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Inadequate Data on Manufacturers of Critical Medical Supplies Weakens U.S. Capabilities for Pandemic Response

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Summary: U.S. policymakers lack a sufficiently complete, accurate and evolving picture of the present state of critical manufacturing of medical supplies to respond effectively to COVID-19 and other pandemic emergencies. This information is essential to guide decisions to coordinate and mobilize additional capacity. While existing surveys such as the Annual Survey of Manufactures and the Economic Census provide snapshots of U.S. capabilities, these data do not capture the rapidly evolving supply status during a crisis such as the COVID-19 pandemic. Moreover, while the White House and entities like the International Trade Commission can make direct requests for information from companies, they are poorly equipped to do frequent and comprehensive large-scale data collection. To assess the consequences of this data gap, we use weekly web scraping of Thomasnet -- a leading North American Manufacturing industrial sourcing platform -- to develop a list of firms that self-identify as having domestic manufacturing of masks, respirators, and their intermediate inputs. We then corroborate domestic location status via additional searches on firm websites, firm Security Exchange Commission (SEC) filings, data from DB Hoovers, and interviews directly with companies. This investigation suggests that small and medium sized firms may be playing an important and poorly documented role in responding to the mask and respirator supply shortage associated with the pandemic. Even less well understood is the extent to which these and other firms could rapidly reorganize production to meet pressing needs, and how they could be incentivized to do so. To guide future policy decisions, including the coordination and mobilization of additional capacity, **we recommend that Congress direct the Department of Commerce to develop a strategy for timely and adaptive assessment of U.S.-headquartered and U.S.-located manufacturing capability of medical supplies for the duration of the present emergency, and document lessons that will allow it to better support the creation of such an effort again in the event of a future emergency.**

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How current U.S. data collection limits COVID-19 response efforts

*No existing public or proprietary data sources capture in real time the evolving universe of firms involved in supplying the U.S. medical supply market***,** despite the critical nature of these supplies in mounting an effective response to pandemic emergencies such as COVID-19.

Government sources of firm data are useful to measure economic activity and composition in a steady state, but are not designed to capture rapid changes during emergencies. The U.S. Census Bureau conducts the Economic Census (on firms) once every five years, and the Annual Survey of Manufacturers (as its name indicates) annually. As currently conducted, the U.S. Annual Survey of Manufactures (ASM) and the Economic Census (EC) are not designed to capture rapid changes during a crisis, such as rapid changes in supply chains and domestic manufacturing capabilities during COVID-19. The Census is known for the quality of its design and development of each of these surveys, and multiple years are put into their design. In addition, it can take over two years for results to be published. The latest year available from the ASM is 2018, which was published in April of 2020. The Annual Survey of Manufactures (ASM) is also skewed towards the largest manufacturing plants. Smaller plants are sampled, but with far less certainty (than the largest). Small and medium sized firms are best captured by the Economic Census, which is done every 5 years. The Economic Census captures all manufacturing plants in the economy (250,000+ plants versus the ~45,000 plants in the ASM). The most recent Economic Census is from 2017 and was scheduled to be released in the Fall 2020. It has now provided summary statistics, and additional data will be released on a flow basis through December 2021.[1] Very few sources include reliable data on plant location and production capacity, and coverage within these is sparse. During a crisis, while the White House and entities like the International Trade Commission (ITC) can make direct requests for information from companies, they are currently poorly equipped to do frequent and comprehensive large-scale data collection.

[1] The U.S. Census Bureau has demonstrated that it can act more rapidly while maintaining quality. The U.S. Census Bureau undertook a nine-week Small Business Pulse survey (https://www.census.gov/data/experimental-data-products/small-business-pulse-survey.html) which was executed between April 26 and June 27, 2020. This survey samples representative of each MSA geographic area by NAICS 3-digit industry sector once out of the 9 weeks. The survey is voluntary and there are reasons it may have selection bias; however, its weekly execution during COVID is unique. While the survey was focused on economic health of small businesses and doesn't specifically target manufacturing plants (or domestic capacity), it does ask about how and whether firms have pivoted since COVID.

