Industrial policy against pandemics

Reda Cherif\textsuperscript{1,2} and Fuad Hasanov\textsuperscript{1,2,3,*}

\textsuperscript{1}International Monetary Fund, 700 19th St, NW, Washington, DC 20431-0001, USA, \textsuperscript{2}The University of Cambridge, The Bennett Institute for Public Policy, Cambridge, UK. e-mail: acherif@imf.org and \textsuperscript{3}Georgetown University, Department of Economics, Washington, DC, USA. e-mail: fhasanov@imf.org

*Main author for correspondence.

Abstract

The coronavirus disease 2019 (COVID-19) pandemic illustrated the inability of the market to meet the needed production scale and speed of essential medical products. The state should adopt a risk-based approach, allowing for experimentation with various technological solutions such as vaccines and tests, while ramping up their production. The intervention should resolve uncertainty, combine resources, coordinate technological choices, lift barriers to entry, ensure knowledge sharing, and support the value chain. The cost of this strategy is dwarfed by the economic fallout of a pandemic. Universal testing, an overlooked solution, is a key component of an infrastructure against future pandemics.

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1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic, which afflicted the world in early 2020, took an enormous toll on human life and economic activity—trillions of dollars of lost income and more than 2 million deceased in about a year (Johns Hopkins University, 2021). The development of successful vaccines to defeat the pandemic, although unprecedented in history in terms of speed, took almost a year, and scaling up vaccine production and distribution has been taking months at a huge cost. Even with the ongoing effort and global collaboration, there is huge uncertainty about the time it would take—months or years—to inoculate most of the global population to achieve herd immunity and end the pandemic, and the longer it takes, the greater the risk of the emergence of more dangerous virus mutations.

The colossal cost of the pandemic calls for an urgent appraisal of the appropriate industrial policy response to gear up the world’s preparedness against future pandemics. Whether a safe and effective vaccine or a successful cure can be developed and produced at scale fast enough when the next pandemic strikes is highly uncertain. Even a few months of raging pandemic, lockdowns, and disruptions to economic and social life are very costly in terms of income and lives lost.

We argue that a risk-based approach to industrial policy in the face of pandemics consists in funding and facilitating the experimentation with a wide range of plausible technological solutions while simultaneously intervening to scale up their production. The portfolio of possible solutions would naturally include multiple vaccine candidates and involve potentially novel technologies. For instance, in the early phase of the COVID-19 pandemic, there were several vaccine candidate technologies, including the novel mRNA vaccines, many of which turned out to be successful. Strong government intervention such as Operation Warp Speed in the USA, granting billions of dollars to fund several firms and “untested” technologies in vaccine production, would be justified \textit{ex ante} even knowing that most would likely fail \textit{ex post}. The same logic calls for
the inclusion of other candidate technological solutions in the industrial policy response such as possible cures and, as we argue below, rapid tests. Meanwhile, as shown by the slow ramp up of production of vaccines worldwide in 2020–2021, there is a need to simultaneously tackle the bottlenecks and market failures facing the manufacturing of these solutions at large scale.

In the absence of a vaccine or a cure or while their production is being ramped up, we argue that the most viable way to squash a pandemic rapidly and reopen economies safely is universal testing and isolation policy, which requires an industrial policy intervention to ramp up the production of test kits quickly. Developing and/or producing vaccines or cures could take a long time while designing and producing rapid test kits could be done relatively fast, including in many developing countries. This approach will buy the necessary time needed to develop vaccines and cures and even fight off potential virus mutations. With a testing infrastructure in place, the pandemic can be squashed relatively quickly, in a matter of months rather than years. The major components of this testing infrastructure are the development of rapid test kits and a scale up of manufacturing production. The existence of both research and manufacturing facilities for testing during normal times would help minimize the impact when a pandemic strikes.

We focus on testing to illustrate several key aspects of the risk-based approach to industrial policy. First, there is evidence that it is a plausible, economical, and relatively fast solution to safely reopen economies, although potentially temporary while vaccines are being developed. As an untested solution, it was largely overlooked throughout 2020 during the COVID-19 pandemic. Second, the development and deployment of rapid test kits would have been much faster if it were explicitly included early in the portfolio of solutions targeted by industrial policy to tackle regulatory hurdles and facilitate experimentation to show a proof of concept. Third, the needed massive scaling up of production of test kits faces numerous market failures requiring appropriate state intervention and drawing lessons for industrial policy modalities for vaccines, cures, and other medical goods such as personal protection equipment.

The feasibility of a rapid scale up in the production of test kits or other essential medical goods is akin to war mobilization efforts during WWII, when the USA and the Soviet Union increased drastically their production of military equipment and machinery on an unprecedented scale and scope and in a record amount of time, in some instances building ammunition factories from scratch in 3 months. The potential existential threat of war motivated policymakers to spring into action. Although not trivial, the current task is minuscule in comparison, while the danger of an endemic or a “whack-a-mole” pandemic is real, which would entail huge costs.

The state intervention can be done using the principles of a True Industrial Policy (TIP) (Cherif and Hasanov, 2019). TIP’s key principles such as creating capabilities in sophisticated products with (domestic and international) competition and accountability for the support received are key ingredients to resolve existing hurdles. To ramp up production fast, the state can facilitate the organization and coordination of resources. Production along the whole value chain needs to be supported, while intellectual property (IP) and knowledge-sharing should be tackled to prevent bottlenecks and create synergies. Moreover, the state needs to coordinate technological choices, assume risks and provide enough financing, and support the redesign of or building from scratch manufacturing facilities. Pooling both public and private resources would achieve the needed economies of scale, creating a market for test kits and bringing the costs down substantially.

