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Processor Problems: An Economic Analysis of the Ongoing Chip Shortage and International Policy Response

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Introduction

The microchip, also known as an integrated circuit or semiconductor device, is a wonder of engineering, a paragon of power, and an overall exceptional object. One finance scholar even went as far as referring to microchips as “arguably humanity’s most outstanding achievement to date” (Qiao, et al., 2022, p. 2678). Thus, it is difficult to overstate the importance in national and global development of maintaining a steady supply of microchips. Between IBM, Intel, Texas Instruments, and several other key firms, the United States not only created the first microchips in the mid-20th century but also dominated the market for them early on. However, a lack of sufficient funding from both the federal government and the private sector relative to other industrialized nations have led to American production capacity falling drastically (Mondschein, et al., 2022, p. 2). The semiconductor market is at one of its most volatile points in its more than sixty-year history; therefore, I believe an economic analysis of the situation will provide practical yet reasonable policy options along with reassurance in international policy.

The semiconductor industry is unique in a variety of ways that warrant research. Firstly, the necessity of microchips has escalated over time as the world has become digital, meaning that “the decisions that semiconductor companies make will reverberate far beyond their industry to touch the high-tech, consumer goods and automotive companies that depend upon them” (Aboagye, et al., 2022). Unfortunately for the shortage, the number of goods that use semiconductors is simultaneously increasing, meaning that better and better chips will be used in more and more goods. *The Economist* describes the phenomenon in a descriptive yet bleak manner: “[D]emand for these [most powerful chips] is likely to grow as silicon infuses products from thermostats to tractors in the uber-connected 'Internet of Things"” (2021). Furthermore, the current pandemic and Russia-Ukraine conflict have created such instability and insecure expectations that producers are unsure of the optimal quantity supplied they should produce, resulting in debates over inventory management. *The tricky restructuring of global supply chains* recognizes that some firms are employing precautionary stockpiling (2022), while others still defend the efficient yet risky just-in-time management strategy (Sheffi, 2021).

Due to the contemporary nature and volatile position amidst the ongoing geopolitical, social, and industrial conflicts which are subject to change at any and all times, my work is not without flaws. With that said, the monumental value of microchips warrants research, especially with the risk of prolonged shortages and absence of domestic production. While there are a myriad of articles on this topic, the vast majority of them are in popular media productions with a lack of source citation. The smaller sample size of articles that *are* in scholarly formats are found almost entirely in engineering or business contexts. Therefore, I believe a macroeconomic paper on this topic will not only be fresh, but also inspirational to a new audience.

Literature Review

In order to contextualize current policy debates, background on international production of microelectronics will be beneficial. Mondschein, et al. provide context on East Asian market command due in part to disparities in government subsidies of the industry (2022). It points to quick product cycles and high initial investment as reasons that have dissuaded Americans from investing in this sector for decades. The article also highlights the high dependence on few firms such as the Taiwan Semiconductor Manufacturing Corporation (TSMC) prompting other countries to shift to domestic production or reduce volatility of supply chains. The initial background in Mondschein's work closely parallels the 'tidbits' provided in Kshetri, et al.'s work (2021), though Mondschein, et al. fail to recognize the reliance of American *fabless* (fabrication-less) firms on Asian *foundry* firms (those capable of fabrication).

In addition to background on microelectronics themselves, the chronology of the chip shortage will bring greater understanding of the conflicts and guide future policy decisions. Wu, et al. affirm that the automotive industry was the first to be affected by the chip shortage in late 2020 initially due to home isolation orders causing decreased demand for automobiles and increased demand for personal electronics (2021). This caused a supply shift that greatly focused on these types of chips, which remains today, and the decreased supply of chips used in automobiles helps explain why the car market is currently inflated. Personal transportation is not the only industry hit early on: Sheffi centers on the issues that both created and continue to prolong supply chain disruptions in automotive and freight transportation markets such as misguided policy, consumer and producer panic (2021). Sheffi outlines how both expansionary fiscal and monetary policy under the Biden-Powell administration, despite achieving their goals of reducing unemployment and encouraging investment to an extent, ended up furthering an increase in consumer demand.

