# What Determines Exports of U.S. States: Distance or Location Factors?

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By

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# List of Tables

# List of Figures

# Table of Contents

# Abstract

This study is an empirical investigation into the export performance of the United States using state level data. Only a few studies have tried to disaggregate national level data. While spatial issues play an increasing role in international trade models, most applications make use of the traditional gravity model, which is based on physical distances. However, the significant reduction in transportation and communication costs experienced over the past few decades makes it questionable that physical distance matters any more.

The study is arguing on two fronts. First, it examines to what extent it may be useful to consider proximity measures other than traditional physical distance variables. To examine this possibility, this study employs an augmented gravity equation with a number of alternative physical and nonphysical/psychic distance measures. Second, the study explicitly allows for the possibility that distance no longer plays any role in explaining trade patterns, regardless of how distance is defined. For this purpose, the study includes a large number of alternative variables that can potentially explain trade patterns. Many of these measures are related at least indirectly to the location decisions of firms that are engaged in the exporting business.

The results of the study indicate that physical distance continues to play a role in determining state manufacturing exports. However, nonphysical/psychic distance, trade agreements, state location characteristics, and conditions in export markets also affect a state's manufacturing exports. These latter effects appear to vary for high-tech and low-tech products.

Tests for the presence of spatial autocorrelation in state manufacturing export equations indicate that physical and cultural proximity does not matter for spatial autocorrelation. Rather, it is the human development proximity of states that explains their similarity in export performance. The results of the spatial autocorrelation analysis are robust only for total and high-tech exports.

Keywords: Export Performance, Augmented Gravity Equation, Spatial Autocorrelation, Location Characteristics.

*JEL Classification Codes*: F000, F100, F140, F220, J240, R120

# Chapter 1

# Introduction

Technological advancements including computer proliferation, fiber optics, and satellite communication systems, coupled with improvements in transportation efficiency, such as containerization, has raised the question whether distance and transportation costs remain key determinants of international trade. One could argue that these improvements in technology and transportation systems have made space and distance largely irrelevant for trade. This study investigates to what extent this argument is true.

Many studies[1] have investigated the effect of physical distance from export markets on export performance. Most of these studies have been done in the context of the well-acclaimed gravity equation, which takes into consideration the distance from the center of the exporting location to the center of the importing location. The gravity equation has been used as the baseline model in explaining the trade deviations caused by trade agreements, currency unions, amongst others. Since the gravity equation relies on distance and trade cost as key determinants trade, then the question of the continued significance of distance and trade cost for trade is also a question of the continued usefulness of the gravity equation in estimating trade equations.

[1] Beckerman (1956), Smith (1964), Lineman (1969), Yeats (1969), Deardorff (1998), Anderson and Van Wincoop (2001), Feenstra et al. (1998), Coughlin (2004).

Some studies, including Coughlin (2004), have shown that physical distance has a significant and time-consistent negative effect on export performance. A few others, including Cheng and Wall (2005), have shown that, due to the reduction in transportation costs over the years, physical distance does not play a significant role in determining export performance any longer. These studies have been done on data for total exports. They have not taken into account the possibility that the effect of distance on exports may differ for different types of goods. Hence, there is the potential for aggregation bias. Studies on firm location theory[2] indicate that factors other than distance from markets play a role in determining the location decisions of firms. If factors other than distance are determining firm location decisions, then these same factors may also contribute to explaining export performance. Thus, a country's export performance may be determined by a large number of factors. These include, among others, (1) a comparative advantage in input factors, such as labor, human capital, and raw materials; (2) an advantageous location; (3) research and development (R&D) investment; (4) infrastructure development; and (5) production capacity. This study seeks to identify to what extent any of these factors add explanatory power to the standard gravity equation.

It is a general knowledge that most countries are comprised of different regions, and these regions are endowed with different types of resources. This creates different comparative and location advantages for different parts of a country. For larger countries like the United States these differences in endowment from one region or. state to another can be large. Due to the difficulty in obtaining state level trade data previous studies on

[2] See Fox, S. (1996), Ambrosius (1989), Eisinger (1988), Gray and Lowery (1990), and Kline (1982).

export performance have concentrated on national or aggregate export levels.[3] Only a few, including Fabel (1988), have attempted to use regional aggregate information. This study employs detailed panel data on the exports of U.S. states by country of destination. This will help avoid problems that may arise from aggregating over rather different regions or states.

In explaining whether it is distance or location factors that drives state export performance, this study will focus on the following aspects: (a) the performance of alternative physical distance measures in explaining exports; (b) the performance of alternative nonphysical/psychic distance measures, which include cultural and political affinity proximity measures; (c) the extent to which distance may be more important to explain the exports of some but not other products, such as low-tech as opposed to high-tech products;[4] (d) the determinants of export performance that are not tied to distance, such as location characteristics and regional and bilateral trade agreements, such as NAFTA.[5] This study also seeks to take into account some aspects of trade modeling that are often neglected in this type of literature, such as correction for spatial autocorrelation.

This study starts off with an investigation into the effect that different physical distance measures have on total export performance of U.S. states. Von Thunen (1826) indicates that those countries close to markets would specialize in goods that command high transport costs, whereas locations further away from markets would produce goods

[3] See Warner and Kreinin (1983), Helpman (1999), and Davis (1997).

[4] Supposedly, old-time (low-tech) products have a low value per weight unit, so distance may matter more than for high-tech products, which have a high ratio of value to weight.

[5] Thus, this study seeks to investigate what can substitute for a distance equation in explaining export performance.

with lower transport costs. Von Thunen's theory indicates that distance from markets might determine what kinds of products a state exports. To investigate whether this theory is relevant for the exports of U.S. states, this study differentiates between exports with high technology content and those with low technology content Assuming that high-tech products have a high ratio of value to weight whereas low-tech products exhibit a low ratio of value to weight, von Thunen's theory would suggest that it would be profitable for low-tech industries to locate in periphery states.

Trade costs consist not only of transportation costs but also of other components determined by differences in the characteristics of trading partners, including language differences, which can cause transaction costs to increase. In an attempt to allow for trade costs other than transportation, this study seeks to identify whether alternative and more sophisticated distance measures may be needed for the estimation of gravity equations.

It is possible that export performance depends not only on the distance of exporting states from importing countries but also on the distance from one state to the other (proximity), which may determine the ability of states' production units to share resources and ideas. Through information sharing, proximate states may produce at similar levels and efficiency. Thus, although proximate states with similar distances to export markets might perform at similar levels on the export markets, this might be due to other similarities shared by proximate states, not distance from export markets. To incorporate this idea into the framework of state export determination, this study allows for spatial autocorrelation to investigate whether proximate states perform at similar levels on export markets.

This study thus presents a unique research approach in that it moves beyond the simple gravity equation. Setting distance measures aside, none of the previous studies has investigated whether the inclusion of other variables known to be important in location theory may explain differences in export performance better than any traditional gravity model, regardless of the distance measure being utilized. Thus this study contributes to the existing literature on state export performance by thoroughly examining (a) the importance of distance in a gravity model format and (b) whether and to what extent the variables that location theory identifies are better predictors of export performance. The latter is important not only for the question how useful gravity models really are. It is also of importance from the perspective of policymakers who are interested in raising export performance. Traditional gravity models do not provide any policy tools for improving export performance. Location theory, by contrast, indicates variables that can be used as levers by policymakers. Hence, the addition of insights from location theory to gravity models may improve their usefulness to policy makers.

Why is a state's export performance important to its policymakers? Exports lead to higher employment, increased income, and a higher standard of living because exports are typically concentrated in sectors with comparative advantage, that is, those sectors with the most significant growth potential. Thus, policymakers who want to develop their state should focus on export development as a means to improve employment levels and income.

The remainder of this study is structured as follows: Chapter 2 traces previous studies that have looked at the determinants of trade and considered distance and geographical location characteristics. The chapter also reviews firm location theory.

Chapter 3 describes the theoretical hypothesis used in this study. Chapter 4 presents the empirical model and data employed by this study. Chapter 5 presents the results of the empirical estimates, and Chapter 6 provides a brief conclusion.

# Chapter 2

## Literature Survey

Empirical studies in international trade have made use of different theories of trade, including the Ricardian and Heckscher-Ohlin models, to analyze the determinants of observed trade patterns. Most studies, including Warner and Kreinin (1983), Helpman (1999), and Davis (1997), have been conducted at the national and cross-country aggregate level. Only a few studies consider state-level trade patterns. Among those are Coughlin and Fabel (1988), which uses cross-sectional state trade data to identify the determinants of the size of state exports, and Coughlin (2004), who employs a panel of state export data to investigate the importance of export market proximity for U.S. states.

The works of Krugman (1991) and Porter (1990) have helped to open up the discussion of the role that geography plays in economics and business matters. Fewer studies, including Martin and Sunley (1996), Gaile and Grant (1989), and Davis et al. (1997), look at the role that geography plays in a country's trade performance. The literature has not investigated the joint effect of the location of production and human capital accumulation on export performance.

Every country has different geographical regions, and in the light of Krugman (1991) and Porter's (1990) findings, one can argue that these different regions of a country are endowed with differing resources and location features. These differences can, at different time, cause products originating from various parts of a country to perform better in the international export market than products from other regions of the same country. This might be due to one region's having the right mix of factors of production and certain locational advantages. By analyzing only aggregate trade patterns, especially of large nations such as the United States, the underlying determinants of export performance may be hidden behind aggregation problems.

## 2.1 Geographical Location and Trade

Traditional classical and neoclassical trade theories are silent about the relationship between trade and geography. Indeed, space becomes irrelevant in the classical trade models, in which trade is determined by comparative advantage in production. For instance, the Heckscher-Ohlin theorem postulates that a capital-abundant country will export capital-intensive goods while the labor-abundant country will export labor-intensive goods. Nothing is said about how distance or geography can alter this theory.

In connecting geography and trade, one is trying to map a country's trade pattern to the characteristics of, its physical location.[6] Two aspects of geography can play a significant role in determining the production structure, trade dynamics, and income of a country or state (Overman et al., 2001). The first aspect denotes the physical geography of a place, including coasts, mountains, ocean accessibility, and endowments of natural resources. The second aspect of geography denotes the distance between pairs of economic agents.

[6] Represented by geographical features such as latitudinal location, proximity to navigable waters, climate, and soil type.

Geography has played an important role in determining the extent to which a country can become integrated into world markets, regardless of that country's trade policies. For example, a distant, landlocked country faces greater costs of integration than a coastal country. Physical distance, which forms an integral part of the second aspect of geography, directly increases transaction costs because of the transport costs of shipping goods, the time cost of shipping date-sensitive products, the costs of contracting at a distance, and the costs of acquiring information about remote economies. General geographical characteristics other than distance may also shape the activities undertaken in each country, since profits depend on proximity to the activities necessary for efficient production. That is, production will take place not only where factor supplies are available but also close to find product markets and to suppliers of intermediate good. However, the effect of distance on production location decisions may depend on industry characteristics, including the cost of transporting final output and the share of intermediate goods and services in costs.

Using country-level aggregate data, Frankel and Romer (1999) show that geography plays an integral part in determining bilateral trade flows between countries. Their study indicates that physical distance deters bilateral trade flows landlocked countries tend to have a smaller share of world trade, their study also indicates that countries that share common borders tend to have relatively high levels of bilateral trade.

Overman et al. (2001) indicates that geography may also impact income levels by causing spatial differences in institutions and technology. This implies that a process of cumulative causation may determine the location of exporters of manufactured goods. This idea is modeled in Krugman (1991), who finds that large markets attract manufacturers, which increases income and lowers prices, which in turn attracts more manufacturers. In Krugman's (1991) model this process can lead to the agglomeration of manufacturing. In the same vein, Gallup et al. (1998) and Radelet and Sachs (1998) find that measures of physical geography[7] and transport costs are important for explaining cross-country income patterns. Hence, geography may play a central role in firm location and export performance.[8]

### 2.1.1 Literature on Physical Distance and Trade

Some early studies on the determinants of trade, including Beckerman (1956), Smith (1964), Lineman (1969), and Yeats (1969), focus primarily on the relationship between distance and trade. These studies establish that distance is a strong determinant of the intensity of trade flows between nations. Nations that are geographically close will tend to trade relatively more than nations that are further apart.

Srivastava and Green (1986), using an extension of Linneman's model to analyze trade flows between 45 countries, conclude that distance is the single most important determinant of trade intensity among nations. They find that distance has a big impact on all product categories as well as on total trade intensity. The magnitude of the effect of

[7] Including fraction of land area in the tropics.

[8] Gallup et al. (1999) find that countries with a large percentage of population close to the coast, low levels of malaria, large hydrocarbon endowments, and low levels of transport costs have higher levels of income per capita.

distance on intensity found in the study is larger than that reported by Linneman, which the authors attribute the largely to differences in the definition of trade intensity.[9]

If one could assume that countries differ only in their distance from the world market and commodities differ only in transport costs, then the key insight of von Thunen (1826) would hold true all the time. Countries and land areas close to markets would specialize in goods that command high transport costs and locations further away from markets would produce goods with lower transport costs.

The new economic geography literature has recently been incorporating transportation costs as a significant variable in models that explain regional economic integration, the location of firms, and international business cycles.[10] Moreover, Radelet and Sachs (1998) indicate that international transport costs have a significant impact on the exports of manufactured goods.

Recently, Venables and Limao (2002) have proposed a model of international specialization that accounts for transport costs in the context of a region's or country's factor endowments. Their model is called a Heckscher-Ohlin Von Thunen model, to express their incorporation of von Thunen's regional development model with the H-O model.[11] From this combination, their central point is that transport-intensive industries

[9] Linneman uses absolute value of trade between nations as a proxy for trade intensity, whereas Srivastava and Green (1986) construct a trade intensity index that represents the ratio of actual volume of trade between two nations to the expected volume of trade between the two nations.

[10] See Krugman (1991, 1993, 1995, 1996, and 1998).

[11] Von Thunen's regional development model indicates that high transport costs lead to spatial specialization in production, whereas the H-O model indicates that relative factor endowments determine specialization and trade.

will "tend to produce close to the center, although transport intensity effects may be offset or overturned by variations in endowments."

With lower transport costs, however, industries would rather locate in peripheral regions to take advantage of lower factor prices. This would lead to the prediction that regions located at a distance from the core may be able to successfully export if they specialize in low-wage industries. Finally, despite market access, fixed costs can be important in the decision on whether or not to export. This can lead to a separation of the decision to produce and the decision to export. In this vein, Venables and Limao (2002), who also allow for different factor endowments, establish that transport-intensive industries may still produce close to the central location.

### 2.1.2 New Perspectives on Physical Distance and Trade

It was the work of Krugman (1991) and Porter (1990) that has helped to open the current discussion on the role of geography in economics and business. The work of Krugman (1991) has led to the development of the so-called "new economic geography" literature, which argues that the uneven distribution of industrial activities across space is a natural result of market processes. The work of Porter (1990), on the other hand, has added to the literature by promoting the importance of industrial "clusters". From the works of these researchers, one can assume that geography does matter in determining economic performance and that location in a peripheral geographical area can have adverse consequences in terms of growth and trade performance when compared to central and border locations.[12]

In contrast, studies by Glaeser (1998), Naisbitt (1995), and Toffler (1980) suggest that geographical and locational characteristics are becoming increasingly less important in determining trade patterns and performance. They attribute this to the reduction in transportation and information costs, which, they argue, stem from the continuous improvement in communication technologies, including satellite and fiber optic technology, and improved transportation technologies, such as containerization and the increased efficiency and frequency of airline services. These factors have led to a reduction in transaction costs across space, thus making geographical location unimportant in determining trade performance.

Improvements in information and transportation technology have led to a reduction in the cost involved in doing business across large geographical areas. However, these developments can also lead to increases in the cost of doing business across space.[13] This argument is reinforced by the advent of technological advances, in which a change in the dynamics of consumer demand, such as increases in the quantity, variety, and complexity of transactions, can lead to increased information costs. In the same vein, consumers now require a level of service customization and delivery speed never before considered possible. With the increase in the demand for high delivery speed come increases in the opportunity cost of time. Thus, relative distances will play a role in determining where consumers will buy a particular product. Situations may arise

[12] See Porter (1990), Krugman and Venables (1990), Overman et al. (2001).

[13] See Cohen 1998, and *The Economist* (1999a).

in which producers will move closer to customers, or customers may order from the closest manufacturer.

The fact that technological improvements are reducing the cost of doing business across space does not reduce the relevance of this paper. For example, products of some states may have had a comparative advantage because of market proximity but, with the reduction in transportation and information cost, may lose this comparative advantage, and exports may decline as a consequence. Alternatively, some states whose exports used to suffer from their distance from markets may perform better because of the reduction in transportation and communication costs. Last, regardless of the reduction in cost involved in doing business across geographical space, distance from markets can lead to relative differences in costs for different locations.

The preceding arguments suggest that technological advancements may have an ambiguous impact on trade, particularly on exports. However, the seeming abiguity can be eliminated if one considers that technological advancements in transactions as described above do not affected all industries in the same way (Vernon, 1966). Thus, different states may be impacted differently by changes in transportation and information technologies simply because they are specializing in and exporting different products and services.

### 2.1.3 State Location/Characteristics and Trade

Under the assumption of perfect competition, a country's real exchange rate reflects the relative prices between its traded and nontraded goods and indicates the welfare-maximizing allocation of resources between the production of tradables and nontradables. Clearly, in this approach it is irrelevant from precisely where within a country a particular export originates, since the implicit assumption is that firms anywhere in the country face the same relative export prices. This theory is in part contradicted by findings from Krugman (1991) and Porter (1990) that different regions of a country may be endowed with different resources and locational features and by findings from other trade studies that point to distance from export markets as a major determinant of export performance. Thus, locational factors may continue to play a role in determining the export performance of states.

In contrast to the impact of technology that reduces locational advantages, Coughlin (2004) finds that the export pattern of U.S. states has changed over the years, with states exporting more to physically close countries, a trend he partly attributes to the formation of the North American Free Trade Agreement (NAPTA). Coughlin and Fabel (1988), who employ state-level data but do not control for distance to export markets, indicates that human and physical capital-abundant states perform better on the international export markets. These studies analyze aggregate export data and do not investigate differences based on industrial specification, thus creating a potential aggregation problem.

## 2.2 Firm Location Theory

Weber, in his theory of the location of industries (1909), created a classical general theory in which the location of firms is determined by the desire to minimize costs. Thus, a firm's location, according to Weber's theory, is determined by the lowest-cost location for a manufacturing plant, where location choice is influenced by transport costs, labor cost, and agglomeration. Weber's theory indicates that industry will locate in areas where the transportation cost of raw materials and final products is minimized. This classical theory of the firm has been criticized as being too production oriented, leaving out other businesses including service-oriented businesses.

In investigating how firms make location decisions, more recent studies have used various approaches including surveys,[14] case studies,[15] and formal econometric studies.[16] These studies indicate that, apart from access to foreign markets, i.e., distance from states to foreign export markets, there are a number of other factors that play a significant role in decisions on firm location. Among these factors are local market size, the local tax climate, local labor market conditions, the local political situation, general local business conditions, political institutions, and the local legal environment and its fairness.

Numerous studies, including Coughlin et al. (1991), Fox and Lee (1996), and Woodward (1992), find that local market conditions such as existing demand, which increases potential local revenue for firms, have a positive and significant relationship to firms' location decisions.

Labor market conditions affect a firm's profits through the cost of doing business in a state. Several studies, including Lugar and Shetty (1985), Coughlin et al. (1991),

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[14] Goldstein (1985), Heckman (1982), Schmenner (1982), and Williams and Brinker (1985).

[15] Bachelor (1990), Fox (1990), Heller and Heller (1974), Lind (1990), Milward and Newman (1990), and Perucci and Patel (1990).

[16] Carlton (1983), Bartik (1985), Coughlin et al. (1988), Friedman et al. (1992), Fox and Lee (1996), Glickman and Woodward (1988), Lugar and Shetty (1985), and Woodward 1997).

Fox and Lee (1996), and Friedman et al. (1992), find that higher state wages are a significant deterrent to foreign direct investment. Bartik (1991) indicates that one factor that influences state wage scales is the power of unions. Unions increase state pay scales and, as shown in Coughlin et al. (1991) and Friedman et al. (1992), union presence may lead to a decrease in foreign direct investment.[17]

In terms of estimating the role of taxes on firm location decisions, the results have been inconclusive. Whereas Newman (1983) finds that low corporate tax differentials in Southern states partially explain the attraction of business to the South, Wasylenko and McGuire (1985) and Friedman et al. (1992) conclude that higher corporate taxes have no significant bearing on firm location and investment decisions.

Hansen (1990) hints that states can use other policy measures apart from tax breaks (that states can use) to lure firms, including financial and pollution control incentives. Milward and Newman (1990) indicate that incentives, especially those designed for worker training, played a significant role in attracting Nissan, Mazda, and Toyota to Tennessee, Michigan, and Kentucky, respectively. Using an incentive effort measure that summarizes state incentive programs geared toward encouraging investment, Lugar and Shetty (1985) find that states that offer more incentives are more likely to attract firms.

In a study of regional and time effects, Fox (1996) examines how political conditions influence firm location decisions over time. His findings indicate that labor market conditions, the extent of the agglomeration of an economy, access to markets,

[17] Friedman et al. (1992) postulate that foreign firms, which face powerfully organized home labor markets, locate in the U.S. to take advantage of the relatively weaker organized labor. Also, Kujawa (1986) and Lind (1990) conclude that lack of labor-management hostilities is one of the reasons why Honda and Mazda decided to locate in Ohio and Michigan, respectively.

taxes, governmental institutions, and policy instruments are significant determining factors in firm location decisions. The importance of these factors in influencing firm location decisions tends to vary over time.

## 2.3 The Contribution of This Study

In spite of the knowledge that different regions of the United States are endowed with different resources and may therefore have different comparative advantages, only a few studies have investigated the determinants of U.S. exports using state-level data. Coughlin (2004) looks at the changing effect of physical distance from states to foreign countries. He controls for the effect of NAFTA but ignores the effect of other trade agreements, nonphysical/psychic distances, and of location factors of states. Coughlin and Fabel (1988) estimate the effect of physical capital, human capital, and labor on state export performance but ignore the possible impact of distance and location factors. This study seeks to contribute to the literature on the determinants of state export performance by (1) estimating the effect of standard and nonstandard physical distance measures, (2) investigating the contribution of nonphysical/psychic distances, (3) testing and correcting for spatial autocorrelation, and (4) investigating the role that other factors that affect firm location decisions play.

Figure 1 presents a summary of what has been investigated in trade theory using gravity models before this study and the contribution of this study. Previous studies have examined export performance, but only a few have focused on state export performance and of these none has checked whether the effect of physical distance between states and countries ($T_{ij}$) differs by product type.

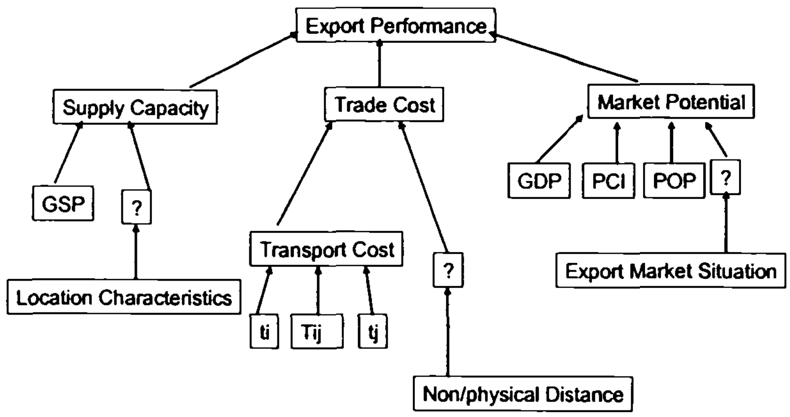


Figure 1: Theoretical Summary and Direction of Study

Standard gravity models account only for gross domestic product (*GDP* and *GSP*), income per capita (*PCI*), population (*POP*), and distance between states and countries. Only a few consider trade agreements, currency blocks, and regional blocks. Thus, previous studies leave out important trade determinants, such as location characteristics, the internal geography of states ($t_i$), the internal geography of importing countries ($t_j$), nonphysical and psychic distances, and export market situation. This study is an attempt to fill the gaps left by previous gravity model studies. This study is about (1) investigating whether standard or more sophisticated measures of distance continue to play a role in determining state export performance, (2) employing the results of firm location theory to identify the role that location characteristics of a state play in determining its export performance, (3) probing the role that internal geography of a state plays for its exports,, and (4) accounting for the role that export market situations other than GDP, POP, and PCI, play for a state's exports.

