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Controversies in Industrial Policy: The Creation of an Explicit U.S Industrial Policy

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by

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ABSTRACT

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As the world continues to globalize, the United States will need to adapt in its industrial policy programs in order to stay competitive. As of today, the United States has no explicit programs to bolster particular industries to increase their performance, but rather does so implicitly through Department of Defense innovations that spill over into the private sector. However, we have seen such explicit policies in countries such as South Korea and China. There has been immense growth in the sectors that have been targeted by these programs, and this has raised questions about if the United States should adopt an explicit industrial policy. This thesis uses previous research on clusters, a new classification for Economic Areas, to inform the development of a U.S tailored industrial policy. This thesis proposes an explicit U.S industrial policy that targets clusters, geographic regions that include multiple related industries, and the results are promising. By using current DOD spending (a measure of U.S industrial policy expenditure), patent registrations as a measure of innovation, R&D expenditure, and value added, an accurate picture of what such a policy *would* do can be extrapolated. This thesis lays the groundwork for future research into this proposal, because as more data become available, statistical analyses will become more robust. If the U.S could capitalize on a program such as the one proposed in this thesis, there could be potential gains in employment, industry growth, and innovation. In addition, the U.S could see decreased income inequality if such a program is employed.

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CHAPTER ONE

INTRODUCTION

A. Background Information

In the last 30 years, trade barriers have fallen dramatically through increased international cooperation. This, and the emergence of multinational commercial juggernauts have spurred a new paradigm shift in international economics. As a result of these changes, however, the question of how to remain competitive in this landscape has arisen in many countries like the United States. For decades, countries such as South Korea, Taiwan, and Japan have surged in economic growth and innovation due to strong industrial policy programs supported by the government. In its essence, industrial policy serves as a tool used by governments to address market failures in order to help strengthen domestic industry. Some examples of industrial policy range from tax breaks for specific firms/industries, import controls, etc, and many countries that have employed these policies have seen great success with such policy. China, for example, has seen dramatic export growth in its solar panels sector due to targeted policies such as tax breaks for solar cell firms. In a world where many countries are reaping the benefits of such policy, the U.S has opted not to follow direct industrial policy. The U.S implicitly does it through the Department of Defense, since certain innovations are made which then spillover to the private sector. While ultimately these spillovers can have some of the same results as more explicit policy, the thesis will explore another, more efficient option.

B. Core Thesis Question

The core question of this thesis is, "if a more efficient form of industrial policy for the United States exists, what would such a policy structure look like and what would its effects be on the economy?" Many scholars agree that industrial policy is an effective tool for creating domestic growth, and this thesis follow a similar sentiment. However, the initial hypothesis is that with a policy model targeting economic clusters rather than industries or firms, there will be a positive relationship between the strength of clusters and governmental spending, with innovation in the United States. In addition, this thesis hypothesizes such a model will be more efficient than the current indirect DOD industrial policy.

C. Implications

Conclusions from this thesis could have some far reaching and important implications for economic policy going forward. The U.S appears to be in a situation currently with low inflation and middling growth overall, and the policy suggestions arising from this thesis could provide a direction for the U.S to go in hopes of spurring real long term growth. This thesis has implications for how the U.S could grow in terms of value added, employment, and innovation.

This thesis proposes a fundamentally different type of industrial policy (one that targets clusters rather than firms or industries), which could open up new doors for growth. As discussed later in the thesis, clusters work through capitalizing on external economies, and therefore investment in those areas could be more efficient than targeting firms or industries. In addition, such a policy could increase employment by getting funding to areas that don’t usually receive it. The more successful a particular cluster becomes, the more employees they will need.

These policies may also have some positive side effects by implicitly addressing income inequality. As it stands now, the U.S is one of the worst countries in the developed world when it comes to income inequality, but in a policy proposal using economic clusters, there are multiple interconnected industries within a single cluster. Therefore, more demographic areas are the targets of industrial policy and therefore may spread job stimulus to more than just one particular industry.

D. Thesis Structure

This thesis will be divided up into four other distinct Chapters (not including this chapter). Chapters two, three, and four are the core components of this thesis, with chapter five being the conclusion of the findings. Chapter two deals with the previous literature on the topic of industrial policy, and will discuss a wide range of scholars. Some scholars propose differing proposals for the optimal industrial policy, but none truly discuss the unique U.S case directly, and what should be done there. Chapter three focuses on analyzing the proposed model of industrial policy, and the rationale for each variable is dissected carefully. For example, Chapter three also discusses the rationale for the “three industry” mode of analysis that this thesis employs (choosing to sample three core industries for the analysis), and why each is included. Chapter four details the data in greater depth, and then proceeds to exhibit the empirical findings. Regression analysis and graphing data will be used in this thesis as the primary sources of evidence. Finally, Chapter four will interpret the results of the empirical data and apply those results to the real world.

CHAPTER TWO

LITERATURE REVIEW

In order to have a complete understanding of the complexities of industrial policy and its variability in different countries, an accurate depiction of the existing research must be detailed. This thesis seeks to answer two core questions: does governmental industrial policy provide a net societal benefit, and, if so, should the proper model for its use be the Chinese model of direct intervention, or the U.S model of indirect, unintentional spillovers from defense department research? Currently, the United States does not have any kind of official industrial policy while some other countries have explicit governmental programs in place. With this in mind, the optimal industrial policy structure in the U.S case will be analyzed. In every one of the following pieces of literature a point of view that adds to the overall picture of the ongoing debate will be produced. On both sides, the data used varies from specific trade data (down to specific goods/parts of goods), to cluster data regarding the external economies of scale and their specific impact on growth.

A. The Theoretical Background

In order to fully understand the relevant literature set forth in this thesis, the theoretical framework revolving around industrial policy must be analyzed. The core economic theory that revolves around this thesis is market failure. Market failure is defined as a situation in which there is an inefficient allocation of goods and services in a given industry, firm, or country. As a result of these market failures, we see the development of externalities, which can be either positive or negative. In the case of industrial policy, there are positive and negative externalities associated with market failure. Examples of these are found throughout the previous literature that this thesis explores. The theoretical justification for industrial policy, however, is that through governmental intervention (through subsidy etc.), the government can capitalize on positive externalities and help level the playing field for the negative ones. In addition, the concept of external economies is closely related to this thesis. External economies develop in situations where you have closely grouped firms in a similar industry, such as we see in Hollywood or Silicon Valley. Because these firms are grouped close together, there are benefits that help lower their costs such as intellectual spillover, resource sharing, etc. As we see later in the thesis, the concept of external economies becomes pivotal in the proposed U.S industrial policy model.

Despite the theoretical arguments for why industrial policy works, there are also some conceptual arguments that allude to some drawbacks of industrial policy. For example, there is a risk of experiencing diminishing returns to scale from investment by government. As we will see later on, Michael Porter discusses the risk of the theoretical "convergence effects" where industrial policy on a the industry/firm level leads to decreasing output from investment.

B. Context to the Chinese Case

Industrial policy has a massive impact on the prices of goods on the international market, because the goal is that by providing governmental support to a domestic industry, firms will be able to lower costs and export more goods more cheaply. This has been the case in China specifically, which has served as a good example of direct governmental intervention in specific industries it wishes to bolster. The most obvious example of this has been in China's solar panel industry. Since 1977, the price of solar cells has fallen from $76.67/watt all the way down to $0.49/watt in 2016. This dramatic decrease is in no small part due to the industrial policy employed by China, which Groba and Cao discuss extensively. For the past 15 years, China has steadily been introducing new policy that would help the solar sector. For example, in 2001/2003 the Chinese Government passed legislation that implemented reduced value added taxation for renewable energy such as solar panels. Since then, "Chinese solar PV exports have increased by a factor of 26, reaching approximately USD 32 billion in 2010" (2015, p 248) Groba and Cao use a Gravity Model for their empirical research to determine what the impact governmental policies had on R&D growth and export growth. They use "energy generated" from solar panels in China to determine "a high demand of, and thus a large market for" alternative energy. (2015 pp 256-258) They find that, when controlling for dummy variables meant to indicate when policy programs that include tax breaks, financial stimulus, etc went into effect, there was clear positive relationship between such policies and export growth.

C. Proponents of Industrial Policy

Some scholars have outlined significant economic and empirical justification for governmental support. For example, Doh and Kim (2014) make the case for government financial support programs by using the example of South Korea. South Korea has become an economic juggernaut in the last 40 years. Its GDP per capita has gone from roughly $875 in 1976 to almost $30,000 in 2016. This growth is in no small part due to their aggressive industrial policy model. In the early 1960's South Korea outlined a plan for labor-intensive manufacturing job support, and for rapid technological growth. Since then, they have had growth in job creation, company operating profit, and total revenue by many South Korean companies, especially ICT firms. In setting up their analysis, Doh and Kim note that specific examples of government strategy for inducing growth has been, public investment in regional industries, and more specifically financial support for technological growth. They propose that particularly in Small-Medium Enterprises, there is a problem due to crowding out by larger corporations. This, they hypothesize is where governmental investment can come into play. The financial investment into these smaller industries can help them overcome some of the pressures from larger players (in particular it allows them to obtain the resources they need) in order to innovate either with a breakthrough or "incremental innovation."(2014, 9-10) In particular, they look at the Korean "Technology Development Assistance Fund" or TDAF, in order to gauge the growth in financial assistance in this sector. With this data (along with other variables such as firm age, firm size, R&D expenditures, and patent filings), they continued to run regression analysis and determined a number of correlations. For example, one revelation from this study was that expenditures from the TDAF are directly correlated with new patent/design registrations in small-medium firms. They also found that resource levels are positively correlated with R&D expenditures, which thereby implies that governmental support can have a profound impact on the ability for firms to spend more on innovating. (2014, 17) Kim and Doh provide a concrete case study of a country's use of industrial policy (specifically financial investment into technology) to boost firm's ability to innovate.