So why exactly did we end up with a shortage in chips and why is it persisting to this day? The scholarly literature identifies three main reasons: fluctuating consumer demand, oligopolistic market structure, and geographic concentration of both capital and firms. Firstly, Maria Grazia Attinasi, et al. highlight the transitions in demand for automobiles and computer electronics over time (2021). As home isolation protocol began, demand fell for automobiles but spiked for home electronics. However, demand for vehicles rose rapidly once the lockdown was lifted, allowing students and workers alike to once again commute. Prolonged uncertainty due to new COVID variants and political mandates continue to puzzle semiconductors manufacturers on the optimal quantity supplied.

While rising demand for semiconductors across industries may appear enticing for new entrants to the market, Carter Young notes that high fixed costs and rapid product cycles have ultimately created an oligopolistic structure in the semiconductor market (2021). Mondschein, et al. note that risks for new firms associated with modifying research and development (R&D) or manufacturing processes only compound the staggering barriers to entry. Finally, numerous articles reference the concentration of market power and its riskiness. Taiwan and South Korea's economies produce **all** of the world's semiconductors sized 9 nm or smaller, while their two dominant companies of TSMC and Samsung, respectively, have a combined foundry market share of 73% ("Where's the Silicon?"). Several East Asian nations attempt to alleviate the exhaustive capital through assistive fiscal policy, with Taiwanese and South Korean governments subsidizing up to 30% of the cost of a new foundry. Chinese governments are even more generous, covering up to 40% of said expenses ("Securing the Microeconomics Supply Chain"). In doing so, these nations help maintain control over an industry that is extremely difficult to enter into.

Due to East Asian countries holding strong semiconductor market power, the United States has recently had immense fiscal policy initiatives to expand its domestic production in order to maintain relevance in the industry. Shephardson identified the reapproval of S.1260 on March 28th, 2022 in a Reuters report: this $52 billion dollar bill mainly seeks to subsidize semiconductor manufacturing in the US, fund additional research in the area, and reintroduce well-paid jobs to the country (2022). Young notes that this bill received support across both major political parties despite the United States' history of laissez-faire policies outside of global financial crises. Moore affirms that several examples of the companies building fabs are indeed American, such as the well-known Intel and its $20 billion planned location near Columbus, Ohio (2022). Heilweil recognizes state governments that are also collaborating in the effort; for example, NY Governor Kathy Hochul joined hundreds in the May 2nd tour of Wolfspeed's new fab outside of Utica in upstate New York (2022). While neither individual fab aims to end the crisis, the broader effort seeks to alleviate the current situation while preventing future conflicts.

American firms can also shift their industrial strategy in order to mitigate the harmful effects of the chip shortage. As more and more products go digital, producers attempt to fit increasingly powerful chips in smaller sizes and architectural structures. This ubiquity of silicon is often referred to as "the Internet of things", and as everything from automobiles to home furnishings become digitized, demand for the most modern chips will skyrocket ("Chipmaking is being redesigned: Effects will be far-reaching"). Because of these shifts, Aboagye, et al. of the World Economic Forum recommend that producers invest more of their resources in R&D in fields such as the Internet of things and artificial intelligence. The authors also noted the effectiveness of *mergers and acquisitions* (M&A) in the industry in order to diversify their output and reach more consumers (2022). Mehta, et al. writes that Broadcom Inc., a large semiconductor manufacturing company, recently purchased VMware, Inc., a cloud computing firm, in May of 2022 for around $61 billion: this merger exemplifies an expansion of Broadcom's consumer pool and sectors of production (2022).

The main section of this paper will analyze the industry and its shortage in three ways. Firstly, it will feature a comprehensive overview of its market structure, using terminology from the industry itself and drawing characteristics from those terms that line up with economics. Secondly, it will contextualize the industry and highlight its integral position in the broader macroeconomy while creating policy recommendations based on this position. Finally, it will include Federal Reserve Economic Data (FRED) graphs in order to qualify those policy recommendations and draw conclusions of how the shortage progressed or declined chronologically.

Body Paragraphs

Market Structure

Of the four principal market structures in Economics (perfect competition, monopoly, oligopoly, and monopolistic competition), the semiconductor industry corresponds most closely to an oligopoly. Like an oligarchy, where a few rulers have power, an *oligopoly* is a structure in which few firms compete. This size contrasts the microchip industry with both monopolistic industries (one seller) and perfect competition (many, many sellers). It also leaves the type of product ambiguous, since monopolistic competition implies a differentiated product depending on which firm in the industry sells it. However, the microchip industry has some elements of monopolistic competition since some firms rely on the differentiation of their product to maintain market power.

