

Tim Phillips [00:00:00]:

Today on VoxTalks Economics how railways help Sweden's inventors work together. Welcome to VoxTalks Economics from the Centre for Economic Policy Research. My name's Tim Phillips. Every week we bring you the best new research in economics. So remember, subscribe follow on Instagram as well at VoxTalks Economics. We still imagine that innovation is done by lone geniuses, but inventing things that has been a team game for decades now. So when it became quicker and cheaper to travel by train, did this help innovators too? A new paper uses the construction of Sweden's rail network to investigate collaboration among inventors in Sweden. Thor Berger of Lund University and Erik Prawitz of Linnaeus University. I checked the're 1 hour, 50 minutes apart by train, collaborated on the research and they join me now. Thor. Welcome to VoxTalks Economics, and Eric, welcome as well.

Thor Berger [00:01:12]:

Hi Tim.

Erik Prawitz [00:01:14]:

Yeah, thanks a lot for inviting us.

Tim Phillips [00:01:17]:

Thor, start me off. How much of innovation today is collaborative? And was this very different in the past?

Thor Berger [00:01:23]:

Yeah, so today innovation is very much a collaborative venture. So, for example, about 75% of Swedish patents are collaborative, so they involve more than one inventor. And you see broadly similar patterns in other countries. And this sharply contrasts the fact that the vast majority of patents in the pre World War I era were granted to individual inventors. We have many well known prolific individuals such as Thomas Edison, Alfred Nobel or Nikola Tesla, but it is an open question why we see this long term shift toward collaboration. So one hypothesis is that over time, technological complexity is increasing and as it becomes harder to find new ideas, producing inventions at the technological frontier may require inventors to collaborate with others. But an alternative explanation is that the rise of collaboration could be driven by a lowering of the cost of interacting with others. So, for example, today Tim is somewhere in the UK, Erik is in Stockholm, I'm in the south of Sweden, and we're interacting at virtually zero cost. And it is the role of such interaction costs in shaping collaboration that we study in our work.

Tim Phillips [00:02:32]:

Make this clear to me as an innovator, why might it potentially be better for me to collaborate?

Erik Prawitz [00:02:38]:

Innovators may complement each other in different ways, so we can think of that they accumulate ideas, so different team members bring different ideas and different competencies to the table. So this is related also to the notion of specialization that we see today more and more. We can also think that combining ideas in a creative process is something that creates new ideas. So it's the creation of a novel mixture of existing material and methods, basically. But it's also important to bear in mind that there are downsides, right, with collaboration. So maybe we might have coordination problems. We can also think of that there are diminished economic incentives of innovating, or there are diminished rewards from a patent, for instance. And importantly for our setting here is that it is also costly to meet, right? So there's a cost involved in collaborating.

Tim Phillips [00:03:31]:

We can pretty easily collaborate by getting on a Zoom call or Teams or something like that. I'm thinking back to before there were trains, how did people collaborate?

Erik Prawitz [00:03:45]:

Local collaboration was clearly possible, right? So we had some collaborations within the bigger cities. But you're right that the costs or the downsides of engaging in the long distance collaboration, which is probably what you have in mind, they were often too large, so it was extremely costly with face to face communication here. And we had a really poor road system, which also limited postal services, for instance. So in general, collaboration was mostly confined to these bigger cities, like Stockholm before the railroad.

Tim Phillips [00:04:18]:

Okay, in this research, you focus on the opportunity to collaborate that was created by Sweden's railway system. So give me some history, first of all, when were these rails laid? Was it as chaotic as the railway mania was in the UK? I hope not.

Thor Berger [00:04:34]:

So actually, to some extent, Sweden learned from other countries, and it also learned from its own failed attempt to rely on market forces to construct a railroad network. So in the mid 19th century, in the 1850s, the Swedish state steps in and plans, funds and constructs the backbone of the Swedish railroad network. So the state basically constructs the main trunk lines, and then private companies were encouraged to construct additional lines to sort of fill out the network. And interestingly for us, these trunk lines were drawn to connect the capital, Stockholm, with

other major cities in the west and the south. But in doing so, many other smaller places along these routes that were not directly targeted by state planners were traversed by the rail network. So for us, this provides a great opportunity to examine what happens in terms of collaboration when inventors in a remote location accidentally gains access to the rail network.