# Chapter 3

# Theoretical Background

## 3.1 Introduction to Export Theory

In explaining the export performance of different states in the U.S., it is assumed that states compete with each other and other countries in differentiated product markets in $j$ geographical export markets. Following Redding and Venables (2002), state and country trade flows are explained in terms of exporting state and importing country characteristics and "between country" information, (in particular distance).

The main task is to separate out the contributions of these different forces and thereby, identify the foreign market access and supply capacity of each state. The gravity model is consistent with alternative theoretical underpinnings.[18] The one chosen is a trade model based on product differentiation derived from a constant elasticity of substitution demand structure.

[18] See, for example, Anderson (1979), Deardorff (1998), and Eaton and Kortum (1997).

## 3.2 The General Theoretical Model

Recently, there have been a number of studies have developed general equilibrium trade models, this result in gravity-like equation models.[19] This study adopts the theoretical framework of Anderson and van Wincoop (2003) for its simplicity.

In this modeling framework, it is assumed that the world consists of $i = 1,\ldots,50$ states, and $j = 1,\ldots,R$ countries, each of which can produce a range of symmetrically differentiated products. Preferences are represented by a CES utility function in which the elasticity of substitution ($\delta$) between any pair of products is the same. The representative utility function of country $j$ is given by

(1) $$U_j = \left[\sum_j^R n_i X_{ij}^{(\delta-1)/\delta}\right]^{\delta/(\delta-1)}, \delta > 1,$$

where $n_i$ is the set of the product varieties produced in state $i$ and $x_{ij}$ denotes country $j$ consumption of a single variety from this set. This function is associated with a price index in each country, $G_j$, defined over the prices of individual varieties produced in state $i$ and sold in country $j$, $p_{ij}$.

(2) $$G_j = \left[\sum_j^R n_i p_{ij}^{1-\delta}\right]^{1/(1-\delta)}.$$

In this framework, the demand in country $j$ for each variety produced in state $i$ is a function of country $j$'s total expenditure on differentiated products ($E_j$), the price of the

[19] Eaton and Kortum (2001) derive a gravity equation from a Ricardian model with many countries separated by trade costs. Redding and Venables (2002) derive a gravity-like equation from an economic geography model based on a standard monopolistic competition framework.

good $p_{ij}$. and the price index $P_j$, which is defined over the prices of individual varieties produced in state $i$ and sold in country $j$. Total expenditure is assumed to be exogenously given. Using Sheppard's Lemma on the price index and taking total expenditure of country $j$ on the differentiated products ($E_j$) as given, country $j$'s demand for each variety of a differentiated product can be derived as

$$x_{ij} = p_{ij}^{-\delta} E_j G_j^{(\delta-1)} \tag{3}$$

where $\delta$ and the term $E_j G_j^{(\delta-1)}$ denote the own price elasticity of demand and the position of country $j$'s market demand curve, respectively.

For this part of the study, the assumption is made that the producer price $p_i$ is the same for all varieties produced in state $i$. The cost of delivery of the products from state $i$ to country $j$'s export market, as reflected in transport frictions, differ across states and countries. This cost is composed of three parts: (1) the cost of getting the products to state borders or the point of shipment ($t_i$), (2) the cost of getting the product from the border of country $j$ or its shipment receiving point to the point of sale ($t_j$), and (3) the cost of getting the product across the border ($T_{ij}$). Thus, $t_i$ and $t_j$, respectively, represent the internal geography and infrastructure of the states and the importing countries in question, whereas $T_{ij}$, denotes intercountry cost, which reflects external geography and policy barriers. Thus, price $p_{ij} = p_i t_i T_{ij} t_j$, and the value of total exports from state $i$ to country $j$ is given as

$$n_i p_i x_{ij} = n_i p_i^{1-\delta} \left(t_i T_{ij} t_j\right)^{1-\delta} E_j G_j^{\delta-1}. \tag{4}$$

Equation 4 expresses the export performance of a state i in market j. The right side of the equation presents information on the characteristics of both the exporting state and the importing country. The result from Equation 4, can be rewritten as in Equation 5, provides a basis for estimating a gravity model to explain the export performance of U.S. states,

(5) $$n_i p_i x_{ij} = \left[n_i (p_i t_i)^{1-\delta}\right]\left(T_{ij}^{1-\delta}\right)\left[E_j (p_i / t_j)^{\delta-1}\right].$$

The first term on the right side of Equation 5 reflects the supply capacity of the state $i$ and is referred to as $scap_i$ hereafter. It is the product of the number of varieties and their price competitiveness, which is measured by the product of producer price and internal transport costs. The term $E_j (p_i / t_j)^{\delta-1}$, which is referred to hereafter as $mcap_j$, denotes country $j$'s market capacity. It depends on the total expenditures of country $j$, its internal transport costs, and the number of competing brands and their prices, as summarized in the price index. Last, the term $T_{ij}^{1-\delta}$ represents transborder trade costs between state $i$ and country $j$. Thus, from the equation above, export performance of a state can simply be expressed as the product of the exporting state's supply capacity, the importing country's market capacity or potential, and the transport and/or delivery costs between the exporting state and the importing country,

(6) $$n_i p_i x_{ij} = scap_i \left(T_{ij}^{1-\delta}\right) mcap_j .$$

This equation underlies typical gravity equations used to estimate export performance. The supply capacity ($scap_i$) and the market capacity ($mcap_j$) are represented by output, i.e., by the gross state product and the gross domestic product of the exporting state and importing country, respectively. The trade cost is normally represented by the physical distance between a state's geographical center and that of the importing country. According to the theory, the supply capacity of state $i$ and the market capacity of its trading partners have a positive effect on the bilateral trade flows between the two trading partners, whereas bilateral trade distance between this same pair will reduce the amount of trade between them.

## 3.3 Distance and Its Effect on Trade Performance

The first part of the empirical investigation seeks to investigate whether the trans-border trade cost, measured as the physical distance between the centroids of states and importing countries, still plays a role in determining the export performance of states. As already discussed, there are credible arguments that discount distance as a determinant of exports altogether given the significant reduction in transportation cost and the improvement in its efficiency. A less extreme position would be to argue that other types of physical distance measures may be more effective in predicting export performance.

Bilateral trade distances are used here as a measure of bilateral trade costs. However, trade cost does not only include shipping costs. There may be nonphysical/psychic distances or factors that contribute to bilateral trade cost. As presented in Equation 7 below, the transborder distance factor in Equation 6 may comprise several different components rather than just the actual physical distance between trading partners,

$$T_{ij}^{1-\delta} = \left(d_{ij} \sum_{1}^{f} npd_{ij}\right)^{1-\delta}, \tag{7}$$

where $d_{ij}$ denotes the physical distance, and $npd_{ij}$ denotes the nonphysical/psychic distance, between state $i$ and country $j$.[20] Not controlling for the nonphysical/psychic distances may yield a biased transborder cost factor. Some possible nonphysical/psychic distances include language differences, regional trade agreements, and development differences.

To identify the effect of distance on export performance, one needs to control for the effect of free trade agreements. For the U.S., one needs to account for the impact of the North American Free Trade Agreement (NAFTA). Otherwise, the effect of distance on exports will be overstated given that Canada and Mexico, the two closest countries to the U.S., are members of NAFTA.

## 3.4 Trade and Internal Geography

Most studies on trade performance that use gravity modeling do not consider the effect of internal geography. According to the theoretical model above (Equations 4 and 5), internal geographical distances form an integral part of the price of a state's variety of exports to a given country and thus form an integral part of the total value of a state's

[20] Note that $f$ varieties of nonphysical/psychic distances are considered in this model.

exports to a given country. Therefore, a state's internal geography may play a significant role in determining export performance. Studies that ignore the role that internal geography plays in determining export performance may overstate transport cost in particular. This study examines the impact of a number of internal geographical factors, such as agglomeration effects, internal transportation distances, and general internal access to external markets.

## 3.5 Supply Capacity as More Than Gross Domestic Product

From Equation 6, it follows that, at the state level, the total value of exports of state $i$ can be derived as follows

$$X_i = n_i p_i \sum_j x_{ij} = scap_i \sum_j \left(T_{ij}\right)^{1-\delta} mcap_j, \quad (8)$$

where the term $\left(T_{ij}\right)^{1-\delta} mcap_j$ denotes state $i$'s foreign market capacity or the market potential of state $i$ in market $j$. This term corresponds to the sum of the market capacity of all state $i$ export destinations, weighted by bilateral trade costs. Thus, the total value of state $i$'s exports is the product of its supply capacity and foreign market access.

In most gravity models of export performance, the supply capacity of a state or country is represented by the gross domestic/state output, which is augmented sometimes by population or per capita income to indicate the size of the state's home market production. However, a state's or country's supply capacity is not dependent only on its output; other factors can help determine a state's export supply capacity. Thus, in order to understand the dynamics of the relationship between a state's supply capacity and its export performance, the export capacity of the state needs to be decomposed beyond its output levels. Up to this point, a state's supply capacity has been defined as

(9) $$scap_i = n_i(p_i t_i)^{1-\delta},$$

where the producer price $p_i$ is assumed to be the same for all varieties produced in state *i*. The question is, what determines the producer price or even the number of varieties produced in a state? Many factors go into determining the producer price of a variety produced in a state. These factors include raw materials, labor, human capital, machinery, and other production factors. If state *i* has a higher abundance of, for example, the type of human capital needed to produce good *t* than state *p*, holding all other factors constant, state *i* is expected to produce good *t* at a lower production price, and have a relatively higher supply capacity than state *p* and perform better in the export market than state *p*. Thus, the availability of factors of production plays a role in determining the production price of a variety produced in state *i*.

The business environment, including the level of taxes, plays a role in attracting firms to a particular state. Thus, states with an attractive business environment will tend to attract companies including foreign direct investments. Most of the time, companies with high technology and efficiency undertake foreign direct investment. Attracting such companies can, therefore, lead to higher output levels, increased state product variety

($n_i = f(fp_i, B_i, tc_i)$),[21] and also lower production prices ($p_i = f(fp_i, B_i, tc_i)$). To account for such effects, the supply capacity equation is augmented to include the business environment as a determinant, as in Equation 10 below

$$(10) \qquad scap_i = n_i(p_i t_i)^{1-\delta} B_i,$$

where *B* denotes the business environment of state *i*. States with a good business environment (such as, good copyright protection) produce more innovations and therefore experience increased supply capacity.

The above considerations suggest that limiting the determinants of export performance to traditional measures of distance and size of the pairs of trading partners may misspecify export equations. To check for such misspecification, this study explicitly considers state characteristics in export equations that go beyond gross state/domestic product and distance measures.

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[21] Note that *fp*, *B*, and t represent factors of production, business environment, and technology, respectively.

# Chapter 4

# Empirical Model and Data

## 4.1 The Gravity Model

The main objective of this study is to investigate whether physical distances from states to export markets play a role in determining a state's export performance. As an alternative to physical distances, internal geography and nonphysical distances, whether real or perceived, are also examined for their impact on state export performance. In checking for the explanatory power of distance, this study controls for numerous factors other than distance, gross domestic product, population, and per capita income.[22]

This study employs the long-established gravity equation model in estimating the effect of the different types of distances on the export performance of U.S. states. The independent studies of Tinbergen (1962) and Poyhonen (1963) were the first to apply the gravity model to international trade. Despite its historical novelty in trade theory, the gravity model has a long history in the social sciences.[23] The model derives its name from its similarity to Newton's law that relates the gravity between two objects to their masses and the distance between them.

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[22] These are the variables normally considered in gravity models that are used to explain bilateral trade, imports, and/or exports.

[23] See Dodd (1950 and 1953), Anderson (1956), Stewart and Warntz (1958), Brown and Jones (1985), and Pettiway (1985).

The basic model of the gravity equation, expressed in log linear form,[24] relates export volumes between two regions to the regions' respective economic sizes and the distance between the two regions. The simplest gravity model for international trade predicts the volume of exports between two trading partners to be an increasing function of their economic sizes and a decreasing function of the distance that separates the two regions. Using $X_{ih}$ to denote the exports from region $i$ to region $h$, and $Y_i$, and $Y_h$ to denote the GDP of regions $h$, and $I$, respectively, and using $D_{ih}$ to represent the distance between regions $i$, and $h$, the flow of goods from region $i$ to $h$ is expressed in log-linear form in equation 11 as

(11) $$\ln(X_{ih}) = \alpha + \beta_1 \ln(Y_i) + \beta_2 \ln(Y_h) + \beta_3 \ln(D_{ih}) + \varepsilon_{ih},$$

where $\beta_1$ and $\beta_2$ have a positive and $\beta_3$ a negative sign. This equation is often estimated using a cross-section of trading countries for a single year or pooled over several years. Typically, distance is measured as the distance between the geographical centers of the trading partners. According to this specification, the volume of region $i$'s exports to region $h$ depends positively on the economic sizes of the regions involved in the trade and negatively on the distance between the two regions.[25]

[24] Theoretical studies that investigate the microeconomic foundations of the gravity equation, such as Anderson (1979), Bergstrand (1985 and 1989), and Helpman and Krugman (1985), provide rigorous explanations as to why the log linear form is the best-fit specification for the gravity model.

[25] Compare Frankel and Romer (1999), Sanso et al. (1993), Anderson and Smith (1999), and Nitsch (2000).

The basic econometric specification of the gravity model can be augmented[26] with other continuous and binary variables that help predict the export performance of a region. Linnemann (1966), for example, includes population as an additional measure of country size.

The perceived empirical success of the gravity model in terms of a high R-squared has led to its wide adoption as a baseline model for modeling a variety of trade policy issues including the impact of regional trading block arrangements, currency union formation, patent rights, and a host of trade distortions.[27] Normally, these policy issues are modeled as deviations from the volume of trade predicted by the baseline gravity model.

The gravity equation model has endured its share of criticism. The model has been criticized on the grounds that it lacks a rigorous theoretical base and that the empirical application of the model is still rather basic. There has also been some controversy about the precise nature of the relation between trade and distance. The concern is whether it follows the classic gravity model or a variation of the gravity model (Alcaly, 1967; and Black, 1971).

Cheng and Wall (1999) show that, despite a high R-squared, the standard estimation method tends to underestimate trade between high volume traders and, consequently, overestimates trade between low volume traders. Their study attributes this phenomenon to heterogeneity bias, which they address by relaxing the restriction that

[26] Oguledo and MacPhee (1994), Boisso and Ferrantino (1997), and Bayoumi and Eichengreen present such augmented gravity models.

[27] See Brada and Mendez (1983), Bikker (1987), Sanso, Cuairan, and Sanz (1993) Wei and Frankel (1997), Frankel, Stein, and Wei (1998), Anderson and Smith (1999), and Rose (2000).

the intercept of the gravity equation must be the same for all trading partners. Deardorff (1998), however, has shown that the gravity equation is consistent with several variants of the Ricardian and HO models.

In spatial economics and gravity models, there are three main types of physical distances that are employed: (a) distance based on national centroids, (b) distance based on regional capital centroids, and (c) distances based on the closest points in two regions or countries. The last approach is problematic, because the closest point between two countries may be two uninhabited areas. Distance measures derived from country or regional capitals may not be ideal, either, because they are not always the business hubs of the respective country/region. For example, in a large country like the United States, if the business hub is Los Angeles and distances are based on the capital, Washington D.C., trade distances may be considerably over/understated. Using national/state centroids based on physical centroids can also lead to misleading results because physical centroids can be very different from the business hub of a country, state, or region. Population centroids may be the best indicator for the actual business hub of a country, state, or region (Eff, 2004).[28]

In investigating the effect that physical distance has on state export performance, this study takes into account that the standard distance measures based on national physical centroids may give misleading results. The study, therefore, employs two different physical distance measures based on physical distance from the geographical

[28] Note, however that, in some cases, the most populated city of a state or country is also the capital of that state/country.

center of a state to that of the importing countries.[29] Next, a distance measure is employed for which distance is based on state capitals and the population-weighted distance from the administrative areas of the importing countries.[30] Thus, to check whether physical distance has any effect on state export performance, this study estimates an augmented gravity equation of the form presented below in equation 12.

According to studies on firm location theory, firms do not base their location decisions only on the distance to export markets but also on other cost cutting, productivity increasing, and efficiency improving factors, such as input factor availability, labor market conditions, the existence of agglomeration economies, taxes, governmental institutions, and policy instruments (Fox, 1996). State officials have used this type of knowledge to extend incentives to firms in order to attract them to locate within their state.[31] The location of highly productive firms in a state has a direct impact on a state's output and also on its export performance, an effect that can be separated from that of distance measures.

As discussed in the theoretical model of Chapter 3, export performance depends partly on access to foreign markets, for which distance between exporting state and importing country can be used as a proxy. However, access to foreign markets also depends on factors that go beyond distance measures and the size and income of the foreign country. Exchange rates are an example of other factors that can have an impact on the level of imports foreign countries procure.

[29] Normally, gravity equations employed in investigating trade issues use the distance from the exporting region's capital (or middle point) to that of the importing region.

[30] For smaller countries, the capital is used in the distance calculations.

[31] See Ambrosius (1989), Eisinger (1988), Gray and Lowery (1990), and Kline (1982).

In an attempt to incorporate both state characteristics and foreign market conditions into this study, the study employs an augmented gravity equation as presented in Equation 12 below. The equation contains variables that represent the impact of innovative capital, transportation efficiency, and the business environment. In addition, there are indicators for states that border on other countries and the foreign exchange rate between the U.S. dollar and the country in question. Equation 12 is given as

$$(12) \qquad \ln(X_{ih}) = \propto + \beta_1 \ln(Y_i) + \beta_2 \ln(Y_h) + \beta_3 \ln(D_{ih}) + \beta_4 \ln(NPD_{aih}) + \beta_5 \ln(PCI_i) + \beta_6 \ln(PCI_i) + \beta_7 \ln(INO_{ai}) + \beta_8 \ln(TRANS_{ai}) + \beta_9 \ln(BUSE_{ai}) + \beta_{10} \ln(REMOTE_i) + \beta_{11} \ln(XR_{uj}) + \beta_{12}(PORT_i) + \varepsilon_{ih},$$

where $ln(INO_i)$[32] represents the natural logarithm of the innovative capital capacity index of state *i,* and $ln(TRAN_{ai})$ represents the natural logarithm of the level of availability of transportation and infrastructure of type *a*[33] in state *i*. $ln(REMOTE_i)$ denotes the remoteness index of state *I*, $ln(BUSE_{ai})$ denotes the natural logarithm of the business environment of type *a* in state *i*, and $ln(XR_{uj})$ denotes the average exchange rate between the U.S. dollar and the currency of country *j*.

In constructing the empirical model for this section, all 50 U.S. states leaving out Washington D.C. are considered. The study investigates state exports to world export markets by mapping state exports to all countries in the world. However, due to the

[32] The innovative capital index includes measures of the number of PhDs, scientists, and engineers in a state, the percentage of the population of a state with a college degree, and the number of patents issued in a state.

[33] Where *a* denotes the transportation and infrastructure types considered by this study, which include the number of airports in a state, the highway density of the states, seaport locations, and Internet usage.

unavailability of data for some countries, this study employs data for 164 countries.[34] The time period under study extends from 1988 to 2000. In sum, the data set for this study consists of pooled data for 13 years, the 50 states of the U.S., and 164 export destination countries. The data definitions and some descriptive statistics are presented in Tables 1 and 2, respectively. Table 6a in Appendix A presents the data sources, and Appendix C provides a list of countries considered in this study by region.

[34] See Appendix B for a detailed listing of countries included in this study.

**Table 1. Variable Description**

| *Variable* | Description |
|---|---|
| **Dependent Variables** | |
| *Total* | State i's total manufacturing exports to country j |
| *H-tech* | High technology embodied exports |
| *L-tech* | Low technology embodied exports |
| **Independent Variables (Physical Distance Measures)** | |
| *DIST* | Distance from state i geographical center to country j's geographical center (kilometers) |
| *ZDIST* | Distance from state i capital to country j's population weighted administrative centers (kilometers) |
| *REMOTE* | State Remoteness Index (weighted average distance to the 3 nearest seaports) |
| **Independent Variables (Non-physical and Psychic Distance Measures)** | |
| *LANG* | Language Proximity Between U.S. and Foreign Country |
| *ENEM* | Enemy relationship proximity between US and country j |
| **Independent Variables (State Variables)** | |
| *GSP* | Gross State Product |
| *SPCI* | State per capita income |
| *HCI* | State innovative capital index |
| *PC* | Number of Households with Computers in state I |
| *HDEN* | State Highway Density (Highway Milage/State land+water surface area) |
| *TAIR* | Number of airports in the ith state |
| *BTARP* | Business taxes as a percentage of business profits in the ith state |
| *CO2ER* | State annual CO2 emmisions Tons |
| *SER* | Share of services in the ith states GDP |
| *LABW* | Hourly wages for production workers in the ith state |
| *SLITR* | State litigation system ranking index |
| *TUNDEN* | Union Density = Total Union Members/Total Employed |
| *CPI* | Regional Consumer Price Index for States |
| *CONT1* | 0/1 indicator variable for location of a top 30 American Containeerized port in a state |
| **Independent Variables (Country)** | |
| *CGDP* | Gross Domestic Product of the jth country |
| *CPCI* | Per capita income of the jth country |
| *IMPORT* | Total imports of the jth country |
| *XRAT* | Nominal exchange rates (FCUs/$) |
| **Trade Agreements** | |
| *BILAT* | 0/1 indicator variable for countries with bilateral trade agreements with the U.S. |
| *APEC* | 0/1 indicator variable for Asia Pacific Economic Cooperation members |
| *NAFTA* | 0/1 indicator variable for NAFTA member countries after 1994 |
| *WTOR* | 0/1 indicator variable for when a country joined WTO and after |

Note: All variables apart from the 0/1 indicator variables are in logs

**Table 2: Descriptive Statistics of Variables**

| Variable | N | Mean | STD | MIN | MAX |
|---|---|---|---|---|---|
| **Dependent Variables** | | | | | |
| *Total* | 145,600 | 4.085 | 4.059 | 0.000 | 17.222 |
| *H-tech* | 145,600 | 3.951 | 4.037 | 0.000 | 17.046 |
| *L-tech* | 145,600 | 2.002 | 3.007 | 0.000 | 15.396 |
| **Independent Variables (Distance)** | | | | | |
| *DIST* | 145,600 | 9.312 | 3.671 | 0.203 | 19.712 |
| *ZDIST* | 145,600 | 2.253 | 0.433 | 0.185 | 3.029 |
| *REMOTE* | 145,600 | 5.765 | 0.918 | 3.714 | 8.247 |
| **Non-physical and Psychic Distance Measures** | | | | | |
| *LANG* | 108,550 | 14.616 | 2.344 | 9.579 | 20.569 |
| *ENEM* | 108,550 | 0.096 | 0.138 | 0.000 | 0.643 |
| **Independent Variables (State Variables)** | | | | | |
| *GSP* | 145,600 | 11.313 | 1.057 | 9.184 | 14.101 |
| *SPCI* | 145,600 | 9.966 | 0.216 | 9.355 | 10.633 |
| *HCI* | 145,600 | 66.538 | 9.827 | 49.521 | 89.386 |
| *PC* | 145,600 | 36.968 | 7.215 | 20.600 | 55.300 |
| *HDEN* | 145,600 | 22.583 | 17.648 | 0.960 | 96.820 |
| *TAIR* | 145,600 | 0.127 | 0.094 | 0.009 | 0.466 |
| *BTARP* | 145,600 | 39.112 | 11.146 | 26.900 | 82.300 |
| *CO2ER* | 145,600 | 1.385 | 0.572 | 0.057 | 2.393 |
| *SER* | 145,600 | 0.199 | 0.035 | 0.115 | 0.319 |
| *LABW* | 145,600 | 10.006 | 1.871 | 7.370 | 13.830 |
| *SLITR* | 145,600 | 57.158 | 8.717 | 28.400 | 78.600 |
| *TUNDEN* | 145,600 | 12.324 | 5.625 | 3.600 | 25.500 |
| *CPI* | 145,600 | 171.636 | 4.735 | 167.200 | 179.400 |
| *CONT1* | 145,600 | 0.360 | 0.480 | 0.000 | 1.000 |
| **Independent Variables (Country)** | | | | | |
| *CPCI* | 111,600 | 1.293 | 1.139 | 0.000 | 4.078 |
| *CGDP* | 111,750 | 2.606 | 1.970 | 0.000 | 8.642 |
| *IMPORT* | 94,950 | 0.027 | 0.071 | 0.000 | 0.944 |
| *XRAT* | 104,850 | 0.186 | 2.792 | 0.000 | 87.736 |
| **Trade Agreements** | | | | | |
| *BILAT* | 116,350 | 0.008 | 0.073 | 0.000 | 0.693 |
| *NAFTA* | 116,350 | 0.008 | 0.088 | 0.000 | 1.000 |
| *APEC* | 116,350 | 0.074 | 0.214 | 0.000 | 0.693 |
| *WTOYR* | 116,350 | 0.223 | 0.324 | 0.000 | 0.693 |

Note: All variables apart from the 0/1 indicator variables are in logs

### 4.1.1 Dependent Variables

The dependent variable for this study is "export performance." It is defined as the manufacturing exports from state *i* to country *j* for a specific year. These state level export data come from the World Institute of Strategic Economic Research (WISER).

