Response to Request for Public Comments:
Risks in the Semiconductor Supply Chain

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Google applauds the Biden Administration's whole-of-government approach to tackling the nation's supply chain challenges, particularly with regard to semiconductor chips. As a designer and large end-user of chips, we welcome the opportunity to provide comments in response to the Commerce Department's Bureau of Industry and Security's (BIS) "*Request for Public Comments on Risks in the Semiconductor Supply Chain*."

GOOGLE'S USE OF SEMICONDUCTORS

Google's mission is to make the world's information universally accessible and useful. In pursuing this mission, the company relies on semiconductor technology as an essential component of its technical infrastructure, cloud products, research, devices, and services. This includes infrastructure equipment and machines that ultimately serve billions of users, through products like Google Search, Google Chrome, and YouTube as well as platforms like Android and ChromeOS. Through our Google Cloud products, we allow customers in the public and private sectors to leverage that same infrastructure to solve their toughest business challenges. Semiconductor chips are also essential to our growing consumer electronics business, which includes products like the Pixel smartphone, Nest thermostats, and Fitbit health and fitness devices. Finally, we invest heavily in research and development ("R&D"), and rely on advanced semiconductors to carry out this work in fields including AI, quantum computing, and robotics.

Google is also on the cutting edge of silicon development as a leading customer and designer of advanced semiconductor technology, which enables us to offer helpful products and services, as well as carry out forward-thinking R&D. To meet our unique compute and efficiency requirements, we design custom chips, including:

- **Tensor System on a Chip ("SoC"),** for the Pixel 6 and Pixel 6 Pro smartphones, that enables us to bring innovative on-device AI capabilities to Pixel users, such as new photography experiences and improved speech and language capabilities.

- **Tensor Processing Units ("TPUs"),** our series of custom machine learning chips that power Google products like Translate, Photos, Search, Assistant, and Gmail. We also offer TPUs to Google Cloud customers to perform AI-powered tasks like translation, image classification, and demand forecasting at scale. We are utilizing AI techniques to more efficiently design our TPUs, optimizing for space and power usage.
- **Sycamore quantum processor,** our aluminum-on-silicon, 54-quantum bit Noisy Intermediate Scale Quantum processor, which we used in 2019 to demonstrate the first beyond-classical computation on a quantum processor. We produce all of our quantum chips in-house and recently opened a dedicated fabrication facility in Santa Barbara.

Google uses a large variety of semiconductor chips, from advanced and custom technology to power AI research, to high-speed processors to run our data centers, to commercial off-the-shelf chips that are integrated into our consumer electronics devices.

CURRENT CHALLENGES

Currently, supply chains are facing shortages in semiconductors, brought on by a number of global trends. The COVID-19 pandemic simultaneously increased demand, while supply was affected by shutdowns or reduced manufacturing capacity in key production markets. These trends, paired with natural disasters and unexpected incidents such as localized fires, windstorms, and floods, created a mismatch between supply and demand that continues to impact many sectors.

These constraints are not limited or confined to a particular supplier, market, or technology, but rather felt across the whole semiconductor ecosystem. Lead times for securing supply have extended significantly, and our supply chain teams have had to identify and qualify new sources in order to maintain supply levels. Our teams, like others in the industry, have been forced to navigate challenges and shortages in the following areas:

- Complex SoC products manufactured using the most advanced fabrication technology nodes (≤5nm), including applications processors that contain CPUs & GPUs;
- Legacy nodes and technologies such as off-the-shelf standard semiconductors using mature technology nodes (28nm, 40nm, 55nm, 65nm, 180nm) and 8 inch wafers;
- Analog, mixed signal, and power management integrated circuits (PMICs);
- Packaging substrate technology used in SOC/ICs.

The chip types mentioned above are used across our products, including in Pixel smartphones, Nest connected home devices, Chromecast streaming devices and wireless earbuds, as well as in infrastructure equipment such as servers, networking and storage appliances.

POLICY RECOMMENDATIONS

Modern supply chains are long and complex, and they are currently distressed. Given the complexity and significance of the challenges at hand, it is essential that policymakers and other stakeholders pursue a multi-pronged approach to support diversified manufacturing capabilities.

While there is no silver bullet, there are opportunities for the US Government to advance solutions to strengthen the semiconductor manufacturing ecosystem. We offer the following policy recommendations:

1. Avoid short-term interventions that could further disrupt supply chains already under stress;
2. Advance the CHIPS Act to expand, diversify, and localize supply chain production;
3. Continue to support investments in R&D that sustain America's leadership role in the semiconductor industry;
4. Encourage greater technical standardization of semiconductor manufacturing components;
5. Drive workforce development for semiconductor manufacturing; and
6. Promote rules-based open trade for semiconductors.

Avoid short-term interventions that could further disrupt supply chains already under stress. We are concerned that blunt, short-term interventions could lead to further distortions and disruptions in the market. The Government is well-positioned to create incentives to onshore manufacturing facilities, and to convene key stakeholders in the industry. It can also drive voluntary standards to give semiconductor customers more supplier options. However, short-term interventions such as directly allocating supply can be counterproductive.

