts are going to become more likely, and we know that water scarcity impacts car production in a very important way.

Also, my model is only allowing for one adaptation mechanism, which is changing and moving this production location altogether. And this, of course, is a very costly adaptation mechanism.

Firms might innovate in different ways. Maybe they're going to make their supply chains shorter or more simple. Maybe these manufacturing firms find better ways to adapt to these extreme weather events.

Or, these firms can invest and come up with novel ways to protect against the floods, conditional and the floods happening. You could think about fortifying plants, for example.

Chad Bown: Juanma, one thing I like about your research is that its insights probably extend to other industries. Not just for cars, policymakers seem really worried about the geographic concentration of production and supply chain resilience in lots of places.

Are there examples of other industries where you think these results might be important?

Juanma Castro-Vincenzi: Another example in which we might think that this type of hedging or diversification, through the production structure of a particular firm, is important is the vaccine industry, as we just went through the pandemic.

In that case, being able to diversify either because of health measures or geopolitical concerns is very important. And clearly vaccines are goods that are very valuable when they are in short supply, when they are scarce.

So again, there is a tradeoff. Firms want to diversify. Firms want to have the option to produce elsewhere when some particular location is impacted by a shock – either weather or some other thing.

But of course holding these plants idle and with excess capacity, and not concentrating production in the actual best place, comes with a cost.

Chad Bown: Vaccines are one excellent example. There is a lot of policy conversation about the future footprint of global vaccine production. Should there be fewer, bigger plants which will inevitably be concentrated geographically, but where you can get a lot of output quickly? Or should there be a lot more smaller plants with diversification but where getting more vaccine output might be slower? There are important tradeoffs to consider.

Another industry example might be semiconductors.

Right now, manufacturing of the highest end chips is really concentrated in Taiwan. Getting more diversification could provide the world with resilience against certain types of shocks – climate change and floods, but also health shocks that might shut down plants, or geopolitical conflict. But getting that resilience will mean more costly semiconductors.

As my last question, what do you think are the main lessons from your research for policymakers?

Juanma Castro-Vincenzi: Policy makers might be worried that these firms are not internalizing (the externalities) or not diversifying enough and might be interested in giving these firms incentives to have more diversification to be more resilient.

I think that policy makers need to recognize that by promoting more diversification and promoting more resilience, they're going to face a tradeoff.

When these extreme events happen, when these very big disruptions happen, of course we're going to be better off, consumers are going to be better off. Because we're going to have more access to goods at cheaper prices because firms have already invested to become more resilient.

However, in normal times, we have to bear the consequences of these firms having a more costly production structure. And we need to bear with, on average, higher prices to sustain these investments in resilience.

This is like an insurance policy. And we need to balance how much we value goods and having low prices in both circumstances.

Chad Bown: Juanma, thank you very much

Juanma Castro-Vincenzi: Thank you so much for having me. It was a pleasure.

Chad Bown: To wrap up this episode, I wanted to reiterate two last points.

First, investing in resilience is going to be costly. Diversification comes at a price. More plants and smaller plants means fewer economies of scale. Add in plants holding spare capacity, and the result is we will spend scarce economic resources on resilience today instead of our other competing priorities.

Second, costly does not mean we shouldn't do it. This is like an insurance policy. We just need to do the calculations, understand the tradeoffs, and be prepared for these costs and to plan to pay the costs of that insurance policy every year, and to put it into the budget.

Then, when the bad event does come – a flood, another pandemic, or even some terrible geopolitical conflict – that is the moment when the investment in resilience will pay off. And you can pat yourself on the back for having taken out that insurance.

But in all of those other times, the good times, it is important both to remember WHY we are taking out that insurance policy in resilience and to not forget to make the insurance payment.

GOODBYE FOR NOW

Chad Bown: And that is all for *Trade Talks*.

A huge thanks to Juanma Castro-Vincenzi at Harvard University. Do check out Juanma's amazing new paper titled "Climate Hazards and Resilience in the Global Car Industry." I will post a link to the paper on the episode page of the *Trade Talks* website.

Thanks to Melina Kolb, our supervising producer. Thanks to Sarah Tew, on digital. As always, thanks to Collin Warren, our audio guy.

Do follow us on Twitter or Mastodon, we're on @Trade__Talks. That's not one but two underscores, @Trade__Talks.

<insert super funny double underscore joke here>. ▮

Read more…

Castro-Vincenzi, Juanma. 2022. "Climate Hazards and Resilience in the Global Car Industry." *Working Paper,* November.