Analysis: Overlooked firms, Underused Capacity, Unknown Challenges and Opportunities

To begin to assess the consequences of spotty real-time data, we have leveraged weekly web scraping of Thomasnet to identify firms that self-identify as having domestic manufacturing of masks, respirators, and their intermediate inputs (see Figure 1). Previous academic work (Agarwal and Bayus, 2007; Agarwal and Bayus, 2002; Klepper, 2002; Klepper and Simons, 2000; Javanovic and Macdonald, 1994; Gort and Klepper, 1982)[2] has leveraged the Thomas Register of American Manufacturers to compile annual data on US-based producers of specific products.[3] In 1995, Thomanet made its online debut as a business-to-business industrial sourcing platform, eventually by 2006 replacing the print edition (Thomas Register.) Today, Thomasnet is a leading business to business industrial sourcing platform for North American manufacturers. While, like Thomas Register, Thomasnet continues to use a verification process, companies self-reporting on Thomasnet are immediately visible online, and the frequency and goals of the verification process are unclear. As categories are not precisely defined and firms may use different rules when self-reporting on Thomasnet, to understand which Thomasnet-listed firms actually have manufacturing facilities of the target medical supplies in the U.S., we then complement the scraped data with searches on firm websites, data from DB Hoovers, and interviews directly with companies.

As of November 16th, 56 Thomasnet-listed firms produced a product of interest at a domestic manufacturing facility: 44 firms manufactured respirators and/or face masks, seven manufactured non-woven fabrics used in medical-grade masks, and five made non-latex elastics. (See Figure 2.) The geographic dispersion of 32 of these 56 companies for which we were able to get exact plant addresses can be seen in Figure 3. Such information on geographic dispersion may prove particularly helpful to local representatives in both federal and state governments, as they respond to the pandemic. The value of real-time data, such as available on Thomasnet, can be seen in our data: as shown in Figure 4, the number of confirmed domestic manufacturers of each of these products has been increasing since the start of the pandemic.

Comparing self-reported capacity numbers for eight of the companies on Thomasnet with White House capacity estimates suggests substantial overlooked capacity: Of the

[2] Agarwal, R., Bayus, B. 2007. “The Role of pre-entry experience, entry timing, and product technology strategies in explaining firm survival.” *Management Science*; Klepper, S. 2002. Firm survival and the evolution of oligopoly. *Rand J. Econom.* 33(1) 37–61; Agarwal, R., B. L. Bayus. 2002. The market evolution and take-off of new product innovations. *Management Sci.* 48(5) 1024–1041; Jovanovic, B., G.MacDonald.1994.The life cycle of a competitive industry. *J. Political Econom.* 102(21) 322–347; Gort, M., S. Klepper. 1982. Time paths in the diffusion of product innovations. *Econom. J.* 92(3) 630–653.

[3] These papers triangulate data from Thomas Register with other sources, such as data from the firms, to study firm entry, exit, and the evolution of market structures

44 facilities producing respirators and/or face masks domestically, only three are one of the five large firms (3M, Owens and Minor, Honeywell, Moldex, and Prestige America) that were used in White House estimates of production capacity in the early phase of the pandemic. Further, our limited view from Thomasnet suggests that **small and medium sized enterprises may be playing an important, albeit poorly documented, role** in responding to mask and respirator shortages associated with the pandemic.

In order to support firms that are attempting to respond to the pandemic, whether through reshoring or pivoting, requires that they first be identified and understanding developed of the universe of firms making such decisions. Three out of eight of the 44 Thomasnet companies for which we were able to find online capacity information had recently purchased equipment to make masks or respirators domestically in the U.S. It's unclear, however, to what extent these firms may be able to achieve their theoretical capacity. An anecdote from a medium-sized U.S. medical supply company illustrates the type of challenges these companies reshoring and pivoting to new products face in reshoring and pivoting to new products. Shortly before the pandemic the company had imported equipment from China capable of manufacturing 9 Million ASTM Level 2 masks per month. They planned to provide the masks at-cost for the duration of the pandemic. With the pandemic in full swing, their colleagues in China supported them in getting the equipment up and running. However, inability to gain access to a number of material inputs prevented them from running at capacity. Their most challenging bottleneck was obtaining elastic for the ear loops, not the highly-publicized and technically-challenging melt-blown polymer used in the mask itself. That elastic needed to have no latex, be a precise width and elasticity (stretchiness), and come in a bag to work in the automated machines. They eventually found a domestic supplier for some of the necessary elastic, but that firm wasn't able to supply the elastic at sufficient scale for 9 million masks. Further, that firm's elastic came on a spool, so for a period of time a worker had to unspool the elastic by hand, with the associated productivity slowdown one would expect. (Fuchs 2020)[4] By collecting data on capacity versus production, it would be possible to identify firms facing challenges -- whether due to regulation, intermediate input supply, labor, critical technical knowledge, or otherwise -- utilizing their capacity. Being able in addition to adaptively add a question about what challenges companies are facing could further guide policymakers.