2. Universal testing: an overlooked solution

A large and growing number of studies show that frequent testing and isolation would be an effective strategy to halt a pandemic. The susceptible, infected, and recovered model, a workhorse model in epidemiology, predicts that a continuous testing and isolation of the infected, at a rate of about 5%–15% of the population per day, would lead to a rapid reopening of the economy even if test kits are relatively imprecise and isolation imperfect (Cherif and Hasanov 2020; Larremore et al., 2020; Romer, 2020a,b; Siddarth and Weyl 2020). Moreover, large-scale testing was shown

1 That is, these are test kits that would not qualify as clinical tests. In addition, a combination of group (pooling individual samples for testing) and periodic testing (e.g., using blocks of population on a geographic grid) as opposed
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to drastically decrease the number of COVID-19 cases when it was implemented, including in China, Slovakia, and the UK, while many smaller scale experiments throughout the world helped schools, universities, and senior housing facilities to reopen while preventing outbreaks.

However, as an untested solution, universal testing was overall ignored in 2020 for three main reasons, all related to the lack of an industrial policy to face pandemics. First, contrary to vaccines that have been used since at least the 19th century to fight infections (and lockdowns since the middle ages), universal testing was never tried at scale to halt a pandemic, generating skepticism and debate, including among experts. Second, it requires a potential change in regulatory framework for epidemiological purposes since test kits are usually designed for a clinical diagnosis rather than for epidemic surveillance. Third, to be feasible, universal testing depends on massive and quick ramp up of production of test kits, facing numerous market failures, which can only be resolved using an appropriate state intervention.

For universal testing to work, an “epidemiological” rather than a “clinical” approach to testing is needed, sacrificing the precision of test kits for scalability, convenience, and speed to identify enough potentially infected rather than to diagnose them (Cherif and Hasanov 2020; Larremore et al., 2020; Mina et al., 2020). Standard regulation assesses tests for clinical purposes, that is, tests used to decide on a treatment course by a doctor. Consequently, tolerance for false negatives and positives is usually small. Universal testing requires frequent and rapid testing to identify the infected that can, thus, sacrifice precision of test kits, making them cheaper as well. This approach requires a change in the regulatory framework to distinguish between clinical and epidemiological purposes. This change may be hard to make in the absence of a coherent and high-level industrial policy tackling all the hurdles.

The perception of “infeasibility” of universal testing stems also from the adoption of a “laissez faire” approach to production. Indeed, the sheer number of test kits needed compared to current production in each country or globally is huge. In addition, the difficulty of approving and scaling up do-it-at-home test kits or collecting and processing a large number of samples seems to imply that universal testing is nearly impossible (e.g., Kofler and Baylis, 2020; Rose, 2020). Even if regulation is changed to achieve a greater scale and convenience while minimizing costs, market failures would preclude an unprecedented increase in the production of test kits needed in a short period of time. The market for test kits during a raging pandemic is laden with market failures stemming from uncertainty, capacity constraints, coordination failures, externalities (e.g., positive externalities related to massive testing akin to network effects and resilience rather than efficiency in production decisions), and market power. In addition, the market would not internalize the long-run positive spillovers and would underprovide compared to the socially optimal quantity.

Similar obstacles were observed in the market of medical equipment as many countries, including advanced ones, faced huge shortages in the early phase of the pandemic (e.g., Azmeh, 2020; Bradley, 2020). However, ramp up of their rapid production in several countries also show that state intervention can radically change the situation.

Ramping up the production of test kits is feasible in most countries, and its cost is dwarfed by the cost of the pandemic. To put it in perspective, the annual cost of production of test kits would amount to less than two months of the projected global economic losses and fiscal stimulus packages induced by the pandemic in 2020 (IMF, 2020). As an illustration, the number of test kits needed is less than half of the equivalent number of soft drink cans consumed globally (about a trillion per year). If enough firms pull their resources, combined with substantial public funding, support, and coordination, many countries could meet the demand for test kits in a matter of few months, and eventually, global demand could be met as well.

A risk-based industrial policy to face COVID-19 or future pandemics would start by including all plausible solutions to end the pandemic. These would include untested ones such as universal testing, which was called for by prominent epidemiologists and economists early in the crisis. Given the colossal cost of the pandemic, in addition to supporting vaccine development and production, a sizable amount could have also been invested in experimenting and providing a proof to random testing would help minimize the number of test kits needed; otherwise, the daily testing rate required would be as high as 20%–30% of the population to halt the pandemic (if transmission rates are relatively high).
of concept for universal testing even if the odds of success were low. For a risk-neutral policymaker, undertaking such a policy would be worthwhile even if the odds of success were about 1% (accounting for economic and social costs of the pandemic). In addition, the diversification of plausible solutions would fit the classical approach to reducing risk while expected returns stay relatively high. This would result in a higher Sharpe ratio or higher expected return per unit of risk than that of pursuing each individual solution (Lo, 2021). However, pursuing all solutions requires much more financing and resources, further justifying a state intervention.

3. Market failures in testing times

The provision of test kits and other critical medical products should be easily met in the context of a standard supply–demand model with perfect competition, perfect information, immediate and costless adjustment, and no capacity constraints. In this theoretical case, the market would provide all the needed products at an equilibrium price reflecting both technological constraints and preferences. In normal times, the market for critical medical products such as test kits would be broadly in equilibrium in most countries. However, amid the COVID-19 pandemic, severe shortages of medical goods have appeared, and the lack of test kits has become the critical bottleneck toward a decisive defeat of the virus. Even with the development of successful vaccines, the production has not been fast enough to ensure quick inoculation of the majority of the global population. We argue that during a pandemic the market could cease to provide the quantity of test kits and other critical medical goods that society would require, leading to severe rationing and welfare losses. We outline the policies and institutional apparatus needed to tackle these market failures using the example of test kits.

