Episode 171. What makes a supply chain resilient

Episode webpage

November 15, 2022

Transcript

(lightly edited)

Chad Bown: Supply chain resilience has become a huge buzzword. Or I guess three buzzwords.

Product shortages have dominated the headlines since the onset of the COVID-19 pandemic: Personal protective equipment, toilet paper, yeast, used cars, semiconductors, new cars, vaccines. The list goes on and on.

But how many of those shortages were due to supply chains that weren't resilient? What does it even mean for a supply chain to be resilient? Are complex supply chains that require many inputs the *least* resilient?

Nitya Pandalai-Nayar: What we did not expect was that complex supply chains that require many inputs were going to be the *most* resilient.

Chad Bown: I guess not.

In this episode, we'll begin by carefully defining what economists mean by supply chain resilience, so we can measure it. Then, we'll figure out what specific features of supply chains seem to make them more resilient when hit with an unexpected event like COVID-19.

To do all that, we'll be joined by a very special guest,

Nitya Pandalai-Nayar: I'm Nitya Pandalai-Nayar. I'm an assistant professor at the University of Texas at Austin.

Chad Bown: Nitya Pandalai-Nayar is one of Trade Talks' favorite economists, when it comes to this incredibly important topic of supply chain resilience. Nitya has some brand new research examining supply chain disruptions during COVID-19 coming from a new and detailed data set from India.

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.

Chad Bown: Hi Nitya.

Nitya Pandalai-Nayar: Hi Chad. Thanks for having me.

DEMAND VS SUPPLY AND THE SUPPLY CHAIN PROBLEM

Chad Bown: When COVID-19 hit local economies everywhere, policy makers were confronted with the fact that there were just lots and lots of changes all happening at the same time.

Nitya Pandalai-Nayar: As a policy maker, you might observe there was this big shock. There's the pandemic. And you see that there's a shortage of toilet paper on the shelves, or there's a shortage of PPE.

The question is, if you're going to make policy, what do you target? The shortage could happen because the medical product supply chain was not resilient and something broke. And so you want to try to fix that. You want to try to help the firm find a new supplier and bring in its PPE as quickly as possible and assemble it.

The shortage could happen because there has been the shock and people have changed what they want. They've stopped wanting new cars and they've instead switched all of their demand to laptops so their kids can go to school. Or everybody wants a Peloton.

Output in some sectors is falling. Restaurant output is falling because no one is going to restaurants, not because of a supply chain issue.

That has a very different policy response. For that, we want to try to understand how much of the output declines we saw when this shock occurred are because of supply chains and not just because of demand changes.

Chad Bown: Demand is important - Nitya does tackle that - and we will come back to demand later, but the main focus of her research today is going to be on supply.

For supply chains, we first need to identify where there was a problem. Only then can we try to diagnose why.

For now, we are going to ignore international trade and focus instead on what we can learn about supply chain disruptions taking place within just one country, India.

THE COVID-19 PANDEMIC HITS INDIA: LOCKDOWN

Chad Bown: Tell us about what happened in India when the pandemic hit in early 2020.

Nitya Pandalai-Nayar: The pandemic started slowly in India, much slower than we experienced here in the US or in Europe. The first cases appeared, or were identified, in February 2020. But even by March, even when Italy was in this huge outbreak, we were hearing it in the news all the time, New York was having this big outbreak, there were actually very few cases in India.

The government was very worried that, because of the population density, COVID-19 would spread very fast, and that they were under counting cases. Maybe they weren't finding them. So what actually happened finally was, one Sunday evening, the Prime Minister made a speech and announced a lockdown that was going to start immediately.

Chad Bown: Within India, the lockdown's effect on the public was pretty severe.

Nitya Pandalai-Nayar: The lockdowns were so sudden and so stringent that because all transportation was shut down, people started walking home. You have a lot of migrant workers from rural areas living in cities or more urban areas where they work in factories and other industries. Because they were really worried about the lockdowns, and there was no public transportation or trains, they actually left their jobs and started walking back home.