Our searches on firm's websites, triangulation with data in DB Hoovers, and interviews with companies allowed us to identify which firms are manufacturing domestically, and understand what aspect of their production is actually domestic. Identifying what

[4] Erica Fuchs, 2020. TRADE, MANUFACTURING, AND CRITICAL SUPPLY CHAINS: LESSONS FROM COVID-19 Ways and Means Committee Hearing (https://waysandmeans.house.gov/legislation/hearings/trade-manufacturing-and-critical-supply-chains-lessons-covid-19)

challenges may exist preventing them from moving manufacturing to the U.S. is an equally complex task. For example, Fulflex is a Thomasnet listed manufacturer of no-latex elastics and non-woven fabric in Brattleboro, VT.[5] Fulflex serves a global market, and primarily relies on international production networks in Singapore and India to manufacture their products. Currently Fulflex has domestic manufacturing capabilities, but with much longer lead times. As a consequence, while they show up in Figure 2 as a domestic manufacturer of no-latex elastic (blue group), the majority of that production occurs in the overseas facilities. Similarly, the Moore Co. Textile Groups is a leading manufacturer of elastic with a large selection of orthopedic and medical elastics (both pre and post COVID). Their primary manufacturing facilities are located in El Salvador, under an El Salvadorian division of the company. The US branch of this company consists of a "network of contract manufacturers that produce uniquely designed and qualified narrow elastics and webbings." Through this network, the company can produce a Berry Amendment qualified product. The Moore Co Textile Group currently does not count as a domestic manufacturer in Figure 2 (blue group), but they may be well-qualified to scale-up domestic manufacturing in response to COVID-19, and also able to speak to the challenges of scaling-up domestic manufacturing. Here again, real-time adaptive data collection capabilities could support policy-makers in changing the information sought so as to better understand what percentage of a firm's final product and intermediate inputs are sourced domestically, the challenges these firms face in manufacturing domestically, and in asking direct questions about such challenges.

Thomasnet also offers a way to search for firms operating in closely relevant product spaces, and who thus may have the potential to pivot into addressing pressing needs. As shown in Figure 1, as of November 17, 2020, 185 firms self-identify on Thomasnet as being manufacturers of FDA-approved or hospital-grade facemasks and/or respirators, 17 as manufacturing melt-blown or spunbonded fabrics necessary for hospital grade face-masks or respirators, and 6 as manufacturing no-latex elastic. An additional 250 firms describe themselves as making masks, respirators, non-woven fabrics, or no latex elastic and as serving medical markets and/or describe themselves as manufacturing products that would likely meet technical specifications for a hospital grade facemask (243 mask or respirator firms and 7 non-woven fabric firms.) Further research would be required to understand which of these additional firms are already making hospital grade masks or the intermediate inputs therefore, which are trying to but facing challenges, and which are not yet producing medical supplies to meet pressing needs but with the right incentives and support might pivot into doing so.

As demonstrated above, real-time adaptive data collection capabilities could revolutionize the ability of policy-makers to understand the complete universe of domestic firms: which are already making hospital grade masks or the intermediate inputs therefore, what challenges they face, and which are not yet producing medical supplies to meet pressing needs but presented with the right incentives and support

[5] While Fulflex is also listed on Thomasnet as manufacturing non-woven fabrics, based on their self-provided description on Thomasnet, we categorize their non-woven fabric offerings as serving the medical market, but not as offering a non-woven product of relevance to standard FDA approved hospital grade masks/respirators. We did not explore the technical relevance of their non-woven fabrics for hospital grade masks/respirators in our interviews.

might pivot to do so. This information is essential to guide decisions to coordinate and mobilize additional capacity.