3.1 From the invisible hand of the market to the leading hand of the state

3.1.1 The inefficiency of the market during a pandemic

The lack of competition is an exacerbating feature but not the binding constraint in the context of a pandemic. Monopolists or oligopolists would choose a smaller supply and higher price compared to a market supplied by price takers with the equilibrium quantity most likely lower than the quantity needed. Yet, the main challenge is the capacity constraints faced rather than the market structure. If the capacity to produce all the needed test kits existed, issuing regulation (e.g., Defense Production Act in the USA) for monopolies to increase production to the needed level or the ramping up of production by competitive firms, irrespective of the initial market structure, would potentially solve the shortage of medical goods. Even if some consumers (e.g., hospitals) are being rationed because of higher prices, various support schemes could be designed to meet the needed production levels at existing prices (e.g., government subsidies to firms or consumers).

However, leaving existing firms in the driver’s seat of the market certainly raises the question of the feasibility of a rapid ramp up of production. The procurement of a huge quantity of medical goods at a price set by the state, as we argue below, would not necessarily maximize their profits. More important, when asked if it were “feasible” to attain a certain production target within a short period of time, firms would refer to their standard market objective of maximizing returns to answer it (with most likely no). Even with state subsidies, it might take longer than desired to scale up the production. In the world of maximizing efficiency to minimize costs (“just in time” delivery) rather than factoring in redundancy and resilience of value chains makes it even harder to scale up relatively quickly. Resilience may not be much factored into the production decision of a firm despite being valued on an industry level in case of unexpected large shocks. The market logic of tackling uncertainty, maximizing earnings, minimizing costs, and taking constraints on the inputs and logistics as given is certainly a guide in “peace” times. The choice of technology could also be influenced by a profit-maximizing motive and run contrary to the need for a simple design and ease to produce and operate. For instance, this has been a major concern in the ability to stockpile and ramp up the production of ventilators in the early days of the COVID-19 pandemic (Azmeh, 2020). In the market for test kits, the test technology to be used, the constraints in the value chain, and the lack of manufacturing facilities indicate the challenges of a complete reliance on the market.
Facing such an urgent crisis by completely relying on the workings of the market is imprudent as the market is riddled with market failures and cannot resolve many of the hurdles faced. Even if the market attempted to ramp up production relatively fast, most likely capacity constraints would be hit due to the huge demand shock. Only with the large resources and coordinating ability of the state could both public and private resources be combined for a common goal. There is a need for coordinating among different actors of the production value chain, overcoming administrative, and regulatory hurdles, considering the social benefits rather than the narrow profits of firms, enforcing accountability for the support received, deciding on the best production technology, and lifting any other constraints. This critical moment requires the leading hand of the state (Cherif et al., 2016).

3.1.2 The fog of uncertainty
In the face of uncertainty, firms may not invest enough in the capacity needed to meet all the demand. One of the reasons for the shortage of masks, ventilators, and test kits in many countries is the fact that firms could not have predicted the scale of the increase in demand. Even if they could have somehow anticipated it, they might not have invested enough ex ante to meet the demand of a tail event. Many firms are scaling up their production in response to the spike in demand. However, investment is costly and the prospects of demand over the months ahead remain largely uncertain, especially in terms of test kits. There are many factors that are difficult to predict such as how long it would take for the virus to disappear, how many people would be infected, when vaccines would be available, and which technology would be picked for mass testing.

Given the asymmetry in the cost-benefit tradeoff, firms would always prefer to err on the conservative side, preferring to take the risk of rationing the market rather than flooding it with extra supply. Firms may still remember the 2009 H1N1 flu pandemic when major pharmaceutical firms ended up with excess capacity to produce vaccines as the virus faded, resulting in large losses (The Economist, 2020). A heightened uncertainty increases the likelihood of underprovision by the market.

For the nascent test kit market, there is an additional layer of uncertainty related to the technological choice. Not only are firms unable to predict the extent of the market, they run into the risk of betting on the wrong type of test, especially in the context of mass testing where the state might choose a limited set of technological solutions to be scaled up. Moreover, as we argued earlier, the lack of distinction between tests for clinical and epidemiological objectives may discourage investment in the most scalable technologies, hampering the effort to halt the epidemic. For instance, rapid do-it-yourself (DIY) test kits could be less precise than rapid point-of-care (POC) test kits but are cheaper and more scalable (under $5). The standard polymerase-chain-reaction (PCR) test kits are very precise but are more costly (above $20) and not scalable enough (unless combined with group or pooled testing when the prevalence rate is low) and require expensive equipment, which could delay reporting of the test results.

3.1.3 Race to the swift
In theory, if the demand increases, because test kits have become critical products, supply would eventually increase to reach a new equilibrium at a higher quantity and price. Even if we assume that the new equilibrium could be met with all the tests needed to defeat the virus, the key issue is how long it would take for supply to increase to meet the necessary demand. There are many constraints that would delay a swift ramping up of production.

