The Influence of Intellectual Property Rights on the International Trade of Advanced Technology Products

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Abstract

The gravity model of international trade is based on the assumption that trade between two countries will tend to be greater as barriers between those two economies become smaller. In the traditional application of the gravity model, the physical distance between two economies, a proxy for transportation costs, represents this barrier in a very physical sense. This paper utilizes the gravity model to evaluate trade flows among a specific subset of traded goods, that of advanced technology products. The overall production costs of ATP goods include expenditures from a substantial amount of research and development, which means that transportation costs tend to represent a smaller portion of the overall production costs. Therefore, in the context of the gravity model, for ATP, the "barrier" effect of transportation costs is hypothesized to be weaker than for overall trade flows. Additionally, due to large investments in research and development of advanced technology products, low levels of intellectual property protection may serve to discourage firms from trading with countries that have comparatively loose enforcement of intellectual property protection regulations. This paper compares the application of the gravity model to exports of ATP and overall exports from the United States. The gravity model is applied to both overall US exports and US exports of ATP for the years 2007 to 2011. The gravity model is further applied to 2011 US exports of 10 ATP subcategories. Through these two approaches, this paper assesses the

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varying influence of transportation costs and intellectual property protections on the trade on of advanced technology products. Results indicate that higher levels of intellectual property protections in an economy are associated with greater imports of ATP from the United States, and that responsiveness to fluctuations in levels of IPR enforcement is not uniform among all categories of ATP.

Key Word: Advanced Technology Products, Gravity Model, Intell-ectual Property Protections, International Trade

Introduction

Background and Rationale

This intent of this paper is to evaluate the role that transportation costs and intellectual property protections play in determining international trade flows of advanced technology products (ATP). This is done through a comparative application of the gravity model of international trade to both trade of overall US exports and US exports of ATP, as well as through a separate analysis of trade among subgroups of ATP for the year 2011.

Generally speaking, transportation costs represent a smaller proportion of overall final costs in bringing an advanced technology product to market than they would represent of the final costs to bring a more "low tech" good to market. This is assumed to be so because there is a higher cost to develop ATP than ordinary goods (both due to high research and development costs, and in some cases due to more exacting production requirements). Therefore, per mass or volume unit, ATP will tend to have higher value (cost to produce), and as transportation costs can reasonably be assumed to be proportionate to the size or weight of the transported good, transportation costs for ATP goods will comprise of relatively less of the cost of the overall final product. There are some notable exceptions, where non-ATP goods have relatively high value-to-weight ratios, such as in the case of luxury goods, art work or antiquities; these, however are the exception not the rule.

The ratio of transportation costs to final costs is therefore assumed to be higher among overall goods and lower among advanced technology products. Therefore, by comparing international trade flows of ATP with overall trade flows, one can evaluate to what extent transportation costs determine trade patterns in ATP compared to trade in other products. This paper seeks to demonstrate the influence that transportation costs have on international trade flows, through a comparative application of the gravity model of trade.

Transportation costs influence the origin of utilized of raw materials, where goods-both intermediate and final-are produced, and how much of which types of products are shipped internationally. The term transportation costs can really be considered an umbrella term for the variation of costs incurred due to distance, geographic features, access to waterways, remoteness, and infrastructural development.

A good deal of economic and business literature focuses on the costs and benefits of opening international production operations: the higher the cost of transportation, the more likely the parent company is to open international production in a host country under the banner of foreign affiliates. The lower transportation costs are the less likely companies will be to open up production internationally. This is because the costs associated with expanded international production operation will not be counterbalanced with a sufficient reduction of transportation costs. It is better to just produce domestically and ship goods to foreign consumers.

Due to the unique characteristics of ATP when compared to products en masse, and the certain circumstances under which they are developed, produced and replicated, intellectual property protections may play a significant role in determining international trade flows of ATP. Over recent decades, intellectual property protections have become a contentious issue in international trade negotiations. Due to this, this paper seeks to determine how significant intellectual property protection levels are in determining trade patterns of ATP, when compared to distance, which is assumed to be a main determinate in standard trade models.

It stands to reason that varying international levels of intellectual property protection could impact international trade flows of ATP. The development process of ATP creates a great cost. This cost is initially borne by the developing company, and then it is passed on to consumers through higher prices. This creates a unique opportunity for "imitation" companies to enter the market: if an outside enterprise finds out the "secret" obtained through the ATP R&D process, when they themselves did not bear the development cost, they are capable of producing the same ATP without any of the sunk costs of the "legitimate" company. Their costs are therefore lower, and they have more flexibility in making pricing decisions and have a presumably larger profit margin. The imitation companies are more competitive than legitimate ones in terms of pricing. One major force inhibiting these imitation companies from entering the market are laws promoting intellectual property protection. The extent to which these laws are enforced varies from country to country. Presumably, in countries where IP protection is weak, "imitation" competition is enabled, and satiates a portion of the domestic market, edging out "legitimate" domestic and foreign ATP firms. Therefore exports of ATP to this country would be slightly decreased. Conversely, one could argue that high levels of IP protection encourage the development of "legitimate" domestic firms, as the technology gained by investing in R&D endeavors would be protected. Therefore the inverse would be the case. Also, increased levels of ATP may encourage firms to enter a market, as they are more confident that their intellectual property is protected. This paper seeks to explore this relationship, and to investigate the role that intellectual property protection has on international trade flows of ATP.

In recent years the trade balance of the United States has become a popular topic in the political discourse; politicians are concerned with how large the trade deficit is and what must be done to rebalance it. As the United States is at a comparative disadvantage in labor-intensive products, it has been suggested that the United States focus its efforts on the promotion of capital-intensive exports, in which the United States would theoretically have a comparative advantage. Therefore, this paper will be of particular interest to members of commercial, academic and governmental organizations throughout the United States. As this paper explores the nature of trade among capital-intensive advanced technology products, this paper would be of interest to global governmental and private sector officials seeking to understand this particular subset of international trade. This will also be of interest to government and business officials that seek to understand how a change in the ability of a trade partner to enforce intellectual property protections will influence trade with that partner.

Objectives and Scope

This paper tests the applicability of a traditional gravity model of trade, as well as a version of the gravity model to which an additional variable concerning intellectual property protection has been added, to trade in advanced technology products.

This paper has two main objectives:

1) To test the impact of transportation costs on the flow of goods internationally, specifically in the context of advanced technology products, which can be reasonably assumed to have a higher value-to-weight ratio than general goods.

2) To test the influence of intellectual property protection on international trade flows of advanced technology products.

Organizationally, in this paper, the objectives above will be explored through three econometric applications of the gravity model:

Application One: This first section of this paper demonstrates the ability of the basic gravity model to describe the characteristics of aggregate trade. This section will utilize US export data to 176 countries for the years 2007, 2008, 2009 and 2010. Oil prices and population are used as control variables.

Application Two: The second section will then analyze the ability of the basic gravity model to describe trade of ATP. This section will utilize US ATP export data to 176 countries for the years 2008, 2009 and 2010. Oil prices and population will be used as control variables.

Application Three: The third section will test the role of intellectual property protections in describing variation among 10 separate subgroups of advanced technology trade for the year 2011. As in the first two applications, oil prices and population are used as control variables.

This scope of this paper's empirical analysis is U.S. exports of advanced technology products. Analysis of U.S. imports is not within the scope of this study, neither is trade between countries other than the United States. The exports of the United States are studied, at the exclusion of other countries, due to the special position of the United States as large producer of a variety of capital-intensive products.

Literature Review

This literature review consists of three sections. In the first section the foundational elements and common applications of the gravity model of trade are introduced. The second section discusses the role of transportation and trade costs-specifically those imposed by distance and geography-in determining international trade flows. The third section examines the role of intellectual property protections in determining international trade flows.

The Gravity Model

Sir Isaac Newton's Law of Universal Gravitation, which holds that two bodies are drawn together by their size and proximity, has inspired the name and underlying ideology of the gravity model of trade. The gravity model is concerned with the determinants of interaction between economies.

In its most basic and essential formulation, the gravity model holds that the size of and the distance between two economies determine the flow of goods between them. The underlying logic of the gravity model holds that the larger and nearer two economies are, then the higher the volume of trade between them will be.

The explanatory variable of distance is usually measured directly as the physical distance between the two economies, often measured between capital cities. The size of each economy is typically measured using GDP.