Another scholar who advocates for government strengthening of the private sector is Montero (2001). He uses the case of Brazil in order to describe what he believes to be a successful use of industrial policy. Montero's model revolves around "horizontal embededness" which he argues is essential to the success of such industrial policy because it involves the government getting involved with private entities on a "close, consultative" (2001, p 52) level. The reason he says this works is because it broadens the role of the government from that of a financier to more of a co-developer in many cases. This, he argues, can help prevent a lot of the hitches that occur in the innovation/production process by sounding off "alarm bells" when progression goals are not being satisfied. In the case of Minas Gerais, Brazil, the technological development of the region was unprecedented under the policy that Montero argues for. In this case, the government would set up small agencies in localities where there could be direct involvement with industry. Not only would there be financial support, but there would also be "official planning by national and subnational firms and agencies" (Montero, 2001, pp 56) For example, in 1972 the government sponsored "company of industrial districts"(CDI) was formed, and it provided logistical, financial, and political support for rising firms in its given region. The result of this, Montero asserts, can be seen best in the automotive sector (specifically the Fiat brand) in Minas Gerais. With the cooperative help of the CDI, which gave land and infrastructure to the industry while also providing political support, and state government, which gave immense amounts of capital to the auto industry. Without such government support, the auto industry in this area would have never been able to compete with other, larger firms that were already established. However, with such industrial policy, Fiat production in the region went from 26% in 1989 to 44.3% in 1995. (2001, pp 66) Government, he asserts, has increasingly been taking on less conventional roles in terms of industrial policy, and that under the "horizontal embededness" model there should be significant gains to innovation output.

One of the strongest positions on this issue comes from Wade (2016). His primary thesis revolves around both proving the existence of something called the "Middle Income Trap"(MIT) in which countries are stuck in low-middle income but cannot break through to what would be considered "high income" due to "forces analogous to gravity" (2016, pp 25-26) such as internal forces (poor institutions/rule of law) and external (orientation within international trade). He goes even further than this and argues that not only is industrial policy helpful, but it is a *necessary* condition for escaping the middle-income trap. In support of his argument, Wade notes that in 2014, a World Bank study concluded that 101 countries were considered middle income, but only 13 could be considered high income. Wade acknowledges that the actual mechanism by which the MIT occurs is hard to identify, but some have suggested poor governance or poor education institutions. (2016, pp 26-27) However, wade's contribution lies in his empirical analysis of the MIT mechanism, and how export structure data can provide clues as to what causes this trap (which then helps explain how to get out of it). He finds that "per capita income is positively correlated with *more diversified* production structure." He also finds that on the international level, multinational firms tend not to create "global" production chains, thus sticking with a few of their trusted suppliers in a few countries which makes it hard for these low-middle income countries to enter the market.

After Wade has identified the causes of the middle income trap, he is safely able to propose the solution to the problem; strong industrial policy. He argues that the decision to engage in industrial policy boils down to one conditional statement “1) the market fails (the necessary condition), and (2) the costs caused by the intervention are less than the costs of leaving the market failure unattended (the sufficient condition)” (2016, pp 33-35). This falls in line with the theoretical framework discussed earlier, because the market failed, thus causing the imbalance leading to the middle income trap, but then industrial policy can be employed in order to counteract negative externalities created by the market failure (provided that the costs of fixing it are less than leaving the market failure alone). Wade criticizes those scholars who say that the government role should simply be to “lead” industry in the right direction, because he says that is a very narrow and limited use of industrial policy. Wade contends that these middle-income countries experience market failures, and that industrial policy *must* be used to capitalize even further than is usually expected under the usual comparative advantage model. He says that simply *leading* countries with industrial policy simply is “stretching”(Wade pp35) comparative advantage rather than breaking free of it completely and going far beyond it. He provides examples of this through Japan, Taiwan, and South Korea post WWII where they experienced changes in comparative advantage *far* outside the bounds that it could be “stretched” to.

D. Theories on Optimal Industrial Policy

Spence (1984) explains a few key policy proposals that could increase domestic industry competitiveness. His ideas are the basis for a lot of the general consensus in international economics regarding proactive trade policy. In his article, he begins by discussing the relative market share disadvantage in certain industries and how that can lead to “cost disadvantages.” For example, in R&D based industries, costs to achieve a certain level of innovation are usually fixed. However, there is a “premium” placed on getting into prime markets that would help pay off the R&D costs, so that forms a cost disadvantage for smaller industries trying to enter an oligopolistic market (1984, pp356-357). In order to counter this, one policy proposal Spence suggests is “blocking of access to a market,” which is a protectionist policy that involves making it easier for domestic competitors to enter the market. For example, if a multinational pharmaceutical firm wanted to sell goods in the U.S but there was a U.S pharmaceutical firm that wanted to break through to the international market, the U.S impose something like import controls to make it easier for the U.S firm to be more competitive. Another policy tool he discusses is government subsidies for specific industries. Spence argues that “subsidies as ‘competitive’ weapons are not really of interest because they simply tip the balance in the (price) equilibrium in such a way that increases net benefits to the *subsidizer*”(1984, pp 359). However, he says that subsidies *can* have a use when the desired effect is to expand the number of competitors in an industry. Subsidies in this case would lower the costs for the country’s firms that are trying to break through, and therefore would make it easier for competitors to grow.

Porter (2012) is an outspoken proponent of industrial policy, and he argues for something called the clusters mechanism in industrial policy. The core premise behind the clusters argument is based around the principle of external economies. As discussed earlier, external economies are when there are groups of firms located in close geographic regions, that they experience falling marginal costs, spillovers, etc (similar to how a large firm would but that would be internal economies of scale). The theoretical framework does support the contention that Porter’s cluster argument is valid, because in the U.S

Clusters are already an area of falling marginal costs and increased productivity, so it makes sense to target these areas for industrial policy (at least from simply a theoretical viewpoint). Porter argues that such a concept can be used to identify regional "clusters" throughout the United States that are linked with high economic performance measured in employment (Porter et al., 2012, pp 4-6). For example, Hollywood moviemaking would be a cluster that experiences external economies of scale, but Porter argues that you can go even deeper to the "industry-region" level, because they experience clustering as well. In the analysis, their "findings thus suggest that the positive impact of clusters on employment growth does not come at the expense of wages, investment, or innovation." In addition, Porter et al. find evidence of innovation growth within these clusters as measured by patent growth (Porter et al, 2012, pp 6-7). In Porter's model, he identifies employment growth as the key left side variable, and a number of right side variables measuring *cluster strength and specialization*. It is also important to note that Porter uses *percentage* changes in his model (logs both sides). He also includes a measure of *industry specialization* to see how employment is impacted on this micro level. Industries within a region are considered to be a size below the clusters that Porter refers to, and these can be subject to convergence effects, which lower employment growth due to diminishing returns to specialization. This variable is measured in the "location quotient" which indicates how "overrepresented" the area's employment in a specific industry is. Cluster strength and specialization are measured using an "employment based location quotient" which measures how concentrated employment is in that industry within that region (Porter et al, 2012, pp. 20-21). After controlling for a number of Economic Area fixed effects, they find that the most substantial employment growth is found at those data points where there is low *industry* level specialization but high cluster specialization. This means that "regional industries that are located in relatively strong clusters experience much higher growth rates in employment," (Porter et al, 2012, pp. 25). In addition, Porter finds a strong, systematic, and positive correlation between cluster strength and wage/patent growth rates. Overall, Porter concludes that there should not be a distinction between "industry specialization and regional diversity," because as he finds, although industries that are highly specialized and not near similar economic areas (clusters) will see diminishing returns, industries that are in clusters with "complementary activity" will see strong growth in wages, innovation, and employment (Porter et al, 2012, pp 34). This research is the foundation on which Porter's paper on industrial policy is built, because he uses cluster theory to inform his assertions on actual policy.

Porter's discussion of how best to go about industrial policy revolves around his conclusions regarding clusters and economic performance. He asserts that "since clusters involve powerful externalities across firms in a location, and associated public goods, there is a strong rationale for public policy," (Porter, 2007, pp. 5). He establishes that clusters are linked with high economic performance, and he urges governments to capitalize on these clusters. In laying out the context of his argument, he again says that dealing with policy at the cluster level avoids many of the inefficiencies that go along with policy at the industry/firm level. However, the core philosophy regarding Porter's suggestions is that he believes such policy should *not* discriminate on which clusters to support. He contends that, "cluster policy is thus fundamentally different from sectoral or industrial policy, whose fatal flaw is their focus on favoring particular types of economic activity, picking winners, and attempting to artificially bias competition in favor of a particular country or region,"(Porter, 2007, pp 6). As a result of this philosophy, Porter lays out how exactly he builds a framework of his version of industrial policy (which he calls "Cluster-based policies"). He argues that good policy will avoid industry/firm oriented programs, use Clusters as a tool to integrate economic policy (they are inherently organized, and therefore can help guide policy in such a way), focus federal stimulus around clusters (whether it be financial or otherwise), and set up an incentives system for the private sector to begin investment in such clusters. With these general ideas, he has some specific suggestions for how to support such clusters. For example, he suggests that governments actually formalize the clusters themselves as actual regions so that targeted investment will be made easier. In addition, Porter advocates for "Cluster Planning Grants," in which the designated clusters would compete for funding, thus increasing the likelihood of innovation through competition. Michael Porter's idea is based on the U.S case, which makes his analysis incredibly valuable for this thesis. His cluster framework will be employed in order to accurately capture what the best U.S case of industrial policy is.