One of the key constraints to substantially increasing the production of test kits is ramping up the production of the whole value chain. The shortage in critical inputs due to uncertainties, capacity constraints, and other hurdles could potentially derail the effort. There is a need for foresight and coordination at every level of the value chain (e.g., chemical reagents, swabs, assays, and logistics) to quickly add the needed production lines, equipment, and workers (which is harder during a pandemic). And without the resources and coordinating role of the state, many of these supply constraints may not be overcome.
Not only the standard long regulatory approvals for medical goods production but also other business regulations need to be expedited. This is particularly important in terms of test approval. Regulatory agencies need regulations for emergency approvals of “epidemiological” tests, which purpose is to detect the infected (e.g., rapid DIY tests) rather than diagnose the disease (e.g., PCR tests) that usually required test kits. The precision could be sacrificed to some extent to allow for cheaper, more scalable, and convenient options. In addition, it covers a wide array of activities such as hiring workers, acquiring licenses and land, expanding existing facilities or building new ones, and importing critical machinery or inputs. A one-stop shop with power of expediting and resolving all these challenges is needed.

Lifting barriers to entry or encouraging “forced” entry could be necessary to increase production quickly. Involving new entrants could be needed along the expansion of existing firms. A main barrier to entry consists in IP rights and knowledge of production processes. In this regard, IP and production process knowledge related to test kits should be provided to all the firms producing the product and its inputs. The state could design various mechanisms such as patent pooling to compensate the IP holders and reward adequately innovation while reining in patent trolls (Stiglitz et al., 2020). If firms do not comply, invoking compulsory licensing (allowed for pharmaceuticals by the World Trade Organization, especially during emergencies) may provide a credible threat for firms to cooperate. In addition, taking advantage of already existing production capabilities and trained staff in related industries, requiring existing firms to re-orient some of their production capacity toward the production of test kits, could be necessary. Both large firms with their enormous ability to plan and execute complex logistical chains and small firms with their agility and entrepreneurial spirit would be called for action.

There is a strong economic case for “forced” entry. If production is not ramped up fast enough, the whole economy suffers not only from temporary output losses and larger unemployment but also from a greater risk of a persistent depression and potential civil turmoil. There is a positive externality of contributing to the universal testing effort, which cannot be captured by an individual firm. By mandating firms to participate, the state can tackle this type of market failure.

The ramp up in production would not necessarily result in a sunk cost in case the virus disappears by a cure, vaccine, or “miracle.” Even if the virus disappears by “miracle” in the short run, as a result of mutation, for example, the world should still need to urgently develop and maintain a massive production capacity of test kits as part of the epidemic preparedness. This is the key component of building a testing infrastructure for pandemics. In the face of the future pandemics, deploying a test kits would be the best line of defense. It is much faster than creating a vaccine or an anti-viral drug, and it would avoid long and costly lockdowns. In addition, in a pandemic, potential “overshooting” of production of test kits should not be an issue. Since the successful mitigation of the virus in other countries would help lower the risks at home, there is very little likelihood of unused production as there is a limited production capacity in many low-income countries. There is also a good case to subsidize or donate the test kits to lower-income countries, especially by neighboring countries or those with strong ties to a home country (e.g., through trade and immigration).

3.1.4 Demand for test kits: free and mandatory for all

Even if the constraints on supply were lifted, the market demand might not necessarily result in universal testing even if testing were free. As discussed above, the amount of testing needed per day implies a large ramp up of production. Let us assume that the constraints on supply were all tackled, and the supply can meet the necessary demand. If everyone is simultaneously internalizing the benefits of universal testing and is willing to pay a relatively high price for the test, then there would be no need for an intervention. A person paying for a test would find it beneficial only if essentially everyone else would do the same to be able to safely interact with others—an externality of testing. The more affordable the test is, the more likely it is to get more people tested. Yet even if the test were free, it would still require consumers and others to voluntarily get tested and demand for testing may be lower than required. Internalizing the benefits of other people getting tested may not happen fully in the market and coordinating
voluntary testing may be complicated even in a repeated setting. Ultimately, the most reliable solution consists in imposing a compulsory and free test for all to resolve a coordination failure, positive externality, and price rationing. Some compliance mechanism to monitor enforcement is needed—a proof of testing for jobs, building entry, test passports, etc.

3.2 Sketching a strategy

The challenges and constraints discussed, which the market, even a highly competitive one, would fail to address, illustrate a sketch of state policies needed. The strategy is based on the TIP principles of setting ambitious goals, building capabilities and adapting fast, engaging the private sector, and providing necessary support while ensuring accountability (Cherif and Hasanov, 2019). Many features of the strategy sketched below are followed in advanced economies to some extent, albeit without the same focus and speed. However, these principles are barely applied in developing ones. The strategy can be summarized along the following lines:

- **Objective:** In addition to identifying a portfolio of plausible solutions, a clear and ambitious production objective (e.g., select a scalable epidemiological test such as rapid DIY or POC test for 5%–15% of the population a day for free and mandatory) is needed with numerical targets (e.g., produce test kits on the order of 5%–15% of the population a day), deadlines (e.g., 2–3 months) and an endgame (e.g., virus free within a month and an early warning system thereafter).

- **Institutions:** The state needs to set up a taskforce responsible for ramping up production and directly reporting to the high-level council in charge of applying the strategy and involving major actors across government agencies and levels (e.g., central and regional), and the private sector with regular meetings and communications to the public. The key agencies such as science, treasury, central bank, development bank, and others would be part of the council.

- **Incentives and accountability:** The task force should have the authority to change the incentives (e.g., moral suasion, tax breaks, and financing) and enforce accountability (e.g., quality and quantity) for firms once the clear objectives have been agreed with them (e.g., new lines in existing factories, new plants, production targets, etc.). It would run the operation and coordinate across firms, the value chain, and government agencies. The access to financing would be provided (e.g., via a development bank).