Tinbergen (1962) developed the model and its early econometric evaluation. Pöyhönen (1963a) applied the Gravity Model to patterns of international trade, as part of a study of trade between ten European countries in 1958.

In its most basic form, the Gravity Model can be defined as:

$EXP_{I,J} = ß_0 + ß_1 GDP_I + ß_2 GDP_J + ß_3 DIST_{I,J} + u_{I,J}$

Where:

$EXP_{I,J}$ represents the flow of goods from Country I to Country J;

$ß_0$ represents a constant term;

GDP_I and GDP_J represent the GDPs of Country I and J, respectively;

$DIST_{I,J}$ represents the distance from Country I to Country J; and,

$u_{I,J}$ represents an error term.

Most commonly a log is taken of both sides, and the gravity equation is expressed as a log-log equation:

$LnEXP_{I,J} = ß_0 + ß_1 lnGDP_I + ß_2 lnGDP_J + ß_3 lnDIST_{I,J} + u_{I,J}$

Based on the underlying logic of the Gravity Model, in this formulation, $ß_1$ and $ß_2$ are assumed to be positive and $ß_3$ is assumed to be negative. This is based on the assumption that the GDP of both Country I and Country J have a direct relationship with the flow of goods from Country I to Country J, and the assumption that the distance between Country I and Country J has an inverse relationship with the flow of goods from Country I to Country J.

In the years since its initial economic application, the Gravity Model has proven to be versatile in its application within trade theory. McCallum (1995) utilized a gravity model to measure trade volumes between individual American states and Canadian provinces. He found that, at least in the case of US-Canadian trade, international borders have a negative effect on trade volume. It is reasonable to assume that this relationship is mirrored by bilateral trade flows between other nations. This negative relationship could presumably be greater as there are many factors specific to the US-Canadian example that could potentially promote trade flows-which other bilateral trade flows would not have the benefit of-such as a common language and a long, easily-traversable land border with interconnecting transit infrastructures.

Martinez Zarzoz and Nowak Lehman (2003) used an alternatively augmented gravity model in testing for the determinants of bilateral trade flows between Mercosur, Chile and 15 EU countries. Their model utilized explanatory variables to account for infrastructural development, income differentials and exchange rates and the influence they could have on trade flows.

Likewise, the effect of regional trade agreements (Carrére, 2006) and common language or cultural traits can also be accounted for, often through the use of dummy variables. Lee and Shin (2006) use a variation of the gravity model to assess trade diversion and trade creation of RTAs in the context of East Asia.

Typically speaking, the gravity model utilizes fixed-coefficients. Efforts have been made to increase the flexibility of this model, through the introduction of a model variation that utilizes variable coefficients. Zhang and Kristensen (1995) have successfully applied this variable-coefficient model to the trade of countries within European Economic Community (EEC) with those outside of the EEC.

The gravity model has been chosen for use in this paper because of its foundational assumption that trade flows are highly influenced by distance and geography, and the ease with which new explanatory variables can be included, as spatiality is certainly not the only or necessarily primary determinate of trade flows. The widespread use of the gravity model and, the accompanying widespread acceptance of its basic explanatory abilities also contributed to its utilization in this paper.

The augmented gravity model used in this paper, in addition to the standard measures of GDP and distance, will utilize explanatory variables that account for macroeconomic events and intellectual property protection levels. It is assumed that these factors could influence trade flows of advanced technology products (the dependent variable), and therefore their ability to determine trade volumes should be measured, or at a minimum, controlled for.

The Role of Trade and Transportation Costs

This section reviews literature concerning trade and transportation costs, and how they impact international trade. As this paper uses a gravity model to describe international trade flows with distance as an explanatory variable, this section of the literature review places emphasis on how distance and topography influence trade flows.

The determinants of international trade flows include more than those alluded to by the theory of relative factor endowments and productive comparative advantage; the influence and importance of trade costs must also be taken into consideration. Anderson and Wincoop (2004) gauge that trade costs are, on average, roughly double that of production costs, and that therefore they are likely more influential than comparative productive efficiency in determining comparative international advantage.

Although distance, as discussed above, can serve as a proxy for some trade related costs, overall trade costs can be broken down into two categories: costs imposed by policy (tariffs, quotas, etc.), and costs imposed by the environment (transportation costs, insurance, time costs) (Anderson and Wincoop ,2004). Transportation costs include direct elements, such as the cost of freight and insurance, as well as indirect elements, such as holding costs, preparation for the shipment, time costs, and costs associated with the variability of shipping schedules (Anderson and Wincoop, 2004).

Transportation costs can be quantified in three main ways. A direct measurement of transportation costs can be taken through the evaluation of industry or firm shipping records. (Anderson and

Wincoop, 2004). Hummels (1999) uses this approach in an assessment of shipping quotes for shipping rates from Baltimore to various international ports. Although direct, this is this approach is not the easiest to take in assessing transportation costs as there are issues of data scarcity.

It is rather difficult to obtain accurate or sufficient information concerning trade costs. While some trade costs (information costs and contract enforcement) are near impossible to measure, transportation-related trade costs are not readily available due to their sensitive nature (Anderson and Wincoop, 2004).

Transportation costs can be more readily deduced, albeit more indirectly, from available US Census data on the value of exports, and taking a ratio of the value in terms c.i.f. to f.o.b. (Anderson and Wincoop, 2004). The IMF provides this c.i.f./f.o.b. ratio for a wide number of countries. Due to the low quality of this data, Hummels (2001) maintains that it should not be used in serious assessment. Nevertheless, due to the wide range of years and countries included in the IMF dataset, it is widely used an accepted.

The Role of Distance and Geography

In terms of transportation costs, the distance between the points of production and consumption are more complex than simply the distance between the two locations; the geographic nature of this expanse, as well as the infrastructure in place to traverse it, impact trade flows.

Distance, and the associated transportation costs certainly do matter a great deal. Over recent decades, roughly 23% of international trade has been conducted between bordering countries (Hummels, 2007). Based on U.S. and Latin American data, Hummels (2007) notes that trade between contiguous nations is typically conducted over land routes, whereas in the case of U.S. trade with non-bordering countries, one third of imports and over half of exports are conducted by air, despite its higher cost than pure maritime transport.

The primacy of air freight is likely due to decreasing relative and marginal air transit costs (Hummels, 2007) and that the composition of internationally traded goods has changed: over time, trade in high-value-to-weight goods has increased while trade in low-value-to-weight goods has decreased. (Hummels, 1999) Therefore, as transportation costs should be considered ad valorem, and as the total value-to-weight of goods is increasing, the premium for air freight becomes decreasingly prohibitive.

It is also worthy to note that not all products are produced nor consumed in coastal cities, therefore maritime shipping comes with associated land transport costs if one or both cities are inland. Transportation by air is therefore not only faster, but may also be cheaper in some cases when compared to the full basket of land and maritime transportation costs. Limao and Venables (2001) investigate the influence of geography and infrastructure on transportation costs. They examine freight data for shipments from Baltimore to 64 cities around the world, 35 of which are in landlocked countries. They use data including both the ultimate destination city and the city of initial landfall, through which they are able to differentiate between the distances traveled by land and by sea, and account for the impact of each on overall transportation costs. Limao and Venables (2001) conclude that landlocked countries have transportation costs that are 55% higher than their coastal counterparts. Limao and Venables (2001) reveal that a deterioration of infrastructural development (measured as the density of the road network, the amount of paved roads, the rail network and the number of telephone main lines per capita) from the median level to the 75th percentile can be associated with transportation costs that are 12% higher. Their findings demonstrate the importance of considering the extent and nature of infrastructural development, inland topography, and spatial layout when examining transportation costs.

Cost Reductions through Technological Development

Recent literature has highlighted the faster growth rate of global international trade when compared to that of global output. During the period of 1950 to 2004, world trade grew at an average rate of 5.9% per annum, with the ratio of world trade to relative to world output more than tripling (World Trade Organization, International Trade Statistics, 2005). The volume of world trade has tripled since 1980, while at the same time, real world GDP has increased by only 75%. (Berthelon, 2004)

This increase in international trade is at least partially due to reductions in transportation costs through technological advancement. (Hummels, 2007).This is not without historical precedent. Harley (1998) demonstrates the impact that the introduction of metal ships and the steam engine had on shipping costs during the late 1700s to early 1900s. North (1958) finds that the technological advancements in railroad technology-and to a greater extent, maritime shipping-provided the groundwork for the development of western civilization from largely self-sufficient to more interdependent economies over the past two centuries: reductions in transportation costs have widened the resource base of the western world and allowed for more efficient resource utilization. Mohammed and Williamson (2004) demonstrate how reductions in maritime shipping costs have resulted in commodity price convergence across various shipping routes.