The supposed "underinvestment" in R&D and innovation by the private sector is viewed as strong justification for the public sector to supplement these areas. In the United States, is no explicit industrial policy in place, and so it could be argued that there is currently "underinvestment" in the key industries that could be producing more innovation with the proper resources. Tassey (2005) advocates for a better way of determining not only whether or not there is underinvestment in industrial R&D, but also a way to find an "optimal" level of investment to provide a net economic benefit for the society. His three stage approach is as follows, "(1) identify and explain the causes of the underinvestment, (2) characterize and assess the investment trends and their impacts, and (3) estimate the magnitude of the underinvestment relative to a perceived optimum in terms of its cost to the economy." Tassey explains that private investors often cannot provide enough investment to get innovative R&D projects off the ground because of "market risk and return" factors. (Tassey, 2005, pp. 94) Some of these risks are the technical complexity of the project, timing, and spillovers/economies of scale. The technical complexity in particular can be a serious hurdle for investors because, especially in the early stages of research, the costs are high and the research requires "multidisciplinary research teams and unique research facilities that do not exist." (Tassey, 2005, pp 95) Tassey also seems to agree with Porter's reservations about specialization for industries/firms by saying that it "accentuates path dependence" and forces them to stick to generic, safe innovation plans that are more likely to guarantee revenue. This is precisely where the security of governmental support could give the push needed to explore more innovative options. Tassey's model for estimating the optimal level of investment in a given industry uses two core variables called Private Rate of Return (PRR) and the Hurdle Rate (HR). An investment will likely not receive high *private* sector funding if its PRR is below its HR because the investment is too risky to become worthwhile. (Tassey, 2005, pp 100) Also, Tassey's model suggests that there is also a variable called Social Rate of Return (SRR). Something that has a high SRR would be something that has a high public good, such as infrastructure or basic research. However, just because something has a high SRR does not mean that it will have a high PRR, and oftentimes PRR wouldn't be close enough to the HR to substantially justify private investment in goods that cause high social benefit. This is where he argues government comes in. Tassey asserts that projects such as basic research are prime "candidate(s) for government financial assistance, usually in the form of cost- shared funding for the conduct of generic technology research. Cost sharing reduces risk enough to stimulate initial private investment in applied R&D." (Tassey, 2005, pp 100) However, Tassey does not believe that governmental support is the final answer. He believes that ultimately, as a government is able to get PRR over HR in an industry, that subsidies can be "phased out" and private investment will be stimulated enough to continue to innovate. (Tassey, 2005, pp 105) Tassey also notes that government investment is an imperfect mechanism because each dollar spent does is not 100% efficient in creating innovation. For example, he cites the fact that "the Department of Defense spent $570 million on research between 1987 and 1995," but despite this investment, "the overall market had not reached $1 billion in annual sales by 1996." (Tassey 2005, pp. 108) In his conclusion, Tassey cites the importance of his three stages again, because with their use industrial policy will be significantly more effective for finding the optimal level of investment.

E. Skeptics of Industrial Policy

Although they are few in number, there are those scholars who are a bit more skeptical of the benefits from industrial policy. The core idea behind industrial policy is to provide net utility to the country that is attempting to do it, but there are a few who suggest more modest policy due to the fact that there may be more consequences than previously imagined. Baldwin and Krugman (1988) argue that there are some hidden consequences to industrial policy, and they use the context of the wide-bodied jet aircraft industry as a context for their analysis. In particular, they create a model revolving around two of Airbus and Boeings competing models; the A300 and the 767. In this case, Boeing was the established giant in this industry, and a European consortium “subsidized ” Airbus’s production. The European governments that supported Airbus denied claims that they were using subsidies since they expected to be paid back in full *contingent on Airbus making a profit.* (Krugman et al, 1988, pp 46). Regardless of the semantics, Krugman argues that this subsidy allowed Airbus to enter the industry by lowering production costs. This entrance lowered the global price for wide-bodied aircraft, but Krugman argues that there were some troubling welfare effects that must be taken into account when looking at the effects of the subsidy. The United States is obviously hurt from the increased competition on the world market, but he uses a model centered around allowing for “intertemporal demand subsitution” (net effect on consumption from changes in new competition) to get more precise measurements. Krugman finds that the U.S actually received a net loss of $3 billion from Airbus entering the industry. However, he finally concludes that, ultimately, whether or not the subsidy was worth it depends on the discount rate of Europe. With this in mind, however, he notes that in order for the subsidy to be worth the investment, Europe would need a discount rate of 3% or below. He argues that “On net, Europe loses (except for the low 3 percent discount rate), the United States loses, and the rest of the world gains.” (Krugman et al, 1988, pp 69) Therefore, he is unsure whether or not such policy is worthwhile because it depends on what a country’s discount rate is (this is extremely hard to determine). However, if the discount rate were high, the losses in the Airbus case would’ve been astronomical (up to $9 billion).

(Krugman et al, 1988) Although Krugman does not give an outward rejection of industrial policy, he is skeptical and is simply more cautious about certain uses of it.

F. Conclusion

As the world becomes more globalized, some countries are trying to find ways of remaining competitive. Production chains are becoming more fragmented, and increasingly countries in the low-middle income bracket are finding it hard to break through into the global production chain. The world has established players whose costs are lowered from scale economies, and for a given country trying to enter, it can be hard to compete. However, even for larger countries like the U.S, the desire to capitalize on market failures has proved difficult given that they do not currently participate in any kind of explicit industrial policy. As of right now, the U.S DOD employs implicit industrial policy, in which spillovers from the DOD spur innovation for the private sector. However, the optimal U.S industrial policy could be derived by using a model that employs the “cluster” level that Michael Porter advocates for. Policy that targets the cluster level is much more likely to be successful since it does not encounter the same convergence effects seen at the industry/firm level, which makes it a very strong starting point. Beyond this, numerous authors have offered their opinions on the best way to conduct industrial policy ranging from “horizontal embededness” as cited by Montero, to Wade who argues that comparative advantage needs to be broken through completely. Another key contribution for this thesis is that by Doh & Kim, which emphasizes the importance of using patent registration (a surrogate for innovation) as the goal of industrial policy.

The relevant literature provides a good framework to begin the construction of a strong industrial policy tailored to the United States. The United States is unique in that it is a net importer (whereas most of the countries currently employing aggressive industrial policy are net exporters), but it is also one of the worlds leading global economies. It also has one of the most disparate income distributions in the entire developed world, and therefore requires a solution that will ensure more areas of the economy are impacted than just a handful of targeted industries.

G. Methodology

This thesis seeks to determine the optimal U.S industrial policy, which is a difficult task given that the U.S currently does not have any such explicit industrial policy. The definition of "optimal" in this case is in regards to the industrial policy that is the most efficient in addressing the market failures present in the U.S economy. The justification for enacting such a policy could be the potential growth in GDP, increased exports, less income inequality, and greater domestic employment. Chapter 3 will explore the justification for our methodology in greater detail.

CHAPTER THREE

ANALYSIS OF THE MODEL

In this chapter, there will be a comprehensive analysis of the model that will be used to determine the optimal U.S industrial policy. However, there is an initial challenge to determine what model would best fit the United States, given that there is no such explicit policy currently in place. This thesis will justify the model, however, by breaking down the rationale for each included variable, while also providing informational context for that variable. Section A will discuss the important things that the model must do in order to be viable, while each succeeding section will discuss individual variables and their historical context, data sources, and the rationale for it's inclusion.

A. What an Optimal Model Must Do

In order to have an acceptable model for a new U.S industrial policy, there are a few things that it must include. The goal of the model is to ultimately create a form of industrial policy that is *more efficient* than the current U.S method involving the DOD expenditures, so that is the underlying philosophy that must inform every aspect of the model. As this thesis determined earlier in the discussions revolving around Porter, targeting clusters for industrial policy appears to be the optimal starting point for the U.S case. Using clusters seems optimal for the U.S (as exhibited by Porter) and if used in a more explicit U.S industrial policy, it could strengthen multiple industries at the same time because of external economies (which could help with income inequality). There may be a concern that using clusters along with “industry level” data may cause some conflict for statistical analysis. However, clusters are simply geographic areas of *related* industries, which means that other variables, such as innovation and investment, will be able to stay at the industry level while still using clusters in the model.

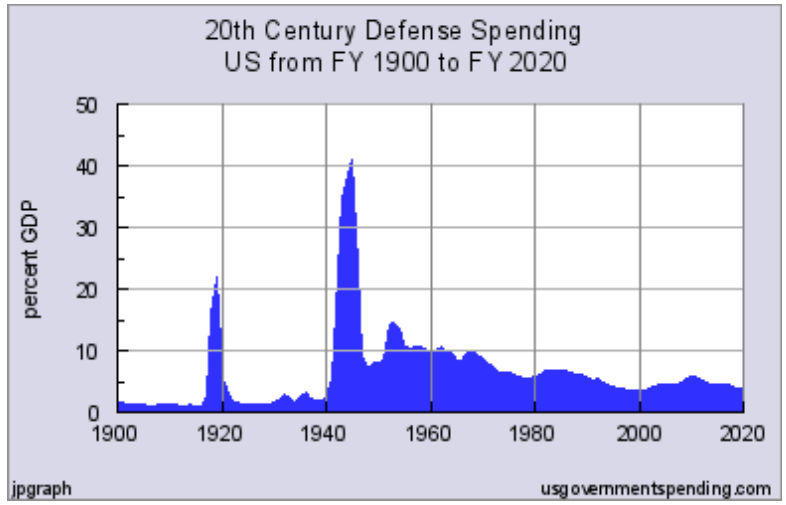
This model must also have a clear variable for governmental input. The nature of industrial policy is that the government invests through some means (grants, contracts, etc) and then they expect to get some kind of gain out of their investment. In addition, there also obviously must be a measure with output that matches up with the input. This would be the left side variable in our model, and would go up or down depending on a change in governmental input. An example of this kind of output would be innovation, because if the government were funding a certain area, they would like to see more innovation as a result.