Dealing with all these challenges calls for a collaboration among firms and policymakers to reduce coordination and informational frictions and gain speed. While the main mechanism of the market is competition, in the crisis times, there is a need to shift toward collaboration. Information-sharing among firms concerning production processes, technology, and resources would help combine efforts to solve common bottlenecks and learn from each other. It would particularly support new entrants to learn from incumbents. Setting up informal and fast information-sharing forums at different levels of the firm (e.g., Research and Development R&D personnel, engineers, and technicians), using industry associations and public–private industry alliances would contribute to knowledge flows, coordination, and collaboration.

The incentives could be put forward by the government to encourage collaboration. The SEMATECH alliance of the US semiconductor companies in the 1980s is an example of the public–private industry alliance in support of the US semiconductor industry. Others have proposed a more direct intervention to create “Pandemic Testing Board” that takes its name and function from the WWII’s war production board (WPB) (Maier and Kumekawa, 2020). Yet, another approach could be what the Federal Reserve Board of the USA did during the 2008 financial crisis, in which it used its crisis powers to coordinate among banks, bring them into one room, and organize bailouts and liquidity support. A high-level policymaking agency could take on a similar role in fighting the pandemic crisis. This type of collaboration or agency would also be needed during normal times, as part of a testing infrastructure, that could be used for preparedness and scaling up of production during crisis times.

Producing a few hundred billion of test kits a year globally may seem like a staggering number, but the world has been producing billions of various medicines and consumer goods. For
instance, in the USA, in 2012–2013 about 39 million people have used statins against high cholesterol levels, amounting to 221 million prescriptions and probably about tens of billions of pills a year (Salami et al., 2017). Johnson & Johnson is producing about 5 billion contact lenses a year (Johnson and Johnson, 2019). In 2018–2019, about 170 million flu vaccines were distributed in the USA and much more globally (CDC, 2019). In the consumer goods markets, in 2019, about 128 billion of equivalent cans (in terms of volume) of soft drinks were produced in the USA and about a trillion of equivalent cans globally (Statista, 2020). About 2.1 billion smartphones, tablets, and personal computers, including 1.5 billion smartphones alone were shipped globally, which are much more complex products to produce with a lot of complex inputs (Lunden, 2020). In 2020, about a trillion of semiconductor units were expected to be shipped globally (Statista, 2021). With a cost of a few dollars per test kits, the production of test kits would be about equal to the global pharmaceutical market, about 1.4 trillion dollars, not a trivial increase but still a small fraction, about one and a half percent, of the global output (The IQVIA Institute, 2020).

A good example of what could be achieved is seen in the efforts of advanced countries to develop and produce vaccines in the race against COVID-19. The pharma companies have ramped up production to produce hundreds of millions of doses with manageable cost. “Operation Warp Speed” of the US Government has set a goal of 300 million vaccines to be ready by early 2021. The government funds have been flowing to biotech and pharma companies to expand production. A Boston-based biotech company Moderna has received about $500 million to expand its facilities to produce tens of millions of vaccines a month by 2021. Manufacturing hundreds of millions of doses would cost firms with existing facilities and personnel about $50 million, reaching $700 million for the new facilities, according to Gavi, a vaccine alliance (Miller and Kuchler, 2020). On a global level, much larger production is needed both for a vaccine and test kits.

To achieve success, incentives must be aligned, and accountability has to be enforced. The objectives and accountability for all the relevant actors should be clearly set. The relevant agencies in charge of regulation and administrative issues (e.g., agencies regulating medical products) need to switch to an emergency mode operation. It should have the responsibility of not only doing quality control but also helping firms meet the needed requirements within the shortest time possible. It should also act as an information disseminator as to how to reach the quality standards. The same applies to the firms involved in the production chain of test kits. If the production target such as the number of test kits, amounts of inputs needed, or specific infrastructure required is clearly specified, incentives would be aligned and accountability can be enforced. A mechanism to share the burden among firms and potential incentive mechanisms to compete and collaborate (e.g., prizes for development and various financial incentives such as tax breaks and loan guarantees) could also be considered as the success of the firms involved would benefit the whole economy. A high-level government task force would coordinate the production orders and information flows.

In addition to production, the whole testing infrastructure needs to be planned out. Deploying tests en masse requires logistical support and potential quarantine facilities (and financial support for the quarantined) and may face bottlenecks depending on the selected test technology. For example, if a test requires face-to-face interaction to collect samples (e.g., rapid POC test), enough protective gear should be made available for the testing centers. Enforcing the isolation of infected people in a quarantine would require similar planning. Similar to voting, testing a large part of the city or country’s population daily can be done using the facilities and parking lots of schools and community centers, making the task manageable.

### 3.3 Learning from the WWII’s production ramp up

Although a huge ramp up in global production of medical goods, including test kits and its inputs, is urgently needed during the pandemic, it is a fraction of the production ramp up during the WWII mobilization in the USA. In the 20 August 1945, issue Time reported: “In the five years since the fall of France, The U.S. industry and labor had turned out: 299,000 combat planes (96,000 last year); 3,600,000 trucks; 100,000 tanks; 87,620 warships (including landing
craft), 5,200 merchant vessels; 44 billion rounds of ammunition; 434 million tons of steel; and 36 billion yards of cotton textiles for war” (Waxman, 2020). In those few years, new technologies were invented, new industries were started from scratch, hundreds of factories were built and expanded, productivity skyrocketed, and labor force increased. Government spending reached about 40% of gross domestic product from less than 10% in the 1930s (Bossie and Mason, 2020).