This trend of transportation cost reductions through technological development has continued. Over the second half of the 20^{th} century, international shipping has benefited from cost reductions and increased speed through two major technological innovations: the jet aircraft engine and the use of containerization in maritime shipping (Hummels, 2007).

Declining air transit costs have the affect of decreasing the cost of speed (Hummels, 2001, 2007). The increased timeliness of air freight allows domestic firms to take advantage of sudden changes in market preferences, better respond to volatile domestic demand and ensure proper levels of stocked merchandise. (Aizenman, 2004 and Schaur, 2006).

Hummels (1999) notes that, over the second half of the twentieth century, maritime freight costs have increased while airfreight costs have decreased. Also, land freight costs have decreased relative to maritime freight costs, and for all forms of transport, costs associated with greater distances have declined over time (Hummels, 1999).

Despite reductions in transportation costs and advancements made in communications technology over the past decades, it seems that the negative impact of distance on trade flows has not decreased. Disdier and Head (2004) constructed a database of 1467 estimates (from 103 papers) of the impact of distance on trade flows and found that the negative influence of distance on trade flows persisted over time, among various sample sets and in studies using varying methodologies. This is perplexing, as it would seemingly be any easy assumption that improved technology would ease the difficulties and cost of trading internationally, and therefore promote its practice.

Brun et al (2005) conducted an assessment of bilateral trade of 130 countries for the years 1962-1996 and also found the influence of distance to be consistent over time. They then introduced an augmented gravity model and found that the impact of distance on trade flows did decrease by 11% over the course of the study, but only for a specific sub segment of trade: bilateral trade among rich countries. This would suggest that the impact of distance could be diminished through advancements in technology, but perhaps only to the extent that both trading partners adopt these advancements.

The Role of Intellectual Property Protections

This section contains a review of literature concerning international intellectual property protections, their potential influence on international trade and the economic and political context in which these protections exist.

First, the role of intellectual property protections as non-tariff barriers to trade (NTBs) is presented. Following this, literature concerning the influence of intellectual property protections on technological innovation and international trade flows is reviewed. Finally, two critical perspectives on intellectual property protections are highlighted: intellectual property protections as nationalist economic platforms and bioethical issues surrounding patented pharmaceutical products.

Policy barriers to international trade include the variety of bureaucratic or human-created costs associated with trade, ranging from defined tariffs to the impact of non-tariff barriers (NTBs) such as quotas, sanctions or other restrictions. Deardorff (1998) notes that "there is a basic difficulty in approaching NTBs as they are defined as what they are not" and that they are not always "barriers" to trade: in the case of subsidies, which are considered to be a form of NTB, there is actually a boost to trade. Whatever form they take, NTBs cause trade distortions.

Evidence suggests, that for developed countries, tariff trade barriers are relatively low, and that NTBs are commonplace and have high tariff equivalents (Anderson and Wincoop, 2003). NTBs are a very common and are instituted in place of a straightforward tariff for a number of reasons: the need to adhere to the letter of WTO/GATT regulations, national constitutional restrictions on tariffs, the fear of trading partner retaliation, the influence of politicians' constituents or corporations and the general (and as Deardorff comments, misguided) perception that tariffs are ineffective (Deardorff, 1987, Deardorff and Stern, 1998).

Deardorff (1987) contends that restrictive trade policies are instituted primarily as a defensive attempt to prevent harm to the domestic economy. Even though there may be a welfare gain through the alteration of an NTB, Deardorff (1987) feels that due to underlying logic of Corden (1974)'s "Conservative Societal Welfare function" (where the utility loss of a certain action is weighed more heavily than an equivalent utility gain) the status quo of NTBs will tend to be upheld.

Despite the interest in the role and impact of international trade policies (tariffs, regulations, quotas and the like) by natioal governments for centuries, data and information on such policies is fragmented and of poor quality. As Anderson and Wincoop (2003) state, "The grossly incomplete and inaccurate information available on policy barriers is a scandal and a puzzle." This is especially perplexing as organizations of such international stature and means as the World Bank and the World Trade Organization have placed international trade policy as one of their primary areas of interest and involvement (Anderson and Wincoop, 2003).

Data restrictions make estimating the size and resulting impact of tariff barriers difficult, especially as specific tariffs must be considered in ad valorem terms, and therefore matched up with price information, which further complicates attempts to evaluate their real impact (Anderson and Wincoop, 2003).

The rationale behind having intellectual property rights protections is that they incentivize innovation and technological progress, while at the same time protecting ownership of the results of intellectual labor. This section reviews literature concerning the relationship of intellectual property protections and innovation.

The endogenous growth model holds that internal forces drive economic growth, two key forces being innovation and the accumulation of human capital. In this model, the pursuit of profit is increasingly seen often as a motivator of innovation and the engine for economic growth (Grossman and Helpman, 1991; Romer, 1990).

That people will create or innovate out of self interest may seem to be a very basic concept, however it is fundamental to arguments for the necessity of intellectual property protections. A government may decide to incentivize innovation by increasing intellectual property protection levels and protecting the ability of innovators to profit from their work; however overly stringent regulations may hinder the development and creation of new ideas (Gould and Grube, 1996).

An increased level of intellectual property protection incentivizes investment in research and development, as illustrated through a survey of Brazilian firms conducted by Sherwood (1990), and by a two-period panel study of 32 countries by Kanwar and Evenson (2003). This increased investment then promotes long-term economic growth. Through a cross-country study for the years 1960-1988, Gould and Grube (1996) found that increased intellectual protection levels were associated with accelerated economic growth rates, and that these growth rates were highest in open economies. Braga and Willmore (1991) suggest that the inherently less competitive framework of closed economies means that they are unlikely to benefit from increased innovation upon instituting intellectual property protections. The Intellectual Property Rights Index 2011 Report (Jackson et al, 2011), a publication of the Property Rights Alliance, found that there is a strong positive correlation between levels of intellectual property rights and economic development (measured as GDP per capita).

This being said, it is important to strike a good balance in terms of the stringency of the enforcement of intellectual property rights: too much leniency destroys returns on innovation, while excessive stringency stands in the way of further innovation. In such industries as software, where each program or product is developed on the basis of and includes hundreds pieces of previously patented materials, the over issuance and strict enforcement of patents has dampened innovation and potentially held back groundbreaking technology (Shapiro, 2001). As innovation has become "increasingly cumulative in nature, the progressive enclosure of technical knowledge, which is at the basis for subsequent advancements in science and innovation, may induce a sort of "lock-out" of potential innovators that are not yet in a dominant position, or, on the contrary, may give excessive bargaining power to small, technology-intensive firms with no physical processing or distribution capacity" (Cimol et al, 2008). Ownership of basic level patent allows a firm to disrupt the business of competitors by filing a lawsuit stating that their patented property had been infringed upon.

Firms like Apple, Google, Microsoft, Research in Motion, HTC and Kodak have all recently engaged in legal battles over the ownership of key digital patents, specifically those crucial and fundamental to the development of mobile digital imaging technology. Some firms, like HTC and Apple have claimed ownership of the same or nearly identical intellectual property for the sake of being more competitive (BBC, 2012). Other firms, such as Kodak, seek to legally establish ownership of key patents in order to attract licensing fees or reap large profits through their sale (Schneider and McLaughlin). Companies such as Intellectual Ventures have come into existence for the purpose of acquiring key patents, sitting on them and extracting fees and lawsuit payouts; this activity has earned Intellectual Ventures the title of "Patent Troll" by some (NPR).

In such cases, which have unfortunately become quite commonplace, the way in which patents are viewed and utilized in practice is markedly different from their intended use. As opposed to a method for rewarding and therefore incentivizing innovation and risk-taking, patents are often used as means to lash out at competing firms and to prohibit them from or punish them for entering certain market segments.

The high monetary value associated with many foundational patents in advanced technological fields implies that if a scientist or engineer is to develop a pioneering technology based on existing knowledge, and therefore require access to the associated patents, they must either have access to large amounts of capital to secure usage rights, or be affiliated with a large technology-and capital-rich firm. That civilization's great technological advances are created through the experimentation of maverick geniuses and visionaries is now little more than a romantic notion. That science is being commercialized is nothing new, and it is a trend that is likely to continue. Given this trend, the competitive nature of business encourages significant investment in research and development-perhaps more resources than would be allocated if intellectual property protections were not so commercialized.