Voiceover [00:05:39]:

In the 19th century, the Swedish government helped to build the railway network. So in the 21st century, should governments use policy to accelerate green innovation? Listen to our interview with Philippe Aghion from July 2023 called; Is green growth possible?

Tim Phillips [00:06:00]:

How far are the distances between population centers? And you said the roads weren't very good. Exactly how difficult was it to travel before the railways came along?

Thor Berger [00:06:09]:

So I think the key takeaway here is that Sweden is a very sparsely populated country. So for comparison, the UK is about half the size of Sweden, but today it has a population that is about seven times larger. So this low population density, combined with the long distances between cities and the poor road networks that you mentioned, meant that interactions over longer distances were more or less impossible prior to the coming of the railroad.

Tim Phillips [00:06:35]:

If I'm an inventor in the 19th century in Sweden, why would trains be an advantage to me? I would imagine that I would already be in Stockholm or I would be working in some factory where the other people who were inventing things that I knew about were.

Thor Berger [00:06:54]:

Absolutely. So many active inventors in this period were located in Stockholm. And we have shown in other work, which is also published as a CEPR working paper, that many inventors actually migrated to Stockholm that facilitated interactions with other inventors, provided access to intermediate services such as patent agents. But the important thing to know here is that Swedish industrialization took place across virtually the whole country. So throughout the country, you have many potential inventors, and it is those more marginal inventors that may have been nudged to pursue invention and collaboration as they gain access to the rail network.

Tim Phillips [00:07:34]:

You're measuring innovation in the usual way by counting patents here. How many patents are

you counting? What dates did you analyze? What type of patents did you include or exclude?

Erik Prawitz [00:07:45]:

Yeah, so we have patent records from the Swedish Patent Office, and we should give credit here to our collaborator on a previous project, David Anderson, who spent many months, I don't know, years almost, in digitizing these patents from handwritten ledgers.

Tim Phillips [00:08:00]:

Yes.

Erik Prawitz [00:08:00]:

So that was an amazing effort. And now for this period of time, we study, so the mid 19th century to World War I. So we have about 17,000 patents in our data, and many of these are related to the rapid industrialization that Thor was talking about during this time. So obviously, machinery stands out as a sector, but we also see patents in chemicals, electricities that came in the end of the 19th century, as well as agriculture and mining, which were like two of the biggest sectors in Sweden still. Yeah.

Tim Phillips [00:08:31]:

First of all, you digitized the patent data, then you have to match it with the location of the people who collaborated to make these patents. How did you do that?

Erik Prawitz [00:08:39]:

So we use geographic information systems with the railroad, the network of the railroad, and we link that to the information we have from these 110 ledgers, which basically specifies the address or the location of each inventor on the patent. This allows us basically to examine collaboration across places. We can measure this distance between team members and so on. Yeah, we can link then these locations observed on the patent with other data we have, most importantly, railroads, but also other municipality characteristics. Right. So in the end, our main analysis will be conducted at the municipal level. So the question will be how invention in a location is affected when it's connected to the railroad.

Tim Phillips [00:09:23]:

So the big question, what was the causal effect of the arrival of the railways in Sweden, in locations in Sweden on collaboration?

Erik Prawitz [00:09:33]:

Right. So we see positive effects on different margins, both extensive and intensive. So we see an increase in the probability that a municipality is engaged in collaborative patents. So that increases by about 100% from the mean. But also see an intensive margin effect where the number of collaborative patents increases across the country. So importantly here you might think that, okay, so there might be a lot of things happening when the railroad comes, right? So there might be a general increase in knowledge below us, you could get an increased incentive for innovation, right? As the market size increases around you, you could also have movement of inventors, right? You could have an inflow of inventors coming into your municipality when you get connected, and you have a general economic activity possibly being affected. And we do see all these things, and we also show that in our companion paper, Thor was talking about as well. So perhaps a better measure here is then to estimate the effect on collaborative patents per inventor or per patent, so we can think of more of it as a share. So doing that, we still see substantial increases, even though we keep the number of patents constant. We see increases in collaborations, so we see a bit smaller than the general increase, but we see still about a 60% increase in collaborations per patent, for instance, from the mean. And I think one interesting thing as well, we can note is that it's mainly the independent inventors that are affected here. So firm inventions is much less affected. So the vast majority of patents during these times were conducted by independent inventors. But it's still interesting that firm invention is not much affected. And I mean, we can only speculate for the reasons for that, but one possibility could be that firms already have some sort of infrastructure in place, while independent inventors are initially more constrained and are more affected by the connection to others.