Like Kennedy’s call for a moonshot a couple of decades later, the goal the president Roosevelt put forth before the nation was ambitious and seemed insurmountable. In his fireside chat on 26 May 1940, he said that the USA needed to produce 50,000 combat airplanes in the next year when it barely had 3000 mostly obsolete planes and it had not produced this amount, even cumulatively, since the first flight of the Wright brothers in 1903 (Trainor, 2019). Three years later, the USA was producing more than 50,000 combat airplanes, a 30-fold increase from the 1940 level. And airplanes were only part of what was needed for the mobilization effort. The construction of Liberty ships went from about a year (from keel laying to delivery) to less than two weeks (and even a few days in some cases) within a couple of years at Kaiser’s shipyards (Tassava, 2003).

Pushing for ambitious targets and inflating the requirements on the production needed, Roosevelt famously quipped to his advisor questioning the numbers: “Oh, the production people can do it if they really try” (Klein, 2013; Zeitlin, 2020). William Knudsen, the president of General Motors who became Roosevelt’s force organizing and coordinating mass production as the director of what later became known as the War Production Board, said: “We won because we smothered the enemy in an avalanche of production, the like of which he had never seen, nor dreamed possible” (This is Capitalism, 2020).

To meet Roosevelt’s call to ramp up production needed a different approach than the market-driven approach tried and failed during WWI. Then, the war mobilization was essentially driven by the private sector. Only 10% spent on new plants and equipment in 1917–1918 was provided by the government. Although the War Industries Board, overseen by the Wall Street financier Baruch, managed to mobilize production, it catered to major corporations, and war profiteering was extensive (Rosenblatt, 2018a). Decentralized purchasing led to bidding wars among military units, production delays, and hiked prices (Brunet, 2020). On the other hand, risk was still largely borne by the private sector as many contractors were left with unwanted goods when the government canceled orders after the sudden end of the conflict in late 1918 (Wilson, 2020).

The approach Roosevelt took at the wake of the war was for the state to take the lead in the mobilization effort. Roosevelt knew he needed industrialists at his side to meet the gargantuan increase in demand at each stage of the production chain. He called Knudsen and asked him to lead the effort and bring industrialists onboard. Knudsen came to Washington, went to his hotel room, and two days later produced a plan to turn the USA into the global manufacturing powerhouse within 18 months (This is Capitalism, 2020). Roosevelt created several agencies to oversee various functions of production and finance with limited and overlapping powers and responsibilities (giving him brokering and decision powers), put in charge capable leaders, and relied on them and the private industry to do the job. When agencies or leaders faltered, they were quickly replaced with others to carry on (Hone, 1991).

The agencies were instrumental in achieving the ambitious goals set. One of the key agencies was the WPB that managed and coordinated production chain. The WPB matched production orders with interests and capabilities of firms and tasked large established firms with more complex orders. Another key agency was the Reconstruction Finance Corporation (RFC) that financed operations. It was a Hamiltonian-style national bank and was instrumental in directing credit during the New Deal (Rosenblatt, 2018a). There were also specialized agencies tasked, for instance, with developing synthetic rubber industry. The National Defense Advisory Council, established by Roosevelt, served as a coordinating body across all the agencies.

The state used various tools and incentives to have the private sector step up production substantially and quickly. Initially, tax credits and incentives were tried but had limited success as the projects were mostly of safe nature. So was the program (Emergency Plant Facilities) that reimbursed firms in the future for building plants thus requiring a large initial investment from the private sector. Despite the future reimbursement, the private sector was reluctant to take
on huge upfront costs. Loan guarantees—the V Loan Program—worked relatively well as they tripled the bank lending to war industries to about 18% of bank loans in 1943. However, they accounted for a small share of total war financing.

The Defense Plant Corporation (DPC), that was a subsidiary of RFC, began directly investing to build factories and financing industries. It would then lease built factories to firms for a notional one dollar per year and cap the profits at a fair and reasonable amount (after the war, firms had an option to buy factories back, but the state retained production rights when needed). These government owned and contractor operated (GOCO) plants were a key mechanism of expanded production. Through the war, the federal government had contributed directly two-thirds of the total invested, ending up owning large, and in many cases majority, shares of the U.S. heavy industry (Bossie and Mason, 2020).

Securing demand for orders allowed firms to ramp up production. The ramp up of machine tools industry made up of many small specialized firms illustrates this point. The tools were a key input in the production of aircrafts, tanks, trucks, and other equipment, and each factory required tens of thousands of tools. A huge shortage of machine tools prompted DPC to create a pool of guaranteed machine tool orders and finance it, spending about $2 billion during the war (about $28 billion in 2020 dollars). Production increased tenfold to about 300,000 machine tools per year from 1938 to 1942 (Rosenblatt, 2018b). More important, DPC placed orders in the pool even before the specific buyers were known to expedite the production process (Bossie and Mason, 2020).

The “leading hand of the state” played a crucial role in creating new industries such as synthetic rubber industry and increasing supply of raw materials. As the supply of natural rubber from Asia, a key input in many industries, was disrupted by the war the DPC invested $700 million (about $10 billion in 2020 dollars) to build 51 plants to produce 700,000 to a million tons of synthetic rubber a year. The production increased by 3000% between 1941 and 1945 (Bossie and Mason, 2020). In addition, the federal government also provided funds for R&D for both basic and applied research. Even in the initial stages of development, the DPC provided seed money to chemical companies to develop synthetic rubber, and the licenses were shared with other producers (Rosenblatt, 2018c). The state essentially owned the industry well into the mid-1950s. Similarly, the large shortages of raw materials such as aluminum, copper, and other metals that were needed for the production effort were addressed by the Defense Supply Corporation, another subsidiary of the RFC. For instance, aluminum production increased from about 400 million pounds a year in 1940 to about 2.25 billion pounds a year in 1943 with over half of the output produced in the facilities built by DPC (Rosenblatt, 2018d).