Anecdotally, my mother works for one of these multinationals, and they have manufacturing plants, and they responded by laying off about a quarter of their workforce.

People that could walk to work or could get to work fairly quickly by themselves without breaking the law could go to work. But a lot of people couldn't, and a lot of people were being bussed in from a very vast distance, and so they could no longer come to work.

Chad Bown: How did they structure the lockdown?

Nitya Pandalai-Nayar: They structured the lockdown based on how they thought COVID-19 was going to spread. There were just not many cases of COVID-19. They were imposing lockdowns in places like Mumbai, which has very densely populated areas, that they thought COVID-19 could spread really quickly. And so they were imposing lockdowns that were very stringent in places that they thought could have big outbreaks.

They divided up the country into a number of districts and they classified districts into Red, Green, or Orange Zones. And the Red Zone districts were given the most stringent lockdown rules, and the Green were the most lax.

The Red Zone districts were almost completely shut down. There was no public transport. You couldn't go to work. You had to basically stay indoors except for maybe one trip a day to buy groceries. E-commerce was allowed, but almost nothing else was allowed. My family actually got stuck in one of the Red Zones, and they were in one of these lockdowns where they couldn't really leave their apartment.

The Orange Zone was somewhere in between, and the Green Zones had the least restrictions – they actually had public transport. There was 50% capacity limits, but there was some transport.

Chad Bown: Think of India's lockdown during Covid 19 as like a traffic light.

In Red Zone places everything stops. Severe lockdown.

In Green Zone places, the economy can still go. People can still work. Buses, trains and public transportation are still operating. There are new speed limits on the economy, even in the Green Zone places, so it's not like before the pandemic. But there is a big difference between Green and Red, and Orange is somewhere in the middle.

Nitya Pandalai-Nayar: We looked at Google mobility trends and there's a very, very sharp decline in mobility in the Red Zones, but much less so in the Green Zones.

Chad Bown: So a Red Zone would have less worker mobility and economic activity as workers couldn't even get to the plants, so factories often had to shut down.

Next, even for goods that had been produced – take an input, maybe that needed to travel within an Indian supply chain being transported from state A to state B – that type of input was going to be affected in other ways.

Nitya Pandalai-Nayar: India is a developing country and most of the transport is happening by road. So a lot of transport is just by truck. There's also a very developed rail network; there's also some transport by train.

Because these Zones varied across the country, if you want to transport goods from state A to state B, you had to go through many Red, Green, and Orange Zones, and crossing Red Zones was nearly impossible.

I recall many news articles about trucks getting stuck at Red Zone borders because they had to have paperwork to cross, the paperwork was very hard to fill out, and they needed COVID-19 tests, which were not exactly available at that point. There were a lot of delays because of this.

DEFINING SUPPLY CHAIN RESILIENCE

Chad Bown: You've been working on supply chains and economic shocks throughout your career, but what questions are you interested in here?

Nitya Pandalai-Nayar: During the pandemic, there was enormous interest from policy makers trying to understand the disruptions we were experiencing. We all remember the grocery stores with products just missing from the shelves or limits on how much toilet paper you could buy and that stuff.

Separately, India had these lockdowns and the authorities were concerned about how to help industries that were affected by lockdowns.

This is also about supply chain resilience. They wanted to understand who would be affected by the lockdowns, and because things are being shipped from point A to point B, and there were all of these disruptions, these Red Zone lockdowns were going to spill over into other zones. So they understood that, but they did not understand the links in the economy, and they did not understand how to identify which industries or which firms would be affected.

The authorities from one of these states reached out to my co-author, Gaurav Khanna, and they asked him to try to identify which firms and which areas would be, would be affected and they said, “We'll provide you the data.”

Chad Bown: Gaurav Khanna – Nitya's co-author, who is an economics professor at the University of California, San Diego – gets this call from Indian government officials looking for help.

He gets their data and immediately does his best to answer their questions.

But when Gaurav and Nitya catch their breath and really begin to dig into researching this supply chain resilience question, they discover another problem.