B. Current U.S Industrial Policy

Unlike other countries such as China or South Korea, the U.S does not outwardly attempt to bolster domestic industry though industrial policy. Instead, there is a more implicit version in which organizations such as the Department of Defense spend money on certain sectors in order to innovate for *military* use. This can, however, create some innovation in the private sector, because the creation of a core technology by the DOD could result in spillovers to the private sector. For example, Epinephrine, a universally used emergency medication for people with severe allergies, was actually created by the DOD for military use. Originally, it was made to allow soldiers to survive a chemical attack (Reinmann, 2016). However, over time there was a spillover into the private sector, and Myelin then created the Epi-Pen, which could be used for a severe allergic reaction.

While this type of industrial policy has been going on for years, other countries have been thriving and seeing massive expansion due to a more explicit approach. Therefore, it could be that the DOD approach is not the most efficient way, so this thesis will propose a new model using clusters, current U.S DOD expenditure in particular industries, and innovation as measured by new patent registration. As seen in Figure 1, the U.S defense spending has largely been a steady (if slightly declining) portion of GDP since World War II, and since the U.S currently has no dedicated program to industrial policy it stands to reason that less money is going towards the growth of private industry. The model for this thesis is below. Each individual variable will be discussed in depth later in the thesis.

Figure 1



$$\mathbf{P_{it}= B_i + B_t + B_1 CS_{it} + B_2 I_{it} + B_3 RD_{it} + B_4 VA_{it}\ ai + a_r}$$

Where $\mathbf{P_{it}}$ is patent registration by industry over time, $\mathbf{B_i}$ is a fixed effect for industry, and $\mathbf{B_t}$ is the fixed effect for time. $\mathbf{CS_{it}}$ indicates the specialization levels (strength) of a cluster (in an industry over time), and $\mathbf{I_{it}}$ indicates the level of investment in a given industry over time. $\mathbf{RD_{it}}$ and $\mathbf{VA_{it}}$ are the control variables “research and development spending” and “Value Added.”

Despite the fact that the U.S does not engage in explicit industrial policy, this thesis proposes an innovative way of estimating the impact of using a cluster-based policy.

It its essence, the core relationship in this thesis is one of inputs and outputs. Inputs would be considered investment (or potentially other forms of support) by a government under industrial policy, and output would be what the government would like to get out of its investment (in this case, innovation). Luckily, truly explicit industrial policy is *not* needed in order to estimate this relationship because we only need to know the *relative* effect on innovation from a given amount of investment. For example, if one looks at the current U.S DOD spending in pharmaceutical research (its likely for military use), and also observed that there was also innovation growth in the private pharmaceutical sector, then we can extrapolate those results to inform the usefulness of more direct industrial policy. Essentially, since there is currently no explicit industrial policy in the U.S, as long as we see that a relationship exists between investments an innovation, it would be sensible to assume that the same relationship *would* exist in a hypothetical explicit form of industrial policy.

With all of this information in mind, a coherent framework of analysis can be built. This thesis uses a model that takes into account the relationship between innovation and investment through the lens of clusters. The relativistic aspect to this analysis allows for an accurate way to devise industrial policy even when such a policy is not in existence yet.

C. Data Set and Methodology

In order to capture the impact of investment and clusters on innovation, there is a very specific setup for the data set that must be used. The type of data that are used in this thesis is panel data, which allows for both a time-series aspect, and a cross sectional aspect. This is crucial, because simply exhibiting the change in innovation over time when compared to the change in investment and cluster specialization over time misses the important cross sectional component to industrial policy. Not all industries in the United States are the same, and there may be differences in the resulting innovation from a given amount of government spending. Therefore, this thesis uses a sample of three different industries, Information Communication Technology (ICT), Biopharmaceuticals, and Aerospace Manufacturing. For each industry, there are data on patent registration, cluster specialization, and government spending over the period of 2007-2013. The fact that this thesis uses panel data was actually key in determining what data to use, because each database had to include both the same time range, and the same industry in order to stay consistent.

D. Justification for Selection of Industries

An integral decision in this thesis was the selection of Biopharmaceuticals, ICT, and Aerospace manufacturing as the key industries that will be measured. The industries must each capture a portion of the U.S market that is significantly different than the other. At the same time, there must be enough industries to ensure that there is sufficient data for a regression analysis. Finally, each industry must also represent an area that the U.S conducts significant international trade. Since the purpose of this thesis is to find the optimal industrial policy (ultimately to make the U.S competitive in markets internationally), it stands to reason that the industries used in this analysis should be those that are currently robust trading sectors. This is in line with what other scholars have done in order to measure the impact of clusters. For example, Porter et al. (2012) elected to use “traded industries” in contrast to local industries because of the fact that traded clusters “concentrate in particular regions but sell products or services across regions and countries.” This gives a far more accurate representation of U.S trade. For example, using the “Apparel” industry in the U.S would not be a strong industry for analysis because of the fact most apparel production is done outside the country.

ICT is a booming industry in the United States right now, and therefore it was one of the frontrunners for application in this thesis. ICT is a broad industry that encapsulates telecommunications via telephone lines, wireless networks, computers, and various other audio-visual networks. This industry also includes digital storage, software, and the integration of these services into consumer products. The United States currently ranks 6th in the worldwide share of the ICT market (OECD, 2016), and according to the “ICT development index,” a benchmark of ICT performance across countries, the U.S only ranks 14th in the world (Information Technology Union, 2014). Other countries such as South Korea (ranked #1), have incorporated strong industrial policy, and there could be a connection between strong industrial policy and ICT performance. In the case of this study, ICT is a prime candidate for analysis because it is a highly connected/traded market, and would be one of the first targets of good industrial policy.

Biopharmaceuticals is another key industry in the United States, but also one that is highly traded. “Big Pharma” is a phrase that gets tossed around a lot today, but it accurately represents the size and scale of the U.S pharmaceutical industry. Many of the largest pharmaceutical companies in the world are U.S based (Pfizer, Johnson & Johnson, etc), and the U.S has the largest Pharmaceutical industry by far with a value of roughly $3.5 Trillion. The closest competitor is Japan with a size of just $940 Billion, and clearly it is a massive worldwide industry for the U.S (World Atlas, 2016). The biopharmaceutical industry will have no shortage of data, and would be representative of a distinctly different U.S market than ICT. Also, given that the Biopharmaceutical industry is very heavily R&D based, strong industrial policy would be extremely helpful in reducing the costs of research, thus allowing for greater innovation/product creation.

Finally, the U.S Aerospace industry was selected because of its large size on an international scale, the fact that it is sufficiently distinct from both ICT/biopharmaceuticals, and also its unique market structure (its very much an oligopoly worldwide). In the U.S, the aerospace market includes both commercial and military aircraft, along with spacecraft manufacturing/development. The U.S Aerospace Sector contributed $144.1 Billion in export sales in 2015 alone, and provides 500,000 jobs in direct scientific/technical work along with 700,000 related jobs (USA Investment Summit, 2015). Big manufacturers such as Boeing and Lockheed Martin dominate the Aerospace market, and although there are currently large government contracts in the military/spacecraft areas, there is not much government investment in other areas such as civilian aircraft manufacturing/R&D. The Aerospace sector in particular provides a unique market structure (an oligopoly), and this will provide the variety in the data set is needed for a strong empirical analysis.

The ICT, Biopharmaceuticals, and Aerospace industries provide strong variation, size, and potential for investment through an optimal U.S industrial policy. Therefore, these three industries will be used in the data set, and each will have a set of variables, (innovation, cluster strength, and government investment) along with a set of years to complete the panel data set.

E. Measuring Innovation (P_{it})

Measuring the output from industrial policy can be difficult because there are a number of different ways to do it. One could look at company revenue growth in dollars, or value added, etc. However, this thesis will measure output through innovation in a given industry, because innovation is one of the core drivers of growth. If an industry is experiencing a lot of growth in innovation, then we should expect that that industry would see greater economic growth. In order to measure innovation, patent registration in a given sector will be used. Patents are helpful because they are widely used as a measure of new ideas/innovation, so if you see that over time there are more patents in a given sector, then that industry has innovated more. When used in conjunction with cluster data and investment data, the potential relationship between investment in clusters and innovation could be observed. It should, however, be noted that there is a potential issue with the use of patents as a measure of output from industrial policy. This is the fact that patents are a *real* number, whereas other data in the model will primarily be used in dollar terms. If it were the case that using patents became problematic, value added would be a viable substitute since it is also in dollar terms.

The patent data needs to have both a time aspect, and an industry aspect. Since the data set this thesis uses is a panel data set (three industries over time), the patent data will need to match up. By using the US Patent and Trademark office, these data are available by both the NAICS Code (classifies a patent by a certain economic activity/industry). NAICS has largely replaced the older version of industry classification, the SIC code, and therefore this will be the categorization standard this thesis will use. Within this database, the data goes back as far as 1964 and provides the number of patents in that sector for a given year. For example, one sector that is used in this thesis is the Biopharmaceutical sector. Therefore, all the patents for a given set of years in the "Pharmaceutical and Medicine" industry (NAICS code: 3254) would be used in the data set. The same thing would be done for the remaining two industries.

