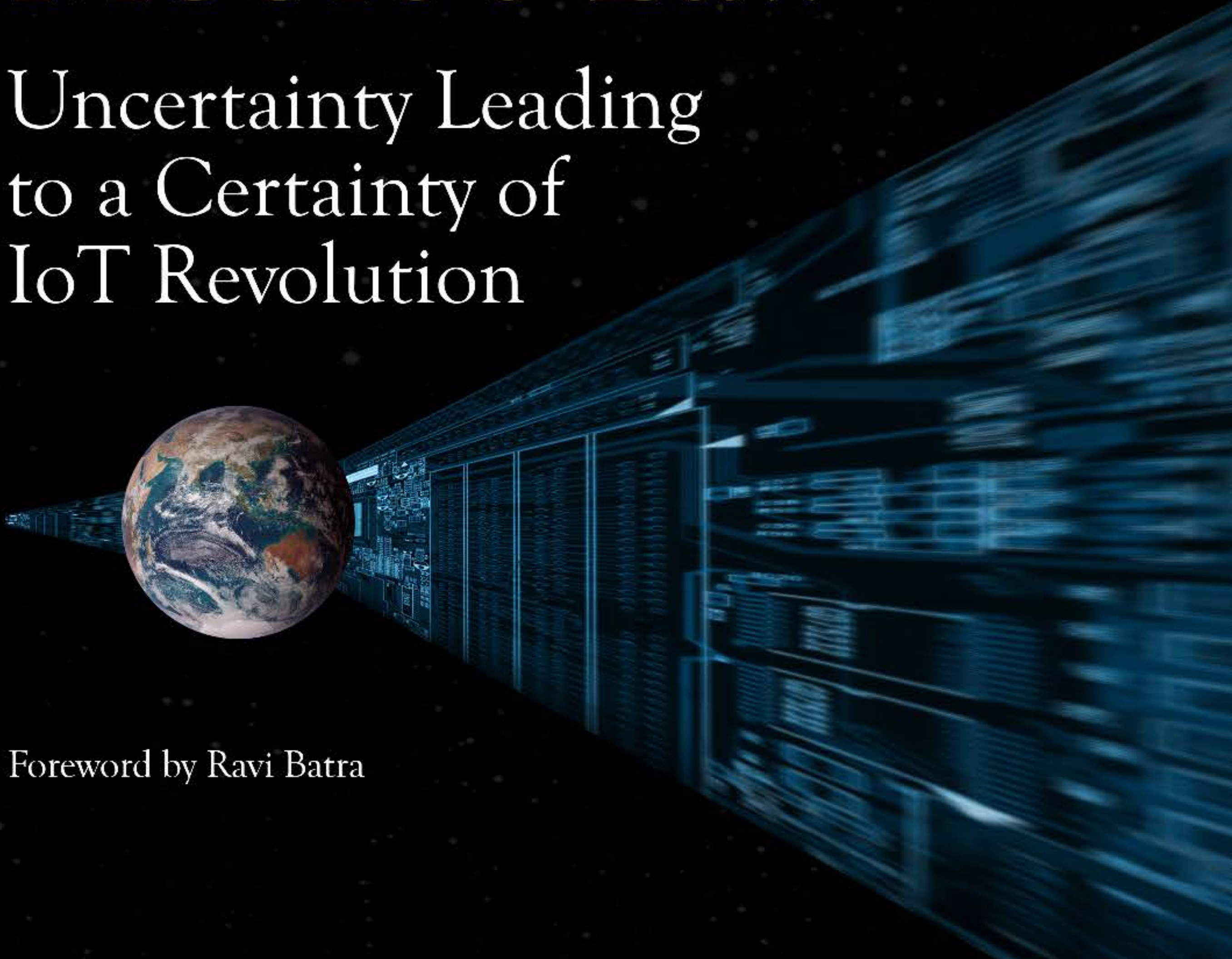
APEK MULAY

SUSTAINING Moore's Law

Uncertainty Leading to a Certainty of IoT Revolution



Foreword by Ravi Batra

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Mulay's Consultancy Services

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ABSTRACT

In 1965, Intel co-founder Gordon Moore, in "Cramming more components onto Integrated Circuits" in *Electronics Magazine* (April 19, 1965), made the observation that, in the history of computing hardware, the number of transistors on integrated circuits doubles approximately every two years. Since its inception in 1965 until recent times, this law has been used in the semiconductor industry to guide investments for long-term planning as well as to set targets for research and development. These investments have helped in a productive utilization of wealth, which created more employment opportunities for semiconductor industry professionals. In this way, the development of Moore's Law has helped sustain the progress of today's knowledge-based economy.

While Moore's Law has, on one hand, helped drive investments toward technological and economic growth, thereby benefiting the consumers with more powerful electronic gadgets, Moore's Law has indirectly also helped to fuel other innovations in the global economy. However, the Law of diminishing returns is now questioning the sustainability of further evolution of Moore's Law and its ability to sustain the progress of today's knowledge based economy. The lack of liquidity in the global economy is truly bringing the entire industry to a standstill and the dark clouds of an economic depression are hovering over the global economy.