Supply chains are incredibly long and complicated with many actors from across the globe and in many sectors. As demonstrated by the present impact of production events abroad, interventions in one area can have ramifications for other parts of industry that compound globally. Even with successful onshoring of manufacturing, the global silicon manufacturing industry will remain interconnected with diffuse sources of materials, equipment, components, and expertise from many countries.

Advance the CHIPS Act to expand, diversify, and localize supply chain production. Ongoing supply chain shortages illustrate the risks associated with concentrating global production. Today, almost all advanced chips are manufactured in East Asia. As a recent White House study concluded, "reliance on imported chips introduces new vulnerabilities into the critical semiconductor supply chain." As long as the US relies on a small number of foreign plants for semiconductors, supply chain shocks may continue to have an outsized impact on the US economy.

In light of this, the CHIPS Act's proposed $52 billion investment in domestic semiconductor research and manufacturing is essential to establishing multiple foundries in the US. These investments will help expand, localize, and diversify semiconductor production, ensuring that US companies are better positioned to weather future shocks.

Continue to support investments in R&D that sustain America's leadership role in the semiconductor industry. Continued American leadership in semiconductor technology and related industries depends on investments in R&D. Increased government R&D funding should be targeted toward areas that will bolster US fabrication capabilities and competitiveness, such as raw materials mining, packaging technologies, SRAM-replacement technologies, EUV lithography tooling, and methods to make US fabrication of prototypes and smaller-volume chips more economically viable. These investments would complement existing academic and industry research on chip design and materials. As they mature, emerging technologies like quantum computing and robotics will drive demand for more specialized semiconductor production. R&D investment in semiconductor manufacturing is critical to the country's future competitiveness in these industries. In addition to the CHIPS Act, legislative proposals to increase R&D funding for emerging technologies provide an opportunity to invest in specialized semiconductor technologies and advance US leadership in these fields.

While the foregoing investments represent important steps, we recognize that R&D leadership requires action by both the public and private sectors. Google has invested over $100 billion in R&D over the past five years, as indicated in our public reports. We will continue to invest in fundamental research in areas like AI, robotics, and quantum computing, which also helps drive semiconductor innovation and development. Furthermore, we invest directly in the development of custom chips like the Tensor SoC and TPU, as well as in the design and US-based fabrication of our quantum processors. The US Government should continue working with the private sector to identify areas of high-potential investment related to advanced and next-generation semiconductor manufacturing.

Encourage greater technical standardization of semiconductor manufacturing components. The market currently lacks voluntary technical standards for chiplets that could increase competition and give companies more options in their choice of suppliers. The Commerce Department, working through the National Institute of Standards and Technology ("NIST"), can play a positive role in facilitating industry dialogue to create standards that support the interoperability of silicon components across the ecosystem. With chiplets for example, increased standardization would support greater interoperability and could enable integrators like Google to utilize dies fabricated by a larger number of foundries, increasing competition and diversity of suppliers.

In doing so it is important to remember that semiconductor components, like the use cases they serve, are highly varied in nature. Standards in this area would need to be sufficiently flexible to

account for a broad range of customer needs and applications. While the Government can catalyze voluntary manufacturing standards, issuing mandatory standards would be counterproductive and could result in slower shifts to new technologies. To meet these needs, NIST should engage with the private sector to support the development of voluntary standards in this area.

Drive workforce development for semiconductor manufacturing. Reshoring semiconductor manufacturing opens professional opportunities to American workers that are important to a flourishing innovation ecosystem. The fierce competition for global talent in the semiconductor industry raises the stakes for cultivating domestic talent. The Administration has the opportunity to bolster its current efforts by clarifying tax, immigration, and other regulatory policies; and by encouraging stronger partnerships between higher education institutions and industry—including funding for labs, apprenticeship, certification programs, and grants for advanced research and degrees relevant to semiconductors. Additionally, changes to the immigration system—such as preserving H-4 employment authorization for spouses of H-1B visa-holders and expanding STEM OPT visas—remain essential for attracting and retaining STEM talent.

Promote rules-based open trade for semiconductors.
As a complement to the domestic measures discussed above, trade policy can promote resilient semiconductor supply chains. This includes ensuring that major semiconductor trade corridors remain open and that US industry can compete on a level playing field. The US Government should continue working in concert with like-minded allies and partners to diversify, rebalance, and strengthen the global semiconductor supply chain. The US-EU Trade and Technology Council's work to enhance the security of supply and cutting-edge design and production capabilities is a welcome step in the right direction. The US should establish similar partnerships with other trusted allies to build upon this progress.

CONCLUSION

We welcome the steps that the Biden Administration has taken to bolster semiconductor capabilities in the face of recent challenges, including advocating to fully fund the CHIPS Act to increase domestic semiconductor production; supporting legislative proposals to increase R&D funding for emerging technologies; and strengthening international partnerships. We encourage the Administration to continue advancing these initiatives, and to make other necessary investments in workforce development and the adoption of voluntary standards to promote more resilient semiconductor supply.

Google looks forward to being part of this process as we expand our presence in chip design and electronics manufacturing and utilize our computing expertise to make information more accessible and useful for everyone.