The export data are based on the Origin of Movement (OM) series, the most frequently used state-level export data series. The OM series allocates exports to a state on the basis of state of transportation origin. The reliability of this series is considered to be good for manufactured exports. However, it has been criticized for overstating exports of bulk commodities, such as grain, from states with large ports.[35]

Alternatively, this study could have employed the Exporter Location (EL) series, which allocates exports to states on the basis of the point of sale. However, one can immediately note that, while this series is reliable for indicating market activity concentration, the series does little to indicate the place of manufacturing. Also, the EL series is criticized for sometimes showing substantial manufacturing exports from states where manufacturing plants are nonexistent.

Only manufacturing exports are considered. Agricultural exports are excluded to deal with the inherent bias of the Origin of Movement state export data, which allocate most of the agricultural exports to states with large seaports even when there is no significant documented agriculture production in those states.

Using the Standard Industry Classification Codes (SIC), this study considers total manufacturing exports by state as well as manufacturing exports of high technology

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[35] See http://www.census.gov/foreign-trade/aip/elom.html#om.

(*HITECH*) and low technology (*LOWTECH*) products. The exports of the *HITECH* and *LOWTECH* industries sum to the manufacturing total.

The breakdown of industries into *HITECH* and *LOWTECH* is done as follows: data for company and non-Federal expenditures for industrial research and development by industry (based on the SIC Code) are obtained from the "2001 National Science Foundation Report on Research and Development in Industry". The expenditures are averaged over a three-year period (1999-2001) for each Standard Industrial Classification (SIC) industry at the three-digit industry grouping level. Any industry with a three-year average of more than $3 billion in company and non-Federal research and development expenditures is classified as a *HITECH* industry, while all industries with less than $3 billion in research and development expenditures are classified as *LOWTECH.*

The above classification yields four industries at the three-digit SIC level that can be classified as *HITECH.* These industries include chemicals and allied products ($19 billion), electronic goods and equipment excluding computers ($6.8 billion), industrial machinery including computers ($36.9 billion), and transportation equipment ($22.6 billion). Thus, state exports from the above-mentioned industries are classified as *HITECH* exports, while the remaining exports are classified as *LOWTECH* exports. Some of the significant industries classified as *LOWTECH* are furniture and fixtures, leather and leather products, plastics and rubber, and the apparel and other textile industries.

The dependent variable for all empirical models is defined as exports plus one. This helps take care of the inherent problem of taking the logarithm of zero for cases where a state does not export *HITECH* and or *LOWTECH* manufactured goods to a foreign country.

### 4.1.2 Independent Variables

#### 4.1.2.1 Gross State Product/Gross Domestic Product

The gross state product (*GSP*) of state *i*, the gross domestic product (*GDP*) of country *j*, and their respective populations are used in gravity equations to indicate the mass or the size of the two entities involved in trade. The country level *GDP* data are from the International Energy Administration.[36] The data on gross state product (*GSP*) are obtained from the Bureau of Economic Analysis (BEA). Country level *GDP* data (billion $) are obtained by converting the gross domestic product (*GDP*) for each country measured in 1995 foreign currency units to U.S. dollars using 1995 annual average foreign currency market exchange rates.

Theoretically, foreign *GDP* figures should be converted by using purchasing power parity (PPP) rates to avoid the problem that the market exchange rate for a foreign currency is not a precise reflection of the purchasing power of that currency. In practice, it is difficult to find useful PPP rates for many countries.

#### 4.1.2.2 Per Capita Income

The study employs per capita income of the states (*SPCI*) and that of the foreign countries (*CPCI*) to control for the purchasing power of the residents of state *i* and

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[36]Presented in the 2002 annual report of the U.S. Energy Information Administration http://www.eia.doe.gov/pub/international/iealf/.

importing country *j*, respectively. When state per capita income increases, residents are expected to consume more of all goods and services and exports to decline. In the same vein, rising per capita income for an importing country means imports and hence U.S. exports go up. The data on country-level per capita income are from the "2002 International Energy Annual Report" of the U.S. Energy Information Administration,[37] whereas data on state-level per capita income are obtained from the Bureau of Economic Analysis (BEA).

#### 4.1.2.3 Bilateral, Regional, and Transnational Trade Agreements

Trade agreement data are obtained from the U.S. Trade Representative (USTR) website.[38] As indicated by studies including Coughlin (2004), trade agreements open foreign and domestic markets to trade and decrease trade costs. Thus, the countries that are part of a trade agreement such as the NAFTA will tend to trade more with each other. It is also the expectation of this study that the U.S. states will export more to countries that have a bilateral agreement with the United States.[39]

### 4.2 Physical Distance Measures

The distance of each state from the export markets of the world is used as a proxy for transportation cost in this study. Therefore, the further a state is from its export markets, the lower is its expected export performance. Thus, Wyoming is estimated to be

[37] See http://www.eia.doe.gov/pub/international/iealf/.

[38] http://www.ustr.gov/.

[39] See Appendix C for a list of countries with bilateral agreements with the United States.

further away in terms of physical distance from Great Britain than New York, then, all things being equal, the state of New York is expected to export more to Great Britain than Wyoming.

In calculating the physical distance from each state to its export markets, all countries for which data are available are considered.[40] Based on the location data from the CIA fact book, the distance from each state's geographical center to that of each importing country is measured using the great circle distance (GCD) formula.[41] That formula is again used to calculate the distance between each state capital and the population-weighted administrative region of each importing country.[42] This process yields two measures of physical distance, which can be compared to determine which physical distance measure is the best determinant of state export performance.

Due to the close proximity of Canada to the U.S., the border sharing of some Canadian cities with some American states, and the generally dispersed nature of the Canadian population across the country, a different methodology is used in calculating the distance from state *i* to Canada. In particular, the distance between each state and all Canadian cities is measured using the GCD formula. Then the distance between the closest Canadian city to each state is used as the distance from each state to Canada. The estimated closest country (or Canadian City) and furthest country (or Canadian City) to each state are presented in Table 1a in Appendix A.

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[40] See Appendix C for a listing of the countries used in this study by region of the world.

[41] See Appendix A for a description of the methods used in calculating the great circle distance.

[42] Note that, if the country is not large enough for administrative regions, the country capital is used in this estimation.

## 4.3 NonPhysical Distance Measures

It has been shown in many studies that not only physical distance from export markets determines a country/state's export. Other nonphysical and psychic distances, such as differences between the home market and the target market in terms of thinking and doing business, play a role for export performance. Typically, companies would prefer to target markets with low real or perceived psychic distances from their home state and avoid markets with a high real or perceived psychic distance from the home state. This is because nonphysical and psychic distance factors can entail substantial risks and costs for exporting firms (Douglas and Craig, 1995).[43]

Some possible reasons for the existence of perceived or actual psychic/nonphysical distances are language differences, cultural differences, communication differences, legal system differences, political system differences, development/standard of living differences, and religious differences.

This study incorporates six nonphysical and psychic distance measures in two groups into the study of the effect of distance on state export performance. A first group includes bilateral, regional, and transnational trade agreements. A second group includes proximity measures that relate to political relationships and cultural similarity between the U.S. and the importing countries.

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[43] The literature on the export behavior of firms includes Robertson and Wood (2000), Bodur (1994), Evangelista (1994), and Katsikeas et al. (1996). It has identified a series of factors that affect a firm's export performance, including political stability, lack of information, different consumer behavior, cultural differences, development, and infrastructure differences.

### 4.3.1 Language Differences between the U.S. and the Importing Country

When conducting business on an international level, it is important to understand the social and cultural differences that affect the trade between different countries. Often, subtle differences in mannerisms, language, and social conduct can make the difference in securing a business contact, negotiating a sales contract, or securing a distributor relationship.

Language differences may lead to an increase in the implicit or explicit cost of export transactions, whereas other cultural differences like religious differences can augment the difficulty of doing business transactions and therefore increase the cost of trade between U.S. companies and their foreign counterparts.

A study released by the British Chamber of Commerce in May 2004, it is reports that poor language skills and a lack of cultural understanding of overseas markets are stunting U.K. export growth.[44] In an attempt to capture the effect that cultural differences between the U.S. and other countries have on state exports to those countries, this study employs a measure of language difference as a proxy for cultural differences. It is expected that countries with similar language and culture will do relatively more business with each other and vice versa.

Why should different official languages in different countries matter for trade? Language differences matter for trade because they increase information costs. As Rauch (1999) points out, most traded goods (especially manufactures) are not traded on organized spot markets. Instead, buyers and sellers in different countries have to make connections through a search process. Clearly, information costs strongly condition this

[44] http://www.chamberonline.co.uk/press_centre/press_24052004

search, and language differences certainly affect these information costs. Previous studies estimate the cost of language barriers to range between 12 and 22 percent in tariff equivalent terms.[45]

This study employs a language/phylogeny proximity matrix created and generously provided by Eff (2004) as a proxy for language similarity. This proximity matrix is calculated from the following formula:

$$S_{rk} = \partial_x - \partial_{rk} + 1/(x+1) \qquad (15)$$

where $S_{rk}$ denotes the similarity between language $r$ and language $k$, $x$ denotes the length of the longest path to the common ancestor of the entire family, and $rk$ is the length of the longest path to the nearest common ancestor of languages $r$ and $k$. Since there are no links between the major language families, the calculated proximity of language pair matrices lies between zero and one. It will equal zero when the pair of languages being considered are from different language families. It will be one when a language is compared to itself. It is expected that states will export more to countries with relatively higher language/phylogeny proximity to the U.S. and vice versa.

Language proximity measure captures a more general cultural similarity, which would make transactions easier since people would understand each other better. For more complex products, that understanding is more valuable since there is more to know about the product: Thus, it is the expectation of this study that *HITECH* exports will be

[45] Frankel (1997) estimates language barriers at 22 percent.

more negatively affected by language differences between the United States and other importing countries than *LOWTECH* exports.

### 4.3.2 Enemy Relationship between the U.S. the and Importing Country

Countries that are allies with one another tend to have a level of mutual agreement on issues pertaining to world affairs. Countries with close ally relations are expected to exhibit higher levels of mutual understanding. This understanding between countries provides an environment that fosters general business and trade. Further, countries that frequently ally with each other may already have close economic and cultural ties that generated their ally relationship in the first place. Thus, the higher the level of ally relations between the U.S. and an importing country, the higher the relative exports by states to that country. In the same vein, "enemy" nations tend not to trade as much with each other because of their hostile stance against each other.

This study employs "enemy" relationship proximity measures from Eff (2004). From the Correlates of War (COW) Project, Eff (2004) uses information from the Militarized Interstate Dispute collection to identify all nations that stood on the same side of a militarized conflict. The importance of each conflict $k$ to participants $i$ and $j$ ($x_{ik}$ and $x_{jk}$) is found. Next, the importance of a particular country $j$ as an "enemy" to country $i$ is derived by taking the geometric mean of $x_{ik}$ and $x_{jk}$ for each conflict $k$ in which the two countries were on opposite sides. Finally, the sum for all conflicts $k$ is calculated as follows:

(15) $$W_{ij} = \sum_k \left(x_{ik} x_{jk}\right)^{\frac{1}{2}}.$$

The diagonal of the matrix is set to zero. Then all elements of $W_{ij}$ are divided by the largest element of $W_{ij}$ to standardize the matrix, and each element ranges between zero and one. The closer a country pair's enmity relationship is to one, the higher is the level of their hostility and vice versa. It is expected that the higher the U.S. enmity relations with an importing country, the higher will be the psychic distance and the lower the level of U.S. exports and vice versa.

## 4.4 State Location Characteristics

### 4.4.1 Innovative Capital Index

Similar to Dosi (1988) and Griliches (1994), this study hypothesizes that innovation increase efficiency, which in turn leads to lower cost in production and higher output. The increase in efficiency and production is a source of comparative advantage for states, and thus it is expected that states with higher levels of human capital and other innovative capacities will perform better in world export markets.

Following Howitt and Mayer (2002), who define "innovative-effective" human capital as a combination of the level of education and effort invested by the economy to develop new technologies based on the existing technological frontier, this study employs an innovative capital index. This index includes the number of PhDs, scientists, and engineers per thousand workers in a state *(PSE)* and the college attainment rate of the states *(COL)* as measures of human capital. The index also incorporates the number of patents issued in a state (*PI*) and investments in research and development (R&D) as measures of innovative capacity. The data used for human capital and innovation assets and capacity are all from the CFED.[46]

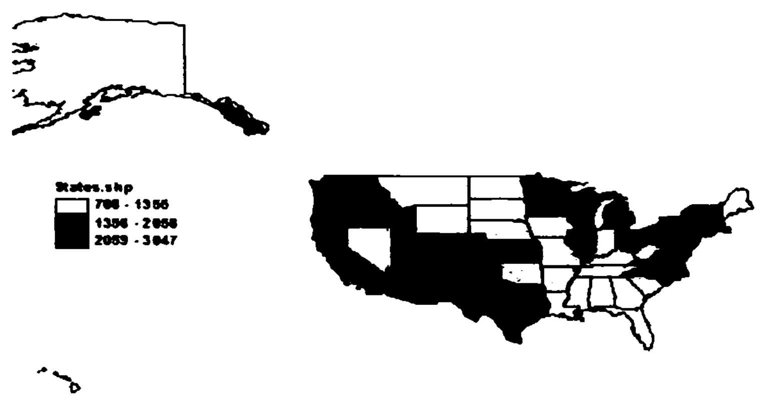


Figure 2: Spatial Mapping of State Innovative Capital Index

Figure 2 above depicts the spatial mapping of the estimated innovative capital index for all U.S. states. The map indicates that California, Colorado, New York, Massachusetts, Connecticut, and Rhode Island rank highest in terms of the innovative capital index.

### 4.4.2 Transportation and Communication Efficiency

In terms of transportation efficiency, it is assumed that states with more and better options in terms of transportation methods will tend to perform better in the export market. One reason for better export performance lies in the fact that firms in these states

[46] See Appendix A for detailed account on the construction of the index and the ranking of states by innovative capital.

have access to more efficient and faster ways of reaching their customers. Another reason has to do with the fact that transporting factors of production to firm locations is faster and cheaper when there is an efficient transportation network. Thus, states with more airports, higher highway densities, and more seaports should perform better in the export market than states with relatively fewer[47] of these transportation mechanisms. In order to control for the effect of transportation and communication capacity and efficiency of the states on state export performance, this study employs a number of transportation and communication measures including seaports, airports, highway density, and information technology proliferation.

### 4.4.3 Sea Transportation

In an attempt to capture the effect on exports of the availability and efficiency of sea transportation, this study employs two different sea transportation variables. A 0/1 indicator variable is constructed for states within which a top 30 U.S. containerized seaport[48] is located. The existence of such a seaport is assumed to be an indicator of efficiency. This indicator variable is used to account for the contribution of sea transportation to the ease with which states can transport their exports to other countries. The variable also helps to alleviate some of the bias that occurs through the use of the OM series, which tends to allocate more exports to states with ports and harbors. The

[47] Note that, in this case, "less transportation mechanism" denotes actual availability and efficiency of transportation mechanisms.

[48] The list and ranking of the top 30 U.S. containerized ports by weight volume of exports is obtained from http://www.marad.dot.gov/MARAD_statistics/Con-pts-02.htm.

data on U.S. seaports and airports and their location are obtained from the database of the U.S. Ports and Harbor Authority.

Figure 3 below presents a map of the location of the top 30 containerized ports in the U.S. The states where these ports are located include Hawaii, Washington, Oregon, California, Texas, Louisiana, Mississippi, Florida, Georgia, South Carolina, North Carolina, Virginia, Maryland, Delaware, New Jersey, New York, and Pennsylvania.

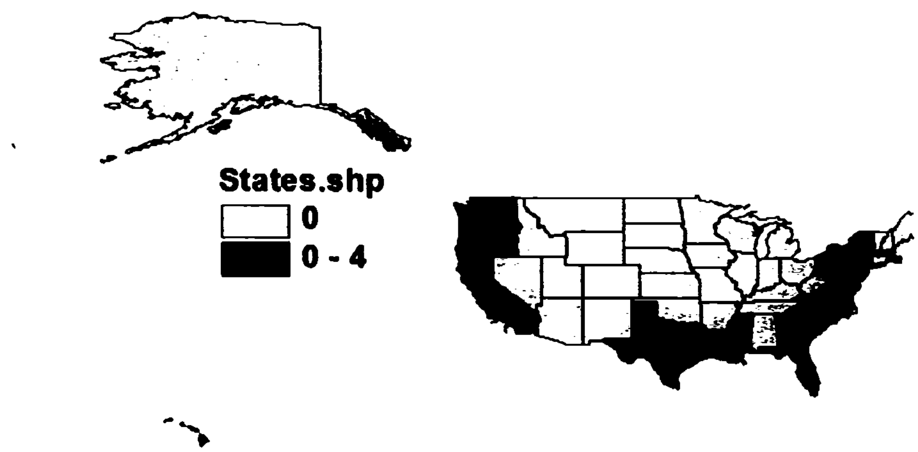


Figure 3: Location Map of the Top 30 U.S. Containerized Ports

### 4.4.4 Air Transportation

To control for the contribution of air transportation to the export performance of a state, the study employs a continuous variable (*TAIR*), which denotes the number of airports and heliports located within a state. In this age when many customers require "just in time" deliveries, air transportation will be used for express deliveries. Thus, the more access firms within a state have to air carriers, the higher their export performance will be. The data on the number of airports within a state is obtained from the National

Transportation Atlas Database 1999 (NTAD99). Figure 4 below depicts air transportation availability in each state of the U.S. in terms of the number of airports and heliports. Darker colors indicate states with higher air transportation density, whereas lighter colors represent relatively lower air transportation density.

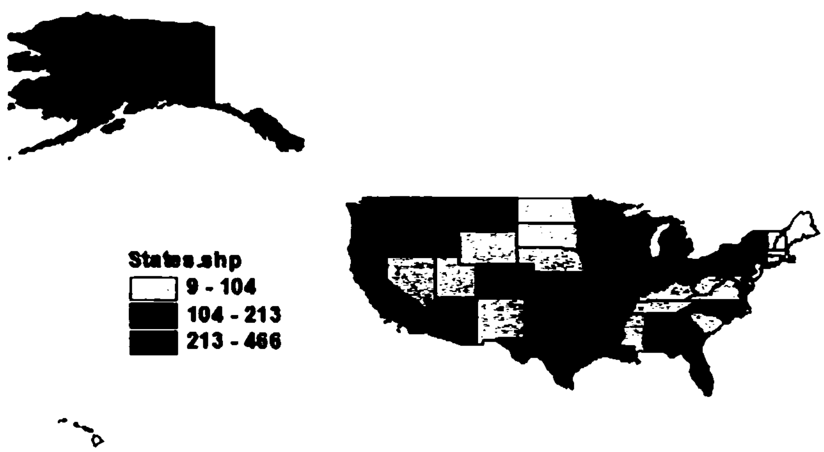


Figure 4: Mapping of U.S. Air Transportation Location Density

From Figure 4, it is apparent that California, Alaska, and Texas exhibit the highest air transportation densities among all states. Thus, holding all factors constant, one would expect Texas and California to outperform all other states in the international export market.

### 4.4.5 Highway Density

The value of state highways in interstate and international commerce is significant.[49] First, availability and efficiency of highways helps in the transportation of

[49] See Cooper (1964), McDonald (1951), Williamson (1964), Taaffe et al. (1963), and Brautigam (1994).

raw materials from areas of abundance to places of need. Second, highways help in the transportation of finished goods to markets. The data employed in calculating state highway density is obtained from the U.S. Transportation Commission. The variable highway density is calculated as

(22) (Number of highway lanes * miles)/state land area in square miles

The working hypothesis is that states with higher highway density will perform better in terms of export performance than those states with relatively lower highway density. This assumption is made because availability of highways leads to lower transportation costs, which in turn lead to lower prices and improved export performance. The availability of highways is even more important in the case of landlocked states because trucks can help the process of transporting finished products from these landlocked states to seaports in other states for shipment onward to international markets.

Figure 5 below presents a graphical mapping of the estimated highway density level of each state of the U.S. Darker colors represent states with relatively higher highway density levels, while lighter colors denote states with relatively lower highway density levels.

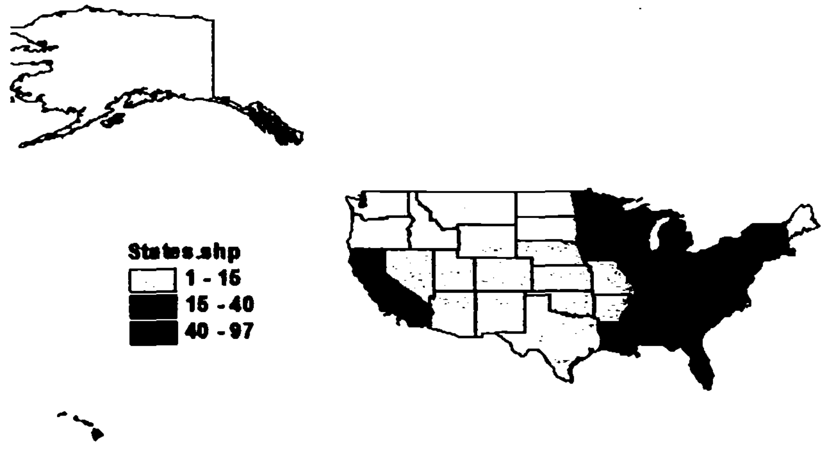


Figure 5: Map of the Distribution of U.S. State Highway Density Levels

From Figure 5, one can discern that states with the highest highway density include Maryland, Pennsylvania, New York, New Jersey, Connecticut, Massachusetts, and Rhode Island.

### 4.4.6 Information Technology Infrastructure

Information technology plays a critical role in business performance and economic growth by reducing the cost of coordination, communication, and information processing (Brynjolfsson and Hitt, 2000). In this study the central argument for the role that information technology plays in business performance is twofold. First, a significant component of its value is the ability to enable complementary organizational investments, such as business processes and work practices. Second, these investments in turn lead to productivity increases through the reduction in costs and, more important, through enabling firms to increase quality in the form of new products or improvements in existing products.