No one has really settled on what supply chain resilience even means.

Chad Bown: We're economists and we've been studying supply chains for a long time. Do we have a universally accepted definition of supply chain resilience?

Nitya Pandalai-Nayar: It's very surprising, but we do not, at least not one that I know of. This is a super important area for policy makers, but it's actually a fairly new area for economists to be emphasizing. I think this really came to our attention during the pandemic.

We looked around for a definition of supply chain resilience, and we did not find a universally accepted definition.

The most comprehensive definition we found is that a supply chain is resilient if the buyer-supplier relationships are prepared and they can adapt very quickly to unexpected events, production disruptions are minimized (output losses are minimized), and these supply chain relationships recover very quickly.

Chad Bown: One way to define a supply chain as being resilient is when a buyer-supplier relationship is prepared and can adapt quickly to an unexpected shock. Like a pandemic.

Being resilient here is defined to mean production disruptions are minimized, and any buyers and suppliers whose relationships are severed somehow recover right away.

I asked Nitya to tell us more about the amazing data from India that she and Gaurav were working with.

Nitya Pandalai-Nayar: It is very, very rich data. It's very unusual to have this type of data.

The data that we have come from one state in India and, because of the confidential nature of the data, I cannot name the state.

You might think this is just one Indian state, but India's a very big country. The state is actually very densely populated. In terms of its population, it's about twice the size of Chile, three times the size of Belgium and seven times size of Costa Rica.

Chad Bown: Is it a state we would've heard of? I know you can't tell us what the state is but…

Nitya Pandalai-Nayar: Quite possibly. ☺

Chad Bown: Okay. ☹

Nitya Pandalai-Nayar: This is a fairly big state and it is very diversified, in terms of its production structure. There's a lot of manufacturing – the industries that we see are food manufacturing, chemicals, plastics, basic metals, but also computer hardware. There's a range of both highly-skilled and low-skill manufacturing.

So this is very, very rich data.

They have almost every transaction between firms. One of the legal requirements of shipping goods from one firm to another in India is that if the value of the shipment is more than about $700 (a fairly low threshold), a firm has to fill out what is called an eWAY bill and pay a tax. This document is very detailed. This document includes information on the value of the shipment, the product that's being shipped – it's very specific, e.g., leather shoes – the firm to whom you're shipping it to, and the price.

It literally includes all of the information you'd typically get from customs data, but it's transaction level and thus has the origin firm or establishment and the destination firm or establishment.

Chad Bown: Trade economists often complain about India's trade policy and its bureaucracy. But one of the benefits of the Indian bureaucracy I've come across is you get these amazing data sets that you don't get access to anywhere else in the world because there's just such detailed record keeping about a lot of these things.

Nitya Pandalai-Nayar: That's true. Another amazing thing about the bureaucracy is that people are worried about not filling out these forms. So we actually have boat loads of these forms that we can use with that data.

Chad Bown: Tell us how you're going to use this data.

Nitya Pandalai-Nayar: We use these data to build supply chains. And we build supply chains with the level of resolution that you typically do not have, or at least we as economists do not have.

And the way we are going to do this is to think about each transaction as having a supplier and a firm that is buying the product.

If we take a particular firm, a particular buyer, and we add up everything it's buying from all its suppliers, then we understand the total value of inputs it's purchasing. If we take a particular supplier and then we add up everything it's selling to all the buyers who are buying its stuff, we have a measure of the total sales of the supplier.

We can map out, very systematically, the entire supply chain and study what happened to it when this lockdown was introduced.

Chad Bown: Nitya has this incredible data that she can use to build out these Indian supply chains. She also has these three different ways of defining whether a supply chain is resilient.

A supply chain is resilient if, when a shock hits, input purchases aren't really affected or output sales aren't really affected - so in those two cases, linkages with existing suppliers are maintained.

Or, in the cases where those linkages are broken, the third definition is that it's relatively easy for buyers to find new suppliers.

From these definitions, she creates three measures of supply chain resilience, using information on buyer-supplier relationships in the Indian data.

