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# NBER Reporter

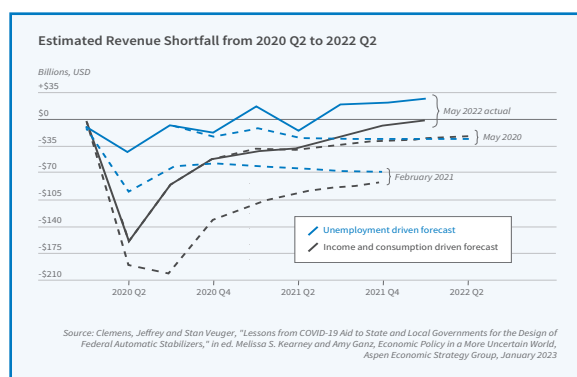
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## Program Report

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## International Trade and Investment

Stephen J. Redding\*

The International Trade and Investment (ITI) Program holds three regular meetings annually, in winter, spring, and at the NBER Summer Institute. The ITI Program has 85 research associates, 11 faculty research fellows, two research economists, and 34 members with primary affiliations in other NBER programs, making a total of 132 members. Research within the group covers a wide range of topics, such as explaining patterns of international trade and foreign direct investment, understanding the impact of trade policies, and examining the spatial distribution of economic activity within countries.

The regular meetings are often complemented with specialized conferences. In recent years, these have included "International Fragmentation, Supply Chains, and Financial Frictions" (2023), organized by Pol Antràs, Sofia Bauducco, Linda S. Goldberg, and Şebnem Kalemli-Özcan; "Trade and Trade Policy in the 21st Century" (2022), "The Future of Globalization" (2021), and "International Trade Policy and Institutions" (2020), all organized by Robert W. Staiger and myself; "The Rise of Global Supply Chains" (2021), organized by Laura Alfaro and Chad Syverson; "Risks in Agricultural Supply Chains" (2021), organized by Antràs and David Zilberman; "Agricultural Markets and Trade Policy" (2020), organized by Dave Donaldson; "Economic Consequences of Trade" (2019), organized by Redding; "Firms and Networks" (2018), organized by Alfaro, Antràs, and Redding; and "Trade and Geography" (2017), organized by Redding and Esteban Rossi-Hansberg.

This report focuses on research during 2016–22 period; the last ITI program report was in 2016. During this period, two ITI program members — Donaldson in 2017 and Oleg Itskhoki in 2022 — received

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# NBER Reporter

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the John Bates Clark Medal, awarded by the American Economic Association to American economists under the age of 40 who have made significant contributions to economic thought and knowledge.

## Trade Policy

The last six years have witnessed a resurgence in protectionist policies and an accompanying renaissance in research on trade policy. Although several previous US presidents have introduced protectionist measures early in their first terms, the Trump administration followed this historical precedent with more breadth and force than hitherto observed, and these policies have largely remained in place in the Biden administration. During 2018, six waves of tariffs were introduced on \$283 billion of US imports, with further waves of tariffs introduced in 2019. As illustrated in Figure 1, the average US import-weighted tariff rose sharply from less than 2 percent to more than 5 percent, with a marked increase in the number of US tariffs of more than 10 percent. In response, China, the European Union, Russia, Canada, Turkey, Mexico, Switzerland, Norway, India, and Korea all filed disputes with the United States at the World Trade Organization (WTO). Many countries retaliated against the US actions by applying tariffs of their own.<sup>1</sup>

A growing body of research has estimated the economic impact of the US-China trade war. Two early empirical studies — one by Mary Amiti, David Weinstein, and me, and one by Pablo Fajgelbaum, Pinelopi Goldberg, Patrick Kennedy, and Amit Khandelwal — estimated aggregate real income losses for the United States of \$8.2 billion and \$7.2 billion, respectively. While these real income losses correspond to less than 1 percent of GDP, they are comparable to estimates of US welfare gains from tariff reductions under the North American Free Trade Agreement (NAFTA).<sup>2</sup> Figure 2 shows event-study estimates in which imposition of the US tariffs is followed by sharp reductions in import values.<sup>3</sup> One surprising finding of these and other empirical studies is that the US tariffs were largely passed through into higher prices for US firms or consumers, with little evidence of reductions in the prices received by Chinese exporters. In contrast, neoclassical trade theory would predict incomplete pass-through for a country that is large relative to world markets, such as the US. These high rates of pass-through into import prices remain somewhat

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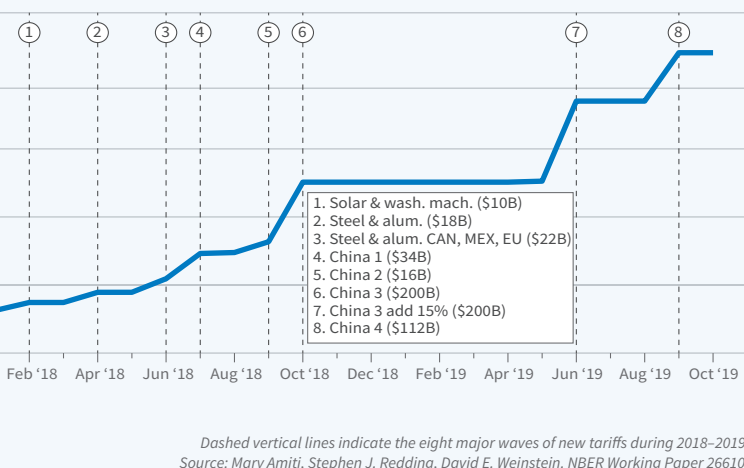
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## Timeline of the Trump Administration's Tariffs



**Figure 1**

of a puzzle for ongoing research.