This study employs the percentage of households within a state with computers (*PC*) as a proxy for information technology proliferation in states. The percentage of households with computers also provides a rough proxy of Internet infrastructure and usage. With the advent of the increase in the use of the Internet as an information and sales medium, one can make a case that manufacturers within areas with a high density of Internet infrastructure probably can be contacted more easily by potential customers, thus allowing such states to export more, and vice versa.

The data used for households with computers are from the CFED. The National Telecommunications and Information Administration has used this information to report on the penetration of telecommunications and the Internet in American society.

Figure 6 below presents a map of the density of U.S. households with personal computers at the state level. Darker colors represent states with the highest density of households with personal computers, while lighter colors represent states with a relatively lower density of households with personal computers.

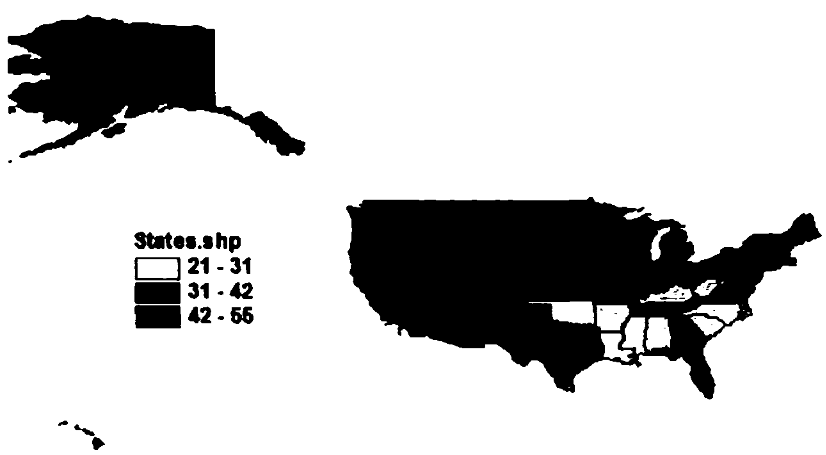


Figure 6: Map of the Density of State Households with Personal Computers

The map indicates that Alaska, California, Washington, Idaho, Utah, Colorado, Virginia, Maryland, Delaware, New Hampshire, and Maine are the states with the highest density of households with personal computers. Holding all other factors constant, the expectation is that states with a relatively higher density of households with personal computers will outperform states with lower density levels in terms of exports.

### 4.4.7 Business Environment

Many studies have shown that the business and political environment of an economy has a significant effect on its growth.[50] Helliwell (1994) uses cross-sectional and pooled data for up to 125 countries to evaluate the linkages between democracy and economic growth. He finds that democracy and personal freedoms have a positive effect on production and growth. It is assumed that export performance is also affected positively by a favorable business environment.

To account for the effect of the business environment on export performance, a number of variables are employed to capture various facets of the business environment in a state. The variables are assumed to improve a state's productivity through the attraction of higher quality companies if the environment is positive.

The variables employed as proxies for the business environment include the level of unionization of a state, the business taxation level, environmental laws, levels of commercial liability, level of unionization, cost of living, employment cost, and the shares of GDP generated in agriculture, manufacturing, and services.

[50] Some of these studies include Inclan et al. (2001), Helliwell (1994), Mauro (1995), Levine (1998), and Grossman and Krueger (1995).

#### 4.4.7.1 Labor Unions

The level of unionization is expected to play a role in determining productivity levels, although the exact the nature of its effect is arguable (Clark, 1980). If unions focus on the more-skilled workers, the unionization variable might proxy for skill level. Unions may also result in higher worker morale through a better work environment. If either or both of these are the case, then one would expect to find a positive relationship between the productivity and export performance of a state and its level of unionization. However, if the unions focus their activity on improving pay and the working conditions of employees, then there is the possibility that higher levels of unionization would be consistent with higher pay levels, more restrictive work rules, and higher costs of labor. These factors would most likely result in lower levels of productivity and exports.

Although the BLS publishes some state and local-level union data, their publications on local level union data are not comprehensive. Hirsch and Macpherson have constructed a useful database on state and local unionization trends at www.unionstats.com. This site presents data on private and public sector union membership, coverage, and density estimates compiled from the Current Population Survey (CPS) using Bureau of Labor Statistics methodology. Economy-wide estimates are provided beginning in 1973. Estimates by state, detailed industry, and detailed occupation begin in 1983, and estimates by metropolitan area begin in 1986.

This study employs the Hirsch/Macpherson estimates for the percentage of persons employed in private manufacturing jobs who were union members (*TUDEN*) as a proxy for union activity density for states for the years between 1988 and 2002. Although union data are available by ownership type and production level, the manufacturing portion of the private union density is most appropriate for studying manufacturing data.

Figure 7 presents a map of state-level union density. The darker colors represent those states with the highest union density, whereas the lighter colors represent those states with relatively lower union density.

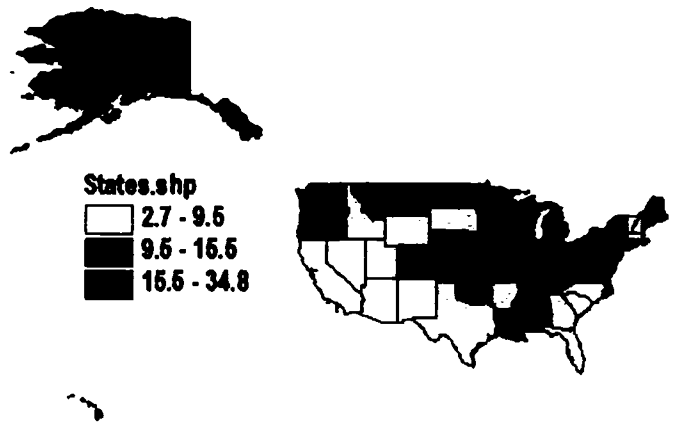


Figure 7: Map of Union Density of U.S. States

Figure 7 indicates that California, Texas, Florida, Nevada, Utah, Arizona, Idaho, New Mexico, Arkansas, Wyoming, South Dakota, South Carolina, North Carolina, Vermont, and New Hampshire are the states with the lowest union density. This study investigates whether, given all other factors, low union density states will perform better in the international export markets than states with relatively higher union density. This would be true if higher union density is mainly an indicator of higher production costs.

However, if higher union density is primarily a proxy for the use of efficiency wages, then unionization and export performance should be positively related.

### 4.4.7.2 Court System and Commercial Liability

Previous studies in economics have found that a better legal system and the protection of individual and firm rights help countries and states to attract highly productive companies.[51] More productive companies, in turn, translate into better export performance. Mauro (1995) finds that corruption, lower efficiency of the court system, and the amount of red tape leads to lower investment, thereby lowering economic growth. Similarly, Levine (1998) finds that countries with good legal and banking systems experience greater growth in output relative to others.

This study employs litigation data from the 2004 State Liability Systems Ranking Study to represent the legal environment. The study was conducted between December 2003 and February 2004 for the U.S. Chamber Institute for Legal Reform. It surveyed a nationally representative sample of 1,402 senior attorneys at companies with annual revenues of at least $100 million. The surveys were conducted by telephone for an average of 18 minutes. The objective was to explore how reasonable and fair the tort liability system is perceived to be by U.S. business organizations. Broadly speaking, the

[51] See Mauro (1995) and Levine (1998).

survey focused on perceptions of state liability systems in terms of 10 selected indicators of the efficiency of state liability systems.[52]

States were given a letter grade from "A" to "F" by respondents for each of the key elements of their liability system. The mean grade was calculated by converting the letter grades on a 4.0 scale where "A" = 4.0, "B" = 3.0, "C" = 2.0, "D" = 1.0, and "F" = 0.0. Therefore, the mean score can also be interpreted as a letter grade. For example, a mean score of 1.8 could be seen as roughly a "C" grade.

This study employs the "Overall Ranking of State Liability Systems," which is calculated by creating an index using the scores given on each of the key elements as a proxy for the litigation environment of a state. The index was created from the mean across the 10 items, which are rescaled from 0 to 100 prior to averaging them together. The higher the litigation score assigned to a state, the better the perception of corporate lawyers about the litigation environment of a state. Figure 8 below presents a map of the litigation score index of the U.S. by state. The darker colors represent those states with the highest litigation index score, while the lighter colors represent those states with the lowest litigation index score.

[52] Including tort and contract litigation, treatment of class action suits, punitive damages, timeliness of summary judgment/dismissal, discovery, scientific and technical evidence, judges' impartiality and competence, and juries' predictability and fairness.

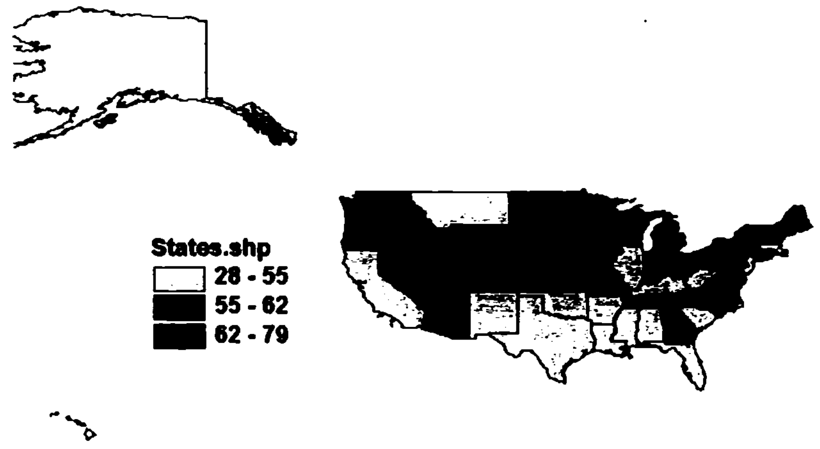


Figure 8: Mapping of State Litigation Scores

It is expected that states with the-lowest ranked liability systems[53] will attract relatively fewer industries, which will lead to lower levels of output from these states and thus lower levels of export performance. The working hypothesis is that the higher the perception of a state's liability system, the higher its export performance level will be.

### 4.4.7.3 State Business Taxes

Companies make decisions to maximize their profits. One of the profit-motivated decisions firms make is the location of their business. Location advantages considered by companies may include the tax system, particularly the corporate tax rate. Inclan et al. (2001) find that the level of corporate taxes negatively affects economic growth and levels of foreign direct investment. In the same light, this study expects states with

[53] Including California, New Mexico, Texas, Montana, Oklahoma, Arkansas, Louisiana, Mississippi, South Carolina, Kentucky, West Virginia, Hawaii, and Alaska.

higher corporate tax rates to attract fewer industries and experience lower output and export levels.

This study employs data from the Tax Foundation's state tax files. The variable of interest for this study is business taxes as a percentage of business profits in the *i* state. Figure 9 below depicts a spatial distribution of the levels of state corporate tax levels.[54] Darker colors represent those states with the highest corporate tax levels, while lighter colors represent those states with relatively lower corporate tax levels.

Figure 9 indicates that Washington, Wyoming, North Dakota, New Mexico, West Virginia, and Alaska are the states with the highest levels of corporate tax. The expectation is that these states will be outperformed by the states with relatively lower corporate tax levels in terms of export performance.

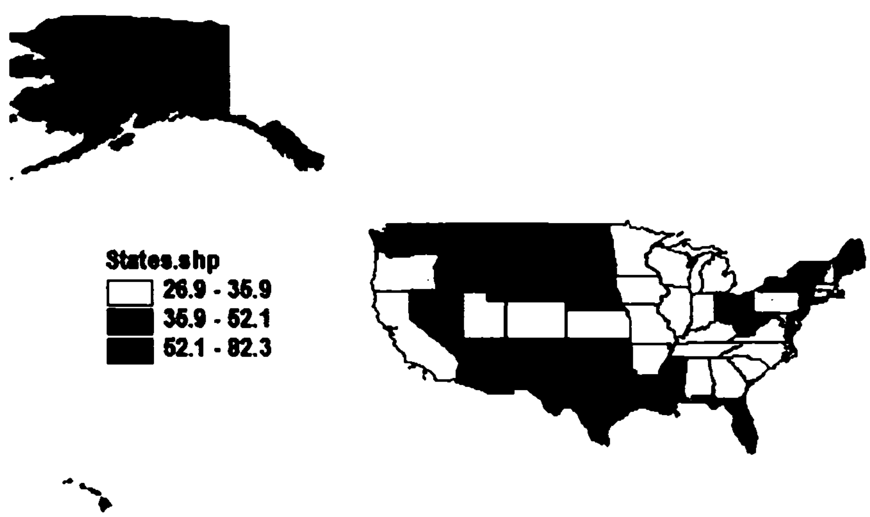


Figure 9: Spatial Distribution of State Corporate Tax Levels

[54] The states are ranked in ascending order in Appendix B.

### 4.4.7.4 State Environmental Laws

In a study of the effect of economic growth and the environment, Grossman and Krueger (1995) find no evidence that environmental quality deteriorates steadily with economic growth. However, with the advent of pollution restrictions, it is possible that companies will locate in areas where the existent pollution restrictions are lax. To capture the effect of lax pollution rules on productivity, and as such on export performance, this study employs $CO_2$ emission levels per state as a proxy for the restrictiveness or laxness of state pollution laws.

The data for $CO_2$ emissions are obtained from the U.S. Environmental Protection Agency (EPA). If the argument that less restrictive pollution laws encourage higher production holds, then it is expected that states with higher $CO_2$ emissions levels will produce and export more commodities. On the other hand, if restrictive environmental policies force firms to streamline their business processes by adopting more efficient and environmentally friendly business processes, then states with lower emission levels will be the best-performing states in international markets.

Figure 10 below presents a map of $CO_2$ emission levels by state. Once again, darker colored states denote those with the highest levels of CO2 emissions, whereas lighter colored states represents those with relatively lower emission levels.

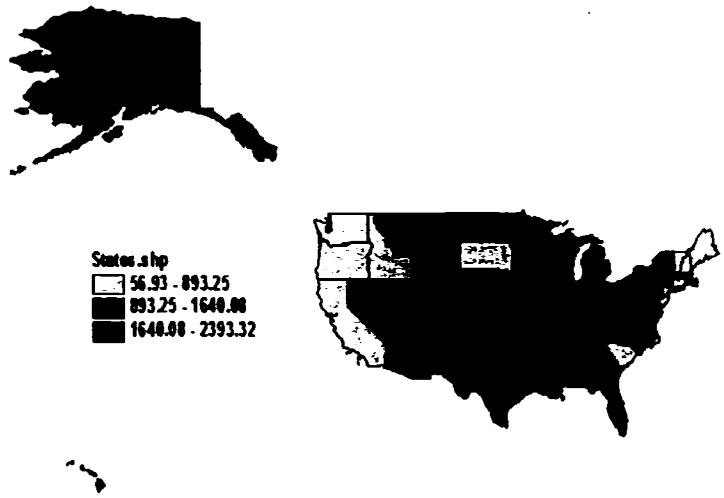


Figure 10: Spatial Mapping of $CO_2$ Emissions by State

Figure 10 indicates that the states with the least $CO_2$ emission levels include California, Oregon, Washington, Idaho, South Dakota, South Carolina, New Jersey, Connecticut, Vermont, New Hampshire, and Maine.

### 4.4.7.5 Employment Cost/Unit Cost

Studies that investigate the effect of wages on export performance have not been able to reach a unique conclusion in terms of the size and even the direction of the effect of wages on export performance. Some studies using ideas from the concept of efficiency wages as their working hypothesis find that higher pay attracts better-quality workers and thus leads to higher productivity, higher quality products, and better export performance (Kravis and Lipsey, 1993). Other studies find a negative relationship between wages and export performance. They cite the increased production cost as the reason. Finally, there are studies whose findings do not show a definite relationship between wages and export performance (Balassa, 1963).

As pointed out by Balassa (1963), there is a possibility that the problem with using wages to explain export shares is that their relationship may not be unidirectional.[55] It may be more fruitful to consider other cost factors such as relative unit cost, in addition to wages. Balassa (1963) finds that export shares tend to favor countries with relatively lower unit costs.

This study employs a more general model of aggregate production by disaggregating labor into different skill groups. Specifically, workers with different levels of education are allowed to have different effects on output. In the empirical models, this study divides the workforce into three education groups: (1) workers who have not completed high school, (2) workers who have completed high school but not four years of college, and (3) workers who have completed four years of college or more. However, one is usually more interested in the structure of the marginal returns to labor since this should correspond, in a competitive economy, to the wages received by workers. Thus, this study employs the wages corresponding to each of the specified education groups as a measure of their marginal product. The data for these educational groups are from the U.S. Bureau of Labor Statistics (BLS).

This study also seeks to account for Balassa's (1963) argument that unit costs have a closer relationship to export shares by incorporating a measure of the average unit costs that prevail in each state. In the absence of a measure of unit cost at the state level,

[55] Balassa (1963) argues that, while lower wages might lead to higher export shares, higher export shares may also lead to the payment of higher wages.

this study proxies net unit costs for states by including a measure of cost of living for the region within which each state is located. These data are obtained from the United States Census Bureau. The expectation is that states with relatively higher unit costs will experience relatively lower export performance.

#### 4.4.7.6 Sector Shares of Gross State Product

In order to give policymakers a rough idea as to which sectors are relatively more important in determining a state's export performance, this study incorporates variables to identify the various shares of a state's *GSP* that can be attributed to specific sectors of the economy. In particular, this study includes the share of manufacturing in each state's *GSP*, which is defined as manufacturing output divided by total state output, and also the contribution of the service sector to a state's *GSP*. The latter is defined as service sector output divided by total state output.

Figure 11: Manufacturing Share of GSP

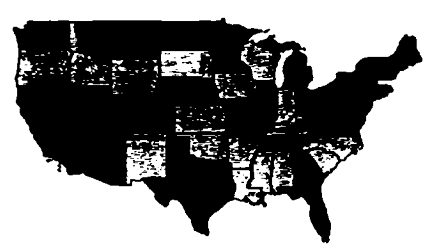

Figure 12: Services Share of GSP

Figures 11 and 12 above present a spatial mapping of manufacturing and service sector shares of the GSPs of each of the states. The states with the highest manufacturing shares of output are Oregon, Idaho, Arkansas, Tennessee, South Carolina, North

Carolina, Kentucky, Iowa, Michigan, Illinois, Indiana, and Wisconsin. California, Washington, Nevada, Colorado, Florida, Virginia, Maryland, Delaware, Pennsylvania, New York, and New Hampshire are the states with the highest services shares.

If manufacturing output is an important determinant of export performance, then states with relatively higher manufacturing shares of their GSP will outperform states with lower manufacturing shares. Thus, holding all other factors constant, Tennessee, which is depicted in the map above as having a high manufacturing share of output, is expected to outperform a state like North Dakota which has a relatively low manufacturing share of output in the international export market. In the same vein, if the service sector is important for a state's export performance, then states with a higher output share of services are expected to outperform states with a relatively lower share of services. Thus, all things being equal, Florida would outperform Texas in the international export market.

### 4.4.8 Remoteness Index

The remoteness of state *i* is calculated as the weighted average physical distance from state *i* to the three nearest major U.S. seaports. At least one of the ports used for this calculation must be located in another state.[56]

The calculations proceed as follows. First, the distance of each state to each major U.S. seaport is estimated using the GCD formula. Then a weighted average distance from each state to the three nearest seaports is calculated, with at least one port being

[56]This index is used to indicate the relative remoteness of a state from U.S borders.

located in another state and the distance to the closest port weighted more heavily. The states are then ranked in ascending order with the state closest to major seaports assigned the rank of one.

Detailed information about the calculation of the remoteness index is presented in Appendix A section 1. As detailed in Appendix A.1, Table 2a, Rhode Island is estimated to be the least remote state in the U.S., whereas Colorado is estimated to be the most remote. The index is built so that a higher value for the index identifies a more remote state. States with a higher remoteness score are expected to be less competitive in export markets than states that are less remote.

Figure 13 presents a map of the estimated remoteness of all U.S. states. The light colors indicate the least remote states while the darker colors represent the more remote states. The map indicates that the midwestern states are estimated to be the remotest of all states.[57]

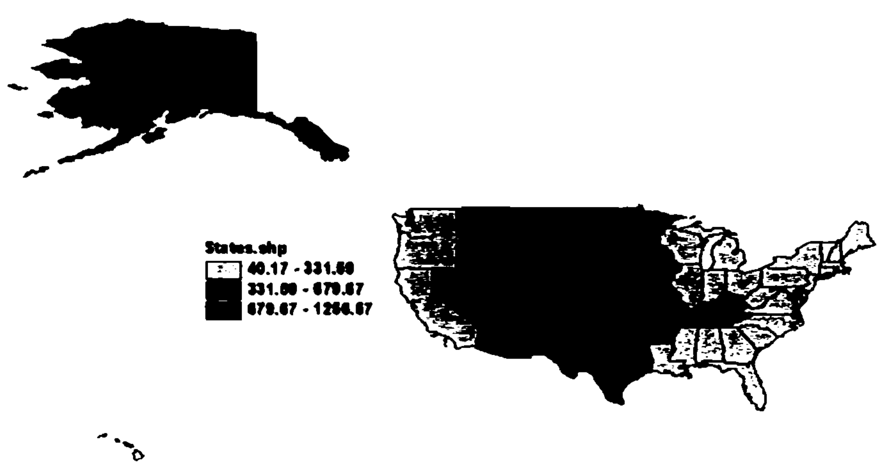


Figure 13: Spatial Mapping of Remoteness Index

[57] The remotest states are Colorado, Idaho, Hawaii, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Utah, and Wyoming.

## 4.5 International Market Situation

The market situation of a country will help determine how much that country imports within a given year. Factors such as a country's output, population growth, and per capita income, which are normally used in gravity equations, are indicators of the market situation of a country. However, other factors may also be helpful. This study includes each country's import volume in dollar terms, and the exchange rates between the U.S. dollar and each country's currency as additional measures of a country's market situation.

### 4.5.1 Exchange Rates

This study employs the overall nominal exchange rate (*XRAT*) between the U.S. dollar and the currency of the importing countries (defined as U.S. dollar per foreign currency unit). The expectation is that the higher the exchange rate, that is, (or price of dollar-denominated exports), the lower will be the exports from all states.

The data for the exchange rate between the U.S. dollar and each importing country are obtained from the international financial statistics (IFS) data set.

### 4.5.2 Country Total Imports

To control for the state of the import markets, this study includes the total dollar value of goods and services that a country imports in a given year in the gravity equation. The working hypothesis is, the higher the level of imports of a country, the better the chance of a state exporting more to that country in any given year. The imports of a country serve as a measure of the demand for importables by the country. Thus, all things being equal, the higher the demand for importables in a given year for a country, the greater the probability that state's exports to that country will be larger than normal. The data for country-level imports are obtained from the World Trade Organization (*WTO*).[58]

## 4.6 Spatial Autocorrelation Revisited

Since the pioneering works of Moran (1948) and Geary (1954) and the subsequent study by Gaile and Grant (1989), the "First Law of Geography" is well accepted: geographic locations influence each other. Although all places are related to each other, closer places are more related. That is to say, proximate states influence each other more significantly than states that are less proximate.[59] As shown, for example, by Anselin and Griffith (1988), the application of standard econometric techniques, including the gravity model, results in misleading significance tests and measures of fit in the presence of spatially correlated error terms.[60]

Although "proximity" means closeness, one needs to take note that it does not necessarily only imply closeness in terms of physical distance. Proximity can take on a variety of dimensions including cultural, ecological, developmental, economic, and regional. As shown in Eff (2004), these different types of similarities can also be broken

[58] Source: http://stat.wto.org/StatisticalProgram/WSDBViewData.aspx?Language=E

[59] This can arise because of knowledge spillovers or cultural similarity.

[60] A recent application of the "first law of geography" can also be seen in Can (1998), where the presence of spatially autocorrelated regression residuals indicates the similarity in the prices of homes that are proximate because they share similar features that are not controlled for in the regression.

down further into different parts. For example, physical proximity can be broken into contiguity and a matrix based on the great-circle distance.