Intellectual Property Rights and Trade Flows

As intellectual property protections impact the ability of firms to safeguard and capitalize on their sunken intellectual property protections, a certain degree of reticence exists on the part of firms in competitive, capital-and IP-intensive industries to enter markets with low levels of intellectual property protections.

There is some empirical evidence suggesting that intellectual property protections may influence international trade flows in some sectors. Maskus and Penubarti (1995) use the Helpman-Krugman model to empirically evaluate the influence of income, trade barriers and intellectual property protections on bilateral sectoral trade flows, and find that, in developing countries, increasing intellectual property protections correspond with an increase of manufacturing imports.

Policy on and enforcement of intellectual property protections vary greatly from nation to nation. This, along with requirements and restrictions placed on advanced or manufactured products by a country's chosen trade policy platform, present firms with a number of things to consider. When deciding whether or not to enter a market because of lax intellectual property enforcement and potential patent infringements, firms will weigh the loss of market power (due to other firms duplicating their technology) against the benefits of access to the market as a whole (Maskus and Penubarti, 1995). The larger the market, and the lower the potential loss of market share, the more likely a firm will be willing to enter a market. It becomes an issue of trade-offs and whether a firm is willing to expose their product to potential bootlegging in exchange for the payoffs resulting from having gained access to the associated market.

This paper approaches this dilemma in the context of the trade of advanced technology products, and measures the influence of intellectual property protections on trade in advanced technology products through an empirical analysis of bilateral trade flows of advanced technology products between the United States and 176 trading partner countries.

The ways that varying levels of intellectual property protections could theoretically influence trade flows of advanced technology products are not necessarily uniform across types of products. Patent-protected innovations in various sectors are not duplicated with uniform ease. Firms, such as those in the chemical, pharmaceutical and software industries, can copy others' innovative production practices with relatively low capital investment; whereas firms in the transportation equipment industry, or other "heavier" industries for that matter, will likely require much greater funding to adopt the innovative practices of others (Mansfield, 1994). Therefore, patented technologies that require higher levels of capital to be incorporated into production processes are presumably less likely to be duplicated. Firms, particularly pharmaceutical and electronics ones, with significant investments in research and development may be reticent to sell or license their resulting products in countries with low intellectual property protections out of fear that the purchasing firm will violate the purchasing agreement without legal consequence (Sherwood, 1990). This decision on the part of the technology-holding firm, if viewed as part of a wider industry trend, could have implications and limit the amount and nature of advanced technology products imported.

The ease of duplicability for these particular technologies could also result in an increase of competition from "imitating" firms within these industries in particular, especially in countries with lower levels of intellectual property protections.

Inward FDI is discouraged by weak intellectual property protection enforcement (Smith, 2001). Weak enforcement discourages technology-holding firms from opening up foreign subsidiaries in or forming partnerships with firms from countries with lax intellectual property protections. This could have long term impact on the development of the potential host country and limit trade of advanced technology products.

Critical Perspectives on Intellectual Property Protections

The varying international levels of intellectual property protections, in terms of both letter and actual enforcement, are evident of varying national perspectives on the purpose and benefit of such policies. This section reviews the nuanced perspectives on intellectual property protections.

As previously outlined, intellectual property protections are justified through their theoretical promotion of technological innovation and economic growth. Through a an analysis of 76 countries, Falvey et al. (2006) found that intellectual property protections are not uniformly correlated with economic growth among all nation types. They found that levels of intellectual property protection were negatively correlated with economic growth in middle-income countries and positively correlated with economic growth in low-and high-income countries. Presumably, the growth of low-income countries is promoted by facilitating their access to advanced technologies, while promoting the patent-compliant sale of such technologies supports the growth of high-income countries. The middle-income countries therefore are hurt through restrictions placed on their domestic high-tech sector and the discouragement of technological growth through imitation (Falvey et al, 2006; Deardorff, 1992). Indeed then, according to these results, middle-income economies would be better served by having lower intellectual property protections in effect.

Reichman (1989) makes note of the benefit of lower intellectual property protections for middle-income countries, and expands on an interesting policy paradox: that developed countries tend to favor free market policies in their domestic economies while that the same time advocating for increased restrictions on intellectual goods internationally, while developing countries tend to favor the exact opposite. It seems then that the policies and enforcement regimes national governments adopt towards intellectual property protections are perhaps greater influenced by national interest than pure ideological perspective as to what appropriate incentives and compensations for innovation and risk-taking are.

Cimoli et al. (2008) believe that developed nations use intellectual property protections as "defacto industrial policy… to sustain the competitiveness of their industries and to protect dynamic advantages in certain technological trajectories."

That the 1883 Paris Convention and the 1886 Berne Convention, the beginnings of the current intellectual property rights protection regimes, were initiated on behalf of patent holders who felt their intellectual property was not being satisfactorily safeguarded is cited as evidence by Cimoli et al (2008) that from its onset the intention of intellectual property protections has not been to promote innovation, but to protect and preserve the dominance of those who had already acquired foundational knowledge and wanted to secure development rights to future offshoot technological advances.

The Bioethical Issues of Intellectual Property Rights

Intellectual property protections continue to be a source of great controversy, particularly those protections placed on pharmaceutical products. Lesser-developed countries (LDCs) contend that strictly enforced intellectual property protections on prescription medication are detrimental to public health and that national governments should be given greater leeway in adhering to the related WTO regulation requirements.

The Uruguay round of WTO negotiations resulted in the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement, which initially required all countries to standardize patent law by 2005, and not engage in the production, exportation or importation of generic pharmaceutical products protected under a patent. There was an exemption outlined within TRIPS for countries to impose compulsory licensing of pharmaceuticals, which would allow for the production of generic versions of patented drugs without patent owner consent; however, the circumstances under which compulsory licensing could be enacted were only vaguely outlined, and in order to enact compulsory licensing under TRIPS, the enacting country would be required to have domestic pharmaceutical production capabilities, something which LDCs tend not tend to possess (Castro and Westerhaus, 2007). To address these concerns and provide better clarity, the Doha Declaration was drafted during the Doha round of WTO negotiations. It asserts the importance of public health concerns over the rights of patent holders in lesser-developed nations and enables disease-torn LDCs without pharmaceutical manufacturing abilities to import generic pharmaceuticals. Which countries qualify to import which generics is still a somewhat vague and contentious issue. (Castro and Westerhaus, 2007). Even with compulsory licensing exemptions in place for appropriate countries, it is questionable how many countries have chosen to pursue them, perhaps out of fear for retaliatory, restrictive trade policies (Oliveira et al, 2004).

The Pharmaceutical market operates under a unique set of circumstances. A 2001 report released by the WHO notes that the pharmaceuticals market does not have uniform levels of competition:

over the counter and generic drugs (like aspirin and cough syrup) are produced in markets close to perfect competition (Creese and Quick, 2001). The production of more complex and prescription drugs (such as anti-retrovirals) is dominated by a limited number firms, and market entry is restricted by patent protections (Creese and Quick, 2001). In light of this, the price of some complex, patent-protected drugs can be significantly higher than that of their production, thus providing returns to patent holders for the drugs' development and innovation. According to the same WHO report, "In the United States, when a patent expires the average wholesale price falls to 60% of the branded drug's price when there is just one generic competitor, and to 29% with 10 competitors" (Creese and Quick, 2001). The higher prices paid by consumers for patent-protected pharmaceuticals is substantial.

It is from the price wedge between the production cost and selling price of patented pharmaceutical drugs that the controversy stems: what exactly is fair compensation for innovation, and how can this be balanced with the potential health benefits if these drugs were made as widely and cheaply available as possible? The world's poorest people, who disproportionately live under poor health and sanitation conditions, typically cannot afford high rent payments to patent-holders. The pharmaceutical market reacts to this, and allocates resources to the development of drugs which bear higher returns: those of interest to consumers in developed countries, where higher prices are more easily shouldered and patents tend to be more respected (Abbott, 2002). Thus, the current market structure arguably causes substantial societal harm by not providing drugs to lower-income consumers, while at the same time incentivizing the development of drugs in demand by richer consumers and guiding the developmental trajectory of pharmaceuticals.