Recommendations

Congress should direct the Department of Commerce to develop a strategy for timely and adaptive data collection of U.S. headquartered and U.S.-located COVID-19 medical supply manufacturing capabilities for the duration of the emergency, and document lessons that will allow it to better support the creation of such an effort again in the event of a future emergency.

The real-time data collection effort should pursue information on these companies' current production capacity in final products and intermediate inputs. In addition to capacity, real-time data should be collected on actual production volumes, so as to identify possible bottlenecks - regulatory, material, labor, knowledge or otherwise - preventing firms from leveraging their full capacity. Further, alongside real-time data, it is essential to be able to rapidly adapt the data collected in response to what is learnt. For example, as analysts learn about deltas between firms' equipment capacity and their actual production, they may add questions about what challenges companies are facing in fully achieving their capacity. Likewise, as analysts learn about firm complexities in domestic sourcing, they might change the information sought so as to better understand what percentage of a firm's final product and intermediate inputs are sourced domestically, the challenges these firms face in manufacturing domestically, and in asking direct questions about such challenges. By combining this domestic production capability data with data on demand (the latter being information collected by other entities such as Johns Hopkins, the CDC, and HHS), local, state, and federal governments can develop more informed demand- and supply-side policies to address gaps in a rapidly changing context.

Finally, aggregate information on gaps between capacity and demand as well as on common challenges or bottlenecks should be communicated through a real-time dashboard to inform public and private sector activities. Along with the overall data collection effort, the dashboard would increase transparency, providing real-time information to both public and private actors, on where additional production and bottleneck-reducing innovations may be most valuable.

In responding to Congress's mandate, the Department of Commerce should consider leveraging

- Automated, large-scale data collection and analysis via market intermediaries of registered transactions,

- The U.S. Census Bureau's survey capabilities as well as its Registrar of Businesses, with a similar approach and (most importantly) speed as was achieved for the COVID-19 Small Business Pulse Survey,
- A public-private partnership that partnered large-scale data collection and analysis capabilities in academia and/or industry (such as at Google, Microsoft, or Amazon) with government entities with access to and also seeking to act on this information, and/or
- The National Institute of Standards and Technology (NIST), given NIST's existing role leading Manufacturing USA (the National Network of Manufacturing Innovation Institutes) as well as governing the Manufacturing Extension Program.

The Department of Commerce's data collection and analysis activity must have a sunset clause such that it ends at the end of the pandemic. As part of the sunset clause, those leading the effort should be required to systematically document "lessons learned" for future crises -- not just pandemics, but also natural disasters and war -- and other strategic decision making where timely and adaptive collection and analysis of data may be essential to inform government decisions.

The data challenges hindering government decision-making under the current COVID crises are not unique. Agencies as diverse as the DOD, DOC (including the Economic Census and International Trade Commission), DOT, DOE, DHS, and FEMA can benefit from harnessing emerging state-of-the-art data collection and analytics capabilities. While S. 1363, the AI in Government Act of 2019, creates a new office in the General Services Administration (GSA), called the ''AI Center of Excellence,'' to promote adoption, use, competency, and cohesion of Federal Government applications of artificial intelligence (AI) to enhance productivity and efficiency of government operations for the public benefit,"[6] efforts are still in their infancy.[7] In the inaugural session of the National Academies' study on U.S. Science and Innovation Leadership for the 21st Century, DARPA and the DOD Strategic Technology Protection Office's representatives both articulated that they lack mechanisms to assess their strategic weaknesses and opportunities versus other nations in technologies critical to national

[6] SR 116-225. 2019. "AI in Government Act of 2019: Report of the Committee on Homeland Security and Governmental Affairs to Accompany S. 1363 to Authorize an AI Center of Excellence Within the General Services Administration, and For Other Purposes" United States Senate. https://www.congress.gov/116/crpt/srpt225/CRPT-116srpt225.pdf