In correcting for spatially autocorrelated residuals, usually a spatially lagged variable is created and added to the regression as a proxy for the omitted spatial variables (Anselin, 1988). In the same fashion, one can create lagged prosperity and cultural dependent variables and add them as proxies for omitted cultural and prosperity related variables in the regression (Eff, 2004a).

This section presents an attempt to construct proximity indices. They are used to investigate the presence of spatial autocorrelation in the data for the states' export performance. Proximity indices can also be helpful in identifying how proximity of states influences their export performance (Goodchild, 1986). A proximity effect is present when neighboring states influence each other's trade performance when proximate states share some values or heritage (Eff, 2004a), or when the value of each state's exports is determined by some other variable that is itself spatially autocorrelated.[61] In the case of this study, it is examined whether the export performance of a state is directly affected by the export performance of neighboring states. The existence of such a relationship would be consistent with the Krugman-type externality in production argument.

This study constructs five types of proximity indices, two physical indices, two cultural indices, and one index corresponding to the similarity in the standard of living.

[61] Note that Greenaway and Milner (1986), in a discussion of gravity type analysis, point out that the models face the problem that countries with similar per capita incomes tend to be clustered geographically.

These indices are then employed to investigate the role played by proximity in the export equations of U.S. states.[62]

### 4.6.1 Construction of Weight Matrices

The spatial linkages or proximities of observations are measured by defining a spatial weight matrix, denoted by $W(n*n)$. The spatial weight matrix represents the strength of the potential interaction between locations. Each weight matrix ($W$) contains elements $w_{ij}$ that correspond to the proximity between state $i$ and state $j$, with higher values of $w_{ij}$ denoting greater proximity of the corresponding pair of states.

As indicated above, the relationship among states can take on multiple dimensions. This study, however, presents the case for only five of the various possible relationships among American states. The study employs the same methodology used in Eff (2004) to construct four different weight matrices. Each of these models exhibits a different dimension of the relationships among states. A summary of the proximity matrices used in this study is presented in Table 7 of Appendix B.

#### 4.6.1.1 Physical Proximity

One of the most important elements of spatial weights matrix is physical distance (Anselin et al., 1992; Can, 1992; Ding and Fotheringham, 1992). In this study, two different weights are constructed for physical proximity. One uses a contiguity

[62] A summary of proximity matrices employed by this study is presented in Table 1b of Appendix B.

(adjacency) matrix and the other a matrix based on the great-circle distance from one state to another.

#### 4.6.1.1.1 Contiguity

A general spatial weight matrix can be defined by a contiguity matrix, which can be generated from the topological information given by a GIS. It can be based on either adjacency or distance criteria. Contiguity modeling is often used when states with shared borders are deemed proximate and other states have no connection. According to the adjacency criterion, the element of the spatial weight matrix ($w_{ij}$) is one if location $i$ is adjacent to location $j$ and zero otherwise. According to the distance criterion, the element of the spatial weight matrix ($w_{ij}$) is one if the distance between locations $i$ and $j$ is within a given distance (d) and zero otherwise. As presented in Equation 15 below, this study employs a weight matrix based on border sharing of states. In this light, the spatial contiguity matrix **W** has elements $w_{ij}$ equal to one when the corresponding pairs of states share common borders and zero otherwise,

(15) $w_{ij} = 1$ if state $i$ shares border with state $j$ , $w_{ij} = 0$ otherwise.

The contiguity matrix approach has been criticized for not being able to differentiate the strength of spatial linkages between adjacent locations, that is to say, sparsely populated borders will bear the same weight as long and densely populated borders.[63]

### 4.6.1.1.2 Physical Distance

In estimating proximity matrixes based on physical distances, the distances can be measured by travel time or general distance or derived from a multidimensional scaling analysis (Gatrell, 1989). This study employs distance calculations between states based on the great-circle distance, calculated from the mid-point of each pair of states. The great-circle distance in kilometers between each pair of states is calculated as

$$GCD_{ij} = 6371.1 \arccos[\sin(y_i)\sin(y_j) + \cos(y_i)\cos(y_j)\cos(x_i - x_j)], \tag{16}$$

where $y_i$ is the latitude in radians for state $i$, $x_i$ is the longitude in radians for state $i$, and the subscript $j$ refers to the same measures for state $j$. The calculated distances are then converted to proximity values using the formula,

$$w_{ij} = (1 + 0.001\ d_{ij}) \text{ and } w_{ij} = 0. \tag{17}$$

The diagonal of the constructed proximity matrix **W**, which denotes how proximate a state is from itself, is set to zero. To standardize this matrix, each element $w_{ij}$ is divided by the largest of the elements $w_{ij}$ so that values of $w_{ij}$ ranges from zero to one.

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[63] See Eff (2004) and Cliff and Ord (1973 and 1981).

### 4.6.1.2 Standard of Living

Numerous studies, including Mitchneck (1995), Hopcroft (1997), and Goldstone (1988), indicate that local conditions and central forces influence economic development initiatives, and also that economic development is accompanied by regular and predictable changes in economic institutions. Thus, states at a similar level of development may be similar with respect to a myriad of economic and social conditions.

This view posits that the economic development level of states may be a good proxy for local institutions and arrangements that can cause the export performance of states to be similar or different. To allow for this possibility, an economic development weight matrix is constructed and used to check for the presence of autocorrelation in state export performance.

The Human Development Index is used by the United Nations and many economists in development economics as the relevant indicator of the level of development of countries. The Human Development Index is comprised of three components, per capita income, life expectancy, and an education measure that combines the literacy rate with educational spending. It serves as an index of life, knowledge, and prosperity, three key aspects of development.

In an attempt to create a human development index similar to that of the United Nations, this study employs state per capita income from the Bureau of Economics and Statistics[64] as a measure of state economic prosperity, state level life expectancy as a

[64] www.bea.gov/bea/regional/spi/drill.cfm

measure of life development of a state,[65] and the percentage of a state's population that has attained a college degree from the CFED as a measure of a state's knowledge level in calculating the development index for this study.

Each of the three measures is standardized with a mean of 100 and a standard deviation of 15. Every one of the 50 U.S. states therefore has a specific location given by its scores for life, knowledge, and prosperity within a three-dimensional space. The proximity in the level of development between states $i$ and $j$ is calculated in the form of the inverse of the Euclidean distance as

$$w_{ij} = \left( \sum_{k}^{3} \left( x_{ik} - x_{jk} \right)^2 \right)^{-\frac{1}{2}}, \tag{18}$$

where $x_{ik}$ denotes the level of development of state $i$ in dimension $k$ and $x_{jk}$ is the level of development of state $j$ in dimension $k$. The geometric means of the standardized measures for life, knowledge, and prosperity are used as the measure of a state's level of economic development. Using the calculated state Human Development Index (*HDI*)and raking the HDIs in descending order as presented in Table 2b of Appendix B, Connecticut is the highest ranked American state and Arkansas ranks lowest.

[65] Data on life expectancy are from Murray et al. (1998) of the Harvard Center for Population and Development Studies, which provides a county-level measure of life expectancy. From this, one can calculate the population-weighted average life expectancy for each state.

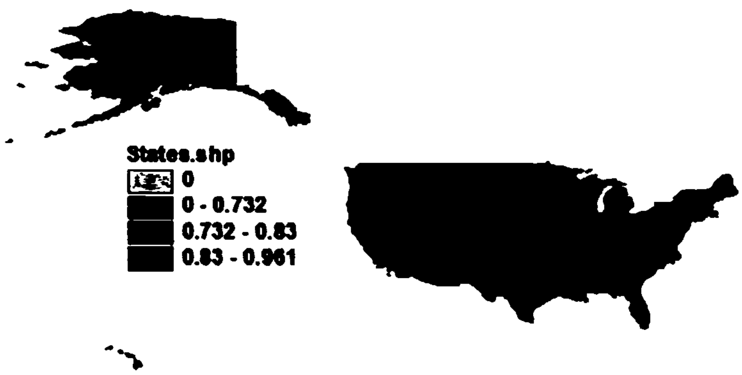


Figure 14: Spatial Mapping of Standard of Living Index for U.S. States

Figure 14 above presents state variations in standard of living as measured by a state version of the United Nations Human Development Index (*HDI*). The standard of living simply equals the geometric mean of the standardized scores for per capita income, average life expectancy, and average educational attainment.

The map divides states into three standard quantile categories. The darker colors identify states with a relatively higher estimated living standard and vice versa. It is noticeable that among the states with the lowest standard of living are the southern states Tennessee, Alabama, Mississippi, Louisiana, South Carolina, Kentucky, and Arkansas. Other states with low standards of living are Oklahoma, Indiana, West Virginia, New Mexico, Arizona, Idaho, Montana, the Dakotas, and Maine. The states with the highest standards of living are California, Washington, Nevada, Utah, Colorado, Kansas, Minnesota, Illinois, Virginia, Maryland, Delaware, New Jersey, New York, New Hampshire, and Connecticut.

### 4.6.1.3 Cultural Similarity

Many studies including Clark (1946) have indicated that the culture and values of a society help determine the types and levels of economic activity that occur in it. It is thus fair to assume that salient differences in state cultures and values can give rise to differences in state export performance levels.

This study employs two similar but slightly different proxies for cultural differences. They are (1) state voting patterns for the 2004 U.S. presidential election and (2) an index that ranks states by their degree of conservatism.

#### 4.6.1.3.1 Presidential Election Voting Patterns

Due to the ideological differences between political parties, voting is expected to follow a pattern by which states vote for the political party whose ideology is closer to their culture or values. If voting behavior is seen as an expression of values, one can use national election results to quantify value differences among states (Eff, 2004a).

Data from the 2004 U.S. presidential election are used to calculate values proximity between states. In performing this calculation, the within-state differences in the percentage of votes going to the Republican and the Democratic candidates are calculated. Next, the inverse Euclidean distance between each pair of states is derived as follows

(18) $$w_{ij} = \left(\sum\left(\left(x_{i1} - x_{j1}\right) + \left(x_{i2} - x_{j2}\right)\right)^2\right)^{-\frac{1}{2}} \quad w_{ij} = \left(\sum\left(x_i - x_j\right)^2\right)^{-\frac{1}{2}},$$

where $x_{i1}$ is the normalized percentage of state $i$'s presidential votes for the Republican Party nominee George W. Bush, whereas $x_{i2}$ represents the normalized percentage of state $j$'s presidential votes cast in favor of George W. Bush. On the other hand, $x_{i2}$ and $x_{j2}$ represent the normalized percentages of state $i$'s and state $j$'s votes cast in favor of John Kerry, the Democratic Party's presidential candidate. The sum of the two differences is used as the basis for the presidential election version of the cultural proximity index.

Figure 15 below portrays the voting patterns of states in the 2004 U.S. presidential election by state. Specifically, it shows the states' voting percentages cast in favor of the Republican Party candidate, President George W. Bush. The states marked in red are those where more than 50 percent of the votes were cast in favor of the President, while the blue states represent those where less than 50 percent of the votes were cast for President Bush. Note that the presidential election voting patterns are being used in this study as a proxy of the cultural values of states, not as an indicator of political orientation of the states.

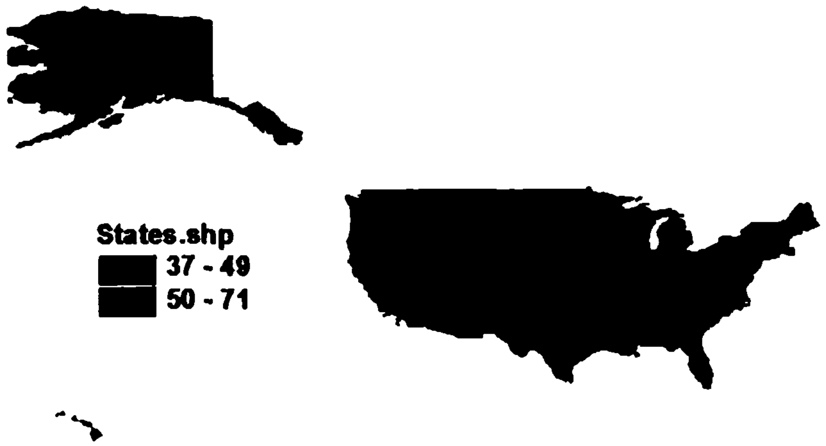


Figure 15: Spatial Mapping of the 2004 U.S. Presidential Election Results by State

### 4.6.1.3.2 Degree of Conservatism

The John Birch Society publishes voting patterns of state representatives on key issues including gun control, budget, and abortion related issues. The voting patterns of each representative are then used in calculating an index of conservative attitudes for each representative. This index denotes how conservative a state's representatives are in terms of his/her voting pattern. If state representatives vote in accordance with the beliefs and needs of the people they represent, then the index of conservatism can be a good proxy for state culture. This study employs a simple average of the index of conservatism of all representatives of a given state as a measure of a state's public policy view.

The conservative ranking of a state is calculated as the normalized average index of conservatism of all individual rankings of a state's representatives. It is presented in Table 4 of Appendix B. This study uses this index as the second proxy for a state's values and culture.[66] Once the index is calculated for each state, the inverse Euclidean distance between each pair of states is derived as

$$(19) \qquad w_{ij} = \left(\sum (x_i - x_j)^2\right)^{-\frac{1}{2}} ,$$

where $x_i$ is the index score of conservatism for state $i$, while $x_j$ denotes the corresponding index score of state $j$. Table 4 in Appendix B presents a ranking of states in ascending order in terms of their index of conservatism.

Figure 20 below presents a spatial mapping of the conservatism index by state. The red color identifies states with a conservatism index of more than 48. These states are relatively more conservative. The blue color identifies relatively less conservative states.[67]

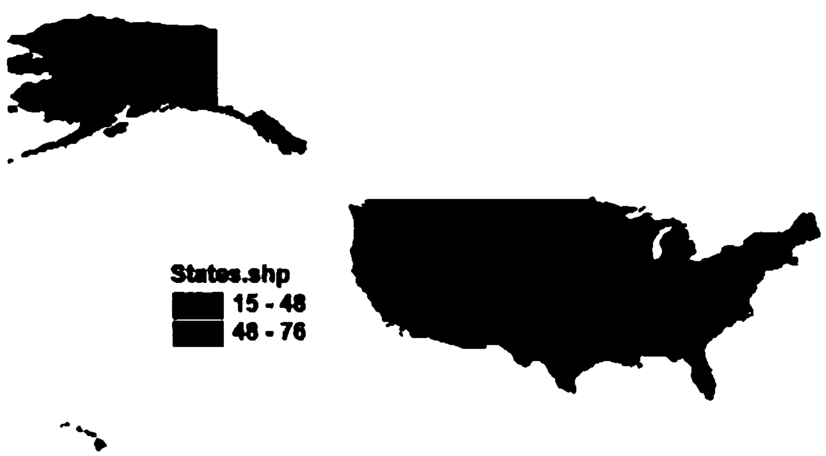


Figure 16: Spatial Mapping of Conservatism Index

[66] (See: http://www.jbs.org/ and http://www.votesmart.org/issue_rating.php?type=category&search_1=Conservative).

[67] The conservative index of a state is used here only to proxy a state's culture.

## 4.7 Autocorrelation and Export Performance

To measure global spatial autocorrelation, this study employs the Moran I indicator. This indicator is the most commonly used statistic for spatial autocorrelation. Its values range from 1, which identifies clustering, over 0, which means no spatial pattern exists, to −1, which identifies a scattered pattern. The indicator helps to assess the influence that geography has and to compare the degree of spatial autocorrelation among various attributes. The Moran I index is defined as

(20)
$$I = \sum_i^n \sum_j^n w_{ij}\left(x_i - \bar{x}\right)\left(x_j - \bar{x}\right) \Big/ \left(S^2 \sum_i^n \sum_j^n w_{ij}\right),$$

where $S^2 = \frac{1}{n}\sum_1^n \left(x_i - \bar{x}\right)^2$, $x_i$ and $x_j$ represents the observed export values for states $i$ and $j$, respectively, $\bar{x}$ denotes the average of the observations over the $n$ states ($n = 50$ states), and $w_{ij}$ denotes the different types of degrees of relatedness described above.

Moran's I compares, in the present case, the value of the export performance for each pair of states arrayed according to their degree of relatedness. Using this information, the variance of Moran's I can be calculated. From the latter a Z-score can be calculated. From the calculated Z-scores, one can then test the null hypothesis that there is no autocorrelation in the state-level export data.[68]

[68] The results of this exercise are presented in Table 9 of Chapter 5.

# Chapter 5

# Estimation Results

## 5.1 General Gravity Equation Estimation

This study estimates two regressions models, one using the standard physical distance measure (*DIST*) and one using the new physical distance (*ZDIST*) employed by this study. In reporting regression results, estimation results are presented for all trade and separately for low-tech and high-tech exports. The coefficients represent the elasticity of the various of state exports with respect to the various explanatory variables.

Table 3 presents the estimation results for total manufacturing exports of the panel cross-section estimation for both the standard physical distance and the new physical distance employed by this study. The data set includes 91,250 observations for the years 1988 to 2000. The year-specific dummy variables are measured relative to the year 1988. Cheng and Wall (2005), interpret year dummies as the effect of globalization on the export performance of U.S. states, however for this study we control for trade agreements, which account for most of the globalization effect, therefore for this study the year dummies are interpreted as occurrences in export markets.

To check whether state location and export market variables belong in these models, this study estimates separate artificially nested models and tests for restrictions on dropping all state location and export market variables using F-tests. The results presented in Table 3 indicate that both state location and export market situation variables belong in the estimation models. From the magnitude of the F-statistics for the state location variables (F-stat loc) and for the export market situation variables (F-stat mk), one can discern that state location variables play a significant role in determining high-tech exports, whereas export market situation variables play a more significant role in determining low-tech export performance. This suggests that comparative advantage is more important for high-tech exports, whereas low-tech exports depends more on export market demand. First, multicollinearity among all the variables is assessed using the variance inflation factors (VIFs). Belsley, Kuh, and Welsch (1980) indicate that a VIF of less than 10 indicates lack of a significant multicollinearity. None of the variables in the models exhibits a VIF of more than 10;[69] thus multicollinearity is not a problem for the present study.

The signs of the coefficients on national and state gross domestic product, per capita income, and distance are as expected, and they are all statistically significant. The coefficients for the trade agreements are statistically significant with the expected signs except *NAFTA*, which has a negative sign in all models for total and high-tech exports. This result indicates that low-tech manufacturing benefited from the NAFTA, whereas high-tech exports somehow did not benefit much from it. This result may be due to two factors: (1) the collapse of the Mexican economy which accounts for about a third of all U.S. exports at the end of 1994, and (2) the movement of firms to Mexico after the birth of NAFTA. The nonphysical and psychic distance measures are all significant, and the coefficients on language proximity and enemy relationships have the expected signs.[70]

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[69] The results for the VIF analysis are presented in Table 4a in Appendix A.

[70] The p-values for the significance of the coefficients are presented in Table 3a in Appendix A.

The estimation results indicate that the state location variables differ in their effect on goods with different technological embodiment. Remote states are shown to consistently export less on both low-tech and high-tech products, while states with a relatively higher highway density (*HDEN*) export more.

Table 3: Regression Results for Models Using Pooled Data

| Model | Total Exports DIST | Total Exports ZDIST | High-Tech Exports DIST | High-Tech Exports ZDIST | Low Tech Exports DIST | Low Tech Exports ZDIST |
|---|---|---|---|---|---|---|
| Intercept | 47.792 *** | 46.699 *** | 49.148 *** | 46.699 *** | 5.086 *** | 2.227 |
| **Physical Distance Measures** | | | | | | |
| *DIST* | -1.507 *** | | -1.366 *** | | -1.581 *** | |
| *ZDIST* | | -1.539 *** | | -1.539 *** | | -1.772 *** |
| *REMOTE* | -0.254 *** | -0.237 *** | -0.238 *** | -0.237 *** | -0.069 *** | -0.069 *** |
| **Nonphysical and Psychic Distance Measures** | | | | | | |
| *LANG* | 0.087 *** | 0.084 *** | 0.085 *** | 0.084 *** | 0.016 *** | 0.016 *** |
| *ENEM* | -1.164 *** | -1.083 *** | -1.091 *** | -1.083 *** | -0.572 *** | -0.562 *** |
| **State Variables** | | | | | | |
| *GSP* | 1.596 *** | 1.610 *** | 1.610 *** | 1.610 *** | 0.956 *** | 0.957 *** |
| *SPCI* | -0.815 *** | -0.665 *** | -0.663 *** | -0.665 *** | -0.461 *** | -0.465 *** |
| *HCI* | 0.380 *** | 0.453 *** | 0.461 *** | 0.453 *** | -0.654 *** | -0.663 *** |
| *PC* | 0.559 *** | 0.588 *** | 0.586 *** | 0.588 *** | 0.848 *** | 0.850 *** |
| *HDEN* | 0.228 *** | 0.233 *** | 0.231 *** | 0.233 *** | 0.473 *** | 0.476 *** |
| *TAIR* | 0.518 *** | 0.437 *** | 0.442 *** | 0.437 *** | 2.585 *** | 2.580 *** |
| *BTARP* | 0.271 *** | 0.461 *** | 0.456 *** | 0.461 *** | -0.678 *** | -0.672 *** |
| *CO2ER* | -0.915 *** | -0.955 *** | -0.955 *** | -0.955 *** | 0.039 | 0.039 |
| *SER* | 0.844 *** | 1.036 *** | 1.012 *** | 1.036 *** | 0.392 | 0.420 |
| *LABW* | -0.224 *** | -0.439 *** | -0.442 *** | -0.439 *** | 0.371 *** | 0.377 *** |
| *SLITR* | 0.675 *** | 0.764 *** | 0.765 *** | 0.764 *** | -0.352 *** | -0.352 *** |
| *TUNDEN* | -0.510 *** | -0.474 *** | -0.470 *** | -0.474 *** | -0.285 *** | -0.289 *** |
| *CPI* | -10.664 *** | -11.638 *** | -11.614 *** | -11.638 *** | -0.513 | -0.539 |
| *CONTI* | -0.191 *** | -0.133 *** | -0.196 *** | -0.133 *** | 0.118 *** | 0.084 *** |
| **Export Market Variables** | | | | | | |
| *CGDP* | 1.213 *** | 1.222 *** | 1.223 *** | 1.222 *** | 0.793 *** | 0.790 *** |
| *CPCI* | 0.393 *** | 0.388 *** | 0.390 *** | 0.388 *** | 0.340 *** | 0.338 *** |
| *XRAT* | 0.051 ** | 0.048 | 0.054 *** | 0.048 | -0.021 | -0.028 |
| *IMPORT* | -1.398 *** | -1.200 *** | -1.400 *** | -1.200 *** | 3.093 *** | 3.194 *** |
| **Trade Agreements** | | | | | | |
| *NAFTA* | -1.558 *** | -0.333 *** | -1.128 *** | -0.333 *** | 0.148 | 1.088 *** |
| *BILAT* | 1.380 *** | 1.300 *** | 1.205 *** | 1.300 *** | 1.362 *** | 1.483 *** |
| *APEC* | 0.535 *** | 0.508 *** | 0.493 *** | 0.508 *** | 0.676 *** | 0.692 *** |
| *WTOYR* | 1.519 *** | 1.501 *** | 1.490 *** | 1.501 *** | 0.972 *** | 0.986 *** |
| **Year Dummies** | | | | | | |
| yr1989 | 0.032 | 0.024 | 0.024 | 0.024 | -0.019 | -0.019 |
| yr1990 | 0.046 | 0.016 | 0.017 | 0.016 | 0.036 | 0.035 |
| yr1991 | 0.170 *** | 0.129 *** | 0.129 *** | 0.129 *** | 0.181 ** | 0.181 *** |
| yr1992 | 0.132 *** | 0.071 | 0.076 ** | 0.071 | 0.183 ** | 0.177 *** |
| yr1993 | 0.105 *** | 0.033 | 0.038 | 0.033 | 0.200 ** | 0.194 *** |
| yr1994 | 0.094 *** | 0.032 | 0.037 | 0.032 | 0.168 ** | 0.162 *** |
| yr1995 | -0.589 *** | -0.658 *** | -0.647 *** | -0.658 *** | -0.281 ** | -0.294 *** |
| yr1996 | -0.732 *** | -0.814 *** | -0.802 *** | -0.814 *** | -0.334 ** | -0.347 *** |
| yr1997 | -0.712 *** | -0.795 *** | -0.784 *** | -0.795 *** | -0.308 ** | -0.321 *** |
| yr1998 | -0.817 *** | -0.907 *** | -0.896 *** | -0.907 *** | -0.365 ** | -0.378 *** |
| yr1999 | -1.003 *** | -1.097 *** | -1.086 *** | -1.097 *** | -0.518 ** | -0.530 *** |
| yr2000 | -1.046 *** | -1.155 *** | -1.143 *** | -1.155 *** | -0.559 ** | -0.572 *** |
| R-square | 0.7222 | 0.7205 | 0.7193 | 0.718 | 0.633 | 0.634 |
| N | 91,250 | 91,250 | 91,250 | 91,250 | 91,250 | 91,250 |
| F-stat loc | 245.34 *** | 244.8 *** | 227.04 *** | 264.24 *** | 120.37 *** | 96.4 *** |
| F-stat mk | 44.89 *** | 38.71 *** | 37.99 *** | 32.83 *** | 244.12 *** | 258.63 *** |

*Note* : All non-dummy variables are in logs, *** and ** dentoes significanceat the 5% and 10% levels, respectively; DIST denote model with distane calculated from geographic centers, ZDIST denotes model with distance measured from state capital to the population weighted country administrative regions; All year dummies are relative to 1988; F-state loc and F-stat mk denotes F-Test for state location and export market situation respectively

### 5.1.1 Distance Measures and Total Exports

Two different physical distance measures are used to estimate the effect of a state's physical distance from its export markets on its export performance. The estimation results show that the type of physical distance measure employed in gravity equations can affect the results of the study. It is apparent that alternating the two measures of physical distance changes the coefficients of distance and some of the other variables (Table 3).