What factors have been ignored by the global semiconductor industry leading to a demise of Moore's Law? Do the existing business models prevalent in the semiconductor industry pose any problems? Have supply chains made that progress unsustainable? In today's globalized world, have businesses been able to sustain national interests while driving the progress of Moore's Law? Could the semiconductor industry help the entire global economy move toward a radiance of the new crimson dawn, beyond the veil of the darkest night by sustaining the progress of Moore's Law?

The entire semiconductor industry is now clamoring for a fresh approach to overcome existing barriers to the progress of Moore's Law, and this book delivers just that. Moore's Law can easily continue for the foreseeable future if the chip manufacturing industry becomes sustainable by having a balanced economy. The sustainable progress of Moore's Law advocates the "heresy" of transforming the current economic orthodoxy of monopoly capitalism into free-market capitalism. The next big thing that everybody is looking forward to after mobile revolution is the "Internet of Things" (IoT) revolution. While some analysts forecast that the IoT market would achieve 5.4 billion connections worldwide by 2020, the poor consumer purchasing power in global economy makes this forecast truly questionable. *Sustaining Moore's Law* presents a blueprint for sustaining the progress of Moore's Law to bring about IoT Revolution in the global economy.

KEYWORDS

global economic crisis, counterfeit electronic components, capitalism and the free market, Moore's Law, mass capitalism, semiconductor industry market trend, Make in India, 450 mm silicon wafers, Internet of Things (IoT)

Contents

Foreword

What is commonly known as Moore's Law is a mystery to most of us, but to those who are engaged in the production and marketing of computers and related products the law is an awe-inspiring discovery made by Gordon Moore as far back as 1965. The law is actually a forecast that processor speeds or a computer's processing power will roughly double every two years. Incredible as it is, the forecast has been fairly accurate over the years.

Moore's Law relates not only to technology but also to the economics of the electronics industry. Moore's forecast suggested that computer costs would fall sharply over the coming decades and that computers would be increasingly used in science as well as R&D activity. Now, Mr. Apek Mulay, an electronics engineer, extends Moore's Law to the workings of macroeconomics. He takes a big leap from the economics of the electronics industry to the economics of a nation.

In a relatively short period, Mr. Mulay has become a prolific writer. His first book, *Mass Capitalism: A Blueprint for Economic Revival*, dealt with the relationship between Moore's Law and macroeconomic policy. Now he has written another volume, *Sustaining Moore's Law: Uncertainty Leading to a Certainty of IoT Revolution*, that extends his earlier analysis to many new areas. It is well known that there is hardly any area of technology left untouched by the law. But it is no longer clear if the law's bold forecast will continue to hold, especially when its validity requires an increasing amount of investment in the computer and semiconductor industry. In other words, experts fear that a well-known rule of economics, the law of diminishing returns, will soon come into play and lower the RoI linked to the upholding of Moore's Law.

In the present work, the author shows how this can be avoided through proper economic policy. This is because, in general, the return on any kind of investment depends on the health of the macro economy, or the basic forces of supply and demand. If a nation's total production is in balance with total demand, goods produced by industries have a ready market and an adequate profit. However, if supply exceeds demand, there is overproduction that leads to a recession and layoffs. In that milieu, the return on investment becomes mediocre and may even be negative. All this only means that proper macroeconomic policy is needed to ensure the profitability of any project.

To my knowledge, Mr. Mulay is the only writer who has made a connection between Moore's Law and macroeconomic policy. The law has played a significant role in the vast computer revolution, but the author argues that without proper economic policies the future validity of this law is at best uncertain. Mr. Mulay's contribution to the economic and technological literature is both monumental and practical. It is an innovative approach that deserves further study and research. It will appeal to those looking for new ideas.

Dr. Ravi Batra
Professor of Economics, Southern Methodist University, Dallas

Preface

In August 2007, Jack K. Steehler wrote a review for David C. Brock's book *Understanding Moore's Law—Four Decades of Innovation* in the *Journal of Chemical Education.* In his review, Jack mentioned that the book does not address a tight definition of Moore's Law. From its original article published by Intel co-founder Gordon Moore, "Cramming more components onto integrated circuits" in *Electronics Magazine* (April 19, 1965) to more recent updates, there has been a discussion focussing on many different aspects of the semiconductor industry and its productivity, rather than focusing on the fundamental definition of Moore's law. Jack believes that, given the wide ranging uses that the general concept has seen in the last 40 years, the lack of a tight focus on one specific formulation of the law is most appropriate.

The capabilities (processing speed, memory capacity, sensors) of many digital electronic devices have been improving at roughly exponential rates and are, thereby, strongly linked to Moore's Law. This exponential technological improvement in electronic devices has dramatically enhanced the impact of digital electronics in nearly every segment of the world economy. Indeed, Moore's Law has been behind the technological advancements and socio-economic developments in the late 20th and early 21st centuries.