[7] Where new data and analytic efforts have been undertaken they have provided important guidance for policy. For example, the National Security Commission on Artificial Intelligence, concluded that initiatives during COVID-19 to create new data-driven support tools on positive COVID-19 tests, hospital bed availability, and deaths – designed with input from economists, medical professionals, and machine learning experts -- provided states with new capabilities to guide reopening strategies.

security.[8] A 2018 MITRE report unpacks how intra- and inter- governmental actions and knowledge pertaining to critical supply chains are siloed and uncoordinated.[9] Further, a 2020 report by Kathy Stack, formerly of the Office and Management and Budget, emphasizes the need to adopt modern data analytics tools and practices in government, and how government programs underperform because of challenges integrating data across agencies and levels of federal, state, and local government.[10] As such, the information collected and analyzed and lessons learned from ramping up real-time adaptive data and analytics capabilities across various aspects of the public and private sector during the COVID-19 emergency will offer important lessons for future undertakings seeking to increase the timely and adaptive collection and analysis of data to inform government decisions.

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[8] NASEM 2019 US Science and Innovation Leadership for the 21st Century: Challenges and Prospects. National Academies Consensus Study. Co-Chairs Erica Fuchs and Eric Lander. https://www8.nationalacademies.org/pa/projectview.aspx?key=51225)

[9] Nissen, Chris, J. Gronager, R. Metzger, and H. Rishikof. 2018. “Deliver Uncompromised – A Strategy for Supply Chain Security and Resilience in Response to the Changing Character of War.” The MITRE Corporation.

[10] Kathy Stack, July 12, 2020. “Harnessing Data Analytics to Improve the Lives of Individuals and Families. A National Strategy Discussion https://9381c384-0c59-41d7-bbdf-62bbf54449a6.filesusr.com/ugd/14d834_38f767d0d95d46a19f314cdceaf0c3af.pdf

Appendix of Figures

Figure 1 displays results of our Thomasnet data collection and categorization algorithm. The faintest bar in Figure 1 is the total number of manufacturing entities listed on Thomasnet as offering our target products (as listed on the y-axis). The faded bar is the number of manufacturing entities listed on Thomasnet that self-identify as *serving the medical market* or as matching our definition of *meeting technical requirements for hospital grade masks/respirators*. The outlined section with the darkest coloring and a number shows the subset of firms on Thomasnet with self-listed text that meets our definition for *producing standard products for FDA approved, hospital grade masks or respirators*. More information on our definitions for each of these categories, written in italics above, is found in Table 1.