The semiconductor industry's limited number of firms and unique characteristics have created its oligopolistic market structure. Rapid product cycles and low returns serve as deterrents for new firms to enter the market (Young, 2022, p. 3), while all firms must bear high capital investment (Mondschein, et al., 2022, p. 1). In Economics, we categorize these traits as part of *fixed costs*, which are independent of how much quantity a firm produces. This means that from the smallest startup to the largest conglomerate, microchip producers must overcome the enormous costs of beginning their production: in dollar values, a minimum of $10 billion for a fabrication plant (Kshetri, et al., 2021) and up to $20 billion for variants using the more advanced 3 nanometer architecture (Mondschein, et al., 2022, p. 2). Combined with expensive research and development (R&D), the semiconductor industry's costly traits create *barriers to entry* that discourage new firms from joining, confirming its status as an oligopoly.

Although the industry has comparatively few firms when compared to those in perfect competition, individual semiconductor producers vary by the model they use to produce and source their product. The more prominent of the two is the foundry-fabless model, which as the name suggests is divided into two main parts. Foundry firms use expensive, cutting-edge technology in fabrication plants (or "fabs" for short) to produce physical microchips. Fabless firms, which do not own or operate fabs, instead devote resources into the design of the chips rather than their creation (Qiao, et al., 2022, p. 2678). Since they do not require much capital, fabless firms not only have lower fixed costs, but also do not require the government subsidies that foundry firms do (Kshetri, et al., 2021). Nonetheless, both foundry and fabless firms face high variable costs due to ever-changing product cycles as technology advances (Mondschein, et al., 2022, p. 1). And in order to stay competitive or gain the upper hand, firms must themselves invest increasingly in research and development, or R&D (Qiao, et al., 2022, p. 2678), which further drives up variable costs.

In spite of the costly burdens, the fabless-foundry model remains extremely popular due to the lower capital costs for fabless firms and the ability to outsource stages of production across the globe. Foundry firms are largely found in East Asia due to the incentives offered by their governments. Indeed, "100% of the world's highly advanced logic semiconductor (smaller than 10 nm) manufacturing capacity is in two Asian economies: Taiwan, 92%, and South Korea, 8%" (Kshetri, et al., 2021). Fabless firms, on the other hand, are found in a variety of industrialized economies worldwide, including more free-market economies such as the United States where federal government subsidies are rare and investment has been historically low (Mondschein, et al., 2022, p. 2-9). In addition, both foundry and fabless firms decrease variable costs through specialization (Qiao, et al., 2022, p. 2679) in stark contrast to the other prevalent semiconductor manufacturing model.

While the foundry-fabless model is the most common in microchip production, the integrated device manufacturer (or *IDM*) model has continued its historic commonality even in the 21st century. The IDM model involves a single firm handling all stages of production in-house; that is, the firm does not outsource any of the steps involved in making or testing semiconductors to third parties. Firms that utilize this model include Texas Instruments and Intel (Qiao, et al., 2022, p. 2678). Similarly to the foundries in the previous model, IDMs have a large fixed cost which creates a barrier to entry. Despite this, *The Tricky Restructuring of Global Supply Chains* reveals that governments across the globe are pushing for autonomy in the semiconductor industry (2022), which in economics translates to *vertical integration*. A firm vertically integrates when it creates or obtains all stages of its production, which parallels the IDM model. Even with normalcy in public health, firms can enjoy many economic advantages with vertical integration.

Vertically integrated firms have four main economic advantages: complete information, aligned interests, monopolistically competitive elements, and economies of scale. Puget Sound's own Professor Andrew Monaco recognizes that "[m]any economic applications are plagued by problems of *incomplete information*, where one party in an interaction has information another party does not" (Monaco, 2022, p. 121). Vertically integrated firms like IDMs remove this issue since the stages of production are all contained within one company, meaning that no single firm holds an information advantage over another. In addition, since information is equal, no members of the firm hold errant incentives surrounding what to do with that information, avoiding the common problem of *misaligned interests.* The other two advantages relate more to the structure itself rather than the members of it. IDMs in the semiconductor industry create unique products, meaning that they can influence the price of their product: economists refer to this control over prices as *market power*. This market power mirrors that of monopolistically competitive firms, and encourages firms to strategically choose what level of output they will produce. To increase quantity demanded and cover their large fixed costs, most IDMs produce a substantial amount of output. This large quantity produced in turn reduces variable costs in a concept known as *economies of scale.*