Patent-holding pharmaceutical companies have a vested financial interest in the stringent and universal application of intellectual property protections, and take the position that without the rents afforded by patent protections, the costs taken to develop such drugs would be uncompensated and discourage future development. The governments of more developed nations, where these large pharmaceutical companies are typically based, tend to favor increased intellectual property protections on pharmaceuticals. This places them at odds with developing countries, which tend to favor more lax enforcement of pharmaceutical patent regulations on health and humanitarian grounds (Abbott, 2002). Intellectual Property protections have been an issue of contention in more than just the pharmaceutical industry, but also in agriculture. Tensions concerning intellectual property protections have bubbled up at many GATT and WTO rounds, beginning particularly in the 1986-1994 Uruguay round, and international trade disputes filed by the United States Trade Representative and the European Commission against South Africa and Brazil (Abbott, 2002).

Intellectual property protection standards continue to be one of many issues that bring international trade negotiations to loggerheads. The increasing assertiveness, unity and influence of developing nations has come to counterbalance the hegemonic role of the United States and Europe in determining international trade terms, especially on controversial trade topics like pharmaceutical licensing and agricultural subsidies, as made evident by the extension of the current WTO Doha round to an eleventh year in 2012.

Research Methods

Objectives and Structure

Based on the above outlined underlying logic of the Gravity Model, in applications one and two, respectively, this study will test the applicability of the traditional gravity model to overall US exports and US ATP exports. In application three, U.S. exports of 10 separate subgroups of ATP will be compared for variation. All three applications of the gravity model will be done through a least squares regression.

As previously established, each application of the gravity model will differ primarily due to the dependent variable used; within each application various explanatory variables will be utilized as control variables. The various variables in each of the three application of this paper are summarized below.

Application One: US Exports for 2007-2010

In application one, the traditional gravity model will be tested for its ability to accurately describe variation in US exports of all goods and services (overall exports) for the years 2007, 2008, 2009 and 2010.

$$\ln GENEX_{I,J,t} = ß_0 + ß_1 \ln GDP_{J\,t} + ß_2 \ln DIST_{I,J} + u_{I,J,t}$$

Given the global economic crisis, it is important to control for macroeconomic events. In this case a linear time trend is not appropriate. Instead of utilizing time dummies, average annual oil prices are used to control for macroeconomic events and their influence on trade levels.

$$\ln GENEX_{I,J,t} = ß_0 + ß_1 \ln GDP_{J\,t} + ß_2 \ln DIST_{I,J} + ß_3 \ln OIL_t + ß_4 \ln POP_{tJ} + u_{I,J,t}$$

Where:

Country I is the United States (exporting) and Country J is one of the 176 partner countries (importing);

$GENEX_{I,J}$ represents the value (M of 2005 USD) of the flow of all exports (goods and services) from the United States to each respective importing partner country for the years of 2007, 2008, 2009 and 2010, according to the U.S. Department of Commerce; and,

GDP_J represents the GDP (M of 2005 USD) of the partner country for the years of 2007, 2008, 2009 and 2010, according to CIA World Fact Book; and,

$DISTANCE_{I,J}$ represents the distance (kilometers) from Washington, DC to the capital city of the respective trading partner country (Country J); and,

OIL represents the average annual price of a gallon of Brent crude in 2005 USD. This is included as a control variable; and,

POP_J represents the population of Country J.

Based on the anticipated relationships between the dependent variable EXP and the independent variables GDP (direct) and DIST (inverse), predicted by the traditional gravity model, if the model is to hold, $ß_1$ should be positive and $ß_2$ should be negative. If this is not the case, then the gravity model would seem to be ineffective in describing variation in overall U.S. exports for the years in question.

Application Two: US ATP Exports for 2008-2010

In application two, US exports of ATP for the years 2008, 2009 and 2010 will be examined. This assessment will be done using the following model.

$$\ln ATPEX_{I,J,t} = ß_0 + ß_1 \ln GDP_{J\,t} + ß_2 \ln DIST_{I,J} + ß_3 \ln OIL + ß_4 \ln POP + ß_5 IPR + u_{I,J,t}$$

Where:

Country I is the United States (exporting) and Country J is one of the 176 partner countries (importing);

$ATPEX_{I,J}$ represents the value (M of 2005 USD) of the flow of ATP exports from the United States to each respective importing partner country in the years 2008, 2009 and 2010, according to the U.S. Department of Commerce; and,

GDP_J represents the GDP (M of 2005 USD) of the partner country for the years of 2008, 2009, and 2010, according to CIA World Fact Book; and,

IPR_J represents the extent to which the government of country J respects and actively protects intellectual property rights; and,

$DISTANCE_{I,J}$ represents the distance (kilometers) from Washington, DC to the capital city of the respective trading partner country (Country J); and,

OIL represents the average annual price of a gallon of Brent crude in 2005 USD. This is included as a control variable; and,

POP_J represents the population of Country J.

Based on the anticipated relationships between the dependent variable ATPEX and the independent variables GDP (direct) and DIST (inverse), predicted by the traditional gravity model, if the model is to hold, $ß_1$ should be positive and $ß_2$ should be negative. If this were not the case, then the traditional gravity model would seem to be ineffective in describing variation in U.S. ATP exports in the years tested. It is likely that the relationships outlined above will hold; the extent of which is not certain.

IPR (intellectual property rights) is also included as an explanatory variable. Based on the assumptions of the traditional gravity model, that GDP will have a direct relationship and DIST will have an inverse relationship with the level of exports, it is assumed that in this new revised model, these two explanatory variables will have a consistent relationship with ATPEX ($ß_1$ should be positive and $ß_2$ should be negative), to what extent is uncertain.

The relationship between intellectual property protections and export levels of advanced technology products is unknown. It is the intention of this paper to test this relationship. If $ß_3$ is positive and significant, then it would seem to indicate that the higher the level of intellectual property rights in Country J, the higher the exports of ATP from Country I (United States) to Country J. If $ß_3$ is negative and significant, then it would seem to indicate that the higher the level of intellectual property rights in Country J, the lower the exports of ATP from Country I (United States) to Country J. If $ß_3$ is statistically insignificant, then it would indicate that there is no strong relationship between the level of intellectual property rights in Country J and exports of ATP from Country I (United States) to Country J.

I expect that the relationship will be positive and significant, even if only slightly, because on the whole, I believe that producers of ATP will be more likely to transfer their products to foreign markets (either for sale or through foreign partnerships) where intellectual property are strong. This assumption does not take the influence of external variables in explaining variation in the trade of advanced technology products: variables influencing the relative competitiveness of countries and firms within certain technologically advanced industries will likely have influence on international trade flows of the relative industry's products.

Application Three: 2011 ATP Subgroups

In application three, trade volumes for 10 subgroups of ATP trade for the year 2011 are used as dependent variables.

$$\ln TOTALATP_{I,J,} = \beta_0 + \beta_1 \ln GDP_J + \beta_2 \ln DIST_{I,J} + \beta_3 IPR_J + \beta_4 \ln POP_J + u_{I,J}$$

$$\ln ATP1_{I,J,} = \beta_0 + \beta_1 \ln GDP_J + \beta_2 \ln DIST_{I,J} + \beta_3 IPR_J + \beta_4 \ln POP_J + u_{I,J}$$

$$\ln ATP2_{I,J,} = \beta_0 + \beta_1 \ln GDP_J + \beta_2 \ln DIST_{I,J} + \beta_3 IPR_J + \beta_4 \ln POP_J + u_{I,J}$$

…

$$\ln ATP10_{I,J,} = \beta_0 + \beta_1 \ln GDP_J + \beta_2 \ln DIST_{I,J} + \beta_3 lPR_J + \beta_4 \ln POP_J + u_{I,J}$$

Where:

Country I is the United States (exporting) and Country J is the importing country

$TOTALATP_{I,J}$ represents the value of the flow of ATP exports from the United States to each respective importing partner country for the year 2011, according to the U.S. Department of Commerce; and,

$ATP1_{I,J}$ represents the value of the flow of ATP subgroup exports from the United States to each respective importing partner country for the year 2011, according to the U.S. Department of Commerce, where ATP1, ATP2, ATP3,…., ATP10 each represent one of 10 different ATP subgroups; and,

GDP_J represents the GDP of the partner country in the year 2011, according to the IMF; and,

$DISTANCE_{I,J}$ represents the distance (kilometers) from Washington, DC to the capital city of the respective trading partner country (Country J); and,

IPR_J represents the extent to which the government of country J respects and actively protects intellectual property rights; and,

POP_J represents the population of Country J.