The transformation of the auto industry in shifting production to the military needs was also remarkable. While more than 3 million cars were produced in the USA in 1941, only 139 were manufactured during the whole war (PBS, 2020). The task was enormous despite the fact that three-quarters of financing for the airplane development came from the DPC (Rosenblatt, 2018c). For instance, Chrysler discovered that a prototype of a tank with 3500 parts required about 200 pounds of blueprints (Rosenblatt, 2018b). When Ford was tasked with producing B-24 bombers, the car of the day had about 15,000 parts and weighed 3000 pounds while the B-24 had 450,000 parts and 360,000 rivets in 550 sizes and weighed 18 tons.²

Many doubted Ford could build the whole airplane, but Ford proved them wrong. The famous Willow Run plant at its peak produced a B-24 bomber every hour, day and night. At the beginning of the venture, Ford’s production chief overnight designed an assembly line that emphasized standardized interchangeable parts and orderly continuous flow like that of the auto assembly. His team disassembled the two planes flown in and came up with the blueprints needed. 42,500 employees were working at the plant, but the mass assembly had not begun until the year after the factory opened as all the bottlenecks such as housing, essential input specifications and input delivery, and labor relations, had to be fixed. To deal with continuous modifications to the plane and avoid costly factory shutdowns, many parts were outsourced to about 1000 Ford factories and independent suppliers so that the Willow Run factory could operate under more predictable conditions (Trainor, 2019).

² Some estimates of the number of parts are close to 1.5 million (PBS, 2020).
Industrial policy against pandemics

The enormous and fast ramping up of the production of a large number of sophisticated goods required for the war mobilization suggests a few key lessons. First, the effort has to combine the coordinating and financing role of the “leading hand of the state” with the production capabilities of the private sector. Second, a high-level council with key state agencies needs to be set up to drive the agenda that has to establish ambitious and clear targets, specify accountability framework with deliverables, profit margins, and labor relations, coordinate information flow across agencies and firms, provide for sharing of designs and IP among firms, engage all capable firms to allow for competition and potential failure, and clear up bottlenecks in supply chain and regulatory regime. Competency and talent of leaders in charge cannot be more emphasized. Third, to reduce uncertainty and risk for firms, demand has to be guaranteed and financing has to be sufficient and, in many cases, it may involve a direct ownership of facilities such as GOCO plants to ensure the provision of critical inputs in the value chain. Lastly, it was continuous effort and ingenuity of many firms and workers, including civil servants in government agencies, that worked together to reach the goal in front of them while removing all the obstacles on their path.

The WWII speedy development of vaccines against various diseases also holds lessons for collaboration and institutional structures for research and development of test kits, vaccines, and cures. The close collaboration among academic, industry, and military scientists in targeted R&D programs was instrumental in harnessing existing knowledge and applying it to the development of vaccines. The institutional arrangement in the Office of Scientific Research and Development (OSRD) featured project managers with clear objectives to develop, test, scale up, and manufacture vaccines. This governance structure combined with the collaboration with the military as a lead user of vaccines, thus providing the needed feedback, improvements, and future demand, produced a lot of innovations in a short time (Hoyt, 2006). As James Conant, the president of Harvard University, and a member of National Defense Research Committee under Vannevar Bush, wrote in 1945: “There is only one proven method of assisting the advancement of pure science—that of picking men of genius, backing them heavily, and leaving them to direct themselves. There is only one proven method of getting results in applied science—picking men of genius, backing them heavily, and keeping their aim on the target chosen. OSRD...had achieved its results by the second procedure...because...its objective was not to advance science but to devise and improve instrumentalities of war” (Hoyt, 2006).

Based on the lessons we drew from the WWII mobilization effort, we provide a blueprint for industrial policy to ramp up test kits, clarifying several aspects of the policy sketch outlined in the previous section and putting forth specific policy instruments. A task force akin to the WPB (e.g., Testing Pandemic Board) would employ competent and experienced people, put forth ambitious and clear objectives in the development and production of test kits, study and solve the challenges such as value chain bottlenecks and regulatory approvals of rapid test kits, and coordinate among private sector and government agencies. It would coordinate among academic and industry scientists and experts on developing test kits under targeted R&D programs with relevant feedbacks from the research community and industry. It would invite new and existing firms to partake in the effort to resolve the demand uncertainty and ensure steady demand on the part of the government. It would facilitate building new plants and expand existing lines to produce both inputs (e.g., assays and swabs) and final products such as rapid test kits at the scale needed. It would coordinate financing (e.g., loans, guarantees, and grants), and if needed, facilitate building GOCO plants. It would ensure accountability for the support provided and IP and knowledge sharing by capping the rate of return earned by firms.

3.4 Why most developing countries should follow industrial policy now

There are several reasons justifying why most countries, including developing ones, should start working on developing a productive capacity in test kits. There is a huge gap between the quantity needed to achieve universal testing and current production in advanced countries. It may take a long time for developing countries to access imported test kits. There is also no guarantee that advanced economies would follow the above strategy and ramp up their production sufficiently. This could lead to a dystopian situation where some parts of the world, mostly advanced, would be open to business resuming relatively free movement among themselves, while the rest would
be fighting for the limited supply of test kits. Most of these countries might not succeed at joining in and could face repeated lockdowns and potentially huge loss of life and suffering. Defeating the virus through testing depends critically on the ability of each country to quickly access the needed test kits and the only effective way to achieve it is through developing its own production capacity. In fact, this scenario has played out in the global vaccine production and distribution as a few successful vaccines were developed against COVID-19. More important, the know-how of producing test kits would lay the ground for the ramping up of vaccine production and for building pharmaceutical and manufacturing capabilities.