The impacts of the ongoing pandemic differ on these two major models of semiconductor production. IDMs, coinciding with domestic production, dominated the market in the late 20th century with the rise of semiconductors. The market then shifted toward fabless-foundry as globalization expanded during the 21st century and outsourcing became efficient through *cost-minimization* (Qiao, et al., 2022, p. 2678-2679), one of the primary objectives of a firm from an economic perspective. In a pandemic-ridden world, however, the top concern of most firms became production independent of other countries whose economies may be closed or limited. This included microchip firms using *both* models, as even IDMs such as Intel have firms across multiple continents (Mondschein, et al., 2022, p. 12).

A principal reason for the difference in these impacts are the aforementioned difference in fixed and variable costs. Qiao, et al. argue that IDMs "take advantage of vertical integration to forge ahead with innovative and expensive technologies needed to iterate chips to new levels", referring to R&D, a variable cost (2022, p. 2). IDMs also fare better due to their integrated business structure and lower *transaction costs*, or the costs associated with facilitating sales. With lower variable costs, firm profit and stability grow as they sell more products. Since one

IDM creates these new chips with relative ease, output increases, leading Qiao, et al. to conclude increased efficiency (2022, p. 1). Meanwhile, disparities between East Asian foundries and global fabless firms are a key factor in the chip shortage and remain a high-risk area for supply chains.

Upstream and Downstream Industries in the Aggregate Model

Much of the scholarly literature recognizes that the microchip industry is crucial to the economy due to its use in national defense, personal electronics, and a myriad of other industries (Wu, et al., 2021, p. 1-2). Attinasi, et al. define it as "a crucial upstream supplier [with] any disruptions… likely to extend to many other sectors in the economy" (2021). The semiconductor industry's categorization as *upstream* refers to its role in sourcing key components to other industries. These other sectors, such as transportation and appliances, are called *downstream* or *runoffs* due to this dependence (Young, 2021, p. 17). Wu, et al. argue that because the exchange between these two has been broken by COVID, automotive manufacturers across the globe have closed production lines (2021, p. 1-3). If these trends continue, the global economy will suffer drastically.

Together, the microchip industry and its dozens of runoffs take up such a large part of our increasingly digital macroeconomy that they fit poorly into microeconomic models of individual firm theory and consumer choice. Instead, decisions by firms, consumers, and governments more accurately parallel big-picture models, as the combined influence of these two industries have had profound impacts on macroeconomic variables such as inflation and employment (Young, 2021, p. 1). The scholarly literature has supported this reasoning in the past: in 2012, JPMorgan estimated that "sales of Apple's iPhone 5 could add as much as half a percentage point to US 4th quarter GDP growth" (di Giovanni, et al., 2012). Bartelsman, et al. even found that sectoral multi-factor productivity (MFP) varied widely, creating profound changes on aggregate MFP and thus aggregate supply (2005, p. 3). Therefore, I will use the aggregate supply/aggregate demand model of macroeconomic theory in order to help identify changes in output, inflation, and the future of globalization derived from the semiconductor industry. In addition, I will propose corresponding monetary and industrial policy recommendations based in part on the decisions made by microchip-producing firms in order to curb inflation and counter harmful supply shocks.

Over the past two years, the international macroeconomy has gone through fluctuations in supply and demand due to changing pandemic protocols. Throughout most of 2020, initial stay-at-home orders created both supply and demand shocks. In contrast to other industries such as healthcare, the microchip industry actually had a positive *aggregate demand* shock due to the prevalence of personal electronics in order to support distanced learning and work (Young, 2021, p. 2-3). Attinasi, et al. note that in mid-2020, this increase in demand outweighed the decreased activity in the automotive market; however, as in-person education and work later reopened, demand for vehicles ballooned with suppliers unable to keep up. This increase in *aggregate demand*, along with several destructive natural disasters, only worsened the shortage (2021). Finally, in contemporary times, inflation across industries and skyrocketing housing prices (as remote work continues for thousands of employees) create further macroeconomic difficulties that complicate addressing the chip shortage, as lowering interest rates to encourage investment would worsen said inflation.