The objectives and assumptions of this application are similar to that of application two, except that multiple subgroups of ATP trade data are now utilized as dependent variables, whereas in application two they were bundled together in one dependent variable. Variations in the coefficients as they are regressed against each ATP subgroup are the subject of interest in this application.

Measurement and Data

Econometrically, this paper uses three applications of the gravity model. Each application will utilize slightly different models, and will therefore have different data requirements. The variables used in each of the three applications are described in this section

Application One: US Exports for 2007-2010

Variable	Source
GENEX U.S. exports to each partner country for the years 2007, 2007, 2008, 2009 and 2010 Millions of 2005 USD	US Bureau of Economic Analysis www.bea.gov (Initially obtained as a nominal value, converted to 2005 real terms using US CPI figures from the OECD database)
GDP 2007, 2008, 2009, 2010 partner country GDP Millions of 2005 USD	CIA World Factbook www.cia.gov
DISTANCE Distance from Washington, DC to the capital of each respective partner country in kilometers	Various Online Databases (Easily verifiable, generally available information)
OIL Average annual price for one gallon of Brent crude, converted to 2005 USD using US PPI	US Bureau of Labor Statistics
POP National Population Millions of People	International Monetary Fund World Economic Outlook Database October 2012

Application Two: US ATP Exports for 2007-2010

Variable	Source
ATPEX Total U.S. exports of ATP to each partner country, for the years 2008, 2009 and 2010 Millions of 2005 USD	US Census Bureau www.census.gov/foreign-trade/statistics/product/atp/2010/12/atpctry/index.html (Initially obtained as a nominal value, converted to 2005 real terms using US CPI figures from the OECD database)
GDP 2008, 2009 and 2010 GDP of the partner country Millions of 2005 USD	CIA World Factbook www.cia.gov www.imf.org/external/pubs/ft/weo/2012/02/weodata/download.aspx
DISTANCE Distance from Washington, DC to the capital of each respective partner country in kilometers	Various Online Databases (Easily verifiable, generally available information)
IPR Index score that measures the level of IP protections	Annual Report, Property Rights Alliance www.internationalpropertyrightsindex.org
OIL Average annual price for one gallon of Brent crude, converted to 2005 USD using US PPI	US Bureau of Labor Statistics
POP National Population Millions of People	International Monetary Fund World Economic Outlook Database

Application Three: 2011 ATP Subgroups

Variable	Source
ATPTOTAL Total US Exports of ATP Nominal, Thousands of USD	U.S. Census Bureau www.census.gov/foreign-trade/statistics/product/atp/2010/12/atpctry/index.html
ATP1 ATP Subgroups Nominal, Thousands of USD	U.S. Census Bureau www.census.gov/foreign-trade/statistics/product/atp/2010/12/atpctry/index.html
NOMEX Nominal, Millions of USD	US Bureau of Economic Analysis www.bea.gov
GDP Nominal, Billions of USD	International Monetary Fund World Economic Outlook Database October 2012 www.imf.org/external/pubs/ft/weo/2012/02/weodata/download.aspx
DISTANCE Distance from Washington, DC to the capital of each respective partner country, in kilometers	Various Online Databases (Easily verifiable, generally available information)
IPR Index score that measures the level of intellectual property, copyright and patent protection in the partner country	Annual Report, Property Rights Alliance www.internationalpropertyrightsindex.org/

Variable	Source
POP National Population Millions of People	 International Monetary Fund World Economic Outlook Database

ATP Subcategory Description

This paper utilizes ATP subgroup classifications developed by the US government. The products included within each ATP subgroup, as defined by the US International Trade Commission, are:

Biotechnology: applications of advanced genetics research to the creation of pharmaceuticals and hormones for human and agricultural use

Life Sciences: application of non-biological scientific advances within the medical industry for the creation of new technologies and improvement of existing production processes

Opto-Electronics: Electronic products that emit/detect light (scanners, disc players, solar sells, semiconductors and laser printers

Information and Communications: Products that process and transmit data at high speeds (CPUs, disk drives, modems, fax machines, radar detection systems, satellites)

Electronics: Electronic products that utilize recent technological advancements to increase performance and capacity

Flexible Manufacturing: the use of robotics and computer controlled machine tools in industrial automation

Advanced Materials: the application of newly-created materials within many industries (semiconductor materials and fiber optics)

Aerospace: New helicopters, airplanes and spacecraft (both civil and military)

Weapons: Advanced weaponry technology

Nuclear Technology: Technology used in the production of nuclear power

Data Issues: Possibility of Zero Trade

It should be acknowledged that in application three, some countries have "not available" data for trade flows of some ATP subgroups. The regressions used in this paper simply exclude these observations. Data unavailability could indicate two things: data is simply not available for these categories, or that there was in fact no trade. If the later is the case, then there could potentially be biases in the coefficients for this regression, as the countries with the lowest trade values would in effect be excluded from the data set and therefore not counted.

Quantitative Assessment

Application One: US Exports for 2007-2010

Initial results from the application of the traditional gravity model to overall US Exports for the years 2007, 2008, 2009 and 2010 can be found in the Table 1, below.

Table 1.1 Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
genex	696	6082.859	21341.5	0.05	236872.6
gdp	696	208848.6	581852.2	24.8	4754787
distance	696	8910.835	3530.316	742.98	16350.49
real_oil	696	106.4314	17.05025	84.32369	132.039
pop	684	30.56813	117.1453	.0099941	1180.306

The table above provides summary statistics for the variables used in the second application of the gravity model, in which the influence of IPR, GDP, distance, oil prices and population on US export levels is assessed.

The average GDP of all trading partner countries in this study for the years 2007, 2008, 2009 and 2010 is 208,848,600,000 USD (2005) with a range of 24,800,000 to 4,754,787,000,000 USD (2005).

The average distance from Washington, DC, USA to the capital city of the trading partner countries used in this study is 8,910.835 km, with a range of 742.98 to 16,350.49 km.

The average annual global price of a gallon of Brent crude for the time period of 2007-2010 is 106.4314 USD (2005), with a range of 84.32369 to 132.039 USD (2005).

The average national population for the period of 2007 to 2010 is 30,568,130 people, with a range of 9,994 to 1,180,306,000 people. On average, the United States exported 6,082,859,000 USD (2005) worth of goods and services to each of its trading partner countries annually, with a range of 50,000 to 236,872,600,000 USD (2005).

Table 1.2 Regression Analysis

Variables	**(1)** **lngenex**	**(2)** **lngenex**
lngdp	0.969***	1.011***
	(0.018)	(0.027)
lndistance	-1.221***	-1.243***
	(0.081)	(0.083)
lnoil		0.323
		(0.255)
lnpop		-0.067**
		(0.033)
Constant	7.360***	5.782***
	(0.764)	(1.440)
Observations	696	684
R-squared	0.825	0.836

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As seen above, the coefficient for GDP is positive and statistically significant, indicating that there is a direct relationship between GDP and US exports. There is also a negative, statistically significant coefficient for distance. These relationships are consistent both with and without the inclusion of oil prices and population as control variables. Both of these relationships are consistent with theory behind general gravity model.

When oil prices and population are included as control variables, as in regression two of the above table, oil prices have a positive coefficient and population has a negative coefficient.

According to the first regression above, where only GDP and distance are used as explanatory variables to describe variation in US export levels, a 1% increase a trading partner country's GDP will equate with a .969% increase in its imports from the United States, and a 1% increase in the distance between Washington DC and the trading partner country's capital city will equate with a 1.221% decrease in imports from the United States.

When oil prices and population are included as controls, as shown in regression two above, it can be seen that a 1% increase in a trading partner country's GDP equates with a 1.011% increase in imports from the United States, whereas a 1% increase in distance between capital cities is associated with a 1.243% decrease in imports from the United States. In this regression, a 1% increase in a trading partner's population would equate with a .067% decrease in that respective partner country's import level from the United States.

Application Two: US ATP Exports for 2008-2010

Initial results from the application of the traditional gravity model to US ATP exports for years 2008, 2009 and 2010 can be found in Table 2.1.

Table 2.1 provides summary statistics for the variables used in the second application of the gravity model. This model assesses the influence that IPR, GDP, distance, oil prices and population have on US ATP exports.