Moore's Law has profound implications both for technology and the U.S. national as well as global economies. As long as it can be sustained, we can continue benefiting from the technological innovations and newly advanced consumer electronic goods. While Moore's Law is, on the one hand, a law of physics, many semiconductor industry professionals believe that the economics of manufacturing—specifically, the high costs of investment in shrinking transistor dimensions—will force its premature end. That would be disastrous for the economy: the end of growth for a huge sector and associated sectors that depend upon it.

While Moore's Law progressed predictably on the physical side as transistor dimensions shrank, macroeconomics was completely ignored by American businesses. Over the past 50 years, Moore's Law has been scaling at all costs and ignoring macro-economy. Moore's Law can easily continue for the foreseeable future if the chip manufacturing industry becomes sustainable by having a balanced economy. That will require some major macro-economic reforms for eliminating the gap between supply and demand caused by the gap between wages and productivity. Restoring a free-market economy in the U.S. will not only ensure the progress of high technology and innovation, thereby sustaining the progress of Moore's Law, but will also help the global semiconductor industry progress to 450 mm diameter silicon wafers in order to improve its profitability from mass production.

Macroeconomic reforms have become critical for the progress of Moore's Law as well as for the transition to 450mm diameter silicon wafers to ensure that money does not remain inert and keeps circulating in the economy. This circulation of money is critical to maintaining increasing consumer demand for the latest and greatest electronic products. Without macroeconomic reforms, the progress of Moore's Law seems impossible and the chances of the U.S. economy transitioning from the present great recession into an economic depression seems inevitable. The sustainable progress of Moore's Law advocates the "heresy" of transforming the current economic orthodoxy of monopoly capitalism into free-market capitalism. This solution involves minimal government intervention, but still requires new economic policies and business models that can help revive the U.S. microelectronics industry.

The human race has benefited exceptionally from the Internet revolution. In the last few years, there has been a dip in PC sales and a multifold increase in smartphone sales. With the high number of smartphones connected on networks comes big data as well as mobile traffic, which has also increased almost eightfold in the last few years. Moving forward, the next big thing after the mobile revolution that everybody is looking forward to is the "Internet of Things" (IoT). As the name suggests, it's a network of things, wherein things can be any smart device (like smartphones, smart home thermostats, blood pressure monitors, industrial sensors, network-connected cameras, etc.) that can communicate with other smart devices. While some analysts believe that the IoT market would achieve 5.4 billion connections worldwide by 2020, up from 1.2 billion devices today, the poor consumer purchasing power in the global economy makes this analysis truly questionable.

Sustaining Moore's Law takes the reader through this journey of the progress of Moore's Law and explains how this technological progress has become unsustainable due to the violation of macroeconomic parameters of economy. Along with offering solutions to sustain the progress of Moore's Law, this book also provides a blueprint for a sustainable increase in the profitability of the global semiconductor industry in this age of falling growth by means of transitioning to 450 mm wafers. It also engages with the semiconductor industry thought leaders about the future of the global semiconductor industry and the IoT revolution.

Chapter 1 exposes the reader to the importance of Moore's Law and the resulting human progress. Chapter 2 highlights a feasible path for transitioning from an unsustainable to a sustainable progress of Moore's Law. Chapter 3 helps the reader understand the impacts of semiconductor business models on the national interests of a country. Chapter 4 provides an analysis of the impacts of semiconductor business models on the sustainability of this industry. Chapter 5 deals with the macroeconomic cycles and proposes modifications to existing fabless-foundry business models in the semiconductor industry for the progress of Moore's Law. Chapter 6 forecasts the demise of Moore's Law due to physics rather than economics. Chapter 7 evaluates the importance of a decentralized supply chain in ensuring the sustainability of the IoT revolution.

Chapter 8 offers macroeconomic solutions for transitioning to 450 mm diameter wafers for the semiconductor industry. Chapter 9 provides a detailed analysis of the progress of Moore's Law and offers a sustainable path for advancing this law beyond its 50th anniversary. Chapter 10 talks about the macroeconomics of semiconductor manufacturing in a developing economy like

India's. Chapter 11 offers macroeconomic solutions for ensuring the success of the IoT revolution. Chapter 12 engages with the thought leaders of the fabless semiconductor industry in the U.S. and offers macroeconomic solutions for ensuring the sustainable progress of Moore's Law for the success of the IoT revolution.

Apek Mulay
September 2015

Acknowledgments

I owe my greatest intellectual debt to the great neohumanist *Shrii Prabhat Ranjan Sarkar,* whose ideas about neohumanism and human progress continue to inspire me to do my part for the greater good of humanity. I am very thankful to Morgan & Claypool for bearing the costs of publishing this book. I should also express my gratitude to *Electronics.ca Publications*, Truthout.org, EBN, *Military & Aerospace Electronics, The Economic Times,* LinkedIn, and Semi.org for their permission to let me use my published work in this book. I would also like to extend my thanks to semiconductor industry professionals around the world who continue giving their best for the continued growth of this industry and who benefit mankind with their technological innovations. I would also like to thank Dr. Kris Iniewski for his support in this venture.