Tim Phillips [00:11:33]:

Yeah. And with the loosening of that constraint, are we seeing that these independent inventors are collaborating over longer distances than before?

Erik Prawitz [00:11:42]:

Yeah. Right. So this first set of results establishes that we do see an increase in collaboration, right? But we'd also see that the geographical collaboration is affected. So in terms of distance, as you said, then we see increases with about 8%. So we see substantial increases in collaborations across different municipalities. And importantly, this is also only with municipalities that connected to the rail network. So you don't increase in collaboration with other locations that are not getting connected. We still see a lot of collaboration taking place within cities, but we here see that with a railroad, inventors also start to collaborate with inventors located elsewhere in more sparsely populated regions.

Tim Phillips [00:12:26]:

Does this mean that the centre of gravity of innovation is changing? Because as you say in your previous work, inventors were drawn to Stockholm. Now it doesn't necessarily mean that you

have to do that. So did the location of innovation change?

Thor Berger [00:12:40]:

So I mean, there's definitely something along those lines going on. So the rail network changed the geography of collaboration, as Erik mentioned, by facilitating long distance collaborations, but also promoted collaboration involving inventors in rural locations. So this suggests that the railroad diffused innovative activity outside of these major urban centers such as Stockholm, and that it encouraged inventors residing in these more isolated locations to enter into collaborations with inventors in other places.

Tim Phillips [00:13:11]:

So, so far we're talking about who's doing the innovation and where they're doing it. But can we also say that the speed of innovation increases because of the railways or the quality of the innovation increases? Can we go that far?

Thor Berger [00:13:26]:

So I mean, we could think about this in two ways. So lowering the cost of collaboration, I mean, it could lead to better collaborations because it could improve the match quality between collaborating inventors. You could find a better match to your knowledge or skill sets, but it could also just simply lead to an increased number of collaborations, but with the same average quality. So we just get more collaborations. So we find that the latter here seems to be the case. So in other words, we get more collaborative patents due to the railroad, but not necessarily better collaborative patents on average. And I think broadly this is consistent with this idea that the railroad encouraged many of these marginal inventors in more isolated areas to enter into collaborations.

Tim Phillips [00:14:17]:

So bringing this up to date, we often hear about the Internet and communication over the Internet as the death of distance. I mean, for the two of you to collaborate, you don't have to jump on a train for a couple of hours anymore, you can get on a call like this. We see that academic papers, especially in economics and innovation in general, as you've pointed out, collaboration is business as usual. So does this have anything to tell us about the future of innovation? Or is it an interesting insight into what innovation was like in the past and how it developed?

Thor Berger [00:14:52]:

I think a puzzle is that despite this so called death of distance, people and innovative activity is still increasingly clustering into large metropolitan areas today. So I think our research shows

that major investments in transport infrastructure so the construction of the rail network in Sweden helped to diffuse innovative activity outside of these major urban centers and thus encouraged a larger number of individuals and places to participate in innovation. So whether similar investment in communication and transport technologies could help diffuse innovative activity in the same way today, or whether the gravitational pull of major metropolitan areas is just simply too strong, I think that's still very much an open question.

Tim Phillips [00:15:37]:

Well, it's a wonderful piece of historical research and it's very interesting to read and to think about afterwards. So Thor, Erik. Thank you very much.

Thor Berger [00:15:46]:

Thank you, Tim.

Erik Prawitz [00:15:47]:

Thanks a lot, Tim.

Tim Phillips [00:15:57]:

The paper is called Collaboration and Connectivity: Historical Evidence from Patent Records. And the authors you heard from them are Thor Berger and Erik Prawitz. It is discussion paper 18031 at CEPR.

Voiceover [00:16:17]:

We hope you enjoyed this Vox Talk from the Centre for Economic Policy Research. If you did, please leave us a review and tell your friends about us. Next week on VoxTalks: Does the presence of asylum seekers lower rental prices in the surrounding neighborhood, and why?