Table 4: Estimation Results for Distance Variables

| Model | Total Exports | | | | High-Tech | | | | Low-Tech | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DIST | | ZDIST | | DIST | | ZDIST | | DIST | | ZDIST | |
| | Estimate | T-stat | Estimate | T-stat | Estimate | T-stat | Estimate | T-stat | Estimate | T-stat | Estimate | T-stat |
| *DIST* | -1.507 | -92.61 | | | -1.366 | -83.52 | | | -1.581 | -105.04 | | |
| *ZDIST* | | | -1.700 | -89.44 | | | -1.539 | -80.58 | | | -1.772 | -100.62 |
| *LANG* | 0.087 | 22.38 | 0.086 | 22.14 | 0.085 | 21.66 | 0.084 | 21.47 | 0.016 | 4.43 | 0.016 | 4.34 |
| *ENEM* | -1.164 | -20.47 | -1.155 | -20.26 | -1.091 | -19.09 | -1.083 | -18.9 | -0.572 | -10.88 | -0.562 | -10.64 |

As highlighted in Table 4, physical distance continues to play a role in determining state export performance.[71] Where physical distance is defined as the distance between a state's geographical center and that of the importing country, the results indicate that a state will export 1.51 percent fewer manufacturing goods to countries whose geographical centers are 1 percent further from the state's geographical center. When physical distance is defined as the distance from a state capital to the population-weighted administrative regions of a country, the results suggest that total a 1 percent increase in distance of states from export markets leads to 1.70 percent fewer manufacturing exports to that export market. Thus, the results show that the elasticity of

[71] Table 4 shows a component of the estimation results of Table 3.

distance on export performance is greater when physical distance is estimated as the distance from state capitals to the population-weighted administrative centers of the importing countries. From Table 4, one can discern that distance has a more significant effect on low-tech exports than on high-tech exports. Regardless of the type of physical distance measure used, the parameter estimates for physical distance and the corresponding T-statistics are higher for low-tech exports than for high-tech exports (Table 4). This result seems to suggest that low-tech exports are more expensive to export and thus more distance dependent than high-tech exports.

In the case of nonphysical and psychic distance, the results presented in Table 4 indicate that language proximity has a positive and significant effect on all types of state exports. The effect is more significant for high-tech products than for low-tech products. This result is not very surprising because the language proximity measure captures general cultural similarity, which makes transactions easier since people from states and foreign countries that are proximate in terms of language similarity understand each other better, thus improving trade relations in general and export performance in particular. For more complex products, this understanding is even more valuable since there is more to know about the product. A hostile or antagonistic relationship between the U.S. and an importing country negatively affects exports of U.S. states. The results indicate that states export between 0.56 percent and 1.16 percent less to countries with an estimated 1 percent more hostile relationship with the U.S. The response of exports is significantly more pronounced for high-tech goods than for low-tech goods. Thus, high-tech products are more sensitive to the nature of the political relationship between the United States and other countries.

The negative effect of distance on state export performance matches with the results from Coughlin (2004); however, the magnitude of the distance effect is different.[72] This study's finding that language and political differences between the U.S. and other foreign countries matches the finding of the British Chamber of Commerce in May 2004 that poor language skills and a lack of cultural understanding of overseas markets are stunting UK export growth.

## 5.1.2 Trade Agreements and Total Exports

Trade agreements, whether bilateral, regional, or worldwide, are assumed to eliminate trade barriers and therefore lead to an increase in trade. The results of the analysis of the effect of trade agreements on state manufacturing export performance are summarized in Table 5.[73]

Table 5: Estimation Results for Trade Agreements and State Exports

| | NAFTA | | BILAT | | APEC | | WTOYR | |
|---|---|---|---|---|---|---|---|---|
| Model | DIST | ZDIST | DIST | ZDIST | DIST | ZDIST | DIST | ZDIST |
| Total | -1.558 | -0.686 | 1.380 | 1.481 | 0.535 | 0.553 | 1.519 | 1.531 |
| | {-9.64} | {-4.30} | {11.05} | {11.84} | {14.53} | {14.95} | {42.76} | {42.98} |
| High | -1.128 | -0.333 | 1.205 | 1.300 | 0.493 | 0.508 | 1.490 | 1.501 |
| | {-6.95} | {-2.07} | {9.60} | {10.34} | {13.32} | {13.69} | {41.73} | {41.94} |
| low | 0.148 | 1.088 | 1.362 | 1.483 | 0.676 | 0.692 | 0.972 | 0.986 |
| | {0.99} | {7.35} | {11.79} | {12.79} | {19.86} | {20.20} | {29.58} | {29.86} |

*Note*: Numbers in brackets denote t-statistics; DIST denotes model with distance calculated from geographic centers; ZDIST denotes model with distance measured from state capital to population-weighted country administrative regions.

[72] This difference in the magnitude of the effect of physical distance on export performance found by this study and other studies may have resulted from the differences in the definitions of export performance and physical distance.

[73] Table 5 shows a component of the estimation results of Table 3.

### 5.1.2.1 NAFTA

The estimation results for the impact on exports of the NAFTA vary considerably with the definition of the physical distance variable. If physical distance is defined as the distance between the geographical center of the states and the importing countries, the inauguration of NAFTA is estimated to have increased total state exports to non-NAFTA member countries by 156 percent, whereas it is shown to have led to only a 7 percent more manufacturing exports to non-NAFTA members, where distance is defined as the distance from state capitals to the population-weighted administrative centers of the importing countries. The advent of NAFTA is shown to have caused a reduction in high-tech exports to NAFTA member countries and an increase in low-tech exports to member countries. This result as mentioned above may be an indication of two occurrences; (1) the reduction in exports to Mexico, due to the slow down of the Mexican economy at the end of 1994, and (2) may indicate that, whereas NAFTA opened up the markets of member countries for state low-tech manufacturing goods, it led to the movement of some production of high-tech goods to member countries, thus reducing their imports of U.S. high-tech goods.

### 5.1.2.2 Bilateral Trade Agreements

Bilateral trade agreements, like any other trade agreements, are usually designed to eliminate trade barriers and thus foster the growth of trade between the countries in the trade agreement. The estimation results (Table 5) indicate that, regardless of the type of physical distance measure used in the gravity model, bilateral trade agreements between the United States and other importing countries lead to an increase in state exports.

The results indicate that bilateral trade agreements lead to between 121 percent and 148 percent more manufacturing exports to countries with bilateral trade agreements with the U.S. The result for high-tech and low-tech manufacturing exports do not deviate much from the total.

### 5.1.2.3 APEC

The Asian Pacific Economic Cooperation (APEC), established in 1989 to enhance economic growth and prosperity for the region and to strengthen the Asia-Pacific community, has 21members including the United States. APEC, which imposes no treaty obligations on its members, is the only intergovernmental coalition in the world operating on the basis of nonbinding commitments decisions are reached by consensus and voluntary commitments.

This study incorporates an indicator variable for APEC membership countries to capture the effect of the inception of APEC on state exports to APEC member economies. The results indicate that states export 53 percent to 55 percent more total manufacturing goods, 50 percent to 5 percent more high-tech manufacturing goods, and 68 percent to 70 percent more low-tech manufacturing goods to APEC member economies. From the above, one can infer that low-tech manufacturing exports benefited more from the creation of APEC.

### 5.1.2.4 WTO

The World Trade Organization (WTO), the only global international organization that deals with the rules of trade among nations, aims at helping producers of goods and services, exporters, and importers conduct business in a tranquil environment through agreements that are negotiated and signed by the bulk of the world's trading nations. To estimate the effect of a country's WTO membership on a state's manufacturing exports to that country, this study employs an indicator variable (*WTOYR)*) designed to capture member nations and when they joined the WTO.

The results, as presented in Table 5, indicate that state manufacturing exports to a foreign country experience a positive surge across all types of manufacturing exports after the country joins the WTO. The results show that total manufacturing exports rose between 152 percent and 163 percent, high-tech total manufacturing exports by 150 percent, and low-tech manufacturing exports between 97 percent and 99 percent. Thus, unlike the results for NAFTA, APEC, and bilateral trade agreements, a country's WTO membership is shown to favor high-tech manufacturing products more than low-tech products. This may be because of the nature of the WTO agreement, which seeks to protect free trade and copyright laws, which tend to favor high-tech exports more.

## 5.1.3 State Location Characteristics and Exports

### 5.1.3.1 Transportation and Communication Infrastructure

This study employs three measures of transportation and one measure of communication and infrastructure capacity. The transportation variables are designed to proxy ground, air, and sea transportation efficiency. The regression results for transportation and communication infrastructure are presented in Table 6.

Table 6: State Location Variables

| | HDEN | | TAIR | | CONT1 | | PC | | REMOTE | | HCI | | SER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Model | DIST | ZDIST | DIST | ZDIST | DIST | ZDIST | DIST | ZDIST | DIST | ZDIST | DIST | ZDIST | DIST | ZDIST |
| Total | 0.228 | 0.230 | 0.518 | 0.512 | -0.191 | -0.129 | 0.559 | 0.562 | -0.254 | -0.254 | 0.380 | 0.370 | 0.844 | 0.870 |
| | {11.09} | {11.15} | {2.88} | {2.84} | {-5.97} | {-5.80} | {6.93} | {6.94} | {-22.01} | {-21.88} | {4.11} | {3.99} | {2.53} | {2.60} |
| High | 0.231 | 0.233 | 0.442 | 0.437 | -0.196 | -0.133 | 0.586 | 0.588 | -0.238 | -0.237 | 0.461 | 0.453 | 1.012 | 1.036 |
| | {11.22 | 11.28} | {2.45} | {2.42} | {-6.07} | {-5.93} | {7.23} | {7.24} | {-20.48} | {-20.39} | {4.97} | {4.86} | {3.02} | {3.08} |
| Low | 0.473 | 0.476 | 2.585 | 2.580 | 0.118 | 0.084 | 0.848 | 0.850 | -0.069 | -0.069 | -0.654 | -0.663 | 0.392 | 0.420 |
| | {24.89 | {24.94} | {15.56} | {15.46} | {3.98} | {4.08} | {11.36} | {11.35} | {-6.50} | {-6.45} | {-7.64} | {-7.72} | {1.27} | {1.36} |

*Note*: Numbers in brackets denote t-statistics; DIST denotes model with distance calculated from geographic centers; ZDIST denotes model with distance measured from state capital to population-weighted country administrative regions.

### 5.1.3.2 Ground Transportation

State highway infrastructure (*HDEN*) is shown to have a positive effect on state total manufacturing exports. A percentage increase in a state's highway infrastructure leads to a 0.23 percent increase in its exports of manufacturing goods than other states with otherwise similar characteristics. The results show that a percentage increase in a state's highway density leads to a positive and significant effect on both high-tech (0.23 percent) and low-tech (0.47 percent) manufacturing exports. The results thus indicate that the effect of highway infrastructure on exports is slightly higher on low-tech manufacturing exports than high-tech manufacturing exports. The results suggest that low-tech products are much more dependent on transportation efficiency because they are more likely to be bulky products.

### 5.1.3.3 Air Transportation

To estimate the contribution of air transportation to a state's export performance, this study employs the number of airports and heliports in a state (*TAIR*) as a proxy for the availability of air transportation in a state. The results indicate that, while the availability of airports and heliports in a state does have a significant effect on both its total and high-tech manufacturing exports, the magnitude the of effect is minimal in comparison to that on low-tech exports. The results indicate that, states with a percentage more airports and heliports export 2.6 percent more low-tech manufacturing goods than states with otherwise similar features. This result may be the cause of firms locating in states with greater access to foreign markets, which enhance their capability to compete in terms of product delivery speed. The result indicates that low-tech export performance is transport cost dependent; thus low-tech manufacturing firms locate to take advantage of transportation availability and efficiency.

### 5.1.3.4 Sea Transportation

This study employs an indicator variable designed to identify states that have a top-30-ranked American containerized port (*CONT1*). This indicator variable is shown to have a more significant effect on a state's total exports (13 to 19 percent) and high-tech manufacturing exports (13 to 20 percent), than on low-tech exports (8 to 12 percent).

High-tech exports are more dependent on sea transportation than low-tech manufacturing exports. Thus, all things being equal, high-tech manufacturing firms may locate in states with easy access to efficient sea transportation facilities in order to reduce transportation cost.

### 5.1.3.5 Information Superhighway

In this study, the central argument for the role that information technology plays in business performance is twofold. First, a significant component of its value is its ability to enable complementary organizational investments, such as business processes and work practices. Second, these investments in turn lead to productivity increases through the reduction in costs and, more important through enabling firms to increase quality in the form of new products or improvements in existing products.

Information technology including the Internet can also lower the cost of doing business across state and national borders through reducing the cost of matching buyers and sellers. To investigate whether the availability and efficiency of information technology in a state improves that state's export performance, this study employs the percentage of households in a state with personal computers as a proxy for the proliferation and efficiency of information highway technology in a state.

The results indicate that information technology as defined in this study has a significant and positive effect on all types of state exports. However, a state's low-tech manufacturing exports are boosted more by the availability of information technology in that state. States with a 1 percent higher ratio of households with personal computers export 0.9 percent more low-tech manufacturing exports than states with otherwise similar characteristics, as against the reported 0.6 percent for high-tech exports. This is more likely to be the result of low-tech consumers using the internet to search and purchase low-tech manufacturing goods from the U.S. and also the improvement in work processes through the availability of information technology.

### 5.1.3.6 Remoteness Index

The study employs a remoteness index as an added measure of the difficulty involved in reaching export markets. The remoteness of a state significantly reduces all types of manufactured exports. High-tech manufactured exports are affected more than low-tech exports.

### 5.1.3.7 Innovative Capital

States with a 1 percent higher innovative capital (*HCI*) export 0.4 percent more total and 0.5 percent more high-tech manufactured exports than states with otherwise similar characteristics. States with a 1 percentage higher innovative capital exports about 0.7 percent fewer low-tech products than otherwise similar states. This is an indication of the firm location theory at work, in which high-tech firms locate their production units in states with high innovative capital to take advantage of the pool of highly skilled labor and also the innovative capabilities of these states, whereas few low-tech industries will locate in states with high innovative capital because of the high cost of labor.

### 5.1.3.8 Service Industry Share of Output

The results indicate that high levels of service industry share of state gross domestic (*SER*) product lead to an increase in all types of exports; however, this effect is higher for high-tech products than low-tech products. A percentage increase in service industry share of output leads to an increase of between 1.01 percent and 1.04 percent in high-tech exports, whereas it only leads to about a 0.4 percent increase in a state's low-tech export performance. This result demonstrates that the states with high service output have characteristics such as high human capital that are not overly important in the production of low-tech products; thus, all things being equal, low-tech firms will not ordinarily locate in states with high service shares of output, thus causing low-tech exports from such states to be lower.

### 5.1.4 State Business Environment

The impact of a state's business environment on exports is summarized in Table 7.[74] The table identifies the effect of the tax system, the cost of living, wages, the presence and strength of unions, the litigation system, and pollution control measures. Overall, the business environment significantly affects a state's export performance. However, the effect differs by product type as defined by the level of technology employed in the production process.

[74] Table 7 shows a component of the estimation results of Table 3.

Table 7: State Business Environment and Export Performance

| Model | BTARP | | CPI | | LABW | | TUNDEN | | SLITR | | CO2ER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DIST | ZDIST | DIST | ZDIST | DIST | ZDIST | DIST | ZDIST | DIST | ZDIST | DIST | ZDIST |
| Total | 0.271 | 0.276 | -10.664 | -10.691 | -0.224 | -0.221 | -0.510 | -0.513 | 0.675 | 0.674 | -0.915 | -0.915 |
| | {5.97} | {6.05} | {-25.85} | {-25.83} | {-3.36} | {-3.31} | {-19.46} | {-19.52} | {9.90} | {9.85} | {-26.18} | {-26.12} |
| High | 0.456 | 0.461 | -11.614 | -11.638 | -0.442 | -0.439 | -0.470 | -0.474 | 0.765 | 0.764 | -0.955 | -0.955 |
| | {9.98} | {10.05} | {-28.00} | {-27.99} | {-6.61} | {-6.55} | {-17.86} | {-17.93} | {11.16} | {11.12} | {-27.19} | {-27.13} |
| low | -0.678 | -0.672 | -0.513 | -0.539 | 0.371 | 0.377 | -0.285 | -0.289 | -0.352 | -0.352 | 0.039 | 0.039 |
| | {-16.10} | {-15.90} | {-1.34} | {-1.41} | {6.04} | {6.09} | {-11.74} | {-11.87} | {-5.57} | {-5.56} | {1.22} | {1.20} |

*Note*: Numbers in brackets denote t-statistics; DIST denotes model with distance calculated from geographic centers; ZDIST denotes model with distance measured from state capital to population-weighted country administrative regions.

The results from Table 7 indicate that states with high business taxes as a percentage of business profits (*BTARP*) export more total and high-tech manufacturing goods than other states with similar characteristics. The results show that a percent higher state business taxes leads to 0.27 percent more total exports and 0.46 percent more high-tech manufacturing exports than other states with otherwise similar characteristics. Low-tech industry's exports are 0.67 percent lower in states with higher business taxes than otherwise similar states. The results indicate a difference in the response of different types of manufacturing exports to business taxes. This result may be due to reasons similar to that found by Tan (1999), who finds that, in addition to factors such as the firm's attitude toward risk and its production technology, "how an input affects risk" plays a significant role in determining the impact of taxation on production location. Thus, the effect of business taxes on a state's export performance may depend on how inputs affect the risks faced by different industries.

States with a higher cost of living (*CPI*) and higher production wages (*LABW*) are shown in Table 7 to export lower levels of total and high-tech manufacturing products. For instance, all other factors remaining equal, a state with a percentage higher cost of living is estimated to experience about 10.7 percent fewer total exports and 11.6 percent fewer high-tech exports than a state with lower cost of living while having no significant effect on low-tech exports. This result can be an indication that higher cost of living implies higher unit cost and thus higher production costs, which lead to lower production and exports. Higher production wages are, however, shown to significantly increase a state's low-tech manufacturing exports. This might be the case of efficiency wages at work.

After controlling for wages, the presence of unions and their density in a state's workforce (*TUDEN*) is estimated to significantly reduce all types of state manufacturing exports. The results indicate that a percentage increase in union proliferation costs a state about 0.5 percent in total and high-tech manufacturing exports and 0.3 percent low-tech exports. This is an indication that higher level of unionization is consistent with higher pay levels, more restrictive work rules, and higher costs of labor, factors that most likely result in lower levels of productivity and exports. This negative impact is less severe for low-tech exports because unions to some extent satisfy the efficiency wage theorem in these types of industries.

States with highly regarded litigation systems (*SLITR*) fare better in terms of total and high-tech manufacturing exports but export significantly fewer low-tech manufacturing products. This result may be due to the fact that most high-tech products need patent rights protection, whereas low-tech products are normally generic in nature, demanding less skilled labor for their production, and thus are more likely to be produced in states with a less-skilled labor force that are also characterized by low-ranking litigation systems.

States with high pollution levels are shown to export fewer total and high-tech manufacturing goods, whereas they export more low-tech manufacturing products. States with a percentage higher pollution levels export about 0.92 percent total and 0.95 percent fewer high-tech products, whereas they are shown to export 0.04 percent more low-tech manufactured products than their less-polluting counterparts with otherwise similar characteristics. A casual examination of Figure 2 and Figure 10 indicates that states with the highest pollution rates mostly exhibit low levels of innovative capital. Thus, the result of states with high pollution exporting more low-tech products might be due to the lack of innovative capital. Second, this result may be the direct result of low-tech firms' taking advantage of lax pollution rules to locate their dated industrial machinery, thus polluting more and exporting more low-tech products.

### 5.1.5 Export Market Situation and Total Exports

To account for the conditions in foreign markets, typical gravity models include output, population, or per capita income. This study adds the following variables: the dollar value of total imports and the real exchange rate. Apart from the importing country's gross domestic product and per capita income, this study includes the nominal exchange rate and the levels of the foreign country's imports.[75]

While the nominal exchange rate does not exhibit much of a significant effect on export performance, increases in imports of countries play a significant role in determining state export performance. A percentage increase in foreign countries' levels of imports leads to a decrease in a state's total exports by 1.2 percent to 1.4 percent and a

[75] Defined as foreign currency units per U.S. dollar (FCUs/$)

decrease of 1.2 percent to 1.4 percent for high-tech exports to those countries. State low-tech manufacturing exports, on the other hand, increase by 3.1 percent to 3.2 percent to countries that experience a percentage increase in imports. Thus, on one hand the results demonstrate a high positive import demand elasticity of a state's low-tech products, whereas on the other hand high-tech exports experience a negative elasticity of import demand.

### 5.1.6 Globalization and State Total Exports

In their analysis of the gravity equation for country-level bilateral trade, Cheng and Wall (2005) interpret the year dummy variables as a measure of globalization. They find that globalization has increased the real volume of trade by 48% between 1982 and 1997. Cheng and Wall (2005), unlike this study, do not include trade agreements in their estimation. Much of the effect of globalization in this study is reflected in the positive effects of the trade agreement dummy variables; thus it makes little sense to interpret the year dummies as proxies of globalization effect. It is more likely that other events occurring in export markets and state production processes may be the cause of observed decreases in state exports, with high-tech exports decreasing somewhat more and low-tech manufacturing exports decreasing somewhat less. From Figures 17 through 19, it is obvious that, relative to 1988, since 1995 there has been a significant and consistent reduction in state total, high-tech, and low-tech manufacturing exports.

One should take note that around December 1994 the Mexican economy, which imports about one-third of U.S. exports, collapsed, and this is likely to be the initial cause of the fall in state exports around that time. Second, it is apparent that the fall in exports stabilized around 1996, then took another tumble around 1998, which is around the time of the Asian crisis. Thus, the year dummy variables are most likely picking up special circumstances in the economies of important trading partners rather than globalization effects.