F. Justifying and Measuring Clusters

Clusters are the key differentiator from previous research for this thesis. Clusters, as Porter (2012) proposes in his works, are the optimal target for industrial policy because they take advantage of external economies. The inclusion of Clusters as the economic area of analysis is justified because of the fact that the U.S has shown to see more wage, innovation, and employment growth in clusters rather than industries or firms. Measuring clusters, however, proves to be an immense challenge because they are a novel economic area without any accepted unit of measurement. Luckily, Porter and Harvard Business School have developed a way of understanding the strength/specialization of a given cluster. In a database created by Harvard and the U.S Economic Development Administration, they created and defined the much sought after unit of measurement, the Location Quotient. The Location Quotient is defined as the "Ratio of an industry's share of total state employment in a location relative to its share of total national employment. Measures the *specialization* or concentration of a cluster in a particular location relative to the national average, with an LQ > 1 indicating higher than average cluster concentration in a location." (U.S Cluster Mapping Project, 2014) This means that the higher the LQ, the more specialized/concentrated a given sector is in that cluster.

By using clusters in this model, it will be possible to discern whether or not a U.S industrial policy targeting particular geographic areas will yield the most innovation. Because of the benefit of external economies that we see in clusters, the U.S should get most "bang for its buck" by using clusters, meaning that a dollar investment (or R&D expenditure) will go further by targeting clusters rather than industries or firms. Theoretically, Porter has laid out why Clusters work for the United States, but they will need to be tested empirically before confirming their viability in the optimal U.S industrial policy.

G. Measuring Governmental Input

This thesis required a concrete measurement of U.S government *expenditure* (which is investment by nature) for an explicit industrial policy, but at the same time there is currently no such policy in existence. However, as discussed previously, the U.S Department of Defense has been doing this implicitly for many years, and therefore it stands to reason that historical data from DOD expenditure in specific sectors could be used to extrapolate on to what an explicit policy *would* entail. There are few other ways to gauge the level of investment ongoing in the U.S for use in the private sector, and since we know that spillovers occur into the private sector from the DOD, this methodology appears to be sound.

Measuring investment through DOD spending in given sectors is a challenge, but it is made possible through government records. The use of the Department of Defense, however, even impacts the types of industries that are used in the analysis. For example, it would be reasonable for the DOD to invest in the Aerospace sector via contracts, but there would be very little reason for it to invest in the Agriculture sector. Therefore, each industry used in this analysis had to be a theoretical fit for the DOD, otherwise the data would be skewed due to unrepresentative investment numbers.

H. Control Variables Justification

The use of research and development as a control variable is essential to ensuring that there is no omitted variable bias in the regression analysis. Levels of research and development in a given sector will obviously have an impact on the level of innovation (patents) in that sector. If there is more research and development spending, there will be more resources available for the creation of new ideas, products, and tools. The level of research and development spending in a given industry, therefore, can be reasonably assumed to have an impact on the level of innovation in a sector, and thus must be a control in the analysis.

Using value added as a control variable may be considered contentious at first, but upon closer analysis, it makes sense that the size of a given industry could impact the level of innovation. Although a lot of this thesis so far has discussed external economies as a key factor in predicting levels of innovation, there is also an "*internal* economies" aspect that must be controlled for. As is taught in Economics 101, the larger firms/industries get, the more spread out their fixed costs get. Lower costs can mean greater available resources for innovation, and thus there must be a control variable to represent this. Value added (by industry by year), is exactly the variable that does this, because it exhibits a particular industries size at the time. This variable would be controlling for the scenario where a larger industry is able to innovate more than a smaller one due to internal economies, and therefore it must be included as well. However, it is important to note that the *core* phenomenon occurring in a cluster based industrial policy is *external economies*, value added is simply a control (unless using patents is problematic, in which case value added will become the *dependent* variable).

I. Conclusion

The model for the optimal U.S industrial policy needs to be able to best estimate the impact of investment (in a cluster economy) on innovation. By using patents for innovation, DOD spending for investment, and the Location Quotient for cluster specialization, the model will be as close as is possible (without actually employing explicit U.S industrial policy in the real world) to determining the optimal U.S policy. In the next chapter, the specific data that are used will be detailed further, regression analysis will be employed, and finally, the results will be presented and interpreted. Through this analysis, the implications of such a policy can then be discussed.

CHAPTER FOUR

DATA AND RESULTS

Now that the model has been dissected piece by piece to understand the rationale for each of its parts, a more in depth data analysis will be conducted in this chapter. In addition, the framework for a regression analysis will be created, and then the results of the empirical work will be exhibited and interpreted. The goal of this section will be to say definitively if the optimal U.S industrial policy is one that targets clusters with governmental funding. The data that are used in this thesis will (units, sources, etc). In order to do this, there will be multiple different avenues of statistical analysis including regressions and graphing.

A. DOD Investment Data

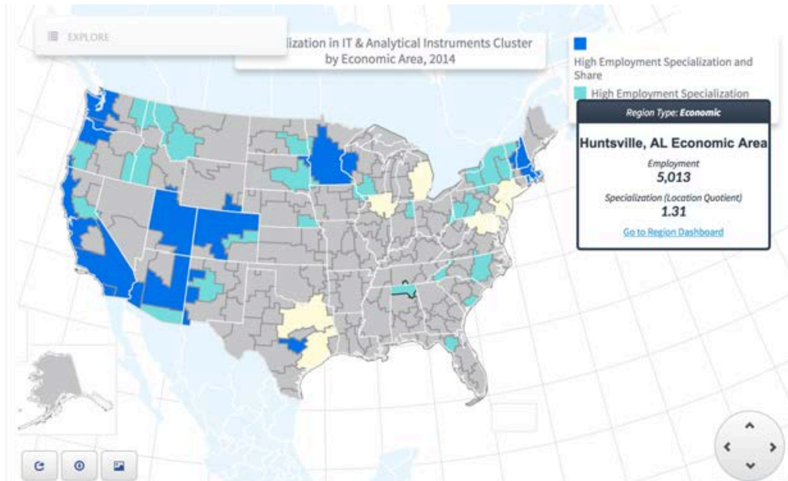
In order to accurately measure the real, current DOD expenditures in each of the three industries (ICT, Biopharmaceuticals, and Aerospace), the data needed to be annualized. Without an annualized measure of DOD expenditure, there would be no way to create the panel data set that was required for this thesis. Unfortunately, there was no readily available "pre-annualized" data set for DOD expenditure, but given the importance of the use of panel data, a new way to annualize the data needed to be constructed. To do this, the initial data were gathered from the USA spending database, which holds all of the current U.S investment data for all industries, all government agencies, and in multiple different forms (grants, contracts, etc). The spending data were presented on a *transactional* level, meaning that each individual contract, grant, etc is logged in this database. In a given industry, there were hundreds of thousands of transactions in the time period given in the database, and the database did not provide the *total* spending in a year. This was seemingly problematic, but it was overcome due to data customization and some work in Microsoft excel. In particular, the data sets could be customized to include only the investment data for the particular industry, agency, and form of the users choosing. For example, in the case of the ICT sector, the search on the USA Spending database was narrowed down to only those investments made in the ICT sector. The ICT sector was identified through the NCAIS code, a unique industry identifier used for both patent and investment data. In addition, including only those investments made by the Department of Defense narrowed the data down even further. Finally, once the dataset included just DOD expenditure in the ICT industry, there were 8250 transactions from 2007-2015 (the only available time frame for the database). In order to change the data set from the transactional format to the annual format, the sum all of the transactions within a given year was calculated, thus providing one annualized number for how much money the DOD spent on the ICT sector in one year.

This process was repeated for each of the other two industries, with roughly 7-10 thousand transactions per industry that were then annualized for use in the panel data set. The unit of measurement for the DOD spending was originally just dollars, but in order to make the spending data match the other variables, the units were changed into millions of dollars in the data set.

B. Cluster Data

As discussed in Chapter 3, the unit of measurement for a given clusters strength and/or specialization is the Location Quotient. However, the process of readying this data for regression was far more involved than simply plugging it into Eviews. These data were sourced from the U.S Cluster Mapping Project, which provides Location Quotient data in the form of a map or an excel file. In order to better visualize what this data looks like in practice, a map of the ICT sector is viewable in Figure 2. In this map, the areas that are shaded blue or turquoise are the ones with above average levels of specialization. For example, in the "Boise City" Cluster, which includes parts of Idaho and Oregon, the value of the location quotient is 4.01, which is significantly above average in the ICT sector. The data from this map, when downloaded to a Microsoft Excel file, has the LQ data for the year selected in every cluster shown.

Figure 2



The issue with the cluster data was that there was no *single* LQ value for a given year, but rather there were 181. In order to preserve the measured change in LQ over time while still making the data useable in a panel data set, the median LQ value for *all* clusters in a given year was used as the singular value for that year. The use of the median is justified due to the fact that it would not be skewed by high LQ values as the mean is, and thus it would be a reliable indicator of a "typical" U.S cluster. In addition, this approach was necessitated by the fact that DOD expenditure data was not available by individual location, and so in order to have an accurate statistical analysis, the cluster data needed to match up with all the other data.