Whether the US tariffs were passed on fully into US consumer prices is harder to discern because of the challenges of developing comprehensive mappings from Harmonized Tariff Schedule (HTS) products to final consumer expenditure categories. Using product-level data from several large retailers, Alberto Cavallo, Gita Gopinath, Brent Neiman, and Jenny Tang find more limited movements in consumer prices, suggesting that these tariffs were mainly absorbed in retail and wholesale margins within the United States.<sup>4</sup> In a detailed study of washing machines, Aaron Flaaen, Ali Hortaçsu, and Felix Tintelnot find that the 2018 tariffs increased the US consumer price of washing machines by nearly 12 percent. Notably, even though dryers were not themselves subject to tariffs, the price of dryers increased by an equivalent amount, suggesting a role for complementarities in demand between goods.<sup>5</sup>

A distinctive feature of US tariffs on imports from China was that the initial waves mainly concentrated on intermediate and capital goods. Later waves expanded to include consumer

of US firms to export, and find a resulting decline in US export growth equivalent to an ad valorem tax on US exports of 2 percent for the typical product and up to 4 percent for products with higher than average exposure.<sup>7</sup>

Although most research has focused on the impact of the US-China trade war on the United States, Davin Chor and Bingjing Li use high-frequency night-lights data across latitude and longitude grid cells to provide evidence on the impact on China.<sup>8</sup> While grid cells with

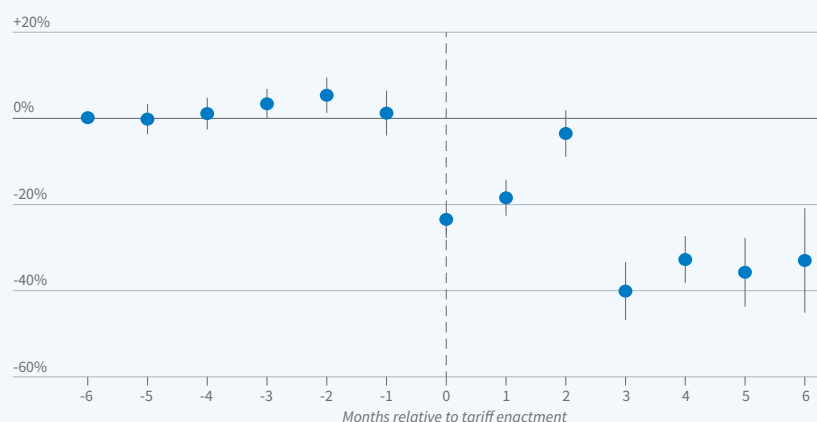
goods as the administration began to run out of intermediate and capital goods to target. Gene M. Grossman and Elhanan Helpman analyze the reorganization of firm supply chains in response to such tariffs on intermediate goods in a setting with costly supplier search and bargaining.<sup>6</sup> Kyle Handley, Fariha Kamal, and Ryan Monarch analyze the impact of these tariffs on intermediate

negligible direct exposure to the US tariffs account for up to 70 percent of China's population, the 2.5 percent of the population located in grid cells with the largest US tariff shocks saw a 2.52 percent decrease in predicted income per capita and a 1.62 percent predicted drop in manufacturing employment. More broadly, Fajgelbaum, Goldberg, Kennedy, Khandelwal, and Daria Taglioni examine the reallocation of global trade patterns and find that a number of third countries, such as Vietnam, benefited from the US tariffs, experiencing increased exports to the United States and the rest of the world.<sup>9</sup> Fajgelbaum and Khandelwal survey the burgeoning empirical literature on the impact of the US-China trade war,<sup>10</sup> while Lorenzo Caliendo and Fernando Parro provide a broader review of the theoretical and empirical literature on the normative and positive aspects of trade policy.<sup>11</sup>

The decades leading up to the US-China trade war were a time of ongoing multilateral and preferential trade liberalization. A number of studies have argued that the recent change in the direction of US trade policy, alongside other retreats from trade liberalization such as the United Kingdom's Brexit decision to leave the European Union, have substantially increased trade policy uncertainty. This increase in uncertainty by itself can depress trade and investment, as firms adopt a "wait-and-see" strategy before engaging in large investments

such as in overseas plant and machinery. Using data on movements in stock prices around the dates of US-China tariff announcements, Amiti, Sang Hoon Kong, and Weinstein estimate that these changes in trade policy lowered the investment growth rate of listed US companies by 1.9 percentage points, and reduced aggregate US welfare through all channels including uncertainty by 4.9 percentage points.<sup>12</sup> More broadly, Andrew Greenland, Mihai Ion, John Lopresti, and Peter Schott use move-