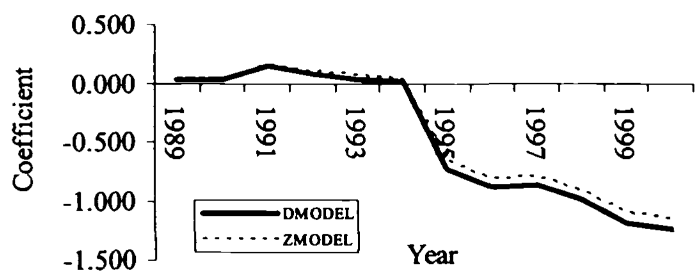


Figure 17: Year Dummy for Total Manufacturing Exports

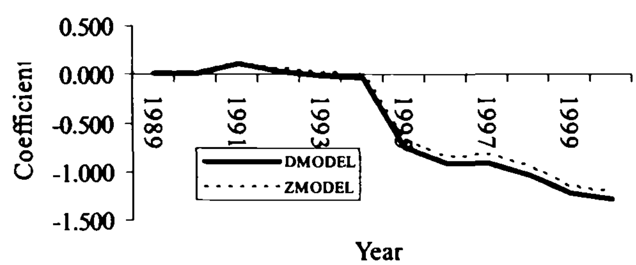


Figure 18: Year Dummy for High-Tech Manufacturing Exports

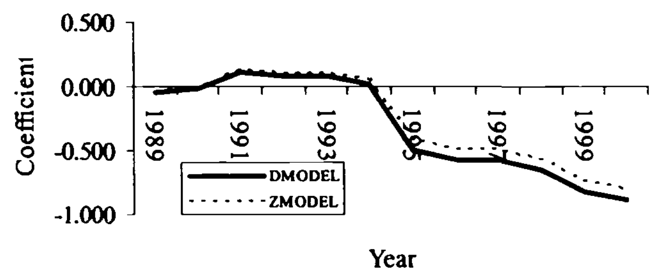


Figure 19: Year Dummy for Low-Tech Manufacturing Exports

## 5.2 Results of Spatial Autocorrelation Analysis

The first law of geography states that "all things are related, but nearer things are more related than far things." This statement suggests that spatial autocorrelation can explain some of the variation in state export performance. For instance, firms in states that are physically proximate can share ideas and labor force and may, therefore, be able to produce and export at similar levels. Proximity does not imply only physical closeness. This study employs one physical proximity measure, two cultural proximity measures, and one human development proximity measure to check whether spatial autocorrelation exists in state export patterns. The results are presented in Table 9.

To check for the robustness of the spatial autocorrelation specification, Moran's I coefficient is calculated for total, high-tech, and low-tech manufacturing exports for the years 1988, 1995, and 2000. The results indicate that, for total and high-tech exports, contiguity, physical distance, and social/cultural values do not matter in determining exports. This applies to all periods covered by this study. By contrast, the human development proximity index does matter. The positive sign of Moran's I coefficient for human development proximity indicates that states with similar levels of human development perform at similar levels in terms of total and high-tech manufacturing exports. This is a robust result because its level of significance does not change over the years.

Table 8: Results of Spatial Autocorrelation

| Export Type | Year | Contiguity | Distance | | Elections | Conservative | HDI | |
|---|---|---|---|---|---|---|---|---|
| | | Moran | Moran | | Moran | Moran | Moran | |
| | 2000 | -0.06 | 0.09 | | 0.08 | 0.06 | 0.55 | *** |
| Total | 1995 | -0.09 | 0.08 | | 0.06 | 0.04 | 0.39 | *** |
| | 1988 | -0.14 | 0.03 | | 0.08 | 0.03 | 0.76 | *** |
| | 2000 | -0.05 | 0.09 | | 0.08 | 0.06 | 0.56 | *** |
| High-tech | 1995 | -0.10 | 0.08 | | 0.06 | 0.04 | 0.40 | *** |
| | 1988 | -0.14 | 0.03 | | 0.08 | 0.03 | 0.76 | *** |
| | 2000 | -0.09 | 0.10 | | 0.06 | 0.04 | 0.14 | |
| Low-tech | 1995 | -0.03 | 0.15 | * | 0.05 | 0.26 | 0.04 | |
| | 1988 | -0.16 | 0.05 | | 0.82 | 0.08 | 0.61 | *** |

*Note*: Moran's denotes Moran's I Coefficient; *and *** denotes significance at 10 percent and 5 percent levels, respectively.

For low-tech exports, the results are not as robust. States that are physically proximate are shown to export at similar levels in 1995 but not in other years. States with similar human development levels exported similar levels of low-tech manufacturing products only in 1988 but not in the other years tested. This result may be just a coincidence or it may be an indication of other spatial factors that are not analyzed by this study.

## 5.3 Gravity Equation and Spatial Autocorrelation Analysis

The results of the spatial autocorrelation analysis indicate that, out of all the proximity measures used in investigating the presence of spatial autocorrelation, only the level of human development consistently explains similarities in export performance of states. To reconcile these findings with those of the gravity model, the human development variable is divided into three quantiles, high, medium, and low human development. Using this division, three different gravity models are estimated, one each for the exports from states with high, medium, and low human development.

This process of estimating separate regressions for the exports of states with different levels of human development is done to check whether states with different levels of human development will respond differently in terms of any of the factors that drive manufacturing exports. For the sake of clarity of presentation, some of the most significant results of this analysis are presented in a graphical format in Figures 20 through 26 below.

### 5.3.1 Human Development, Physical Distance, and State Exports

The results of estimating separate equations for states with low, medium, and high human development indicate that physical distance to export markets continues to negatively affect all types of state manufacturing exports. However, the magnitude of this negative effect varies greatly by type of exports and also by the level of human development. The results (Figure 20) show that exports from states with low levels of human development are in most cases more affected by distance than those with higher levels of human development. This result indicates that a state's factors that drive its human development of may reduce the negative impact of distance from export markets. Economic growth, through advances in production and consumption is commonly understood to be the stimulus for increases in living standards. Thus, higher human development in this case proxies for advances in production and increased consumption, hence rendering remote states with high human development viable for firm location. This result is similar to what Venables and Limao (2002) finds in their H-O von Thunen model.

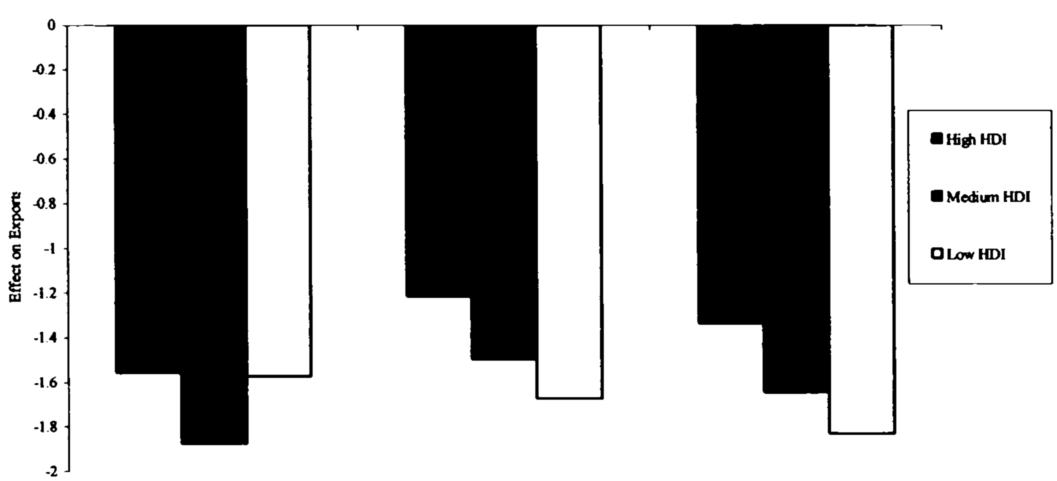


Figure 20: The Effect of Distance on State Exports by Type of Exports and Level of HDI

## 5.3.2 Human Development, Location, and Low-Tech Exports

The results in Figure 21 indicate that the low-tech export equations have rather different regression coefficients when they are estimated separately for states with low, medium, and high levels of human development. For example, the low-tech exports of states with low human development are negatively affected by a high level of the remoteness index. This result suggests that low-tech exports are high in transport costs and therefore, if the factors that drive human development, which also can lead to cost cutting for firms are not present to offset the distance cost of a firm locating in a remote state, these firms, will prefer to locate in less remote or high human development states, thus driving exports of low-tech goods from less remote states.

Although high levels of business taxes affect low-tech exports negatively, this negative effect is higher for states with lower human development than for states with medium and high human development. Once again, the result suggest that factors that drive human development also lead to cost cutting for firms, which offsets some of the negative effect of high business taxes on firm location decisions and thus exports.

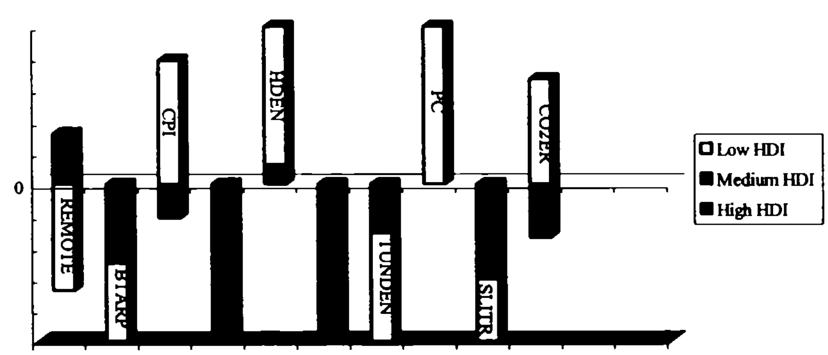


Figure 21: Differences in the Effect of Location Characteristics on State Low-Tech Exports by Levels of State Human Development

The consumer price index, which is used as an additional measure of the cost of operating a business, has a positive effect on low-tech exports of states with low human development, no significant effect on low-tech exports of states with high human development, and a significantly negative effect on low-tech exports of states with a medium level of human development. Higher wages have a significant and negative effect on the low-tech exports of states with medium and high human development, while they have no significant effect on the low-tech manufacturing exports of states with low human development. The results indicate that the efficiency wage theory does not work in high human development states for low-tech products. This may be because, with a higher level of wages coupled with higher human development, it is not feasible to produce low-tech products in such states because of high operation costs.

The innovative capital index used in this study is designed to portray the availability and productive capacity of human capital and the innovation capacity of a state and its effect on state export performance. The results indicate that states with high innovative capital and high levels of human development export smaller amounts of low-tech manufacturing products. However, a state's innovative capital does not have any significant effect on the low-tech manufacturing exports of states with low and medium human development. This result is interesting because it suggests that high-tech products are innovation intensive and that human development enhances the effectiveness of innovation in advancing high-tech production and exports.

An increase in highway density has a significantly positive effect on low-tech manufacturing exports of states with low and medium levels of human development. There is no such effect for states with high levels of human development. The proliferation of personal computers in a state increases low-tech manufacturing exports significantly but only for states with low-levels of human development. This result suggests that transportation and infrastructure availability may offset some of the cost for low-tech manufacturing firms locating in low and medium human development states and thus improve those states low-tech exports performance.

The low-tech manufacturing exports of states with low and medium human development are negatively affected by unions. States with lower levels of human development, the presence of unions only leads to increases in production costs, which cause low-tech firms to locate in less unionized states to take advantage of lower production costs and hence reduce low-tech exports of highly unionized states.

The examples above suggest that location characteristics of a state play a role in determining its low-tech export performance; however, their role depends largely on the level of human development of that state.

### 5.3.3 Human Development, Location, and High-Tech Exports

The high-tech exports of states with high human development are shown in Figure 22 not to be affected by a state's remoteness. By contrast, the high-tech manufacturing exports of states with low human development are significantly negatively affected by a state's remoteness. This result indicates that having high human development somehow offsets some of the cost of producing and exporting high-tech products from remote areas. Thus, if a state is remote and also exhibits low human development, cost-minimizing firms are less likely to locate in the state; hence the state will experience low high-tech export performance.

The results also indicate that the high-tech manufacturing exports of states with high and medium levels of human development are positively affected by high business taxes. The same taxes affect the high-tech exports of states with low human development negatively. The positive effect of high business taxes of states with high human development may be the result of the use of the taxes to create amenities that facilitate production and also improve the drivers of human development. Also, it is possible that the drivers of human development lead to cost cutting for firms, hence absorbing some of the tax costs and attracting high-tech firms to locate in high human development states, thus causing an improvement in the state's high-tech export performance. In this case, locating a firm in a state with high business taxes and higher human development can be seen as an efficiency-wage phenomenon.

The high-tech manufacturing exports of states with low human development are negatively affected by a state's cost of living but positively affected by high levels of wages. While the cost of living is a proxy for the overall cost of doing business in a state, labor wages are likely to proxy the actual payments made to labor. The result for wages is very similar to the result for high business taxes; thus one can say that the efficiency wages theorem may be in play. This result suggests that the high cost of labor in this situation is offset by the benefit of locating in a state with high human development.

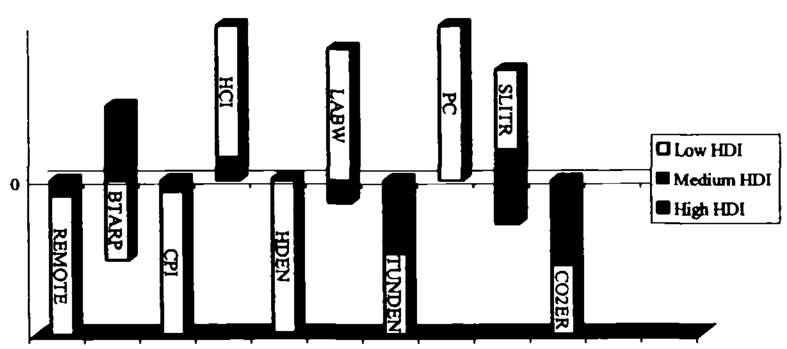


Figure 22: Differences in the Effect of Location Characteristics on State High-Tech Exports by Levels of State Human Development

The results presented in Figure 21 indicate that the magnitude of the effect of innovative capital on a state's high-tech export performance is larger for states with low human development than for states with medium and high human development levels. This result indicates that some of the lost benefit of human development on high-tech goods production can be offset through improvements in innovative capital.

Figure 22 reveals that union density levels negatively affect high-tech exports of all states. However, the variable's negative effect is more pronounced for the high-tech manufacturing exports of states with low and medium human development levels. This difference in the effect of union density on high-tech exports may be due to the benefits of human development offsetting the business cost incurred due to the presence of unions.

### 5.3.4 Human Development, Location, and Total Exports

Figure 23 shows that total manufacturing exports of states with high human development are not significantly affected by the remoteness of a state. However, the latter negatively affects the exports of states with medium and low human development. The magnitude of the negative effect of a state's remoteness is larger for states with low human development than for states with medium human development. Once again this result suggests that the drivers of human development lead to cost cutting for firms, thus offsetting the cost of locating in and producing from a remote state. Hence, in the absence of high human development, firms will generally not locate in remote states, and thus total exports of these remote states will be low.

The transportation and communication proxies, the highway density of a state, and the availability of personal computers significantly affect the total exports only of states with low human development. Figure 23 shows that states with high highway densities and low human development export less, while states with low human development but high numbers of households with access to personal computers export more. This result suggests that, all things being equal, firms will only locate in a low human development state if its transportation and communication infrastructure is good.

The effect of business taxes on total manufacturing exports of a state ranges from being negative for states with low human development to positive for states with medium and high human development. The effect of the cost of living on a state's total exports is significantly negative for states with low human development and slightly negative for states with medium human development. The cost of living does not have any effect on the total manufacturing exports of states with high human development. This result occurs once again because the benefit of the drivers of human development to production and exporting offsets some of the cost of locating and producing in high business taxing and wage states. This is to say that since economic growth which is driven by productivity and consumption largely determines standard of living, the benefits of high productivity and consumption somewhat offset the negative effect of high business taxes and wages.

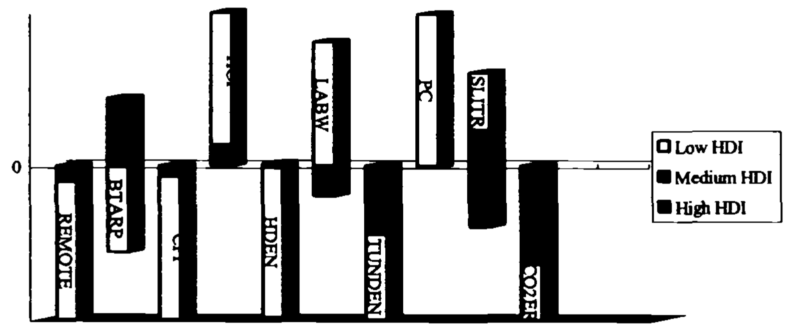


Figure 23: Differences in the Effect of Location Characteristics on State Total Exports by Levels of State Human Development

States with high union densities export less, but this negative effect of unions on state export performance is more pronounced for states with low human development than for states with high human development. This result is indicates that the benefit of human development offsets some of the cost of union presence in a state. This is because states with a higher standard of living experience higher economic growth through increased productivity and consumption and thus are viable for firm location.

### 5.3.5 Globalization Effect and Levels of Human Development

Unlike in Cheng and Wall (2005), the year dummies in this study as discussed above may not represent the effect of globalization; rather they may proxy developments in import markets not controlled for in this study. Figures 24 through 26 indicate that the effect of occurrences in export markets not controlled for by this study differs by type of export good and by a state's level of human development.

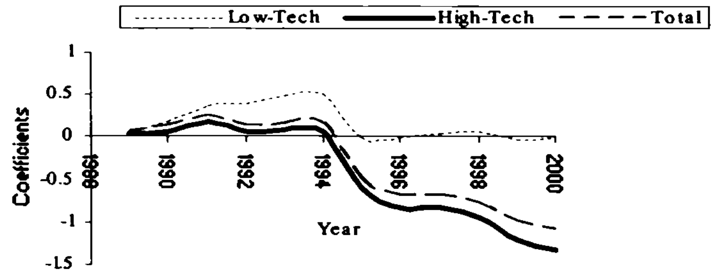


Figure 24: High Levels of HDI and the Globalization Effect on Different Types of State Exports

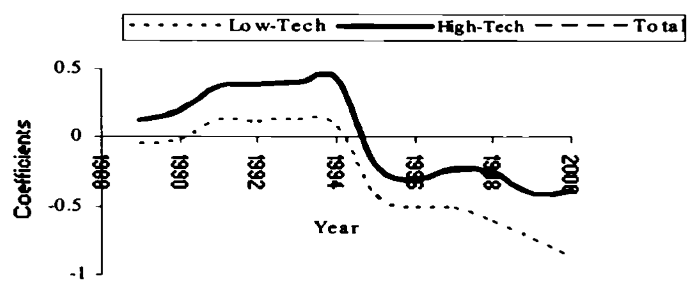


Figure 25: Medium Levels of HDI and the Globalization Effect on Different Types of State Exports

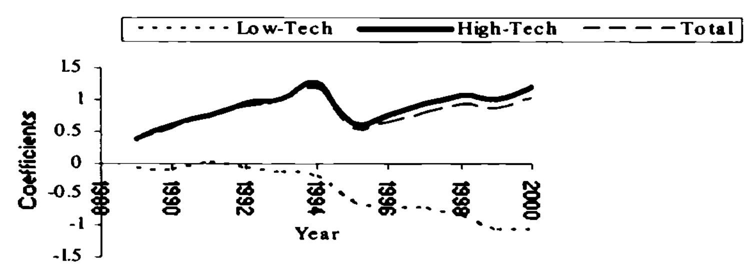


Figure 26: Low Levels of HDI and the Globalization Effect on Different Types of State Exports

The results presented in Figure 24 show that states with high human development have experienced negative effects from these unobserved occurrences in importing countries on their high-tech and total exports since 1995. Their low-tech exports are at best minimally affected.

The case for states with medium levels of human development is presented in Figure 25. Since 1995, occurrences in import markets not controlled for by this study have led to a downturn in all types of manufacturing exports for states with medium levels of human development. However, the negative effect is more pronounced for low-tech manufacturing exports than for high-tech and total manufacturing exports.

Figure 26 shows that, for states with low levels of human development, globalization has reduced low-tech manufacturing exports since 1989. Apart from the slight dip in total and high-tech exports for these states between 1994 and 1995, the low human development states have enjoyed a rise in high-tech and total manufacturing exports since 1996 due to the unobserved occurrences in the importing countries. This result might be due to the exports from high human development states being more susceptible to the unobserved import country shocks than those of low human development states.

# Chapter 6

# Discussion and Concluding Remarks

## 6.1 Discussion

The preceding analysis has addressed five basic questions about the geography of state export performance. First, to what extent do different physical distance measures result in different conclusions about the dependence of state export performance on the physical distance of a state from its export markets? Second, do nonphysical and psychic distance measures add anything in explaining state export performance? Third, to what extent do state's location characteristics predict its export performance? Fourth, what role do the conditions in export markets and trade agreements play in explaining state manufacturing export performance? Last, do the determinants of state exports differ in their effect on high-tech versus low-tech manufacturing products?

### 6.1.1 Distance Effect

Physical distance is shown to still play a significant role in determining state manufacturing exports. However, it is important to note that the effect of physical distance depends on the physical distance measure and the type of exports. The difference in the size of the effect of the two physical distance measures used in this study can be large and, therefore, makes the reported effect of physical distance on export performance unreliable. The result indicates that, for all export types, distance when measured as the distance from state capitals to the population-weighted administrative centers of countries consistently decreases exports to the countries by at least 0.2 percent. Thus, depending on which distance measure is the right proxy for the transportation cost of trade, one can over or under-predict export performance by two basis points when using physical distance as a proxy for transport cost.

This study employs two types of nonphysical and psychic. According to the results, language proximity between the U.S. and a country leads to an increase in exports, a result that is not very surprising because the language proximity captures general cultural similarity and thus makes transactions easier since people from states and foreign countries that are proximate in terms of language understand each other better, improving trade relations in general and export performance in particular. This effect is slightly more pronounced for high-tech products than for low-tech products because, for more complex products, this understanding is even more valuable since there is more to know about the product.

Hostile or antagonistic relationships between the U.S. and foreign countries significantly reduce a state's exports to these "enemy" countries. The effect of a hostile relationship is less pronounced for low-tech manufacturing exports, which might be due to the fact that trade in low-tech products involves fewer physical contacts and contractual agreements, whereas more complex products sometimes require more understanding and physical contact. The differences between the nonphysical distance measures in the different models are not very large. This makes for a more robust explanation of export performance than is achieved with the physical distance measures.

### 6.1.2 Trade Agreement Effect

Four different types of trade agreements are analyzed in their effect on state exports. This study covers bilateral, regional, and multilateral trade agreements. The results show that, for the most part, trade agreements lead to increases in state exports; however, in the case of NAFTA, high-tech products exports to NAFTA member countries decreased significantly with the institution of NAFTA. The effects of trade agreements on manufactured exports differ by the type of good considered. Low-tech manufacturing goods benefit the most from regional and bilateral agreements, whereas high-tech manufacturing goods benefit the most from international trade agreements, such as the World Trade Organization, which deals more with patent and copyright protection.

### 6.1.3 State Location Characteristics

State location characteristics are shown in this study to impact a state's export performance significantly. The proliferation of unions in a state is shown to lead consistently to a negative impact on all types of exports. Although the union elasticity of state export performance is negatively inelastic, the level of inelasticity is more pronounced for low-tech exports. This may be due to efficiency wages brought about by unions in the low-tech industries.

The magnitude and size of the impact of location variables on export performance differ, for the most part, by type of export and location characteristics. For example, as indicated by the positive elasticity of business taxes and litigation systems, higher business taxes and better state litigation systems significantly improve a state's high-tech export performance but lead to a reduction in its low-tech export performance. On the other hand, states with higher production labor wages are shown to export more low-tech products and-fewer high-tech products. This result may suggest the effect of efficiency wages on productivity in the low-tech industry and thus lead to improvements in low-tech exports of states with higher manufacturing labor costs.