Using that information, she can then zoom in on the impact of the Red, Orange, and Green Zone lockdowns emerging across India in response to the pandemic.

Nitya Pandalai-Nayar: In March 2020 when the pandemic happened, there was a lot of variation in lockdown policies across India and across districts.

Some firms were very affected because all of their suppliers, or many of them, were in Red Zones and they had to shut down. And some of them were less affected because they were in Green Zones.

We are going to use exactly this variation in the period after March 2020 to look at how outcomes differed across two firms, maybe they were both in the same district. They were right

next to each other. They made the same thing. So you and I are firms, we are making the same thing, we're both making shoes, but my suppliers for all of my leather were all in Red Zones and yours were all in Green Zones.

I'm going to compare how your output and your inputs changed, and your links changed, relative to my links and then understand what the effects of the lockdown were and what the effect of the shock was.

Chad Bown: That's your setup. What do you find?

Nitya Pandalai-Nayar: We find that, unsurprisingly, if you had a lot of your suppliers in high lockdown areas, you had more input declines, and your output declined by quite a lot. You had more supplier-link disruptions – so you broke links with suppliers that were in Red Zones, and you couldn't find necessarily new suppliers very easily. We find that being more exposed to suppliers in Red Zones really negatively affected the firm in all dimensions that we're measuring.

Chad Bown: For this part of the analysis, did any results surprise you?

Nitya Pandalai-Nayar: For this part, no. We expected that the lockdowns were so stringent in the Red Zones that firms were going to have trouble obtaining their inputs from suppliers. And we find everything that is exactly as expected.

Chad Bown: So this basically establishes the credibility of these measures that you're using as being useful indicators of supply chain resilience.

Now that you've got those measures and you're convinced that you're capturing something important, what do you do next?

Nitya Pandalai-Nayar: So now we get to the really interesting part of what we're doing.

WHAT MAKES A SUPPLY CHAIN MORE RESILIENT

Nitya Pandalai-Nayar: So we want to understand which supply chains are typically more resilient to shocks.

I already said that you and I are firms. We are in this district. Let's just say it's in an Orange Zone. We're in the same district, we're in the same industry, you had Green suppliers, and I had

Red suppliers. I've already identified how different our input declines were or how different our separation rates were.

Now I'm going to say there's also two other firms, and they are in the same district. They're in the same industry, but they had more complex supply chains.

You and I used five inputs to produce our output. Those firms used 10 inputs to produce their output. Again, one of those firms had all of their suppliers in Red Zones, and one of the firms had all the suppliers in Green Zones.

I'm going to look at the difference in responses in output or inputs or separation, between those two firms. Maybe it was big, maybe it was small, and I'm going to compare that to the difference in responses between you and me.

Chad Bown: When the pandemic hit, Nitya knows from her data, which supply chains were resilient and which were not.

For the supply chains that worked, she now wants to figure out why.

For the buyer-supplier relationships that broke apart, the firms that stopped buying inputs and stopped making output, she also wants to know what characteristics made those sorts of supply chains not resilient.

It could be that a company making something that needs to buy 10 inputs – compared to a firm that only needs five inputs – is going to be more exposed.

Nitya is using this amazing Indian data to recreate the details behind these supply chains to come up with measures of their complexity.

Nitya Pandalai-Nayar: We think really of complexity as…we are using network theory. It's really just about how complicated is your production process. How many inputs do you need to make your output?

You can imagine that if you're making computers, your production process is much more complex, on average, than if you're making wood tables. Very few inputs. Very simple production process.

There's another way to think about complexity, which is, I use a lot of inputs, and my inputs themselves are very complicated to make.

I'm producing cars and cars require many parts. They require engines, they require bodies, they require, the doors and all of these parts. But the engines are also very complicated to make. So cars are exceptionally complicated because they require many inputs, and those inputs are also very complex.

Chad Bown: There are a number of ways that these supply chains could be complex. One way is to simply have more inputs. Another is if those inputs require a lot of other inputs.