C. Patent Data

The patent data for this thesis were the least troublesome to obtain, although there were a few things that needed attention in order to ensure consistent results. The data were gathered from the US Patent & Trademark Office (USPTO), which stores every domestic registered patent since 1968. Again, in order to ensure that the industries lined up correctly the exact NCAIS code that was used for spending was used to find the industry for this data set. The only issue with the industry summation data set was that it only went up to 2012, but the individual *technology* patent data went up to 2015. Therefore, a manual summation of all groups of technologies within a particular industry was conducted for 2013, 2014, and 2015. This yielded an accurate estimate of the number of new patent registrations an industry had in those years. The unit of measurement used for patents in this thesis is simply the number of new patent registrations in a year.

D. Control Variables

The research and development variable data were gathered from the OECD, and was measured in millions of dollars just like the DOD spending variable. In this case, the entire data set needed to be limited because of the fact that the R&D data only went up to 2013. After extensive research to find any industry level R&D data for the 2014-15 years, the results were unsuccessful, and therefore the 2014-2015 years needed to be omitted from the sample. However, the addition of a new cross section for the regression ultimately outweighs the loss of the two years. Although the two lost years removed some observations, a similar amount were added back on due to the fact that there was R&D data for three separate industries.

The value added data were gathered from the Bureau of Economic Analysis (BEA), and was also measured in millions of dollars. The range of this data is from 2007 to 2013 and also is across the three core industries of analysis. One small hiccup arose, but it was corrected during the data collection process. In the BEA database, there were two separate categories for ICT, one for "manufacture of computer, electronic, and optical parts," and another for "information and communication." To address this, the sum of these two value added categories were taken to account for the entire size (in value added) of the ICT sector.

E. Empirical Analysis

The following section will exhibit the setup, execution, and analysis of the empirical data for this thesis. The program used for the statistical analysis was Eviews 8, and all data were imported from Microsoft Excel. There were 21 observations in the sample (7 years X 3 industries = 21 observations) for each variable. A complete breakdown of the Eviews name for each variable is viewable in Appendix 1: Figure 4. In this analysis, there were a total of five regressions run, each offering a different approach to understanding the results of this new model. In order to account for multicolinearity, a correlation matrix was also run. There is also extensive analysis of scatter graphs, which actually can say a lot about the relationship between the variables.

The first step before analyzing the data is to generate a correlation matrix, and although the results weren't perfect, many of the variables did not exhibit multicolinearity. As seen below in Figure 3, R&D was highly correlated with value added and moderately correlated with cluster specialization, and value

Figure 3

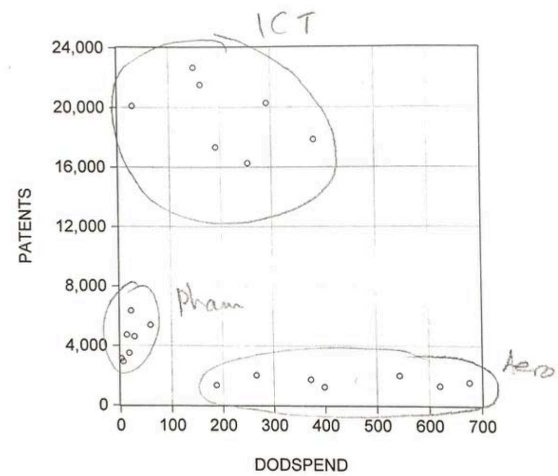
Correlation

	CLUSTERSP	DODSPEND	VALUE_ADD	R_D
CLUSTERSP	1.000000	-0.551901	0.607147	0.566440
DODSPEND	-0.551901	1.000000	-0.325832	-0.212695
VALUE_ADD	0.607147	-0.325832	1.000000	0.976281
R_D	0.566440	-0.212695	0.976281	1.000000

added was correlated with cluster specialization. Despite these few hiccups, the rest of the variables were normal, and much of the multicolinearity problem was taken care of during the regressions.

Even from the initial graphic analysis, some interesting patterns begin to emerge about the relationship between the independent and dependent variables. For example, one key result is seen from the suggestion of a *possible* positive trend between DOD expenditure and patents. As seen below in figure 4, there is an upward trend; the more the DOD spends, the more patents we see registered (when excluding Aerospace). However, there is a very interesting discovery from this graph, which is the clear difference in gains from investment *between* industries. There are clearly three distinct *patterns* that emerge from this information, and because each industry has a differing relationship between DOD spending and patents. The obvious example in this graph is the aerospace industry. Unlike in the pharmaceutical and ICT industries, there appears to be a flat trend between DOD spending and patent registration. This phenomenon, however, is likely due to the fact that in the Aerospace industry, funding is almost exclusively done through very long-term contractual agreements. This means that the potential innovation gains from government investment would not be seen for a number of years, and thus could not be reflected in the short seven-year sample from this data set. It is also important to note that this thesis is not

Figure 4



necessarily asserting that there is a causal relationship between these variables, but rather there is a possible correlation. In addition, there are likely other variables that are influencing patents that this graph does not capture, so while there is important information to be gained from this, it is far from perfect. The disparities between particular industries can be seen in other variables as well such as cluster specialization, value added, and R&D. Other graphs exhibiting this phenomenon can be seen in Appendix 1: Figures 2 and 3.

F. Regression Results

On this page and the next are the results of each of three core regressions ran during this thesis. Each will be detailed separately to discuss the rationale, results, and changes made between regressions.

Dependent Variable: <u>Patents</u>	Regression 1
Value Added	0.007 (1.69)*
Cluster Spec	-17973.04 (-2.527)***
DODSpend	0.515 (0.317)
Clusterspec*DODspend	N/A
R&D	0.1689 (4.74)***
AR(1)	N/A
AR(2)	N/A
N	21

Dependent Variable: <u>Value Added</u>	Regression 2	Regression 3	Regression 4
Patents	N/A	-18.673 (-2.57)***	N/A
Cluster Spec	N/A	N/A	N/A
DODSpend	N/A	N/A	N/A
Clusterspec*DODspend	238.99 (1.47)*	510.269 (4.249)***	499.383 (2.340)***
R&D	3.346 (2.95)***	9.240 (5.849)***	5.300 (14.622)***
AR(1)	0.933 (14.45)***	N/A	N/A
AR(2)	N/A	0.353 (3.401)***	0.402 (1.632)*
N	12	10	10

t-stat in parentheses
* p<.20 **p<.10 *** p<0.05

Regressions 2-4 do not include Aerospace
See Regressions in Appendix 2

a. Regression 1

The first regression was the obvious initial step after formulating the initial model. In this regression, all of the core variables are regressed with all industries used. In addition, as stated in the model, Patents, a measure of innovation, are used as the dependent variable. However, even after attempting to modify the regression with time and cross sectional fixed effects, the results presented were the best available. There were issues with regression 1 in the value added, cluster specialization, and DOD spending variables.

The issue with the value added variable is that, although it had the expected positive sign, it was only significant at the 20% level, which is a questionable measure of statistical significance. One of the most troubling issues is the fact that the cluster specialization sign was negative and significant. This is the exact opposite of what the hypothesis predicted, and it would not be sensible to argue that as a cluster becomes more specialized that you see a decrease in innovation. This would fundamentally disagree with Porter et al's research on clusters, and therefore it had to have been an issue with the regression. Another issue was that DOD spending was not statistically significant, even at the 20% level. After this regression, there needed to be a few significant tweaks to the data to get results that worked.

b. Regression 2

After comparing the results from regression 1 to some of the graphs (viewable in appendix 1), especially the Patent-DODspending graph seen in Figure 4, using aerospace as an industry no longer seemed practically viable in a regression. As previously discussed, the long contractual agreements of the aerospace industry make the data analysis nonviable. Also, if one views the cluster specialization-patent graph (Appendix 1), the aerospace industry appears to have a negative trend, which could be contributing to the negative coefficient in the regressions. Therefore, that industry was removed.

As the regression process went on, there was a shift in how this thesis measured the output of industrial policy. It became apparent that patents might not be the best measure of progress from investment due to the fact that they are simply a number rather than a monetary amount. The issue with this, as we see throughout the graphs detailed in Appendix 1, is that different industries have widely varying levels of patent output. For example, the ICT industry sees tens of thousands of new patents per year, whereas the Aerospace industry might only see a few hundred (but, Aerospace patents could be "worth" more in dollar terms, thus adding further confusion). However, if one uses value added as the primary left side variable, then the direct growth in that particular industry as a result of changes in cluster specialization and DOD spending can be measured.

As we see in Chapter 2, Porter et al. explains that the greater the cluster specialization, the stronger the external economies should be. However, combined with the new information that perhaps it matters *which* industry the government chooses, it could be that DOD spending is actually impacted by how strong cluster specialization is. For example, the amount of value added gained from a particular DOD investment would actually be contingent on the specialization level of a given cluster. This led to another change for regression 2, in that it includes an interaction term to capture this “DODspend*clusterspec”. This concept is not new, since it is truly the essence of what industrial policy is. When a government is trying to figure out where to spend their money, they have to decide what industry to spend it on. Krugman (1983) emphasizes this idea by stating that an explicit industrial policy “may include general incentives for capital formation, R&D, retraining of labor, and so on, but it will also almost surely involve ‘targeting’ of industries thought to be of particular importance.” In addition, there was evidence of serial correlation in regression 2, so the AR(1) term was included to take care of that problem (spreads out the error terms to avoid this).

In regression 2, interaction term is positive, R&D is positive and significant at the 5% level, and the AR(1) variable is positive and significant even at the 1% level. However, this regression results are far from perfect given that the interaction variable only had a P value of 0.178, but the interaction term’s p value was improved in subsequent regressions. Using the data from Regression 2, a real world example is exhibited below in Figure 5.