## Effect of US Tariffs on Import Quantities, 2018



**Figure 2**



ments in stock prices around trade policy announcements to develop an overall measure of trade liberalization.<sup>13</sup>

A growing number of studies examine the relationship between international trade flows and trade policy uncertainty. Alejandro Graziano, Handley, and Nuno Limão find that increases in the probability of Brexit in prediction markets reduced both bilateral export values and the extensive margin of firm trade participation.<sup>14</sup> Saad Ahmad, Limão, Sarah Oliver, and Serge Shikher show that these increases in the predicted probability of Brexit had a pronounced impact on services trade, with reductions in services exports from Britain to the European Union of around 20 log points.<sup>15</sup> Using data on Chinese firms, Felipe Benguria, Jaerim Choi, Deborah L. Swenson, and Mingzhi Xu find that increases in both US tariffs and Chinese retaliatory tariffs raised measures of trade policy uncertainty (TPU), with a one standard deviation increase in TPU reducing firm-level investment, research and development (R&D), and profits by 1.4, 2.7, and 8.9 percent, respectively.<sup>16</sup> Isaac Bailey, Laura Veldkamp, and Michael E. Waugh demonstrate that the effects of greater uncertainty are in fact uncertain. They provide conditions under which increased uncertainty can promote trade.<sup>17</sup> Handley and Limão survey this growing literature on trade policy uncertainty.<sup>18</sup>

The recent resurgence of protection in the United States and elsewhere has led to renewed debate about the future of the WTO and the multilateral rules-based trading system that has characterized the period since the Second World War. Staiger reviews recent research on the economic rationale for the WTO and its underlying principles of reciprocity and nondiscrimination, as captured in the so-called most-

favored-nation (MFN) rule. These principles can be rationalized as a mechanism for countries to overcome the externality from each nation having an incentive to introduce protection in order to improve its terms of trade.<sup>19</sup> Kyle Bagwell, Staiger, and Ali Yurukoglu develop a quantitative model of tariff negotiations between countries to study the design of the institutional rules of the General Agreement on Tariffs and Trade and the WTO. Abandoning the MFN principle in bilateral tariff negotiations is found to reduce world welfare as a whole, although some individual countries, such as Japan and the United States, experience welfare gains.<sup>20</sup>

Recent years have seen a proliferation of so-called “new trade agreements”

## Global Value Chains (GVCs) and Networks

One of the distinctive features of globalization in recent decades has been global value chains (GVCs). Sometimes called slicing the value-added chain, fragmentation, vertical specialization, trade in tasks, or the unbundling of production, this refers to the spreading of stages of production across national borders. In contrast, international trade in earlier episodes of globalization, such as the late-nineteenth century, was concentrated on the exchange of raw materials and final goods.<sup>22</sup>

Antràs and Richard Baldwin provide recent reviews of the evolution of globalization and the emergence of GVCs.<sup>23</sup> As shown

in Figure 3, world trade grew substantially more rapidly than world production from the end of the Second World War to the 2008 financial crisis, after which it stagnated. Measuring GVC trade is more complicated than measuring overall trade, but a natural measure is the share of a country's exports that flow through at least two national borders—for example, a semiconductor chip that is shipped from Japan to China, where it is put into an iPhone which is then shipped to the United States. GVC trade based

on this measure grew substantially more rapidly than overall trade over the same period, again before stagnating after the 2008 financial crisis.

This stagnation of both overall trade and GVC trade since the 2008 crisis has led to much debate about the extent to which the world economy will experience “deglobalization.” It is important to keep in mind that 1986–2008 was a period of especially rapid trade integration—sometimes called “hyper-globalization”—as shown by the dashed gray linear time trend for this period in Figure 3. This was driven by the conflu-