Above all, I am thankful to all my family members and friends for their love and support without which it would not have been possible for me to make this achievement.

Apek Mulay
September 2015

CHAPTER 1

Impacts of Moore's Law on Human Progress

1.1 INTRODUCTION

Human beings have been constantly progressing physically and intellectually, overcoming all the obstacles in their path. Human beings continue their endless efforts for progress because to remain stagnant is contrary to human wants. The obstacles in the path of progress have always resulted in clashes and cohesion. Every progression has occurred through these clashes and cohesion. Today, we observe that human beings are racking their brains in the search for new ways to win battles, and therefore their brain cells are also developing. They are devising new ways to preserve past history. After thinking for some time humans devised words as pictures. By looking at the pictures, they remembered what they did a few days ago. This is called pictography. The pictorial script was devised in this way. Even today, China uses a pictorial script—the alphabet in pictures.

Human beings developed all of this out of necessity. The quest to store, retrieve, and process information is one task that makes humans different from other animals. Thus, the human civilization evolved out of its primitive past. No known animal uses tools to store, retrieve, and process information. Moreover, the social and technological progress of the human race can be directly traced to this human attribute.

1.2 THE HUMAN MIND AND DATA STORAGE

Thinking and memorizing are two functions of the human mind. The more the thinking capacity increases, the more the power of memory develops. The nerve cells also change, leading to a corresponding change in the nerve fibers. These changes create a stir and a revolution in the world of thought. No other creature thinks like this—only humans have the power of contemplation. Human literature, art, etc. reflect this sort of contemplation. With the aid of modern science, the people of today do not have to labor quite as hard as our ancestors had to do in order to discover the way to progress further. This endeavor to progress further has made human beings superior beings.

Man's earliest attempts to store, retrieve, and process information date back to prehistoric times when humans first carved images in stone walls. Then in ancient times, Sumerian clay tokens developed as a way to track purchases and assets. By 3000 B.C., this early accounting tool had developed into the first complete system of writing on clay tablets. Ironically, these were the first silicon-based storage technologies and would be abandoned by 2000 B.C., when the Egyptians developed papyrus-based writing materials. It would take almost four millennia before silicon would stage a comeback as the base material, with the main addition being the ability to process stored information. In 105 A.D., a Chinese court official named Ts'ai Lun invented wood-based paper. But it wasn't until Johann Gutenberg invented the movable-type printing press around 1436 that books could be reproduced cost effectively in volume.

1.3 EARLIER FORMS OF STORAGE MECHANISM

The first large book that was published by Johann Gutenberg was the Gutenberg Bible, published in 1456. Something akin to Moore's Law occurred, as Gutenberg went from printing single pages to entire books in 20 years. At the same time, resolution also improved, allowing finer type as well as image storage. Yet, this was primarily a storage mechanism.

It would take at least another 400 years before retrieval would be an issue. In 1876, Melvil Dewey published his classification system that enabled libraries to store and retrieve all the books that were being made by that time. Alan Turing's "Turing Machine," first described in 1936, was the step that would make the transformation from books to computers. So Moore's Law can be seen to have a social significance that reaches back more than five millennia.

1.4 ECONOMIC VALUE OF MOORE'S LAW

The economic value of Moore's Law is also understated, because it has been a powerful deflationary force in the world's macro-economy. Inflation is a measure of price changes without any qualitative change. So, if price per function is declining, it is deflationary. Interestingly, this effect has never been accounted for in the national accounts that measure inflation-adjusted gross domestic product (GDP). The main reason is that, if it were, it would overwhelm all other economic activity. It would also cause productivity to soar far beyond even the most optimistic beliefs. This is easy to show, because we know how many devices have been manufactured over the years and what revenues have been derived from their sales.

A logical way to analyze the economic impact of Moore's Law is price per transistor. The benefits of Moore's Law towards human progress can be traced to the universal value to an end user in the form of transistors. The more the number of transistors on an electronic circuitry, the greater is the functionality of the product the consumers can buy. In this way, the number of transistors translates into system functionality. Therefore, by cramming more transistors on an integrated circuit, it is possible to not only add value to the final product but, by means of mass production, it becomes easy to reduce the costs of production. In this way, Moore's Law has been able to offer greater value to the semiconductor industry by offering a higher value to consumers and reducing costs for manufacturers. In this way, it has contributed to ever new innovations in consumer electronics and provided a profitable business model for the semiconductor industry.