Figure 5

δ(Value Added)/δ(DODspend) = 238.99 (Cluster Spec)

Then use the median cluster spec data point for each industry (Location Quotient) .

Biopharma→238.99(0.446) = \$106.58 Million of Value Added

ICT→ 238.99(0.458) = \$109.45 Million of Value Added

In the Biopharmaceutical industry, for example, a \$1 million increase in DOD spending should result in a \$106.58 million increase in value added. However, if the cluster specialization number were higher, we would expect to see an even greater gain in value added as a result of a \$1 million increase in DOD spending.

c. Regression 3

As with the second regression, the final, and most promising regression excluded the Aerospace industry due to the fact that it did not fit with the model. In addition, the interaction term was kept as well because of the promising results from regression 2. For both regressions 3 and 4, the primary goal was to make the interaction term significant, but both have tradeoffs.

The primary change in regression three was changing AR(1) to AR(2), and essentially this means that the serial correlation corrects for two years prior instead of one. Another change was the inclusion of patents to test if increased levels of patents had any impact on value added. The hypothesis was that the greater patents/innovation in a sector, the greater the value added. The results of this regression were even more promising, but with a few issues. In this regression, every single one of the core variables (patents, the interaction term, R&D, and AR(2)) were significant at the 5% level. This was a very promising result, however the only problem was that the patent variable was negative, which was not the anticipated sign.

d. Regression 4

The final regression attempted to maintain the strong significance of all the variables while also getting rid of the patent variable since it had the wrong sign in regression 3. This regression was essentially the same as regression three, and as a result there were similarly strong results, with one exception. In this case, the AR(2) variable was only significant at the 20% variable. However, given the shortage of data, regressions three and four are likely the one of the best ways to estimate the effect of an explicit U.S cluster-based industrial policy *without* the actual policy being put into practice.

G. Implications

There are a lot of promising results from the statistical analysis, and it provides a strong case for a cluster based U.S industrial policy. As seen from the graphing data, there is clearly a relationship between the specialization levels of a cluster and its output in terms of value added or innovation. The same goes for governmental investment; there is a positive and significant relationship between DOD spending and positive output in terms of innovation and value added. However, a key revelation from this data is the need for an interaction term when conducting research. The decision of what clusters to invest in *does* matter for government. With this in mind, there are fundamental problems with the data, most significantly that there is a real shortage of both spending data and R&D data. For example, the DOD spending data gathered from the USA Spending database only provides data dating back to 2007. This is an issue that likely will be solved with time, because more and more data will become available, however for this thesis it likely contributed to a lot of the practical problems in the regression analysis.

Porter’s (2012) hypothesis that clusters appear to have a positive relationship with innovation and investment appears to be confirmed by these results, and they suggest that there are real benefits to an explicit industrial policy. The explicit industrial policy was something proposed by scholars such as Montero (2001) in the form of “horizontal embeddedness” and this thesis confirms the value of a more direct approach to industrial policy. As these results suggest, even a small investment can lead to huge gains in value added (contingent on the specialization levels of the cluster). Therefore, the results of the statistical analysis are encouraging, but certainly not without fault.

CHAPTER FIVE

CONCLUSIONS

A. Review of Findings

In 1983 Krugman argued that “At some point in the next decade, the U.S. will probably adopt an explicit industrial policy,” (Krugman, 1983) and yet, this prediction has yet to come to fruition over 30 years later. However, it is true that the current U.S. form of industrial policy through DOD spillovers is likely not capitalizing on the potential gains that would come from a more explicit program. This thesis set out to propose a new form of explicit, cluster-based industrial policy specifically tailored to the United States, and by using such a program, the United States could potentially see significant gains in employment, income inequality, innovation, and industrial growth.

The previous literature from scholars such as Porter (2012), Montero (2001), and Wade (2016) has laid the groundwork for this proposal, and their contributions have strong ties throughout this thesis. Porter in particular had derived the idea of clusters as an economic area (EA) that takes advantage of external economies. His work noted the substantial gains to employment, innovation, and growth within stronger clusters, and that is the basis for targeting clusters in this industrial policy proposal.

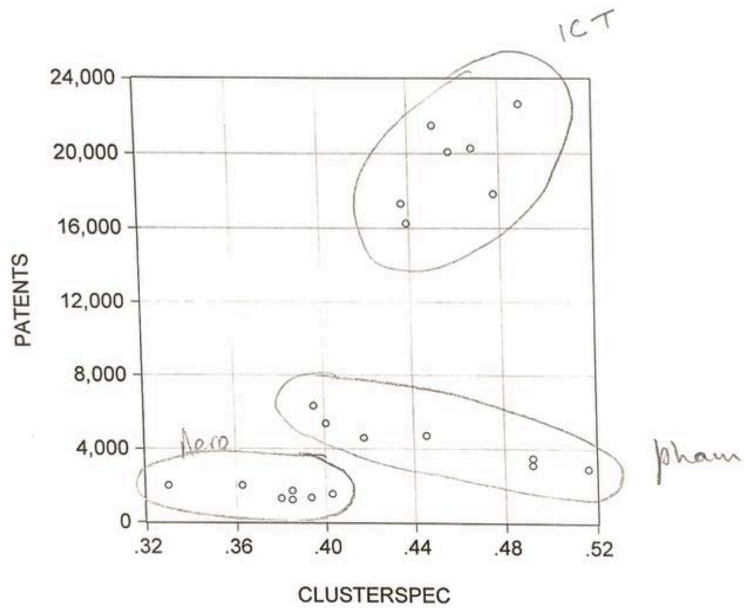
This thesis derived a model for this industrial policy proposal to statistically measure the impact of such a policy if it were used in the United States. To do this, a model that uses DOD expenditure, a measure of cluster specialization (how strong a cluster is), patent data, value added, and R&D was used. In addition, the data used were panel data, meaning that the data ranged from a period of 7 years (2007-2013) across three carefully chosen industries. These industries were chosen in an effort to accurately depict distinct areas of U.S trade as it exists today. The graphic analysis revealed some interesting patterns that *suggested* a positive relationship between DOD expenditure, cluster specialization, value added, and R&D with patents. However, it became clear that patents was not a viable measure of industrial policy output for regression analysis due to the fact that the units were in real numbers but every other variable was in dollars. This, and the fact that each industry (especially the Aerospace industry) was so different, made it difficult to use patents as the dependent variable in the regression. However, when excluding the Aerospace industry, using value added as the dependent variable, and an interaction term (between cluster specialization and DOD spending) there were positive and significant results.

B. Recommendations for Future Research

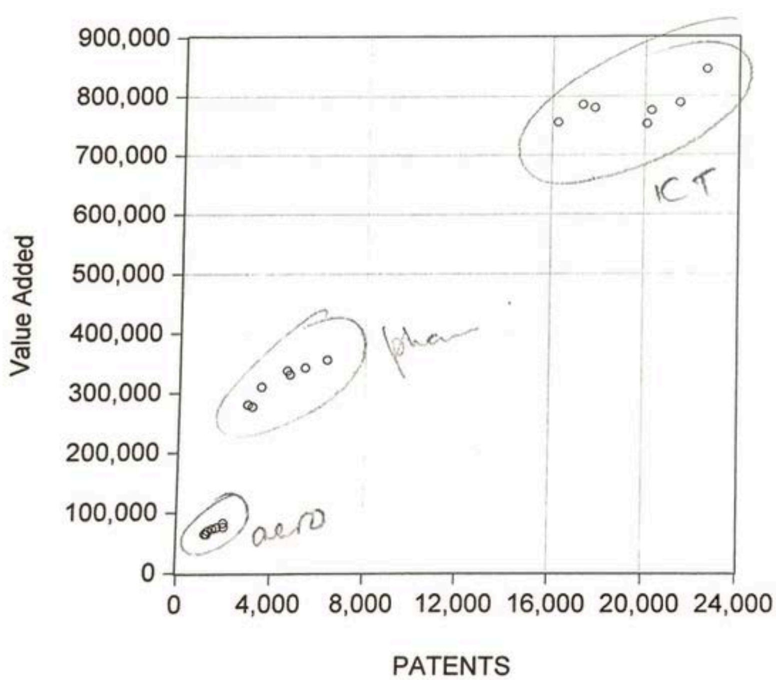
The results gained from this thesis are promising, but also confirm the necessity of greater research into this particular policy proposal. In particular, the results from the regression analysis were encouraging, but there were a few notable issues, primarily with the lack of data available at the time of writing this thesis. However, this opens the door for promising future research. For some regressions, there were only 10 observations available, but this is simply because of the lack of both DOD spending data and value added data. The DOD spending data only dates back to 2007, so there will need to be further research done on this particular policy when more data inevitably becomes available. In addition, future research should potentially focus on finding a new set of industries to examine, because perhaps those will yield differing/stronger results. If in the future, a form of explicit industrial policy is incorporated into the United States trade strategy, then at this point there could be some interesting research done on its real world impact. However, the policy that has been put forth in this thesis is primarily meant to be a starting point, a first step in the direction of making truly explicit industrial policy a reality in the United States. There are clusters that are ripe for U.S industrial policy intervention, and if they are capitalized on, then there could be substantial gains for the U.S. If future researchers are able to expand on the work of this thesis, or even derive a new proposal as a result of this work, then perhaps an explicit industrial policy in the United States is closer than we think.