Table 2.1 Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
distance	337	8540.801	3469.061	742.98	16350.49
gdp	337	316314.5	703753.5	1306.67	4699380
ipr	337	5.14362	1.745921	1.8	8.7
real_oil	337	107.7643	19.31866	84.32236	132.05
pop	337	42.60964	140.5068	.3518333	1172.081
atpex	337	2022.588	4327.73	1.06	24929.95

The average GDP of all trading partner countries in this study for the years 2008, 2009 and 2010 is 316,314,500,000 USD (2005) with a range of 1,306,670,000 to 4,699,380,000,000 USD (2005).

The average distance from Washington, DC, USA to the capital city of the trading partner countries used in this study is 8,540.801 km, with a range of 742.98 to 16350.49 km.

The average IPR score, represented by the 0-10 index score developed by the Property Rights Alliance, is 5.14362, with a range of 1.8 to 8.7 and a standard deviation of 1.745921.

The average annual global price of a gallon of Brent crude for the time period of 2008-2010 is 107.7643 USD (2005), although there was a range of 84.32236 to 132.05 USD (2005). This is a considerably wide spread, especially in light of the fact that this fluctuation occurred over a mere three years.

The average national population for the period of 2008-2010 is roughly 42,609,640 people, with a range of 351,833 to 1,172,000,000 people.

On average, the United States exported 2,022,588,000 USD (2005) worth of advanced technology products annually to each its trading partner countries, with a range of 1,060,000 to 24,929,950,000 USD (2005).

Table 2.2 details three separate regressions, in which three distinct sets of explanatory variables are evaluated for their influence on the flow of advanced technology products. In the first regression only distance and GDP are used as explanatory variables. In the second regression, in addition to distance and GDP, intellectual property protection levels are included. In the final regression, distance, GDP, IPR protection levels are included, along with average annual oil price and national populations as controls.

Table 2.2 Regression Analysis

Variables	(1) lnatpex	(2) lnatpex	(3) lnatpex
lndistance	-0.712***	-0.682***	-0.636***
	(0.126)	(0.126)	(0.129)
lngdp	1.166***	1.112***	1.201***
	(0.034)	(0.043)	(0.066)
ipr		0.094**	0.039
		(0.045)	(0.055)
lnoil			0.119
			(0.344)
lnpop			-0.112*
			(0.064)
Constant	-1.102	-1.255	-2.665
	(1.204)	(1.200)	(2.043)
Observations	337	337	337
R-squared	0.784	0.787	0.789

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As can be seen above, in each of the three regressions, the coefficient for GDP is positive and statistically significant. This is consistent with the assumptions of the gravity model: that the larger the economy of a country, the more they will trade. In the case of this paper, this means that the larger the economy of a country, the more ATP they will tend to import from the United States.

The coefficient for distance is also as expected-negative-and statistically significant in all three regressions. This demonstrates that the fundamental assumption of the gravity model-that the greater the distance between two economies, the less they will trade-is applicable to trade in advanced technology products.

In regression two of the above table, IPR has a coefficient value of .094 and is statistically significant. When, in regression three, and oil price and population are included, the statistical significance of the relationship between IPR and ATP trade flows is lost, although the coefficient retains its sign.

Application Three: 2011 ATP Subgroups

Application three applies the gravity model to U.S. exports of 10 separate subgroups of advanced technology products. Oil prices (oil) and national populations (pop) are included as controls.

Table 3.1 Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
distance	142	8664.585	3646.411	742.98	16350.49
ipr	120	5.66	1.365567	3.4	8.5
gdp	142	379.1513	953.3243	.48	7298.15
pop	142	43.89246	153.6574	.07	1347.35
nomex	142	10136.05	31376.83	20.07	280889.6
atptotal	142	1.95e+09	4.87e+09	3301688	3.19e+10
atp1	134	6.58e+07	2.34e+08	2685	2.16e+09
atp2	142	2.03e+08	5.28e+08	37873	3.35e+09
atp3	138	3.94e+07	1.19e+08	2900	7.13e+08
atp4	142	6.20e+08	2.33e+09	90720	2.11e+10
atp5	141	2.82e+08	9.46e+08	2564	6.21e+09
atp6	141	8.60e+07	2.89e+08	4322	2.05e+09
atp7	119	1.71e+07	4.23e+07	2577	2.56e+08
atp8	140	6.27e+08	1.43e+09	5220	7.12e+09
atp9	114	2.18e+07	5.52e+07	2810	2.98e+08
atp10	126	1.35e+07	6.78e+07	2700	7.14e+08

IPR: In 2011, the IPR index of the 120 reporting countries included in this section of the paper ranged from 3.4 to 8.5, with an average score of 5.66 and a standard deviation of 1.37.

GDP: The average 2011 GDP of the 142 countries included in this regression was 379,151,300,000 USD (2011), with a range of 480,000,000 USD to 7,298,150,000,000 USD.

POP: The average national population in 2011 was 43,892,460 people, with a range of 70,000 to 1,347,350,000 people.

NOMEX: The 2011 general exports (not only ATP) of the United States to the 142 partner countries included in this regression averaged 10,136,050,000 USD (2011), with a range of 20,070,000 to 280,889,600,000 USD (2011).

ATPTOTAL: The average amount of U.S. ATP exports to each of the 142 individual partner countries in 2011 was 1,950,000,000,000 USD, with a range of 3,301,688,000 USD to 31,900,000,000 USD.

The average of US exports to partner countries by ATP product category (10 subgroups) is described below:

ATP1 (Biotechnology): Range: 2,685,000 to 2,160,000,000,000 USD; Average: 65,800,000,000 USD

ATP2 (Life Sciences): Range: 37,873,000 to 3,350,000,000,000 USD; Average: 203,000,000,000 USD

ATP3 (Opto-Electroncis): Range: 2,900,000 to 713,000,000,000 USD; Average: 39,400,000,000

ATP4 (Information and Communications): Range: 90,720,000 to 21,100,000,000,000 USD; Average of 620,000,000,000 USD

ATP5 (Electronics): Range: 2,564,000 to 6,210,000,000,000 USD; Average: 282,000,000,000 USD

ATP6 (Flexible Manufacturing): Range: 4,322,000 to 2,050,000,000,000 USD; Average: 86,000,000,000 USD

ATP 7 (Advanced Materials): Range: 2,577,000 to 256,000,000 USD; Average: 17,100,000,000 USD

ATP 8 (Aerospace): Range: 5,200,000 to 7,120,000,000,000 USD; Average: 627,000,000,000 USD

ATP 9 (Weapons): Range: 2,810,000 to 298,000,000,000 USD; Average: 21,800,000,000 USD

ATP 10 (Nuclear Technology): Range: 2,700,000 to 714,000,000,000 USD; Average: 13,500,000,000 USD

Table 3.2 Regression Analysis

Variables	(1) Biotechnology	(2) Life Sciences	(3) Opto-Electronics	(4) Information & Communications	(5) Electronics
lndistance	-1.533***	-0.710***	-1.158***	-1.378***	-1.064***
	(0.408)	(0.179)	(0.259)	(0.263)	(0.372)
lngdp	0.596***	1.324***	0.791***	0.938***	1.485***
	(0.219)	(0.095)	(0.138)	(0.140)	(0.197)
lnpop	0.665***	-0.279***	0.251*	-0.012	-0.235
	(0.230)	(0.100)	(0.147)	(0.147)	(0.208)
ipr	0.493**	0.112	0.398***	0.086	0.131
	(0.235)	(0.101)	(0.149)	(0.148)	(0.209)
Constant	21.512***	17.445***	19.008***	25.727***	18.365***
	(3.688)	(1.619)	(2.349)	(2.388)	(3.369)
Observations	117	120	118	120	120
R-squared	0.539	0.867	0.711	0.671	0.670

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.3 Regression Analysis

Variables	(1) Flexible Manufacturing	(2) Advanced Materials	(3) Aerospace	(4) Weapons	(5) Nuclear Technology
lndistance	-0.573**	-1.110***	-0.076	0.118	-0.106
	(0.260)	(0.345)	(0.324)	(0.430)	(0.279)
lngdp	1.288***	1.081***	1.181***	1.009***	1.315***
	(0.139)	(0.228)	(0.175)	(0.285)	(0.158)
lnpop	-0.062	0.125	-0.008	-0.096	-0.250
	(0.145)	(0.226)	(0.182)	(0.284)	(0.161)
ipr	0.177	0.360*	0.332*	0.485*	-0.020
	(0.148)	(0.215)	(0.185)	(0.268)	(0.161)
Constant	13.955***	16.369***	11.492***	5.521	9.080***
	(2.352)	(3.114)	(2.934)	(3.834)	(2.515)
Observations	119	102	118	100	111
R-squared	0.777	0.639	0.677	0.508	0.699

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The influence of distance, GDP (Country J), population (Country J), and intellectual property protections (Country J) on the volume of exports from the United States to Country J for the year 2011 is quantified above.