To me, lots of inputs and then inputs needing lots more inputs sounded bad. When all it takes is one thing to go wrong, having lots of links in a chain could make it fragile.

Those sorts of complex supply chains were probably not very resilient.

Chad Bown: Turns out, I was wrong.

Nitya Pandalai-Nayar: So these supply chains were perhaps somewhat surprisingly more resilient to the shock.

Controlling for everything else, the demand and all the things that we were already doing, firms with more complex supply chains and whose inputs were more complex, they separated *less* from their suppliers.

When they separated, they actually found new suppliers (what we call net entry, separation minus how many new suppliers you find, worked better for them). They had less of a decline in their input values as well.

Chad Bown: Initially this was really puzzling to Nitya as well.

Nitya Pandalai-Nayar: So what we thought was that these complex supply chains might actually be less resilient to the shock because I need so many inputs to produce something, some of these suppliers are going to end up being in Red Zones, and I can't really make a car without an engine. And so what do I do then? If I can't find another supplier very quickly, I'm probably not very resilient to the shock.

Chad Bown: But then, when Nitya's team dug deeper, it all began to make sense.

Nitya Pandalai-Nayar: What could also happen is as a firm, I realize my production process is very complex. And so I've really invested in my relationships with all of my suppliers. I want to make sure that even my engine manufacturer, if they're in a Red Zone, they shift my order to maybe another plant that they have that is not in a Red Zone, and they still get the input to me.

Chad Bown: I asked Nitya if we could rule out that this complexity measure maybe capturing something else. Maybe policy makers were actually somehow prioritizing these complex supply chains, but for a different reason.

The car example she was giving us…

Maybe an industry like autos is just so important politically or economically – autos typically do have a lot of jobs – that policy makers were less stringent at enforcing lockdowns for those companies. And it just so happened that those same companies were the ones who supply chains were more complex.

Nitya Pandalai-Nayar: We are really looking at March to May and sometimes a little bit longer than that – March to August – of 2020. The initial period of lockdown in India was very, very stringent. The primary concern was really the pandemic getting out of control and so there was very little room for local area officials to get around these issues.

The other reason I don't think it was happening that much is the reason why we got the data. We got the data because the government of the state reached out to my co-author to try to understand whom to help. And this happened almost in real time, and this was because they did not know how to target their policies.

Chad Bown: More complex supply chains were also more resilient to the most severe lockdowns in India during the pandemic.

What other characteristics do you look at?

Nitya Pandalai-Nayar: We can look at the suppliers of a firm, and we can try to gauge whether these suppliers are more or less important as suppliers of a product.

We use network measures – technically it's called an out degree. It is how important is a specific supplier to people or to firms that are buying that supplier's output.

Unsurprisingly we find that firms don't break their links with these very important suppliers. These supply chains are less disrupted, they're more resilient to the shock, along all of our measures of resilience.

Intuitively, you might think there's a reason this supplier is so important. It might be that it is the best supplier of this good. It has a specific, very good technology.

It could also just be the largest. It could have infrastructure that it needs to minimize production disruptions. Maybe it has a way to get around what is going on and shift production to a Green Zone establishment instead of a Red Zone establishment. Maybe it can get its own buses and transport its own workers.

So we don't know specifically what it does, but whatever reason it is more important and these links are not broken.

Chad Bown: Being the largest supplier is another characteristic that could be important, and it is also something that Nitya can measure. Maybe all that matters for a resilient supply chain is having a really big firm.

Chad Bown: How important is size in all of this?

Nitya Pandalai-Nayar: For aggregate effects, if I'm looking at, why did output fall in India after the shock? The biggest firms are going to really be the most important, they produce the most output. We know even in the US the really big firms – think of GM and Amazon – all of these firms have way more of a share in aggregate outcomes than very small firms do.

So size, of course, it's important.

But it turns out that size does not explain all of supply chain resilience. All of these results that I've told you about, so the complexity, the link with the supplier, the importance of supplier – all of our results remain, even when we control for size.

Even if you're not say, a very big firm, what matters is if you have a more complex supply chain, then you will still be more resilient.