APPENDIX 1

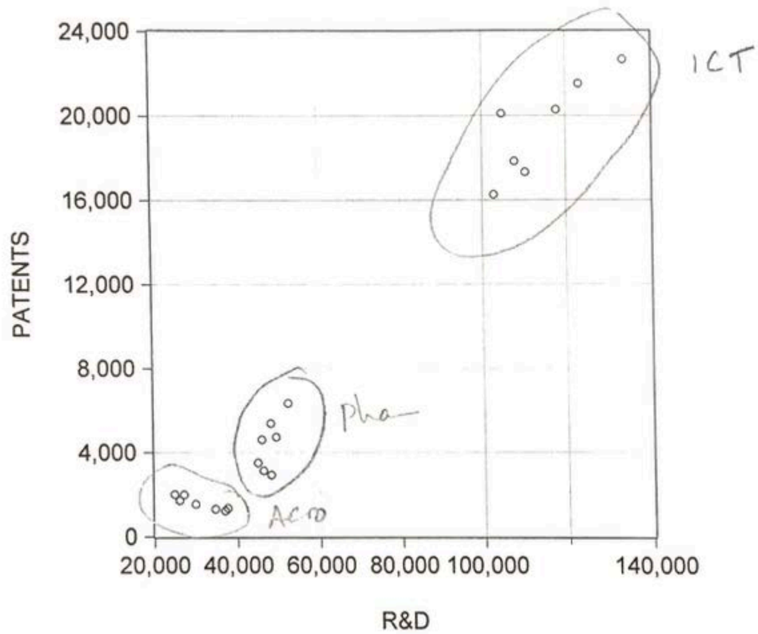
Appendix 1: Figure 1



Appendix 1: Figure 2



Appendix 1: Figure 3



Appendix 1: Figure 4

Eviews Variable Name	**Definition**
CLUSTERSPEC	Measure of cluster specialization using the location quotient. The higher this number, the greater the cluster specialization.
DODSPEND	Measure of expenditure by year from the DOD in a given sector. Units: millions of dollars
DODSPEND*CLUSTERSPEC	Interaction term between cluster specialization and DOD spending. Change in dependent variable is contingent on specialization level of cluster.
R_D	Measure of research and development in a given industry. Units: millions of dollars.
VALUE_ADDED	Measure of value added in a given industry in millions of dollars (size of industry).
PATENTS	Measure of innovation by taking # of new patent registrations in a given year (by industry)
AR(1)/AR(2)	Eviews tool to correct serial error correlation. Creates a lag for the error terms of 1 (or 2 years)

APPENDIX 2

Appendix 2: Regression 1

Dependent Variable: PATENTS				
Method: Panel Least Squares				
Date: 02/07/17 Time: 14:53				
Sample: 2007 2013				
Periods included: 7				
Cross-sections included: 3				
Total panel (balanced) observations: 21				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DODSPEND	0.515226	1.625740	0.316918	0.7554
CLUSTERSPEC	-17973.04	7113.568	-2.526586	0.0224
R_D	0.168855	0.035615	4.741128	0.0002
VALUE_ADDED	0.007648	0.004518	1.692795	0.1099
C	2192.058	3015.341	0.726969	0.4777
R-squared	0.985462	Mean dependent var		8454.442
Adjusted R-squared	0.981827	S.D. dependent var		8165.538
S.E. of regression	1100.764	Akaike info criterion		17.04965
Sum squared resid	19386888	Schwarz criterion		17.29835
Log likelihood	-174.0214	Hannan-Quinn criter.		17.10363
F-statistic	271.1386	Durbin-Watson stat		1.479945
Prob(F-statistic)	0.000000			

Appendix 2: Regression 2

Dependent Variable: VALUE_ADDED				
Method: Panel Least Squares				
Date: 02/22/17 Time: 14:38				
Sample: 2007 2013 IF @CROSSID<3				
Periods included: 6				
Cross-sections included: 2				
Total panel (balanced) observations: 12				
Convergence achieved after 14 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DODSPEND*CLUSTERSPEC	238.9918	162.6250	1.469588	0.1799
R_D	3.345606	1.134497	2.948977	0.0185
C	313708.3	201660.9	1.555623	0.1584
AR(1)	0.933492	0.064596	14.45134	0.0000
R-squared	0.995930	Mean dependent var		557241.7
Adjusted R-squared	0.994404	S.D. dependent var		243170.6
S.E. of regression	18190.34	Akaike info criterion		22.71637
Sum squared resid	2.65E+09	Schwarz criterion		22.87801
Log likelihood	-132.2982	Hannan-Quinn criter.		22.65653
F-statistic	652.5904	Durbin-Watson stat		2.143721
Prob(F-statistic)	0.000000			
Inverted AR Roots	.93			

Appendix 2: Regression 3

Dependent Variable: VALUE_ADDED				
Method: Panel Least Squares				
Date: 02/23/17 Time: 12:40				
Sample: 2007 2013 IF @CROSSID<3				
Periods included: 5				
Cross-sections included: 2				
Total panel (balanced) observations: 10				
Convergence achieved after 7 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DODSPEND*CLUSTERSPEC	510.2690	120.0801	4.249404	0.0081
R_D	9.239699	1.579680	5.849096	0.0021
PATENTS	-18.67303	7.264792	-2.570346	0.0500
C	-4555.740	45795.25	-0.099481	0.9246
AR(2)	0.353265	0.103886	3.400508	0.0192
R-squared	0.998321	Mean dependent var		562120.0
Adjusted R-squared	0.996978	S.D. dependent var		240660.7
S.E. of regression	13229.39	Akaike info criterion		22.12512
Sum squared resid	8.75E+08	Schwarz criterion		22.27641
Log likelihood	-105.6256	Hannan-Quinn criter.		21.95915
F-statistic	743.3334	Durbin-Watson stat		2.913741
Prob(F-statistic)	0.000000			
Inverted AR Roots	.59	-.59		

Appendix 2: Regression 4

Dependent Variable: VALUE_ADDED				
Method: Panel Least Squares				
Date: 02/23/17 Time: 12:41				
Sample: 2007 2013 IF @CROSSID<3				
Periods included: 5				
Cross-sections included: 2				
Total panel (balanced) observations: 10				
Convergence achieved after 9 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DODSPEND*CLUSTERSPEC	499.3838	213.4488	2.339595	0.0579
R_D	5.295684	0.362179	14.62173	0.0000
C	89169.72	36510.91	2.442276	0.0503
AR(2)	0.402258	0.246417	1.632428	0.1537
R-squared	0.995707	Mean dependent var		562120.0
Adjusted R-squared	0.993561	S.D. dependent var		240660.7
S.E. of regression	19311.48	Akaike info criterion		22.86396
Sum squared resid	2.24E+09	Schwarz criterion		22.98500
Log likelihood	-110.3198	Hannan-Quinn criter.		22.73119
F-statistic	463.9085	Durbin-Watson stat		1.589245
Prob(F-statistic)	0.000000			
Inverted AR Roots	.63	-.63		

Bibliography

Bureau of Economic Analysis. Accessed March 9, 2017. https://www.bea.gov.

Delgado, Mercedes, Michael Porter, and Scott Stern. "Clusters, Convergence, and Economic Performance." 2012. Accessed October 31, 2016. MyEconLit doi:10.3386/w18250.

Doh, Soogwan, and Byungkyu Kim. "Government Support for SME Innovations in the Regional Industries: The Case of Government Financial Support Program in South Korea." Research Policy 43, no. 9 (2014): 1557-569. Accessed November 2, 2016. doi:10.1016/j.respol.2014.05.001.

Groba, Felix, and Jing Cao. "Chinese Renewable Energy Technology Exports: The Role of Policy, Innovation and Markets." *Environmental and Resource Economics* 60, no. 2 (2014): 243-83. doi:10.1007/s10640-014-9766-z.

Kgrugman, Paul, and Richard Baldwin. "Industrial Policy and International Competition in Wide-Bodied Jet Aircraft." *National Bureau of Economic Research*, 1988, 45-77. Accessed November 18, 2016. MyEconLit.

Krugman, Paul. "Targeted Industrial Policies: Theory and Evidence." Proceedings - Economic Policy Symposium - Jackson Hole., 1983, 123-76. Accessed March 5, 2017.

Montero, Alfred P. "Making and Remaking "Good Government" in Brazil: Subnational Industrial Policy in Minas Gerais." Latin American Politics and Society 43, no. 2 (2001): 49. doi:10.2307/3176971.

Porter, Michael. "Clusters and Economic Policy: Aligning Public Policy with the New Economics of Competition." Harvard Business School, November 2007. Accessed October 31, 2016. MyEconLit.

Reimann, Matt. "The story of the EpiPen: from military technology to drug-industry cash cow." Timeline. August 24, 2016. Accessed March 08, 2017. https://timeline.com/epipen-technology-drug-industry-b28d19036dee#.3tqavs72e.

Spence, Michael. "Industrial Organization and Competitive Advantage in Multinational Industries." American Economic Review, May 1984. Accessed November 2, 2016. MyconLit.

Tassey, Gregory. "Underinvestment in Public Good Technologies." *Journal of Technology Transfer*: 61-85. Accessed November 16, 2016. doi:10.1007/0-387-25022-0_6.

United States Patent & Trademark Office. Accessed March 9, 2017. https://www.uspto.gov/web/offices/ac/ido/oeip/taf/reports.htm.

U.S Cluster Mapping Project. Accessed March 9, 2017. http://www.clustermapping.us

USA Spending.Gov. Accessed March 9, 2017. https://www.usaspending.gov/Pages/Default.aspx

Wade, Robert. "The Role of the State in Escaping the Middle Income Trap: The Case for Smart Industrial Policy." METU Studies in Development 41 (April 2016). Accessed November 2, 2016. MyEconLit.