Counter-inflationary measures by the Federal Reserve coupled with domestic investment and merger strategies from firms will not only aid the current shortage, but also lessen the blow of future instances. Young argues that the Fed has little influence over negative supply shocks that Chairman Powell categorized as contributing to inflation, but rather “the direct effects of those shortages” (2021, p. 2-3). With this in mind, the Fed increased its interest rate by 0.75% in June 2022 in order to curb inflation, choosing to address the short-run drawbacks rather than let the economy adjust independently in the long run. While this increases the costs of borrowing, which theoretically should slow economic growth, a diverse and relatively strong job market helps reinforce this decision. The U.S. federal government has also seeked to address the shortage: the Biden administration’s infrastructure plan and March 2022 subsidy bill both seek to maintain or expand production levels and decrease dependence on other nations (Shephardson, 2022).

Long-run uncertainty for firms in the industry creates conflicts in addressing the shortage through fiscal policy. Current counter-inflationary measures by the Fed (increased interest rates) are expected to decrease long-run economic growth: this phenomenon further adds to the barriers to entry already faced by microchip producers. Furthermore, if firms are incentivized to onshore production in the United States by the microchip bill, the shift to solely domestic production and pressures to handle pandemic-induced disruptions encourage the more capital-intensive IDM market structure (Qiao, et al., 2022, p. 2678). Data on the losses incurred by firms and the higher prices endured by consumers is hard to come by amid such a recent pandemic; governments will have to weigh the costs suffered by individuals with those paid in subsidies in order to create optimal solutions to further market disturbances.

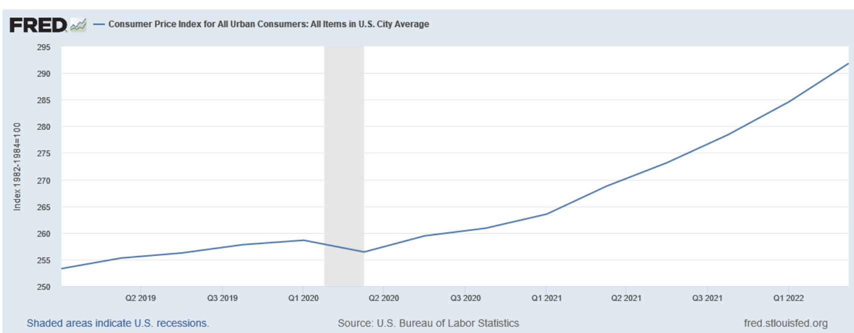
Finally, consumers and producers alike can change their practices to lessen the consequences of the chip shortage. Indeed, the problematic nature of customers “hoarding” certain goods during the pandemic such as toilet paper worsened the shortage. Firms have also engaged in over-ordering input parts, fearing shortages of their own despite essentially creating one since they stockpiled “even though suppliers could not meet their demands” (Sheffi, 2021). This fear is part of the economic concept of *irrational choice*, where consumers lack complete information and therefore make an increasing number of decisions based on “what-if” scenarios. The World Economic Forum advises agility in firm decisions, which manifests in mergers and acquisitions (M&A) and shifting investment to rapid-growth sectors like artificial intelligence (Aboagye, et al., 2022). If American firms consolidate in this manner, it will also increase domestic production, while adaptable investment will better address unpredictable consumer demand.

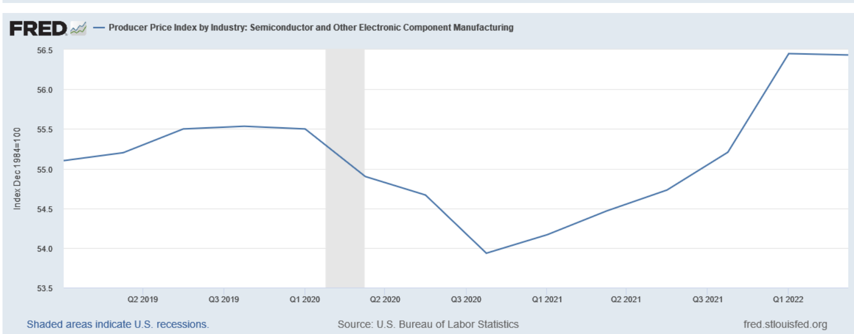
The pandemic-heightened chip shortage defied expectations of traditional inflationary expectations found in macroeconomic theory due to unprecedented public health conditions and concentrated consumption. According to macroeconomic theory, short-run inflation is cyclical in nature. Inflation is caused by firms increasing prices, which decreases quantity demanded by consumers. As firms sell less, they fire workers, causing the unemployed to spend less on non-essential goods. This decrease in consumption brings down inflation and puts this cycle back to its starting point.