WHAT FIRMS LEARN FROM THEIR SUPPLY CHAIN MISTAKES

Chad Bown: The third thing you do in the paper is you look at supply chain linkages that were broken and you examine the possibility of finding new suppliers.

Nitya Pandalai-Nayar: We wanted to look at how do firms learn from the shock? What do they do after the shock uh, do they improve the resilience of the supply chain? It turns out that firms actually seem to switch towards suppliers that are more resilient, consistent with all the characteristics that we looked at.

Firms switch towards larger suppliers, they switch towards more connected suppliers, towards more important suppliers.

They also shrink the distance in their supply chain. So they do seem to be doing something that's like re-shoring, except this is all within the same country.

But clearly the firms are actually switching towards supply chains that should be more resilient to future disruptions, according to these measures.

Chad Bown: During the pandemic, India had both supply chain disruptions and shocks to demand. Because of lockdowns, people stopped buying certain types of services like restaurants or maybe travel. They spent more on things they would need if stuck at home.

Dealing with these demand changes is necessary to identify those features of resilient supply chains that Nitya told us about.

Nitya Pandalai-Nayar: It's extremely important to deal with that precisely because we want to separate the demand side from just supply chain issues.

The way we do deal with it technically is using fixed effects. This is a favorite tool of economists. Suppose you are a firm producing in a Red Zone. To the extent that you have some local customers, they are really locked down. Their demand is going to change in a very different way than, say, people that live in a Green Zone.

We're also going to control for firm industry-time fixed effects. There was a negative shift to many service sectors. This service industry-time fixed effect, if the firm is in the service industry, will control for the demand declines that that sector experienced.

IMPLICATIONS FOR POLICY

Chad Bown: Stepping back from all this, what do you think are the main takeaways from your results?

Nitya Pandalai-Nayar: When thinking about supply chain resilience, first, it's important to be specific about what the concept of resilience that the policymaker's is interested in.

We do find that the breaking of these links is linked to significant input loss and output loss, and finding new suppliers is not easy in the short run.

But also when thinking about which supply chains will fare better when there's this big, unexpected shock, it's important to consider what investments the firms in those supply chains might have made in the past to keep their buyer-supplier relationships strong.

To us, what we did not expect was that complex supply chains that require many inputs were going to be the most resilient. For us, that was surprising.

But it underscores that firms that have many inputs – and there is some theory on this – should be more worried about the fragility of their supply chain, and so should actually undertake investments to make sure that their supply chain is resilient to shocks. I think the evidence we have very strongly supports that.

Chad Bown: How about policy implications? If you were going to meet with Indian or any policy makers – suppose they were hit with this same exact shock again – what would you tell them?

Nitya Pandalai-Nayar: It depends on really is the output decline coming because of demand or is it coming because of the supply chain? And if it is because of the supply chain, then perhaps the policy goal is to minimize these production disruptions and maybe then there is a way to incentivize firms to build these stronger relationships and to better anticipate how their supply chains will react to shocks.

In a way you want firms to think about this and think about stress testing their supply chains. How would it react to a shock? They need to understand where they need to build relationships to prevent output losses.

Chad Bown: Is it right to say that, at least in certain types of shocks such as this one that we saw with COVID-19, diversification isn't necessarily the answer that's going to save you?

Nitya Pandalai-Nayar: Absolutely. COVID-19 was really a global shock. So it affected all countries to some extent. There was a lot of variation, but everybody was affected. It affected sectors differentially.

So diversification can help. It doesn't have to help. It can go both ways.

Diversification can help because if you have a supply chain, and let's say we stay within India and different parts of India are more or less affected, everyone is affected to some degree. But if I am producing in a Red Zone, the fact that I'm diversified because I have some inputs coming from a Green or an Orange Zone, those Zones are relatively less affected. And so I'm better off than if all my entire supply chain was in my Red Zone.

But there's the other side where it can hurt. Suppose I happen to be in a Green Zone if my entire supply chain was in my Green Zone, great. But because I diversified and I have some inputs coming from a Red Zone and an Orange Zone, I get exposed to those shocks. So I'm worse off than if my inputs were all in my Green Zone.