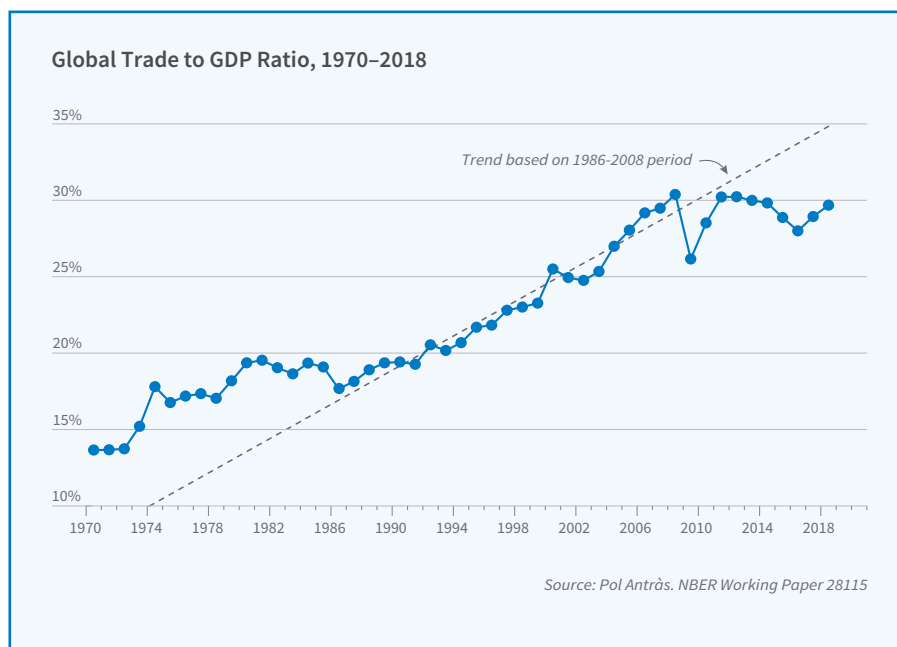


Figure 3

which not only constrain governments' choices of tariffs, but also restrict their domestic regulatory policies. Grossman, Phillip McCalman, and Staiger study the rationale for these new agreements in a setting in which firms design products to cater to local tastes.<sup>21</sup> If government choices of tariffs are constrained by international trade agreements, but domestic regulatory policies are not restricted, these domestic regulations can be used as a form of protection that benefits domestic consumers and producers at the cost of exerting a negative externality on foreign consumers and producers.

ence of three sets of forces: (1) multilateral and regional trade policy integration; (2) technological innovations such as the computer, satellite phone, and internet that reduced the cost of international communication; and (3) geopolitical and institutional changes, such as domestic reform in China, Eastern Europe, and India and their emergence into world markets. Against this backdrop of especially rapid trade integration, some slowdown in the pace of globalization might be expected, which has led a number of authors to refer to “slowbalization” rather than deglobalization. Nevertheless, the recent resurgence of protectionism and increased geopolitical tensions, such as the potential decoupling of China and the United States and the Russia-Ukraine War, provide considerable headwinds that could stall or reverse the increasing economic integration of the last few decades.

Recent research has examined the implications of the emergence of GVCs for our understanding of international trade. This is part of a broader and growing wave of research in economics on networks domestic and foreign. Viewing international trade as a network of buyers and sellers has a number of implications for our understanding of the causes and consequences of such trade.<sup>24</sup> A first set of implications relates to the international propagation of shocks, an issue which has received renewed prominence in the wake of the large-scale shocks from the US-China trade war, the COVID-19 pandemic, and the Russia-Ukraine War. From a theoretical perspective, a classic insight from the closed-economy macroeconomics literature is Hulten’s theorem: for efficient economies and under minimal assumptions, the first-order impact of a technology shock to a firm or industry is equal to that industry’s or firm’s sales as a share of output. David Baqaee and Emmanuel Farhi show how to generalize this result to open economies in order to characterize the response of the aggregate economy to productivity shocks, tariffs, and iceberg trade costs.<sup>25</sup> Emmanuel Dhyne, Ken Kikkawa, Magne Mogstad, and

Tintelnot show that although relatively few firms directly import, many firms are indirectly affected by foreign shocks because they are connected through production networks to direct importers.<sup>26</sup> Zhen Huo, Andrei A. Levchenko, and Nitya Pandalai-Nayar show that the network transmission of shocks is quantitatively relevant for the international comovement of GDP, although most comovement is explained by the correlation of the underlying national shocks.<sup>27</sup>

The aftermath of the COVID-19 pandemic saw large-scale disruptions to supply chains, shortages of critical components such as semiconductors, growing transportation delays, and record transportation rates on key shipping routes, such as from Shanghai to the West Coast of the United States. Additionally, the US-China trade war and growing geopolitical tensions have raised concerns about the national security implications of GVCs. In response, there is a growing debate about the resiliency of supply chains and the extent to which these large-scale shocks will lead to onshoring, reshoring, friend-shoring, and/or diversification. Grossman, Helpman, and Hugo Lhullier develop a theoretical framework to analyze optimal policy in the face of supply chain disruptions. In general, a government needs at least two policy instruments, such as subsidizing or taxing diversification while subsidizing or taxing offshoring, to achieve efficient sourcing. When a government is limited to one policy instrument, either policies towards diversification or those towards onshoring or offshoring can dominate.<sup>28</sup>