The issue during the pandemic arose after the inflation: with a combination of stimulus checks from the government, low interest rates, and concentrated consumption, consumers did *not* decrease quantity demanded of most goods despite an increase in price. Some workers were indeed fired, but not due to the inverse relationship illustrated in the model between consumption and unemployment. Rather, home isolation orders and input shortages prompted firms to lay some workers off as factories themselves were shut down. Because of these complications, inflation never fell, helping to explain where it is today and why the Fed has made historic interest rate increases.

Macroeconomic Analysis and Policy Recommendations

Since the microchip industry is so prevalent, and since consumption was limited to such a narrow number of sectors during the early pandemic, a shortage in this industry and its runoffs had massive effects on the macroeconomic variables of inflation and real GDP. *Inflation* is defined as a percentage change in the price level. In traditional short-run macroeconomic theory, inflation is related to two variables: the money supply (a *direct* relationship) and real GDP (an *inverse* relationship); that is, inflation should increase when the money supply increases and/or real GDP decreases. Yet since the global financial crisis of 2008-2009, the Fed has pumped enormous amounts of money into the economy to stimulate demand with inflation hovering consistently around 2%. This helps to disprove the validity of the first relationship in contemporary economics, though the connection remains with *real GDP*, defined as the value of all final goods and services produced in an economy.





CPI (above) and PPI for semiconductors and other electronic equipment (below) since Jan. 2019 using quarterly frequency and average aggregation method.

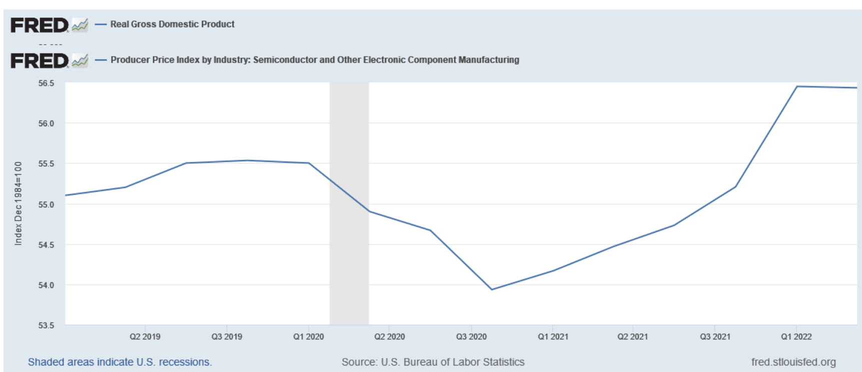
I will start by comparing the Consumer Price Index, or CPI, of all urban goods with PPI of semiconductors since both can be measured quarterly. When comparing it to the price of semiconductors and related goods, we see strong correlation in two time periods: the recessionary section (early 2020) featuring falling prices in both areas and the expansionary section (all of 2021) showing strong price growth. Semiconductor prices actually kept falling until the third quarter of 2020, likely because the tech sector struggled to expand further after such a boom earlier on during that year. Or, as Young puts it: "Most companies in the industry did well throughout the beginning of the pandemic… Now that the economy is slowly recovering, analysts expect information technology companies will be unable to match last year's high growth" (2021).

Notice how rises or falls tend to occur first in the CPI chart and then show up later in the Producer Price Index, or PPI. This shows that the semiconductor industry lags behind the total changes in price. In terms of policy, this indicates that if we manage inflation consistently through monetary policy outside of money supply changes (such as the federal funds rates and the discount rate), we can also manage its corresponding expectations in order to reduce shocks in crucial industries such as the semiconductor sector and its runoffs. As with most economic decisions, however, there is a drawback: higher interest rates that tend to reduce inflation also reduce growth, which may seriously hamper our country or global economy in a time featuring such massive digitalization.