What diversification does is it reduces how affected I am by my own shocks, but it exposes me to other people's shocks. And that can go both ways, depending on what the shock is.

NEXT STEPS FOR SUPPLY CHAIN RESILIENCE RESEARCH

Chad Bown: Research on supply chain resilience is so important, but it is also very new. Nitya really is a pioneer here.

As my last question, I asked Nitya, what should be next. With access to other data, maybe in other countries, maybe looking at other types of shocks, what other things do we need to investigate to really learn more about what makes a supply chain resilient?

Nitya Pandalai-Nayar: It would also be super useful, we think, to understand what other margins firms could have to improve their supply chain resilience. These are things that we don't have in our data, including inventory management technology, workforce management, and so on.

Also, do firms change their production? We don't find any evidence that firms change what they produce in response to the shock, but perhaps that would happen in the longer term. Our data ends fairly soon after the initial pandemic, but that might actually happen in the longer term.

Chad Bown: Nitya, thank you very much.

Nitya Pandalai-Nayar: Thank you for having me. That was, that was "fun."

SUPPLY CHAIN RESILIENCE SUMMARY

Chad Bown: To wrap things up, let me try to pull this all together.

First, Nitya has come up with formal ways for economists to measure supply chain resilience. In the face of a shock, the definitions are based on what happens to a firm's input purchases, what happens to its output or its production, and what happens to its relationships with its suppliers.

She finds evidence, as expected, that those measures were negatively impacted by the Red Zone lockdowns in India during the early months of 2020.

Second, now that we have these measures of supply chain resilience and we know that they're useful, Nitya looks at what characteristics made supply chains resilient in India during COVID-19.

Perhaps surprisingly, more complex supply chains seem to be the ones that are more resilient and stay together.

The theoretical explanation is that firms with more complex supply chains recognize they need to invest in preparedness in the first place. That may be what makes complex supply chains better able to withstand actually getting hit with a shock like COVID-19.

The third thing Nitya does is to examine the behavior of firms whose links were broken during the pandemic.

Did they learn? She finds that their new relationships tend to look more like those firms whose supply chains were successful and more resilient during the lockdown. These second chance firms are now hooking up with connected and important suppliers.

Chad Bown: Overall, these results are hugely important. There is still a lot of work for researchers to do as there are lots of different types of shocks in different types of countries.

But these findings are super interesting and an incredible advancement for economic research on what makes supply chains resilient. As always, the answer is complicated.

GOODBYE FOR NOW

Chad Bown: And that is all for *Trade Talks*. A huge thanks to Nitya Pandalai-Nayar, an assistant professor of economics at the University of Texas at Austin.

Do check out her new paper with Gaurav Khanna and Nicolas Morales "Supply Chain Resilience: Evidence from Indian Firms."

Nitya really is one of the world's great trade economists with expertise on how supply chains respond to shocks. I highly recommend a second article of hers about how supply chain disruptions from the Fukushima tragedy in Japan wound their way across the Pacific through international supply chains to impact the US economy.

That one is titled "Input Linkages and the Transmission of Shocks, Firm Level Evidence from the 2011 Tohuku Earthquake." I'll put all these in the show notes on the *Trade Talks* website.

Thanks to Melina Kolb, our supervising producer. Thanks, as always, to Collin Warren, our audio guy.

Do follow us on Twitter. We are on at @Trade__Talks. That's not one, but two underscores, @Trade__Talks.

<insert super funny joke here>

References

Boehm, Christoph E., Aaron Flaaen, and Nitya Pandalai-Nayar. 2019. Input Linkages and the Transmission of Shocks: Firm Level Evidence from the 2011 Tohoku Event. *Review of Economics and Statistics* 101(1): 60-75.

Khanna, Gaurav, Nicolas Morales, and Nitya Pandalai-Nayar. 2022. Supply Chain Resilience: Evidence From Indian Firms. University of Texas working paper, October.