National security concerns in particular have led to a renewed debate about the potential scope for industrial policy. Dominick G. Bartelme, Arnaud Costinot, Donaldson, and Andrés Rodríguez-Clare study the rationale for industrial policy in the presence of external economies of scale in some sectors. Although they find evidence of significant and heterogeneous economies of scale across manufacturing sectors, the implied welfare gains from industrial policy are relatively modest, and equal to less than 1 percent

of GDP on average.<sup>29</sup> Jaedo Choi and Levchenko examine the impact of South Korea’s industrial policy in the form of its Heavy and Chemical Industry (HCI) Drive. Combining historical data on the universe of firm-level subsidies with a theoretical model of trade and development, they find that the HCI Drive was overall welfare improving for South Korea, in part because of an externality from firms’ learning by doing. Ernest Liu and Song Ma study the cross-sector allocation of R&D in a multisector growth model with an innovation network in which each sector can benefit from other sectors’ innovations. A social planner that values long-term growth should allocate more R&D to central sectors in the innovation network, but this incentive is muted in open economies that benefit more from foreign knowledge spillovers.<sup>30</sup>

A second set of implications of a network perspective relates to the sources of firm success in international markets. Andrew B. Bernard, Dhyne, Glenn Magerman, Kalina Manova, and Andreas Moxnes develop a theoretical framework in which larger firm size can come from high production capability, more or better buyers and suppliers, and/or better matches between buyers and suppliers.<sup>31</sup> They find that the production network, in the form of access to buyers and suppliers, can account for more than half the cross-sectional dispersion in firm size. Ezra Oberfield and Johannes Boehm find that the cost of contract enforcement influences firms’ sourcing of intermediate inputs in production networks.<sup>32</sup> In Indian states with more congested courts, plants in industries that rely more heavily on relationship-specific intermediate inputs shift their expenditures away from intermediate inputs and adopt more vertically integrated production structures. Jonathan Eaton, Marcela Eslava, David Jenkins, C. J. Krizan, and James R. Tybout develop a model of firm-level export dynamics with costly consumer search, in which a firm’s customer base is a valuable intangible asset.<sup>33</sup> Costly consumer search shapes the dynamic response of firm exports to foreign demand shocks, with

the five-year response of total export sales to an exchange rate shock exceeding the one-year response by about 40 percent. Jonathan Eaton, Samuel S. Kortum, and Francis Kramarz develop a model of firm-to-firm matching in which domestic and imported intermediate inputs compete directly with labor in performing production tasks.<sup>34</sup> Applying this framework to the 2004 expansion of the European Union, they find that workers benefited overall, but those competing most directly with imports gained less, even losing in some countries entering the EU.

More generally, ITI researchers have explored the determinants of GVCs and their aggregate economic implications. Antràs and Alonso de Gortari develop a multistage general equilibrium model of GVCs in which the optimal location of production of a given stage in a GVC is not only a function of its own marginal cost in each location, but also depends on the proximity of that location to those of the preceding and subsequent stages of production.<sup>35</sup> Reductions in trade frictions generate somewhat larger welfare gains than in models without multistage production, in part because the lower trade costs accrue at each of the stages of production. Antràs develops a model of multistage production in which the time length of each stage is endogenously determined.<sup>36</sup> Letting the production process mature for a longer period of time increases labor productivity, but comes at the cost of higher working capital needs. A worldwide decline in interest rates lowers the cost of working capital and raises the share of GVC trade in world trade.

Multistage production can be organized either within firm boundaries — foreign direct investment (FDI) — or in separate firms — outsourcing. Antràs, Evgenii Fadeev, Teresa C. Fort, and Tintelnot combine Census Bureau and Bureau of Economic Analysis data to provide new evidence on the role of multinational enterprises (MNEs) in the US economy.<sup>37</sup> MNEs comprise only 0.23 percent of all firms in the United States, yet employ one-quarter of the

workforce and account for 44 percent of aggregate sales, 69 percent of US imports, and 72 percent of US exports. Other related ITI research provides evidence of spillovers from MNEs to domestic firms, including work by Brian McCaig, Nina Pavcnik, and Woan Foong Wong for Vietnam, and by Bradley Setzler and Tintelnot for the United States.<sup>38</sup>

## COVID-19

Antràs, Rossi-Hansberg, and I develop a theoretical framework for analyzing the two-way interaction between globalization and pandemics.<sup>39</sup> In this framework, business travel facilitates trade, and travel leads to human interactions that transmit disease. This trade-motivated travel generates an epidemiological externality across countries, such that whether a global pandemic occurs depends on domestic disease transmission in the country with the worst domestic disease environment. If agents internalize the threat of infection, social distancing leads to a reduction in travel that is larger for higher-trade-cost locations, which generates an initial sharp decline and a subsequent rapid recovery in the ratio of trade to output, as observed during the COVID-19 pandemic. The outbreak of the COVID-19 pandemic triggered an explosion of research by economists on the spread of the disease.