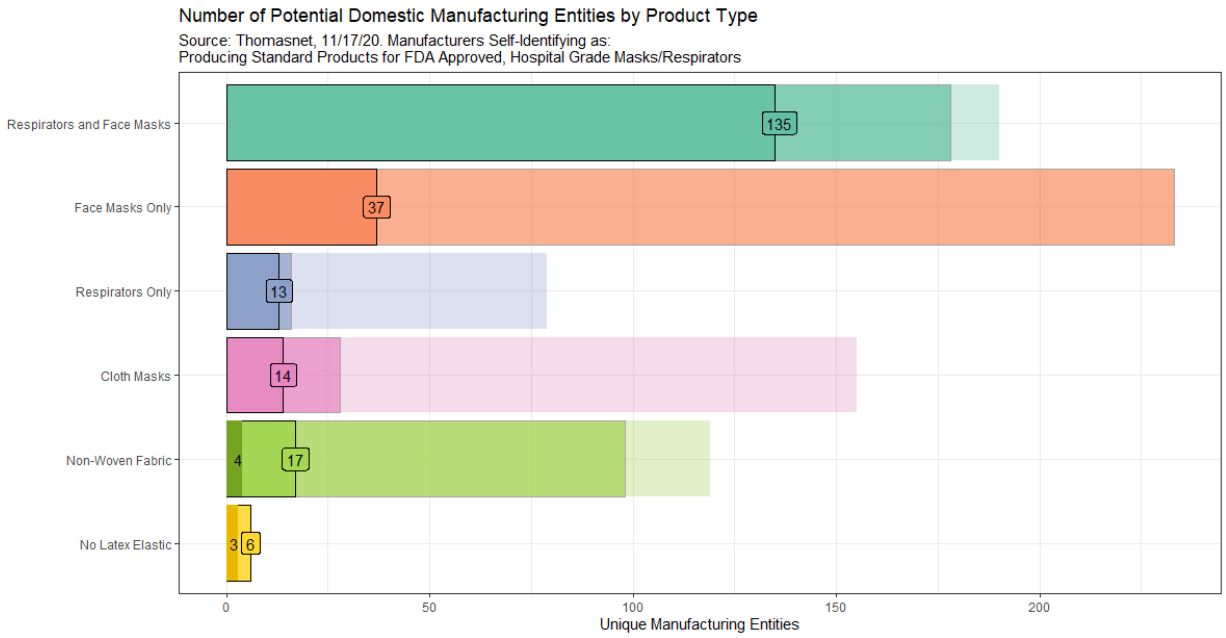

Figure 1: Thomasnet-Listed Manufacturers of Masks and Respirators and Intermediate Inputs Self-Identify as Producing Standard Products for FDA Approved, Hospital Grade Masks/Respirators. "Unique Manufacturing Entities" on the x-axis represents firms that self-identify on ThomasNet as a manufacturer. The data in Figure 1 is a snapshot of Thomasnet data on November 17th, 2020. We are collecting this data weekly. Note: Company locations listed in Thomasnet may not be their manufacturing plant locations in general, or for our target product.

Table 1a: Term Definitions for End Products

Term	Definition
Producing Standard Products for FDA Approved, Hospital Grade Masks:	Self-identifying as producing an N95, KN95, 801, NIOSH, FDA, ASTM, ANSI, or AAMI product.
Supplying the Medical Market:	Self-identifying as producing a “medical”, “surgical”, “dental”, “veterinary” product, or “PPE”.
Producing Products that Meet Technical Requirements for Hospital Grade Masks/Respirators:	Self-identifying as producing a “medical”, “surgical”, “dental”, “veterinary” product, a “dust mask”, a mask or respirator for cleanroom environments, a “3-ply” or “non-woven” product, or “PPE”.

Table 1b: Term Definitions for Non-Woven Fabrics (*)

Term	Definition
Producing Standard Products for FDA Approved, Hospital Grade Masks:	Self-identifying as producing a meltblown or spunbonded fabric.
Supplying the Medical Market:	Self-identifying as producing a “medical”, “surgical”, “dental”, “veterinary” product, or “PPE”.
Producing Products that Meet Technical Requirements for Non-Woven Fabrics for Hospital Grade Masks/Respirators	Self-identifying as producing “spunlace”, “hydroentangled”, or “electrospun” fabric; or a fabric with metal (silver, nickel, or copper) coatings

(*) For Non Latex Elastic: By definition, non-latex elastic meets the technical requirements for hospital grade masks/respirators.