Emerging economies have a relatively higher chance to succeed at this endeavor than low-income countries as they already have the needed human capital, industrial knowledge, and financing. But even smaller emerging market and lower-income economies could coordinate regionally to share the costs and human capital to produce the needed test kits with the technical and financial assistance from other economies. In additional to regional cooperation, international organizations could provide further technical and financial support. The good news is that the universal testing and isolation strategy is easier to implement for a small population.

As to the question if countries could do it or it would be too costly and time-consuming, cheap and fast test kits already exist. There are test kits being developed that are technically simple, akin to pregnancy test kits, and cheap and do not require complex equipment or even electricity to provide the results. In terms of the industrial scale, for example, soft drink companies already produce more than 100 million drinks a day on the African continent.

Even innovation could come from developing economies with experience in fighting past pandemics such as Ebola. For example, a test invented by the Senegalese National Institute for Health and a British biotechnology company (Bradley, 2020) could cost as little as a dollar per test. Not only can low-income countries in Africa and elsewhere produce at an industrial scale, they can also innovate on adapted technologies laying the ground for a recovery and manufacturing renaissance and paving the way for sustained long-run growth.

Finally, one could argue that for many low-income countries with low capabilities and urgent needs across a wide spectrum, engaging in industrial policy to produce test kits could be a luxury they cannot afford, although it may eventually more than repay the spent resources by creating new industries. The answer would depend on the true cost of such a policy, which could be relatively low even for low-income countries that need to diversify their exports and economies, and whether the prospect of a severe and resurgent pandemic with devastating effects is taken seriously enough.

4. Conclusion

A risk-based approach to industrial policy to fight pandemics is a key to reopening economies faster and saving lives. In the face of a pandemic, this approach would simultaneously pursue key technological solutions like vaccines, cures, and test kits, invest substantial amounts, and coordinate resources and efforts with the private sector. This diversification of solutions would provide the largest bang for the buck with a high Sharpe ratio or high expected return per risk. Experimentation and provision of a proof of concept, followed by a ramp up in production and distribution, are key elements of this strategy.

Among plausible solutions, we argue that a viable strategy to end the pandemic is universal testing and isolation policy coupled with industrial policy to increase production. For future pandemics, while a vaccine or a cure is developed, testing policy could be the first line of defense and building a testing infrastructure is a key to preparedness. Countries following this strategy would need to achieve a rapid increase in the number of test kits produced during the pandemic. As cheap test kits are developed and with economies of scale, the cost of the production ramp up would be negligible compared to the economic fallout and lives lost due to repeated lockdowns or the spread of the pandemic.

The production ramp up of test kits is possible with the support of the state, that is, the application of industrial policy against the pandemic. An epidemiological approach to testing, sacrificing precision to provide cheap, fast, and scalable test kits, needs to be taken into account by the regulator. Market failures stemming from market power, externalities, short-term profit
motives, capacity constraints, and coordination challenges would not be solved by the private sector alone. Instead, it is the combination of the state and the market, thanks to coordination mechanisms, large resources, and harnessing market forces that could support a rapid ramp up of production and distribution of test kits and critical medical products. This approach would constitute a key feature of the testing infrastructure for future pandemics. Both the institutional structure and research and productive capabilities to quickly develop and then scale up the production and distribution of test kits would need to be in place as part of preparedness for future pandemics.

The principles of a TIP strategy, especially in developing countries, and the WWII mobilization effort are a blueprint for such an industrial policy. The TIP strategy needs to set an ambitious goal in terms of the number of test kits produced. A task force at the highest level of the government needs to coordinate among all the key stakeholders in public and private sectors to tackle bottlenecks (e.g., regulation, supply chain, distribution, etc.). Large firms as well as innovative small firms need to contribute to this endeavor. Sharing information and knowledge would expedite the process. The state needs to provide support to firms but must make firms accountable for the goals agreed upon. The resources spent on this endeavor cannot compare to the costs of high unemployment and potential social unrest and even starvation of the poorest in developing countries. State intervention in this context can draw lessons from war mobilization efforts, albeit at a miniscule scale in comparison.

Ramping up the production of test kits and other medical gear in developing countries is even more pressing. Doing so would not only stimulate production and growth in the short run when major service sectors (e.g., tourism) and commodity markets are suffering, but it would also pave the way for the manufacturing of vaccines (Okonjo-Iweala, 2020). The acquired capabilities would prepare developing countries for future pandemics. More important, this production mobilization would also be an opportunity for developing countries to refocus their resources from non-tradable services back to manufacturing, creating manufacturing capabilities, reversing “premature deindustrialization,” and paving the way for sustained growth.

As the US President Franklin D. Roosevelt said, “Powerful enemies must be out-fought and out-produced.” The strategy outlined in this paper is necessary and urgent not only to fight the COVID-19 pandemic but also to have an insurance policy against future pandemics. Building a testing infrastructure is a key to a country’s pandemic preparedness program. Even in an optimistic scenario where a vaccine becomes available in a few months, countries should not miss this opportunity to build a testing infrastructure as a bridge to mass vaccinations. However, it is equally plausible that when another pandemic strikes, perhaps more lethal than COVID-19, no vaccine would be quickly found, and humanity ought not to look back and regret this missed opportunity.

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