The constancy of this phenomenon is so stunning that even Gordon Moore has questioned its viability. Moore's Law proved to be a predictable business model for the semiconductor manufacturing industry from its inception in 1965 through the end of the millennium, up to today. When Gordon Moore came up with his observation, he understood the economic impacts of the progression in transistor technology nodes. In his assessment, Moore also took into consideration user benefits, technology trends, and the economics of manufacturing. Moore had confidence in the future of the semiconductor industry because it looked predictable. The planning and investing components of the business model were based on Moore's Law, which states that the integration scale of transistors would always rise within a year or two. This would make the existing electronics in the market obsolete, and the faster and cheaper new products that would be introduced with the evolution of transistor technology nodes would help generate greater demand for those products. Economic incentives encourage producers to crowd more and more components on each integrated circuit, which proportionately increases the speed with smaller transistors and proximity of components.

1.5 WHAT DRIVES TECHNOLOGICAL INNOVATIONS

The human psyche demands at different ages drives the technological innovations of that age. In order to overcome physical and psychic problems and inconveniences, the people of a particular era invented and popularized bullock carts for transportation. Later they developed faster horse-drawn carriages. Subsequently, as time passed, public demand also changed. That is why different types of transportation, such as motor cars, aeroplanes, rockets, etc. have been invented at different times. None of these inventions should be condemned. They are all simply designed to meet the demands of different ages.

Conflicts in the physical sphere gradually awaken dormant human potential. Environmental influences also increase the degree of complexity of the human body. The problems of ancient and modern people cannot be considered as identical. To keep pace with the changing problems of life, the human body and mind have gradually become more complicated. The physical structures of ancient humans would have certainly been unfit for solving the problems of today. As the mind becomes more complex, its direct centers, the nerve cells, and its indirect centers, the glands, undergo corresponding biological changes. As the nature of problems change, the human mind responds by making new scientific discoveries and technological innovations. Hence, a steady cultivation of science and technology must go on and such cultivation will never be an impediment to human progress.

1.6 CONCLUSION

The progress of Moore's Law has made significant contributions to economic and human advancement. There has been a rapid growth in technological progress because of the predictable business model based on the continued progress of Moore's Law, which ensures steady profitability and productivity. The continued progress of humanity depends on the scientific and technological progress of Moore's Law for the benefit of humanity.

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CHAPTER 2

From an Unsustainable to a Sustainable Progress of Moore's Law

2.1 INTRODUCTION

The price or cost per transistor has been used as one metric of measuring the economic impacts of Moore's Law. The cost per transistor is an exceptionally good metric because it can easily be translated into a universal measure of value to a user: transistors. Transistors are a good measure because in economic terms they translate directly into system functionality. The more the number of transistors, the greater the functionality of electronic products that consumers can buy. Hence, a lower cost per transistor translates into a higher buying power for the consumer. Hence, the goal of the progress of Moore's Law is essentially growth in consumer purchasing power for the end user.

2.2 UNSUSTAINABLE PROGRESS OF MOORE'S LAW–A PROGRESS OF "SUPPLY-SIDE ECONOMICS"

In recent times, there is a growing concern about the state of the global semiconductor ecosystem. The entire economic structure that was supposed to lead to next-generation manufacturing technologies, like 450 mm wafers, extreme ultraviolet (EUV) lithography, and transistor technology nodes below 14 nm CMOS, is on the verge of coming apart due to poor consumer demand for electronic goods. Whether it is transition to 450 mm wafers, higher power requirements for EUV lithography, or shrinking transistor dimensions for keeping up with progress of Moore's Law, the problems facing the semiconductor ecosystem are essentially the same—increased manufacturing costs that result in poor RoI threaten our progress.

Whether you take into consideration 450 mm silicon wafers, EUV lithography improvements, or scaling transistor geometries, from an economic standpoint there is one thing that is common to all their respective contributions to the supply of silicon to the economy. While 450 mm silicon wafers would increase the diameter of wafers for mass production to reduce the costs, the increased yield from larger wafer sizes contributes to an increased supply of silicon. When it comes to EUV, no one, including lithography systems maker ASML, has yet demonstrated an EUV tool capable of providing the necessary source power concentrations for sustaining production volumes.

This evolution of EUV lithography would again make a contribution only to the supply of silicon wafers. The relentless progress of Moore's Law, since Gordon Moore made his famous observation in 1965, has essentially been reducing manufacturing costs by scaling geometries, thereby reducing prices for consumers while providing silicon with a higher performance. The progress of Moore's Law has essentially been the progress of supply-side economics. There has been little to no incentive to boost consumer demand in the U.S., as well as global, economy besides luring consumers into an unsustainable debt. The term "supply-side economics" was thought, for some time, to have been coined by journalist Jude Wanniski in 1975, but this term "supply-side" ("supply-side fiscalists") was first used by Herbert Stein, a former economic adviser to President Nixon, in 1976, and only later that year was repeated by Jude Wanniski.

Its use connotes the ideas of economists Robert Mundell and Arthur Laffer. Supply-side economics is likened by critics to "trickle-down economics," a theory that believes money trickles down from the producers to the consumers. Trickle-down economics advocates that producers are job creators in an economy and, hence, it supports giving tax cuts to the producers as a way to boost economic growth so that producers can hire more employees. However, there is a flaw in this approach because, if the producer is not able to sell what he/she has already produced, why would the producer consider hiring more employees (even with an added incentive of tax cuts) if the consumer demand for his product does not increase?