Distance, one of the two foundational explanatory variables of the gravity model is negative (as expected) and statistically significant in the case of seven-out-of-ten ATP subgroups, with the exceptions being aerospace, weapons and nuclear technology. Aerospace and nuclear technology both had negative coefficients, but were not statistically significant. Weapons was not only statistically insignificant, but interestingly had a positive coefficient (meaning the further a country is from the US, the more weapons they will tend to buy from the US). This is interesting as it is counter one of the fundamental assumption of the gravity model: that the further two countries are from each other, the less they will trade. In the case of US weapons exports, distance seems to not matter at all.

The other foundational variable-GDP-remained positive and significant in all ten cases, as expected, meaning that the larger the country is, the more of each advanced technology product subgroup they will tend to import from the US.

The variable representing the national population of the importing country has a negative coefficient in the case of seven of the ten subgroups. Subgroups with positive coefficients are advanced materials, biotechnology and opto-electronics. Only two subgroups of the ten total groups are statistically significant: biotechnology is positive and statistically significant and the life sciences subgroup is negative and statistically significant.

Intellectual property protection levels, represented in this regression by the variable IPR, have a positive coefficient and therefore correlation with ATP exports for nine of the ten ATP subgroups (with nuclear technology being the exception). This means that, in the case of these nine groups, the higher the level of intellectual property protections in a trading partner country, the higher their imports of US ATP will tend to be. This being said, IPR is statistically significant in the case of biotechnology, opto-electronics, weapons, advanced materials and aerospace. It seems that for these five groups, intellectual property protection levels tend to be more capable of describing trade flows.

In application two, where the gravity model is applied to overall ATP exports, the statistical significance of IPR is lost when control variables are included. When these same control variables are included in the application of the gravity model to subgroups of ATP, as done in application three, IPR is statistically significant in the case of five subgroups. All ten subgroups have a positive coefficient for IPR. This demonstrates that IPR levels-in general-has a positive relationship with the volume of US ATP exports, and that this relationship is not uniform among subgroups. The statistical insignificance of half of the ten subgroups could very well drag down the statistical significance of the group when examined as a whole, as was done in application two.

Interpretation of Results

The five subgroups where IPR is both positive and statistically significant, and where therefore the relationship between higher levels of intellectual property protections and higher values of US exports for the respective ATP subcategory are the strongest, are biotechnology, opto-electronics, weapons, advanced materials and aerospace. US firms in these industries are less likely to export (or likely to export less) to countries with relaxed intellectual property protections. This could be due to reticence, on the part of the exporting countries, to risk duplication of their products by competing firms. In these industries, perhaps the benefit of gaining market access is not enough to offset the risk of loosing their competitive advantage and unique product offerings, which they've gained through high investment in research and development. This could also be due to increased competitiveness of domestic firms within countries with low IPR levels, thus limiting the amount imported.

It is then not surprising that biotechnology is on this short list of five subgroups most influenced by IPR, as the pharmaceutical industry is included in this subgroup. Investment in research and development is very high in this industry, as are the prices demanded by companies in an effort to compensate for this initial investment. This means that companies are particularly vulnerable to the theft and imitation of their intellectual property.

Similarly, the development of advanced materials requires a great deal of scientific research. Advanced materials are in some cases at the forefront of scientific development, especially as they are applicable to, and have the potential to revolutionize so many industries. Because of this, firms may be even more likely to safeguard their hard earned territory in this industry. The nature of the opto-electronics industry could influence the behavior of firms similarly.

Weaponry and Aerospace are more associated with politics than the other ATP subgroups. US exports of these two subgroups are likely more regulated and restricted, meaning that only certain types and quantities can be exported to countries of certain political alignments. Countries with higher IPR scores tend to be developed western democracies. Weapon and Aerospace exports to these countries are likely to be higher.

The unique status of weaponry and aerospace products (along with nuclear technology) can be seen in the fact that none of them have statistically significant coefficients for distance (interestingly, coefficient for weaponry is even positive). For trade flows of these three subgroups, distance doesn't play a role, as should intuitively be the case. There is therefore something more powerful at work, which could be the role of politics.

Other Considerations

It should also be acknowledged that there are some industries that the United States is not competitive enough in for firms to take IPR levels as seriously. If a firm is not at the top of the industry in terms of research and development, they are likely to place less importance on safeguarding their position. The impact of this, although interesting, is not within the scope of this paper.

There is also the aspect of US firms producing ATP goods internationally. A US firm could feel so comfortable with the IPR protection levels in a country (in addition to a number of other attractive aspects of the host country) where they decide to actually produce their ATP in that country. This paper does not look into the effect of this, although it would make interesting further study.

Intellectual property protection levels are certainly not the only determinant of the international trade of advanced technology products. US ATP exports must not be viewed in a vacuum; the efficiency and technological development of other economies, and their ability to outperform the United States, plays an undoubtedly influential role in influencing the choice that importers make when purchasing comparable products from either the United States or elsewhere. Other influential variables influencing an economy's competitiveness in advanced industries are likely linked to that country's previous development, human capital and ability to invest in capital-intensive industry. The influence of these variables in conjunction with IPR protection levels would make for interesting further study.

Conclusion

This paper explores the determinants of trade flows of advanced technology products, with special emphasis placed on the explanatory power of intellectual property protections.

This paper first applies the traditional gravity model, with GDP and distance as its explanatory variables, to US exports. Through this, the greater the GDP of an importing country, the greater the value of their imports from the United States is shown to be. This is in line with the foundational assumptions of the gravity model.

This paper then applies the same gravity model to trade of advanced technology products. Through this application, it can be seen that the assumptions regarding the role of distance and GDP in influencing international trade patters hold true even among trade exclusively in advanced technology products. GDP retains a positive coefficient and distance retains a negative coefficient, both of which are statistically significant.

The role of intellectual property protections is then explored through the inclusion of intellectual property protection levels (as represented by a 0-10 index score from the Property Rights Alliance) as an explanatory variable. When included, intellectual property protection levels are shown to have a positive-and statistically significant-relationship with trade volumes of advanced technology products. The statistical significance of this relationship is lost when population and oil prices are included as a control variable. The coefficient does however remain positive.

The influence of intellectual property protection levels on trade flows of ATP was further assessed through the application of the same gravity model to US exports of ten subgroups of advanced technology products for the year 2011. From this application, it can be seen that higher levels of intellectual property protections tend to be associated with higher levels of ATP exports for each subgroup. Although the coefficient for IPR protections was only statistically significant when applied to trade among the biotechnology, advanced materials, aerospace, opto-electronics, and weaponry subgroups, the coefficient was positive in the case of each of the ten groups. The statistical significance of IPR in the case of only five subgroups is likely due to the political nature of the aerospace and weaponry technology, and the high research and development costs of biotechnology and advanced materials technology.

Policy Implications

This paper demonstrates that there is correlation between US exports of advanced technology products and the level of intellectual property protections in the importing nation.

In the context of international competition, it is then in the economic best interest of the United States to promote strong intellectual property protection regimes in trading partner countries. The United States should then take a more aggressive approach in encouraging trading partners to adopt intellectual property protect-ions. As mentioned in the literature review of this paper, there is a great deal of controversy surrounding the role of more developed countries (such as the US) as pushing intellectual property protections on lesser-developed countries. From an economically nationalistic perspective, if interested in the net economic outcome, the US Government should therefore prioritize pushing for protections in high-value industries with the lowest amount of political pushback.

In broader terms of encouraging competitiveness in the production of advanced technology products, the United States should capitalize on its advanced educational and research capabilities. Education at all levels should stress the importance of science, mathematics, engineering and computer science. Nurturing knowledge in this area among the general workforce, in addition to potentially inspiring the next generation of scientific prodigies, will serve to organically promote US competitiveness.

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