While the FRED data on the price of microchips does not perfectly match up with real GDP, some valuable conclusions can be drawn between the two variables. Firstly, the price of microchips fell together with GDP starting in quarter 1 of 2020 in the early days of the pandemic. The falling prices of microchips in this segment matches up with Wu, et al.'s proposal of increased chip production used in personal electronics (2021, p. 2-3). Secondly, and perhaps most importantly, both real GDP and the price of microchips increased throughout all quarters of 2021. This makes sense from a supply standpoint since many sectors reopened, causing increased production and input demand for microchips in runoff industries, with perhaps the most notorious example being automobiles. Combined with lagging supply constraints due to the pandemic, supply chain issues, and market structure, the semiconductor shortage has had lasting impacts on real GDP.

Real GDP (above) and PPI for semiconductors and other electronic equipment (below) since Jan. 2019 using quarterly frequency and average aggregation method.

Once again, shortages occur where quantity demanded exceeds quantity supplied at a



certain price point. As seen in both basic economic theory and this data, shortages incentivize producers to drive up prices, hoping that quantity supplied will increase and quantity demanded will decrease. Along with supply-side motives, demand (and price) for digital goods grew due to thousands of service industries shutting down, the government providing rounds of stimulus checks, and remote work enabling new living and working arrangements. These increases in prices are reflected in both the above charts of CPI and semiconductor PPI, which Young argues has a specific impact on the poor health of the macroeconomy including its key variables (2021,

p. 1). While this relationship is not entirely causal, the vital microchip industry combined with its runoffs are having lucid, substantial effects on inflation and the broader macroeconomy.

Conclusions and Acknowledgements

We can draw multiple conclusions from the shortage, varying from monetary and industrial policy to the relationship between macroeconomic variables. In monetary policy, we've seen how money supply and inflation are no longer tied together ever since the United States has been steadily increasing the amount of money in circulation after the global financial crisis of 2008-2009. In its place, alternative methods of regulating inflation, such as interest rate management, have become much more popular in recent years. With that said, increasing interest rates in order to limit inflation will also decrease growth since the cost of borrowing for new entrants will increase. Since the industry has already taken the form of an oligopolistic market structure, further disincentivizing borrowing may dispel domestic investment and creation of new fabrication plants, which would make our stronghold in international competition even weaker. Therefore, managing price levels along with industrial policy that incentivizes domestic factory creation and entry is strongly recommended alongside monetary actions.

We can also draw inferences from the big-picture variables of CPI of all city items and real GDP when comparing them with the more small-scale PPI for just semiconductors and related electronic components. Though some similarities exist, both in quarter 1 of 2020 and all of 2021, the most important area for analysis is quarters 2-4, where the two trends diverge. During this time period, PPI for semiconductors decreased, while CPI for city items increased. There are several factors that may have contributed to this divide, with the most likely one being the increased semiconductor production for personal electronics, which would create a positive supply shock that would decrease the price of semiconductors. This phenomenon occurred as resources were transferred from automotive production in the wake of home isolation orders. However, decreased demand from struggling runoff industries such as public transportation or entertainment may have also contributed to these price drops. The increased production in personal electronics came at the expense of transportation, which when combined with the later demand spike in automotive markets strongly accelerated the shortage. These types of unpredictable supply fluctuations are a clear incentive to manage supply chains through industrial policy domestically and perhaps internationally.

As I alluded to in the introduction of this work, my findings are somewhat tentative. They are dependent on the current state of international and domestic policy alike, foreign relations, and the state of the pandemic, which are themselves subject to rapid change. With that said, I assert that these qualifications do not diminish the value of a macroeconomic paper on this subject, but rather contextualize it. In addition, they open up the possibility for more fascinating work to be done in the future. For example: what industrial strategies will East Asian countries that already hold dominant market power use to maintain it? What incentives are most compelling to firms in this industry to create fabrication plants or IDM firms in a specific country? What are the environmental impacts associated with our continued dependence on microchips and can we conduct an economic analysis on this dependence that leads us toward a greener future? I implore readers and researchers alike to explore these questions and others in order to better understand the microchip's role in economics today.

Lastly, I would like to thank several individuals and institutions for their support and prominent roles in my work. Firstly, my faculty advisor Garrett Milam for his continuous help and recommendations throughout this summer. Secondly, program manager Elize Hellam for organizing Zoom meetings, providing resources, and offering frequent answers to any questions I came across. Thirdly, social sciences librarian Andrea Klyn for her assistance over email and provision of library resources. And last but certainly not least, the University of Puget Sound and its Summer Research Program for providing the grant for this research. I am extremely grateful to all listed above and proud to have worked with them.

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