In an interesting article, "Reagan: The Great American Socialist," published on Truthout.org, economist Ravi Batra argues that the supply-side economic policies adopted by Ronald Reagan's economic advisors in 1981 resulted in budget deficits soaring from 2.5% of GDP to more than 6% of GDP, alarming financial markets, sending interest rates sky-high, and culminating in the worst recession since the 1930s. Reagan's supply-side economic policies resulted in the wealthiest facing a 28% tax rate, while those with lower incomes faced a 33% rate. In addition, the bottom rate climbed from 11% to 15%. This is how supply-side economic policies since their inception have increased the income disparity across U.S., as well as global, economy. This is verily why free-market capitalism has been transformed into crony capitalism over the years, which is now bringing this global economy and global semiconductor industry to a standstill due to poor consumer demand resulting from a poor RoIs.

2.3 FREE-MARKET ECONOMY–A PATH TOWARDS SUSTAINABLE PROGRESS OF MOORE'S LAW

We need to implement economic solutions for sustaining the progress of Moore's Law through establishment of a true free-market economy where the real job creators in the economy are not only producers but also consumers. Without a healthy consumer demand for the latest and greatest electronic products, any further investments in the progress of Moore's Law—transitions to 450 mm silicon wafers and EUV lithography improvements—are bound to provide a poor RoIs for the producers.

If free-market economic reforms can usher in a healthy consumer demand for electronic products, then the RoIs for the producers can also be ensured. Hence, we can conclude that the slowing of EUV rollout, halting of 450 mm wafers, and uncertainty in economic demand resulting in poor RoIs beyond 14 nm technology node is essentially a failure of supply-side economics and could not be claimed to be the demise of Moore's Law.

The minimum necessities of human society should be met through a growth in consumer purchasing power in the economy. Semiconductor industry professionals are not only to recognize the importance of higher consumer purchasing power in the economy but should also be actively involved in ushering true free-market economic reforms that guarantee the growth in consumer purchasing power in the economy for the continued progress of Moore's Law. It also becomes a social responsibility to provide individuals with higher purchasing power. When such free-market reforms based on mass capitalism are carried out, there would be special incentives provided to individuals with special abilities. Each and every human being requires clothes, medicine, housing accommodation, proper education, food for proper nourishment, etc. These demands must be fulfilled by means of providing work by creating jobs and not by means of offering any kind of dole.

While free markets ensure that wages catch up with productivity, there should be special amenities provided to intellectuals, scientists, and people performing special services. However, when offering these amenities, it needs to be ensured that the consumer purchasing power of the overall economy also grows, while minimizing the growth of huge disparities in the economy. There will always be a gap between the minimum necessities, which decide the standard of living, and special amenities that are offered to meritorious people. A free-market approach to minimize the gap between minimum necessities and maximum amenities is to raise the consumer purchasing power through a productive use of technology, which would also boost the minimum amenities for all. For example, in a certain country, leaders and intellectuals would require a luxury car, and these should be offered to them because of their profound contribution to the society. But after that endeavor, the buying power of other individuals should also proportionally increase so that they are able to afford to buy at least a motor bike, if not a car.

However, in this process of improving the consumer purchasing power by productive use of technology, it could be noticed that, after some time, the purchasing power of leaders and intellectuals needs to be higher for them to be able to afford an airplane. In that regard, the consumer purchasing power of the rest of economy (excluding the leaders and intellectuals) should also be high enough (to keep economic disparity in check) so that they are be able to afford at least an ordinary car, if not a luxury one. Diversity is the inevitable law of nature. However, if this approach is taken, then it would be possible to raise the standard of living for all citizens in an economy while still rewarding hard work and merit. In fact, this approach would be a sustainable one, as it would ensure that the consumer debt and national debt do not grow due to the growth in consumer purchasing power of the overall economy, thereby minimizing huge economic disparity. Although the gap between minimum necessities deciding the standard of living of citizens and the maximum amenities that are provided to meritorious people will remain unbridged forever, this gap should not exceed the certain limits that have resulted in recessions and depressions in the global economy. In this way, a productive use of technology would increase the consumer purchasing power such that wages will keep track with productivity, thereby sustaining the progress of Moore's Law through growth in consumer purchasing power. One example of productive use of technology over an unproductive use of the same can be explained based on unemployment created due to automation.

Today, many modern economic thinkers blame automation, based on technological progress, as a major cause of job losses. However, technology could be productively utilized in such a way that the manufacturing sector could cut back on work hours while paying workers a high wage due to their high productivity. This is because automation enables a worker to be highly productive through the use of machines to manufacture products. High worker productivity significantly increases the supply of goods to the economy. As a result of this increased productivity, workers would be able to work for a fewer number of hours to achieve their production target. They could use their spare time to pursue higher education, leisure, hobbies, vocational training, etc. In this way it is also possible to minimize, if not eliminate, the problem of high unemployment resulting from automation, while still keeping the supply of goods proportionate to consumer demand, thereby maintaining an economic balance. This is how productive utilization of technology would not lead to a problem of unemployment.