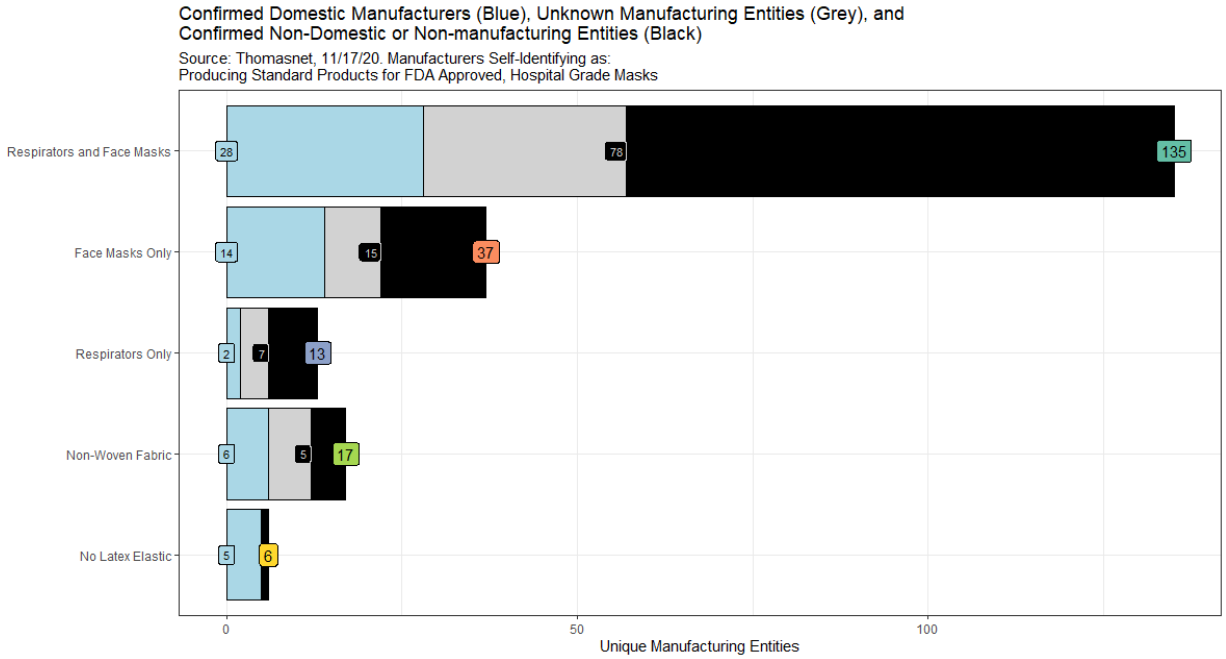

Figure 2: Domestic Manufacturing Breakdown of Thomasnet Listed Manufacturers of Standard FDA Approved Hospital Grade Masks/Respirators
"Unique Manufacturing Entities" on the x-axis represents firms that self-identify on ThomasNet as a manufacturer of standard FDA approved hospital grade masks/respirators on November 17th, 2020. The blue portion of the bar is the number of firms with confirmed production facilities in the U.S. The black portion of the bar is the number of firms confirmed as a non-domestic or non-manufacturing entity. The grey portion represents companies whose production location we have yet to confirm. To create the data reported in Figure 2, we triangulated the Thomasnet data against the information on the companies' websites and engaged in interviews, calls, and emails with the companies to identify whether the companies are actually producing the product listed on the y-axis in the U.S.