Barthélémy Bonadio, Zhen Huo, Levchenko, and Pandalai-Nayar study the role of global supply chains in shaping the impact of the COVID-19 pandemic on GDP growth using a multisector quantitative model and data on 64 countries.<sup>40</sup> One-quarter of the total model-implied real GDP decline is explained by cross-country transmission through global supply chains. However, “renationalization” of global supply chains does not in general make countries more resilient against pandemic-induced contractions in labor supply because reducing reliance on foreign inputs increases reliance on domestic inputs, which are also disrupted by lockdowns. Gaurav Khanna, Nicolas Morales, and Pandalai-Nayar use Indian data to identify firms with larger supplier risk fol-

lowing COVID-19 lockdowns.<sup>41</sup> They find that firms that buy more complex products with fewer available suppliers are less likely to break buyer-supplier relationships in response to lockdowns. Alfaro, Anusha Chari, Greenland, and Schott use stock market returns and an event-study approach to show that COVID-19–related losses in firm value were larger in industries with higher capital intensity, greater leverage, and greater scope for disease transmission.<sup>42</sup>

Fajgelbaum, Khandelwal, Wookun Kim, Cristiano Mantovani, and Edouard Schaal examine optimal dynamic lockdowns against COVID-19 within a model of a commuting network.<sup>43</sup> Applying this framework to Seoul, Daegu, and New York City, which differ substantially in terms of initial disease diffusion, they find that spatial lockdowns achieve substantially smaller income losses than uniform lockdowns. Actual commuting reductions were too weak relative to this optimal policy in central locations in Daegu and New York City, and too strong in Seoul.

A growing body of research has begun to examine the long-run implications of the COVID-19 pandemic in terms of a shift to remote and hybrid working. Jonathan I. Dingel and Brent Neiman provide evidence on the feasibility of working from home (WFH) for workers in different occupations. Overall 37 percent of jobs in the United States can be performed entirely at home, with substantial variation across occupations. Examples of occupational roles in which workers are largely able to work from home are managers, educators, and those working in computers, finance, and law. In contrast, examples of occupations in which workers are largely unable to work from home are farming, construction, and production.

## Spatial Economics

One area of particularly active ITI research in recent years is spatial economics, namely the study of the distribution of economic activity across locations within countries.<sup>44</sup> Many of the same issues involved in studying inter-



national trade also apply to internal trade within countries, with a key difference being that labor mobility is typically much higher within countries than across national borders.<sup>45</sup>

Three factors have contributed to this growth of research in spatial economics. First, new theoretical techniques have been developed that enable researchers to analyze spatial interactions in settings with many heterogeneous locations connected by a rich network of trade and migration costs. Second, data from geographic information systems that encode latitude and longitude have dramatically improved our ability to measure the distribution of economic activity within countries at a fine spatial scale. Third, new sources of data have expanded the range of economic activities that can be measured at this fine level, including ride-hailing data, GPS data from smartphones, firm-to-firm shipments data, credit-card data, barcode-scanner data, and satellite-imaging data. An exciting aspect of this research on spatial economics in the ITI Program is the connections that it makes with related research in other NBER programs, including Development Economics, Industrial Organization, Labor Studies, and Public Economics.

Another active area of research has been on the economy's response to local labor demand shocks from, for example, changes in technology or international trade. Building on their own previous research, David Autor, David Dorn, and Gordon Hanson show that the China trade shock had persistent effects on US local labor markets out to 2019, despite the fact that this trade shock plateaued in 2010.<sup>46</sup> Rodríguez-Clare, Mauricio Ulate, and José Vásquez show that incorporating nominal rigidities is important in accounting for the estimated impacts of the China trade shock on unemployment and labor force participation across local labor markets.<sup>47</sup> Rodrigo Adão, Michal Kolesár, and Eduardo Morales, and Adão, Costas Arkolakis, and Federico Esposito, develop improved methods for estimating the effects of

these local labor demand shocks which take into account the spatial correlation of these shocks across locations and spillover effects to proximate locations.<sup>48</sup>

Robert C. Feenstra and Akira Sasahara highlight the importance of taking into account both exports and imports in understanding the impact of international trade shocks on US employment across sectors.<sup>49</sup> Dingel and Tintelnot argue that granularity, in which the idiosyncratic decisions of individual agents affect equilibrium outcomes, can be important at small spatial scales.<sup>50</sup> Rafael Dix-Carneiro, João Paulo Pessoa, Ricardo M. Reyes-Heroles, and Sharon Traiberman provide theory and evidence that aggregate trade imbalances shaped the impact of the China shock on the US manufacturing sector.<sup>51</sup>

In general, the economy's response to local labor demand shocks can be gradual because of migration frictions for mobile factors such as labor, and the gradual accumulation of immobile factors such as plant and equipment. Benny Kleinman, Liu, and I show that capital and labor dynamics interact to shape the economy's speed of convergence to steady state.<sup>52</sup> When the gaps of both capital and labor from steady state are positively correlated across locations, this reduces the economy's speed of convergence because of the interdependence between factors' marginal products in the production technology. A high capital stock relative to steady state raises labor's marginal product, which retards its downward adjustment, and vice versa. Using data on US states between 1965 and 2015, we find this interaction between capital and labor dynamics plays a central role in explaining the observed decline in the rate of income convergence across states and the persistent and heterogeneous impact of local shocks.