2.4 CONCLUSION

The progress of Moore's Law since its inception has been the evolution of supply-side economics. However, this has resulted in not only an increase in the supply of goods to the economy, but has also resulted in a very poor consumer demand for these goods. For a sustainable progress of Moore's Law, not only the supply but also the demand has to increase proportionally, leading to balanced economic growth.

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CHAPTER 3

Impacts of Semiconductor Business Models on U.S. National Interests

3.1 INTRODUCTION

The business models[1] prevalent in the semiconductor industry have had a profound impact on the progress of Moore's Law. The semiconductor industry has undergone a transformation from Integrated Device Manufacturers (IDMs) business model to Fabless-Foundry business model. The fabless-foundry business model has resulted in increased collaboration between fabless semiconductor companies and their foundries. However, the policies of globalization led to the transformation of the entire U.S. Semiconductor Industry from a few integrated device manufacturers (IDMs) to several fabless small businesses, leading to new innovations in the microelectronics business. Deceptive "free trade" agreements have resulted in not just a transfer of manufacturing technology to China, but also in increased threats of counterfeit electronics entering the U.S. supply chain. This chapter explains how U.S. National security may be impacted by the transfer of U.S. semiconductor manufacturing technology.

3.2 ECONOMIC REFORMS CAN DEFEND AGAINST COUNTERFEIT ICS

In addition to nearly $600 billion in trade deficits that have resulted from free-trade policies, the counterfeit electronics entering the United States supply chain from China has become a national security threat for the United States. Initially, the U.S. manufactured all defense-related products at home, while building consumer electronics in China to capitalize on low labor costs of manufacturing. The progression to advanced transistor technology, however, required increasingly large investments on the part of private defense contractors that manufactured semiconductor wafers in the U.S.

Hence, several independent and for-profit defense contractors based in China started making use of Chinese-built ICs for military weapons such as missiles, machine guns, and drones.

[1]The first version of this text appeared in Truthout.org, `http://truth-out.org/speakout/item/22910-transformation-of-us-semiconductor-industry`. Reprinted with permission.

The state-of-the-art infrastructure and technical know-how to make advanced technology products have also been transferred to China. China is now flooding the U.S. defense supply chain with counterfeit ICs. The Government Accountability Office (GAO) claims that 40% of the U.S. Department of Defense's supply chain is undermined by fake or defective parts. It has become very expensive to mitigate the introduction of counterfeits into the U.S. supply chain, and this is cutting into the profits of U.S. defense contractors.

There is no solution for the twin (budget and trade) deficits under the exploitative free trade scenario. The U.S. cannot afford to run year-over-year budget deficits. To protect its sovereignty, it needs to reexamine its internal economic policy, as well as its foreign policy. We need to restore the U.S. manufacturing supply chain to ensure a sustainable economy, eliminate budget and trade deficits, balance consumer demand with supply, and minimize the wealth concentration in the economy in order to ensure more circulation of currency by means of ushering true free-market reforms based on the theory of *Mass Capitalism*.

This would ensure that wages of hard-working Americans catches up with their productivity. It would establish a free-market economy, thereby ensuring that supply and demand rise and fall with minimal government intervention. Additionally, such a system would establish a balanced economy without running any trade and budget deficits.

3.3 UNSUSTAINABLE BUSINESS MODELS OF THE U.S. SEMICONDUCTOR INDUSTRY

The growth of the fabless semiconductor industry in the last two decades—which has resulted in more silicon consumption for the manufacture of handheld mobile devices as compared to traditional PCs—has an important role to play in ongoing mobile revolution. The recent shift in consumer demand for smartphones over PCs has reduced consumer demand for Intel's processors. Intel's decision to enter into the wireless business was late, as fabless businesses like Qualcomm, Broadcom, etc. had developed a competitive edge over Intel due to matured manufacturing processes at external fabs like Taiwan Semiconductor Manufacturing Corporation (TSMC). This forced Intel to outsource the manufacturing of its wireless business unit to Asian fabs like TSMC.

Today, Intel Inc. has three idle fabs in Arizona, Oregon, and Ireland. These idle fabs have exposed the failure of the IDM business model, as idle time often indicates a loss of revenue due to accelerated depreciation of state-of-the-art tools. Intel has been forced to open up its foundry business to offer manufacturing services for fabless companies in the U.S. and Intel Inc. competes in its business with some of these fabless companies for whom it has opened up its manufacturing services. The flaw in the existing fabless business model of U.S. companies lies in U.S. trade policies. "Free trade" policies have enabled Asian fabs to manufacture and export goods back into the U.S. without any kind of import duty. This fabless-foundry business model is a major contributing factor to U.S. trade deficits.