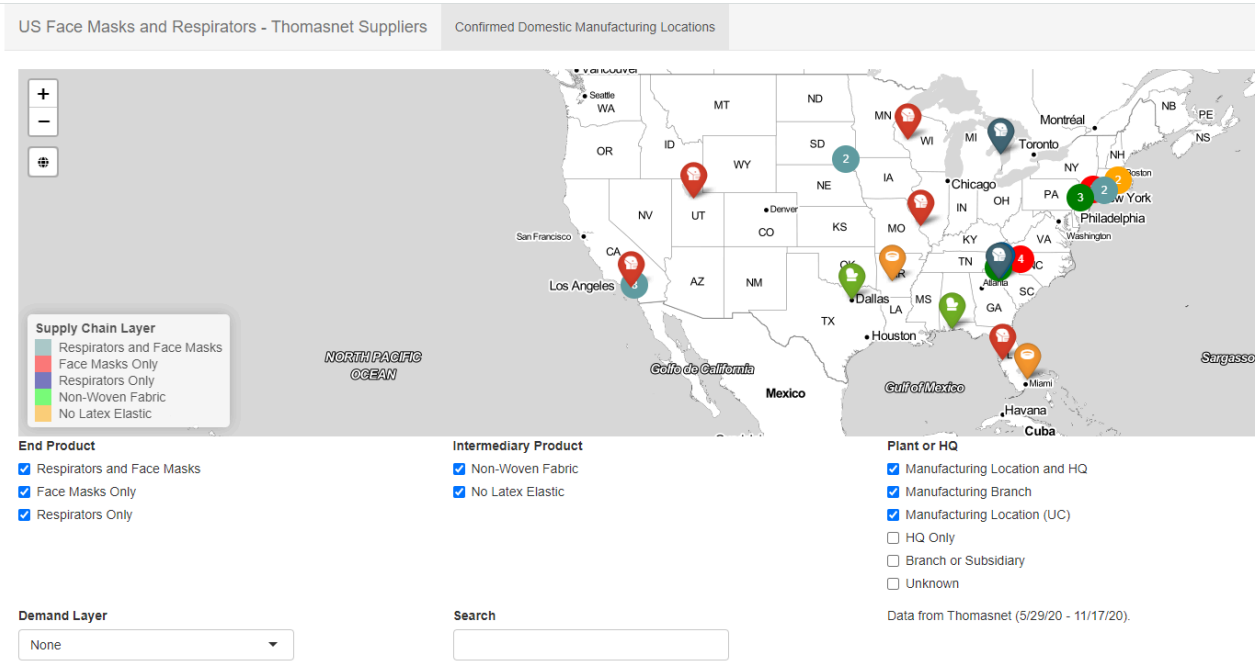

Figure 3: Manufacturing Locations for Confirmed Domestic Manufacturing Entities. Confirmed manufacturing sites (32 of the 56 firms in the blue section of the bar in Figure 2 for which we have been able to confirm the manufacturing facility address) of domestic manufacturing entities of standard FDA approved face masks, respirators, and intermediary products thereof.

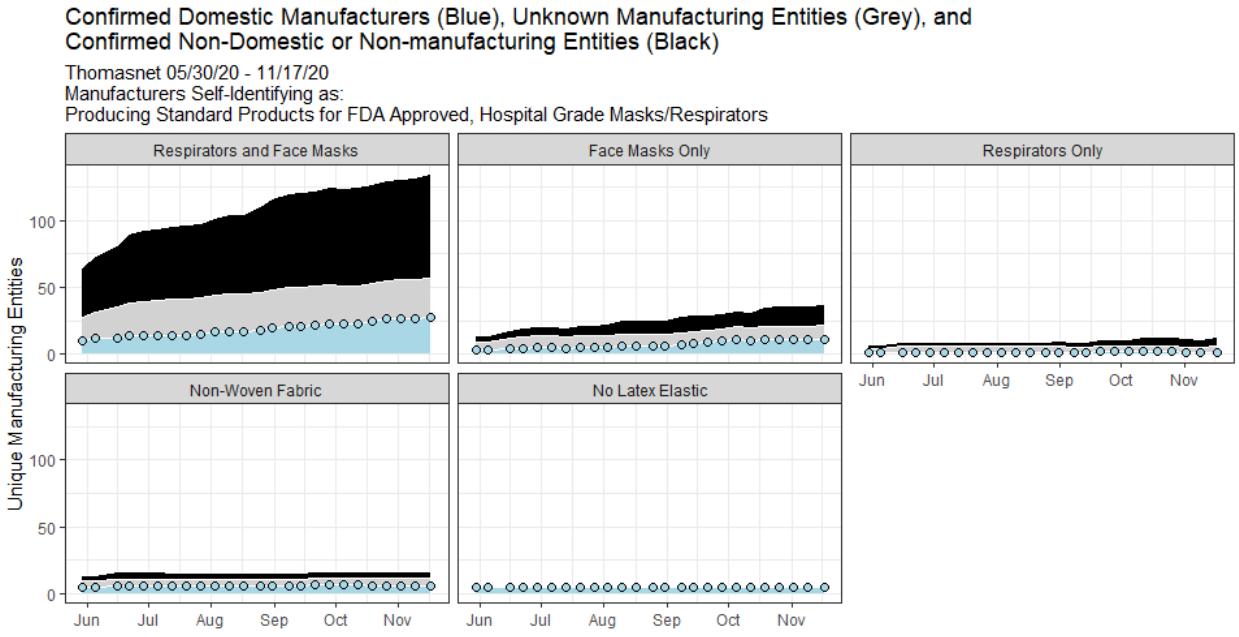

Figure 4: Domestic Manufacturing Breakdown of Thomasnet Listed Manufacturers of Standard FDA Approved Hospital Grade Masks/Respirators Over Time "Unique Manufacturing Entities" on the x-axis represents firms that self-identify on ThomasNet as a manufacturer of standard FDA approved hospital grade masks/respirators from 05/30/20 to 11/17/20. This figure represents the same data categories as Figure 2, just over time: The blue portion of the bar is the number of firms with confirmed production facilities in the U.S. The black portion of the bar is the number of firms confirmed as a non-domestic or non-manufacturing entity. The grey portion represents companies whose production location we have yet to confirm.