Treb Allen and Donaldson investigate the role of history in shaping the current distribution of economic activity through either *persistence*—the long-lived dependence of current outcomes on temporary events—or *path dependence* where temporary events can permanently affect long-run outcomes. The analysis incorporates agglomeration externalities,

forward-looking agents, and many heterogeneous locations which are connected through costly goods trade and migration. Despite this rich economic environment, the analysis yields sharp conditions on model parameters under which there are unique dynamics that nevertheless feature substantial persistence and path dependence. Estimating the model using data on US counties from 1800 to 2000, they find that small historical shocks leave a sizable trace for several centuries, and can cause large and permanent differences in long-run aggregate welfare.<sup>53</sup>

Related research has explored the implications of the sorting of heterogeneous agents across geographic space. Cecile Gaubert examines the role of the sorting of firms of heterogeneous productivity in explaining the productivity advantages of large cities.<sup>54</sup> Victor Couture, Gaubert, Jessie Handbury, and Erik Hurst study the implications of the sorting of workers of heterogeneous skill for gentrification and changes in real income inequality.<sup>55</sup> Such sorting of heterogeneous agents across geographic space has important implications for the rationale for so-called place-based policies that target particular regions, as analyzed by Fajgelbaum and Gaubert; Gaubert, Patrick Kline, and Danny Yagan; and Rossi-Hansberg, Pierre-Daniel Sarte, and Felipe Schwartzman.<sup>56</sup>

There is also a growing body of empirical research on the impact of transport infrastructure investments on the location of economic activity.<sup>57</sup> Stephan Heblich, Daniel Sturm, and I use the natural experiment of the mid-nineteenth-century invention of steam railways to provide evidence on the role of transport networks in shaping the spatial organization of economic activity.<sup>58</sup> Their key finding is that this new transport technology dramatically reduced travel times, thereby lowering commuting costs and permitting large-scale separation of workplace and residence. A quantitative urban model is shown to be remarkably successful at capturing the sharp divergence between nighttime and daytime population observed in the historical center of London from the mid-nineteenth cen-



tury onwards, as shown in Figure 4. Although this historical center experiences the largest absolute increase in employment as it specializes as workplace rather than residence, the highest percentage rates of growth in employment and population occur in the outlying suburbs, as these are transformed from open fields. These findings suggest that present-day technological changes that further reduce commuting costs, such as innovations in remote working and autonomous vehicles, have the potential to further decentralize economic activity.

Policymakers are often interested in comparing possible alternative transport investments, such as which links in a railway or highway network to improve. To develop a theoretical framework to address this question, Allen and Arkolakis embed a specification of endogenous route choice in a quantitative spatial model.<sup>59</sup> In their approach, individuals consider travel costs and choose the least-costly route. A key implication of this framework is that the welfare effects of a small improvement in a transport link are equal to the percentage cost saving multiplied by the initial value of travel along that link. Applying this framework to both the US highway network and the Seattle road network, they find that the returns to investment are highly variable across different links in the transport

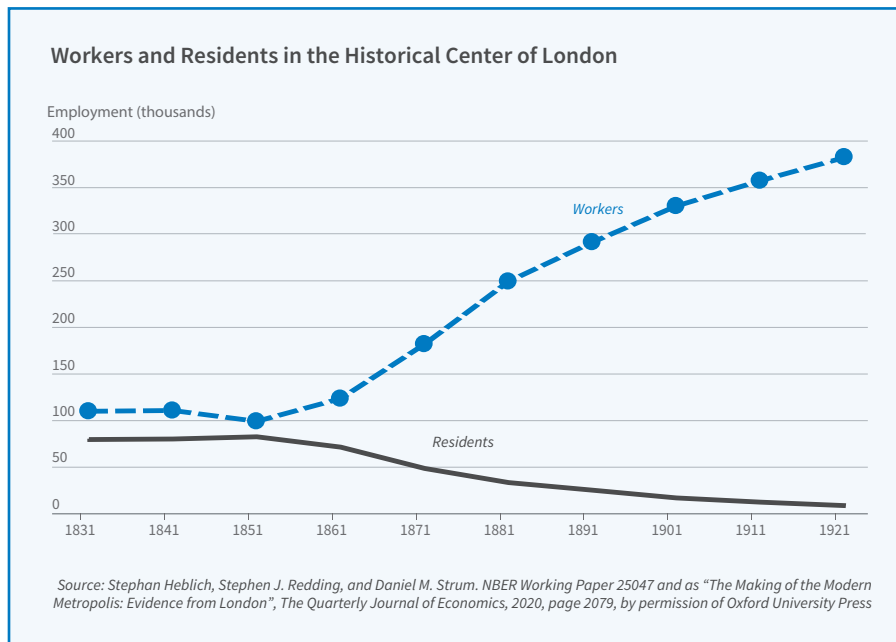


Figure 4

network, as shown in Figure 5 for the US highway network, highlighting the importance of well-targeted infrastructure investment.