3.4 ADVANTAGES OF AN INDEPENDENT DOMESTIC FOUNDRY TO THE U.S. FABLESS SEMICONDUCTOR INDUSTRY

There are several advantages to the business model whereby U.S. fabless businesses get manufacturing done from an independent domestic foundry. First, the U.S. is running a huge annual trade deficit with countries like China and Japan as a result of sending semiconductor manufacturing to these countries. Hence, when manufacturing gets done domestically, the trade deficits would be eliminated over time. Second, free trade policies with Asian countries like China have also resulted in a distorted supply chain of manufacturing. The centralized supply chain that is followed by U.S.-based MNCs to increase their annual profits has resulted in rising trade deficits, which have resulted in a negative economic growth in U.S. economy for the first quarter 2015 and an economic stagnation in subsequent quarters. However, these "free trade" practices have also resulted in the introduction of counterfeit electronics into the U.S. supply chain and it has become very expensive to mitigate this. Third, by creating more jobs domestically, U.S. unemployment could be trimmed and the government would not have to spend money to pay for the unemployment benefits of laid-off workers.

3.5 UNITED ARAB EMIRATES' (UAE'S) TRACK RECORDS ON TECHNOLOGY RE-EXPORT

The UAE record on preventing re-export of advanced technology, particularly to Iran, has been mixed in the past few years. Taking advantage of geographic proximity and the high volume of Iran-Dubai trade ($10 billion per year), numerous Iranian entities involved in Iran's energy sector have offices in the UAE that are used to try to procure much-needed technology and equipment. The Institute for Science and International Security issued a report in January 2009 entitled "Iranian Entities' Illicit Military Procurement Networks," which asserted that Iran has used UAE companies to obtain technology from U.S. suppliers and that the components obtained have been used to construct improvised explosive devices (IEDs) shipped by Iran to militants in Iraq and Afghanistan. The report also alleged that other UAE companies that were involved in this network included not only Mayrow Electronics, but also Majidco Micro Electronics, Micatic General Trading, and Talinx Electronics, which are headquartered in Iran.

3.6 U.S.–UAE TRADE DEAL

According to the statistics from the U.S. Census Bureau's Foreign Trade Division, the UAE has been the largest market for U.S. exports to the Middle East for four years in a row. In 2012, U.S. firms exported nearly $24.81 billion worth of goods to the UAE. In addition to ongoing free trade talks between the U.S. and UAE, as part of the Gulf Co-operation Council (GCC), the UAE is negotiating with the United States a "GCC-U.S. Framework Agreement on Trade, Economic, Investment, and Technical Cooperation," an umbrella instrument for promoting ties between the two sides in the economic area—essentially a GCC-wide trade and investment framework agreement (TIFA). Since GlobalFoundries Inc. has a 300 mm semiconductor foundry planned in Abu Dhabi in the future, it is obvious that, because UAE's ATIC (Advanced Technology Investment Corporation) owns the GlobalFoundries Fab in Malta, New York; it would use this ownership as a leverage to transfer manufacturing technology from its fab in New York to its upcoming fab in Abu Dhabi. If manufacturing technology does get transferred from the New York fab to the Abu Dhabi fab in the future, Iranian scientists and engineers working in Abu Dhabi could easily get access to this manufacturing technology, due to geographic proximity and the high-volume trade deal between Iran and Dubai. In the past, free trade agreements with China have resulted in the introduction of counterfeit electronics into the U.S. supply chain and ownership of trillions of USD by China in its foreign exchange (forex) reserves.

3.7 CONCLUSION

In order to avoid the transfer of advanced semiconductor manufacturing technology to politically unstable regions of the world like Iran, which have supported radical Islamist and terrorist groups in the Middle East, the U.S. semiconductor industry should have its manufacturing done in a domestic foundry and should not rely on any kind of foreign investments. Therefore, the top notch foundries in the U.S. supporting the fabless semiconductor businesses in the U.S. should find a way to become independent of their foreign investors. If domestic fabs in the U.S. decide to go for an initial public offering (IPO), based on the history of Wall Street when it comes to a capital intensive business, Wall Street investors would pressurize shareholders of these fabs to ship manufacturing abroad due to the high cost of upkeep, maintenance, and upgrade of the wafer fab. The other option is to partner with the US government. A symbiotic partnership with the government would make this foundry business very sustainable.

Only with the backing of the U.S. government can any top-notch wafer fab be at the leading edge of technology development with sustainable capital investments, helping to keep the foundry independent of any foreign capital. Additionally, ownership of a top-notch fab by the U.S. government, as compared to any foreign government, would also give confidence to the U.S. fabless semiconductor industry, due to protected intellectual property for those fabless businesses. To keep this partnership with the U.S. government symbiotic and efficient, the business model of the U.S. semiconductor industry should transform from a globalization-based model to a sustainable business model. One such model will be presented in Section 5.3, "A Three-Tier Business Model for the Semiconductor Industry." This new business model would transform the entire U.S. semiconductor industry and generate high profits for years to come by means of a growth in consumer purchasing power in the economy. Such a transformation of industry would take the US Semiconductor industry to the next level of innovation and financial success.

3.8 REFERENCES

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