More generally, Fajgelbaum and Schaal develop a framework for characterizing optimal transport networks in spatial equilibrium.<sup>60</sup> They show that the problem of finding the optimal transport network can be transformed into the problem of finding the optimal flow

around 2 percent.

## Trade and the Environment

The ITI Program has also contributed to research on the economics of climate change and the clean energy transition as a leading issue of contemporary debate.<sup>61</sup> Joseph S. Shapiro examines the role of international trade policy in shaping global carbon dioxide (CO<sub>2</sub>) emissions patterns.<sup>62</sup> In most countries, import tariffs and non-tariff barriers are substantially lower on "dirty industries" — those with high CO<sub>2</sub> emissions per dollar of output — than on "clean industries," thereby providing an implicit subsidy to CO<sub>2</sub> emissions. Using a quantitative trade model to undertake a counterfactual in which similar trade policies are applied in clean and dirty industries, researchers find that global CO<sub>2</sub> emis-

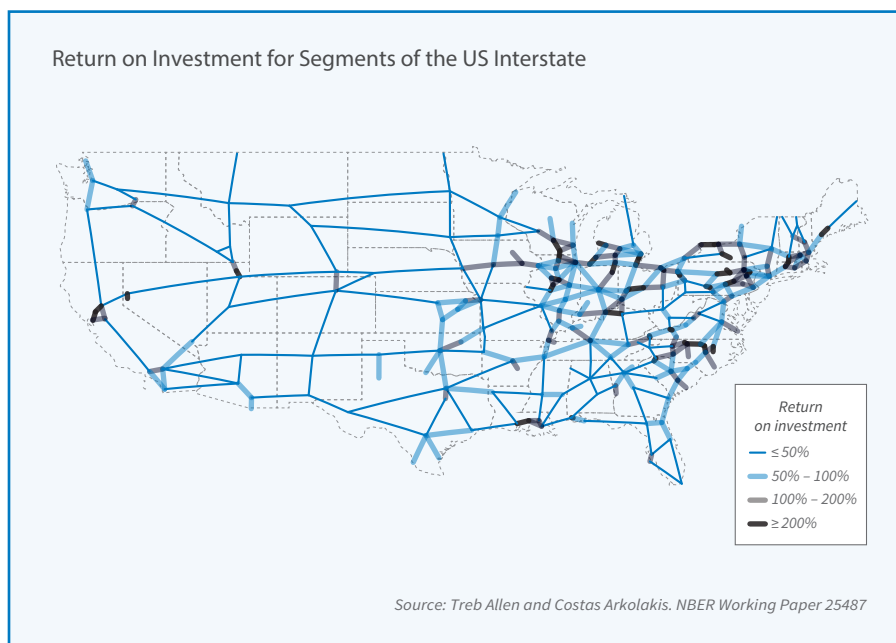


Figure 5

sions fall substantially, with little cost in terms of global real income.<sup>63</sup>

A central feature of climate change is its uneven impact across locations, depending on initial climatic conditions, temperature, and proximity to the coast. Klaus Desmet, Robert E. Kopp, Scott A. Kulp, Dávid Krisztián Nagy, Michael Oppenheimer, Rossi-Hansberg, and Benjamin H. Strauss use a dynamic model of the world economy that features migration, trade, and innovation to evaluate the economic cost of coastal flooding.<sup>64</sup> Under an intermediate greenhouse gas concentration trajectory, permanent flooding is projected to reduce global real GDP in 2200 by 0.11 percent. Adaptation mechanisms are important in mitigating these real income costs of climate change. When the adaptation mechanisms of migration and investment are shut down, the loss in real GDP in 2200 increases to 4.5 percent. José-Luis Cruz and Rossi-Hansberg study the economic geography of global warming in a setting in which temperature directly affects both productivity and amenities, and the economy can adjust through goods trade, migration, innovation, and natality.<sup>65</sup> Welfare losses from global warming are as large as 15 percent in parts of Africa and Latin America, but also highly heterogeneous across locations, with northern regions in Siberia, Canada, and Alaska experiencing gains. Carbon taxes delay consumption of fossil fuels and help flatten the temperature curve but are much more effective when an abatement technology is forthcoming.

An important challenge in tackling environmental externalities that are global in scope is the so-called problem of leakage: when climate policies vary across countries, energy-intensive industries have an incentive to relocate to places with few or no emissions restrictions. David Weisbach, Kortum, Michael Wang, and Yujia Yao characterize optimal policy in such a setting with leakage and show it involves taxing both the supply of and demand for fossil fuels.<sup>66</sup> Bruno Conte, Desmet, and Rossi-Hansberg examine the economic impact

of local carbon taxes in an economic geography model with agglomeration and congestion forces, in which regions are linked through both trade and migration.<sup>67</sup> In the presence of agglomeration and congestion forces, the market equilibrium need not be efficient. A unilateral carbon tax can be welfare improving, even in the short run when its effects on temperature have not been fully realized, with the effects of this policy depending importantly on how the revenue from the unilateral carbon tax is rebated.

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