Innovative capital, which in this study includes the availability of human capital, and measures of innovative capacity and output, is shown to have a significant positive effect on high-tech export performance, whereas it impacts low-tech export performance negatively. States with 1 percent higher innovative capacity are shown to export 0.4 percent more high-tech exports and 0.6 percent fewer low-tech exports. This is to say that high-tech exports respond positively to the availability of innovative capital but low-tech exports respond negatively. This might be due to high-tech products' being more dependent on innovation than low-tech exports; thus, given all other explanatory factors, high-tech manufacturing firms will locate in states with high innovative capacity to take advantage of it in their production processes.

The result for transportation and infrastructure variables underscores the importance of infrastructure in production, development and export performance. The results indicate that the availability of better ground transportation, air transportation, and information technology consistently improves a state's exports for all product types. While the transportation variables improve the speed of delivery of both raw materials for production and finished products to export markets, information technology leads to better production and management processes and also communication efficiency, all of which decreases cost of production and trade, thus improving export performance.

Transportation and infrastructure variables play a more significant role in determining low-tech exports. For example, states with 1 percent more airports export 2.6 percent more low-tech and only 0.4 percent more high-tech manufacturing products than otherwise similar states. This result suggests that low-tech exports are more sensitive to transportation and infrastructure capacity and efficiency than high-tech exports. This may suggest that low-tech manufactured exports are more sensitive to the speed of delivery and cost of transportation than high-tech exports.

### 6.1.4 Spatial Autocorrelation

The new economic geography emphasizes the importance of geography in explaining economic phenomenon. In the same vein, the first law of geography indicates that, although all things are related, nearer things are more related. Thus, proximate states are expected to perform at similar levels in terms of exports. The spatial analysis performed by this study indicates that physical and cultural proximity among states does not play a significant role in explaining similarities in state exports. By contrast, the similarity in human development does appear to explain similarities in state export performance. In sum, the spatial autocorrelation analysis downplays the importance of physical distance in predicting exports. It highlights instead the importance of location characteristics.

In trying to reconcile the estimates of the gravity equation with the results of the spatial autocorrelation analysis, the result indicates that the coefficients of the explanatory variables of the gravity model differ by a state's human development level.

The results show that, although all state exports are negatively affected by distance, this negative effect differs significantly among states with different levels of human development. This result is a clear sign of the importance of location characteristics in determining a state's export performance. This result is similar to the findings of Venables and Limao (2002), that endowments may offset the negative effect of distance on production and hence on trade.

## 6.2 Policy Conclusions and Concluding Remarks

Physical distance, which has been used in many gravity equations to explain trade patterns, has been shown in this study to be a good predictor of exports only when it is defined in a particular way. Therefore, physical distance measures should be used with care to proxy trading costs. At a minimum, one should employ more than just one or just the most convenient measure of distance.

Since the distance from a state to its export markets cannot be changed, it cannot serve as a policy tool. However, there are measures that can be used to reduce the trading costs associated with distance. The results of the spatial autocorrelation analysis indicate, for example, that exports from states with higher levels of human development are less affected by physical distance. Thus, a remote state seeking to improve its export performance may do so through increasing its human development.

Variations in other location variables may also be used as policy tools to improve state export performance. Improvements in transportation and communication infrastructure are an example. However, policymakers need to proceed with care when planning to use location and business environment variables to improve export performance, because the results may vary for different types of goods. Thus, policymakers should decide ahead of time what types of exports they want to promote, because this at times determines what location and business environment characteristics they need to improve or reduce.

It has been shown that trade agreements usually improve state export performance but not for all product types. Thus, state representatives should carefully analyze their industrial mix and the potential effect that new trade agreements will have on the exports of products produced within their states.

If state representatives seek to improve all types of a state's exports, the results of this study suggest they should work on improving the state's infrastructure and information technology system. The study indicates that an increase in transportation and information technology leads to improvements across all exports. On the other hand, if a state's industry mix lies with high-tech products, improving its export performance will entail improving its litigation system, and its innovative capacity.

The study indicates that states with a higher litigation score index exhibit a higher total export performance and significantly higher high-tech exports. This result is significant because it indicates that high-tech products, which are usually copyrighted, tend to be produced and exported from states with the best legal systems so that legal issues, such as protection from copyright infringements, can be upheld. This result can be also interpreted to mean that states with lower-ranked litigation systems attract low-tech manufacturing production and exports.

Innovative capital, which consists of measures of a state's human capital accumulation and variables that denote a state's innovative capacity and efficiency, is shown to significantly increase total state manufacturing exports. If a state's export niche lies in a high-tech industry, then it is important for the state government to institute policies that will lead to a surge in innovative capacity and efficiency.

In conclusion, this study set out to investigate whether physical distance or other forms of distance still play a role in determining state export performance or if state location characteristics now determine exports. The lack of consistency in the magnitude of the effect of physical distance on all types of export performance indicates that physical distance may at best be a good explanatory variable for only some types of exports. The results from the spatial analysis show that state location characteristics are more consistently important in predicting the manufacturing exports of U.S. states.

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# Appendix

# Appendix A

## A.1 Calculating the Distance between States of the United States and Countries around the World

Two types of distances are calculated in this study: first, the distance between each state's geographical center and the geographical center of the foreign country in question), and second, the distance from the state capital to the population-weighted administrative regions of a country (if this is not present, the study uses distance to the capital city of the country).

However, as indicated in Chapter 4, due to the close proximity of Canadian cities to American states, the sharing of borders with some states, and the dispersed nature of the Canadian population, the distances from a state to Canada is calculated differently as discussed below.

From the GIS world latitudinal and longitudinal location files, the Central Intelligence Agency's (CIA) fact sheet, and the Massachusetts Institute of Technology's geographic database (http://www.mit.edu:800/geo?location), data on the longitudinal and latitudinal location of each country of the world (geographic, and administrative), and for each state (geographic and state capital) are obtained. Then the latitudes and longitudes of each state and those of the importing countries are first converted into decimals and then converted into radians using the following formula:

$$Latitude/longitude\deg rees + \left(\frac{Latitude/LongitudeMinutes}{60}\right) * \left(\frac{3.141593}{180}\right)$$

The earth's shape is technically an oblique spheroid; therefore, calculating an accurate distance between two points requires the use of spherical geometry and trigonometric math functions. In spite of the existence of simpler functions for calculating distances, their results are only an approximation of the actual distances between two places. For many applications, approximate distance calculation provides sufficient accuracy with much less complexity.

Since the earth is approximately round, all lines are actually circles that eventually return to themselves. These are called great circles because they divide the earth into two halves (an example of a great circle is the equator). On a sphere such as the earth, the shortest distance between any two points is a great circle.

The great circle distance (GCD) formula provides greater accuracy for distance calculations. This formula requires the use of spherical geometry and a high level of mathematical accuracy. The math functions used in the formula require the conversion of the latitude and longitude values from decimal degrees to radians; then, one can proceed to use the radians and the earth's radius to calculate the distance from one point to the other using the following formula for calculating the GCD.

$$GCD = r * \arccos[\sin(lat1) * \sin(lat2) + \cos(lat1) * \cos(lat2) * \cos(lon2 - lon1)] ,$$

where $r$ is the radius of the earth, which can be measured in statute miles (3,437.74), normal miles (3,963.0), and kilometers (6,378.7) (Note that all distance calculations of this study are done in kilometers). In this formula, *lat*1 and *lat*2 represent the latitudes of each state in the United States and foreign country capital in question, respectively;, whereas *lon*1 and *lon*2 represent the longitude of the U.S. state capital and that of the foreign country capital in question, respectively. Note that arccos, sin, and cos represent the arccosine, sin and cosine trigonometry functions.

## Example

Calculating the distance from the state of Alabama to the Mexican city of Cancun

| | Latitude | Longitude |
|---|---|---|
| Alabama | 32:45:00 N | 86:45:00 W |
| Cancun | 21:26:00 N | 86:51:00 W |

Step 1. Convert the latitude and longitude degrees into decimals

For Alabama: Latitude $=32+(45/60)=32.75$ and Longitude $=86+(45/60)=86.75$

For Cancun: Latitude $=21+(26/60)=21.43$ and Longitude $=86+(51/60)=86.85$

Step 2. Convert the decimals into radians

For Alabama: lat1 $=32.75*\left(\frac{3.14}{180}\right)=.5731$ and lon1$=86.75*\left(\frac{3.14}{180}\right)=1.518$

For Cancun: lat2 $=21.43*\left(\frac{3.14}{180}\right)=.3551$ and lon2$=86.85*\left(\frac{3.14}{180}\right)=1.677$

Step 3. Calculate the distance

$$6378.7k * \arccos[\sin(.5731) * \sin(.3551) + \cos(.5731) * \cos(.3551) * \cos(1.677 - 1.518)]$$

$$d = 1{,}768.824K$$

Due to Canada's close proximity to some states in the U.S., the expectation of this study is that states will trade more intensely with Canadian and Mexican states that are closer to them than those that are further from them. Therefore, using the distance from the state capitals to the capitals of Canada and Mexico to explain trade between U.S. states and these two countries may give a distorted picture of the effect of distance on trade between U.S. states and the two countries.

In an attempt to correct the aforementioned problem, the distance from each state to each Canadian and Mexican city is calculated using the GCD formula; then the distances from the state capitals to the nearest Canadian and Mexican cities are used as proxies for the distances between the state capitals and Canada and Mexico, respectively. Table 1a below presents a list of all states and their corresponding closest and furthest country or Canadian city and the corresponding distances in kilometers.

Table 1a: Closest/Most Distant Country/Canadian City

| FIPS | State | Closest | Distance | Furthest | Distance |
|---|---|---|---|---|---|
| 1 | AL | The Bahamas | 1,153.52 | Cocos (Keeling) Islands | 17,711.98 |
| 2 | AK | Whitehorse (Canada) | 1,020.13 | Heard & McDonald Island | 17,081.64 |
| 4 | AZ | Victoria (Canada) | 1,847.81 | Mauritius | 18,153.65 |
| 5 | AR | Toronto (Canada) | 1,478.29 | Heard & McDonald Island | 17,684.71 |
| 6 | CA | Victoria (Canada) | 1,286.94 | Reunion | 18,150.34 |
| 8 | CO | Regina (Canada) | 1,276.39 | Heard & McDonald Island | 18,447.45 |
| 9 | CT | Montreal (Canada) | 452.60 | Heard & McDonald Island | 17,200.53 |
| 10 | DE | Toronto (Canada) | 607.92 | Heard & McDonald Island | 17,196.39 |
| 12 | FL | The Bahamas | 487.39 | Cocos (Keeling) Islands | 18,240.51 |
| 13 | GA | The Bahamas | 914.80 | Cocos (Keeling) Islands | 17,733.97 |
| 15 | HI | Kiribati | 1,982.99 | Botswana | 19,711.72 |
| 16 | ID | Calgary (Canada) | 615.26 | Heard & McDonald Island | 19,007.30 |
| 17 | IL | Toronto (Canada) | 946.42 | Heard & McDonald Island | 18,052.26 |
| 18 | IN | Toronto (Canada) | 729.80 | Heard & McDonald Island | 17,895.47 |
| 19 | IA | Winnipeg (Canada) | 933.29 | Heard & McDonald Island | 18,437.96 |
| 20 | KS | Winnipeg (Canada) | 1,274.01 | Heard & McDonald Island | 18,276.90 |
| 21 | KY | Toronto (Canada) | 846.03 | Heard & McDonald Island | 17,687.82 |
| 22 | LA | Mexico | 1,359.96 | Cocos (Keeling) Islands | 17,753.08 |
| 23 | ME | Fredericton (Canada) | 203.46 | Heard & McDonald Island | 17,193.72 |
| 24 | MD | Toronto (Canada) | 586.15 | Heard & McDonald Island | 17,254.98 |
| 25 | MA | Montreal (Canada) | 417.07 | Heard & McDonald Island | 17,169.18 |
| 26 | MI | Toronto (Canada) | 418.94 | Heard & McDonald Island | 18,107.71 |
| 27 | MN | Winnipeg (Canada) | 476.69 | Heard & McDonald Island | 18,821.03 |
| 29 | MO | Toronto (Canada) | 1,245.96 | Heard & McDonald Island | 18,049.74 |
| 28 | MS | The Bahamas | 1,410.40 | Cocos (Keeling) Islands | 17,642.20 |
| 30 | MT | Calgary (Canada) | 565.33 | Heard & McDonald Island | 19,259.19 |
| 31 | NE | Winnipeg (Canada) | 957.32 | Heard & McDonald Island | 18,630.11 |
| 32 | NV | Victoria (Canada) | 1,218.10 | Heard & McDonald Island | 18,204.50 |
| 33 | NH | Montreal (Canada) | 233.51 | Heard & McDonald Island | 17,291.07 |
| 34 | NJ | Toronto (Canada) | 575.01 | Heard & McDonald Island | 17,206.57 |
| 35 | NM | Mexico | 1,219.20 | Heard & McDonald Island | 17,912.32 |
| 36 | NY | Ottawa (Canada) | 291.43 | Heard & McDonald Island | 17,483.60 |
| 37 | NC | Toronto (Canada) | 944.37 | Cocos (Keeling) Islands | 17,428.84 |
| 38 | ND | Winnipeg (Canada) | 359.31 | Heard & McDonald Island | 19,252.18 |
| 39 | OH | Toronto (Canada) | 475.51 | Heard & McDonald Island | 17,718.10 |
| 40 | OK | Mexico | 1,350.23 | Heard & McDonald Island | 17,947.21 |
| 41 | OR | Victoria (Canada) | 529.40 | Heard & McDonald Island | 18,585.64 |
| 42 | PA | Toronto (Canada) | 337.39 | Heard & McDonald Island | 17,472.99 |
| 44 | RI | Montreal (Canada) | 464.44 | Heard & McDonald Island | 17,128.14 |
| 45 | SC | The Bahamas | 884.81 | Cocos (Keeling) Islands | 17,617.17 |
| 46 | SD | Winnipeg (Canada) | 676.97 | Heard & McDonald Island | 18,929.01 |
| 47 | TN | Toronto (Canada) | 1,040.32 | Heard & McDonald Island | 17,517.86 |
| 48 | TX | Mexico | 872.67 | Heard & McDonald Island | 17,524.45 |
| 49 | UT | Calgary (Canada) | 1,297.12 | Heard & McDonald Island | 18,456.77 |
| 50 | VT | Montreal (Canada) | 208.04 | Heard & McDonald Island | 17,337.57 |
| 51 | VA | Toronto (Canada) | 636.22 | Heard & McDonald Island | 17,351.01 |
| 53 | WA | Victoria (Canada) | 229.52 | Heard & McDonald Island | 18,810.88 |
| 54 | WV | Toronto (Canada) | 537.61 | Heard & McDonald Island | 17,469.35 |
| 55 | WI | Winnipeg (Canada) | 792.24 | Heard & McDonald Island | 18,494.69 |
| 56 | WY | Regina (Canada) | 860.24 | Heard & McDonald Island | 18,891.46 |

*Note*: Distances are in kilometers

## A.2 Calculating the Remoteness Index of Each State

The remoteness index used in this study is calculated from seaport longitudinal and latitudinal location data from the U.S. Ports and Harbor Authority. The index is the weighted average distance of each state from the three nearest seaports; however, this study requires that at least one of the seaports used in calculating the index be located outside the state for which the index is being calculated. The distances are calculated using the same model of GCD formula as described above in the calculation of the distances between each state and all foreign importing countries. Then, a weight of 50 percent is placed on the distance to the nearest seaport and 30 percent for the next closest port. Last, a 20 percent weight is placed on the third closest seaport to the state. The estimated remoteness index for each state is presented in ascending rank order below in Table 2a.

Table 5: Descending Order Ranking of State Remoteness Index

| Rank | State | Rindex | Rank | State | Rindex |
|---|---|---|---|---|---|
| 1.00 | Rhode Island | 40.17 | 26.00 | Alabama | 273.95 |
| 2.00 | New Jersey | 58.07 | 27.00 | Georgia | 276.05 |
| 3.00 | Massachusetts | 63.92 | 28.00 | West Virginia | 331.59 |
| 4.00 | Delaware | 80.69 | 29.00 | Arkansas | 366.55 |
| 5.00 | Maryland | 98.04 | 30.00 | Kansas | 366.55 |
| 6.00 | Connecticut | 98.37 | 31.00 | Minnesota | 383.69 |
| 7.00 | Hawaii | 104.97 | 32.00 | Nevada | 408.40 |
| 8.00 | Florida | 115.13 | 33.00 | Alaska | 427.27 |
| 9.00 | New Hampshire | 124.76 | 34.00 | Texas | 448.92 |
| 10.00 | Washington | 147.24 | 35.00 | Kentucky | 492.83 |
| 11.00 | Louisiana | 147.81 | 36.00 | Iowa | 494.30 |
| 12.00 | California | 155.66 | 37.00 | Tennessee | 548.64 |
| 13.00 | Virginia | 178.62 | 38.00 | Arizona | 572.17 |
| 14.00 | Maine | 188.28 | 39.00 | Missouri | 578.88 |
| 15.00 | South Carolina | 197.34 | 40.00 | Idaho | 652.90 |
| 16.00 | Mississippi | 203.54 | 41.00 | Oklahoma | 679.67 |
| 17.00 | Michigan | 204.81 | 42.00 | Utah | 822.61 |
| 18.00 | Indiana | 208.51 | 43.00 | North Dakota | 830.17 |
| 19.00 | Ohio | 210.98 | 44.00 | South Dakota | 848.24 |
| 20.00 | Wisconsin | 221.80 | 45.00 | Nebraska | 928.81 |
| 21.00 | New York | 221.90 | 46.00 | Montana | 939.55 |
| 22.00 | Pennsylvania | 225.10 | 47.00 | New Mexico | 1,068.69 |
| 23.00 | North Carolina | 231.29 | 48.00 | Wyoming | 1,218.52 |
| 24.00 | Oregon | 233.84 | 49.00 | Colorado | 1,256.57 |
| 25.00 | Illinois | 262.63 | 50.00 | Vermont | 1,782.65 |

Calculations presented in Table 2a above indicate that the state of Colorado is the most remote U.S. state, whereas; Rhode Island is estimated to be the least remote U.S. state.

## A.3 Construction of the Innovative Capital Index (HCI)

To mimic Howitt and Mayer's (2002) idea that "innovative-effective" human capital must be composed of a combination of the level of education and the effort invested by the economy to develop new technologies based on the existing technological frontier, this study creates an Innovative Capital Index (*HCI*), which takes into consideration educational attainment, investment in new technologies, and production of new technologies.

The *HCI* includes four key components - college attainment rate; number of physicians, PhD's, and scientists per 1,000 population; patents issued; and research and development investment, which are combined in a three-step process to estimate the *HCI*. First, the score for the top-ranked state in each category is used to standardize the categories. Thus, each state's score will be between zero and one, where the state with a score of one in a category denotes the highest-ranked state in that category. Second, state scores in all four categories are summed and divided by four and multiplied by 100. The *HCI* in theory can thus rank between zero and 100, with 100 denoting states with the highest possible innovative capacity. Table 3a presents a ranking of states by their innovative capacity index scores.

Table 3a: Innovative Capital Index Score Ranking by State

| Rank | State | HCI | Rank | State | HCI |
|---|---|---|---|---|---|
| 1 | Delaware | 89.73 | 26 | North Carolina | 42.06 |
| 2 | Massachussetts | 85.68 | 27 | Kansas | 41.76 |
| 3 | California | 72.34 | 28 | Iowa | 39.55 |
| 4 | New Jersey | 71.87 | 29 | Indiana | 38.22 |
| 5 | Connecticut | 69.93 | 30 | Georgia | 37.55 |
| 6 | Colorado | 69.85 | 31 | Missouri | 36.67 |
| 7 | New Hampshire | 67.15 | 32 | Florida | 35.88 |
| 8 | Vermont | 60.08 | 33 | Tennessee | 31.93 |
| 9 | Maryland | 59.52 | 34 | Nebraska | 31.67 |
| 10 | Idaho | 58.40 | 35 | Nevada | 31.64 |
| 11 | Minnesota | 57.48 | 36 | Oklahoma | 31.61 |
| 12 | Michigan | 56.78 | 37 | South Carolina | 31.52 |
| 13 | Washington | 55.08 | 38 | Alaska | 31.07 |
| 14 | Utah | 53.84 | 39 | Wyoming | 30.81 |
| 15 | New York | 51.67 | 40 | Montana | 30.74 |
| 16 | Illinois | 51.25 | 41 | Hawaii | 29.37 |
| 17 | Rhode Island | 51.00 | 42 | Alabama | 29.32 |
| 18 | Oregon | 50.14 | 43 | Kentucky | 26.68 |
| 19 | Pennsylvania | 48.03 | 44 | Louisiana | 26.38 |
| 20 | New Mexico | 47.40 | 45 | Maine | 25.27 |
| 21 | Ohio | 46.88 | 46 | South Dakota | 24.65 |
| 22 | Virginia | 46.46 | 47 | North Dakota | 24.55 |
| 23 | Texas | 45.21 | 48 | Mississippi | 23.21 |
| 24 | Wisconsin | 43.07 | 49 | West Virginia | 22.27 |
| 25 | Arizona | 42.69 | 50 | Arkansas | 20.65 |

Table 4a: P-values for the Significance of the Coefficients

| | Total Exports | | High-Tech Exports | | Low-Tech Exports | |
|---|---|---|---|---|---|---|
| Model | DIST | ZDIST | DIST | ZDIST | DIST | ZDIST |
| Intercept | <.0001 | <.0001 | <.0001 | <.0001 | 0.0083 | 0.2494 |
| **Physical Distance Measures** | | | | | | |
| *DIST* | <.0001 | | <.0001 | | <.0001 | |
| *ZDIST* | | <.0001 | | <.0001 | | <.0001 |
| *REMOTE* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| **Nonphysical and Psychic Distance Measures** | | | | | | |
| *LANG* | | | | | | |
| *ENEM* | | | | | | |
| **State Variables** | | | | | | |
| *GSP* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| *SPCI* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| *HCI* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| *PC* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| *HDEN* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| *TAIR* | 0.0039 | 0.0157 | 0.0143 | 0.0157 | <.0001 | <.0001 |
| *BTARP* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| *CO2ER* | <.0001 | <.0001 | <.0001 | <.0001 | 0.224 | 0.2299 |
| *SER* | 0.0114 | 0.002 | 0.0025 | 0.002 | 0.2038 | 0.1753 |
| *LABW* | 0.0008 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| *SLITR* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| *TUNDEN* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| *CPI* | <.0001 | <.0001 | <.0001 | <.0001 | 0.1793 | 0.1594 |
| *CONTI* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| **Export Market Variables** | | | | | | |
| *CGDP* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| *CPCI* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| *XRAT* | 0.0862 | 0.1102 | 0.074 | 0.1102 | 0.4407 | 0.3116 |
| *IMPORT* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| **Trade Agreements** | | | | | | |
| *NAFTA* | <.0001 | 0.038 | <.0001 | 0.038 | 0.3218 | <.0001 |
| *BILAT* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| *APEC* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| *WTOYR* | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| **Year Dummies** | | | | | | |
| yr1989 | 0.4148 | 0.5434 | 0.5416 | 0.5434 | 0.5984 | 0.6005 |
| yr1990 | 0.2471 | 0.6854 | 0.6758 | 0.6854 | 0.338 | 0.3464 |
| yr1991 | <.0001 | 0.0019 | 0.0018 | 0.0019 | <.0001 | <.0001 |
| yr1992 | 0.0023 | 0.1017 | 0.0803 | 0.1017 | <.0001 | <.0001 |
| yr1993 | 0.0179 | 0.4618 | 0.3906 | 0.4618 | <.0001 | <.0001 |
| yr1994 | 0.0439 | 0.5026 | 0.4324 | 0.5026 | 0.0001 | 0.0002 |
| yr1995 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| yr1996 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| yr1997 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| yr1998 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| yr1999 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| yr2000 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |

Table 5a: Variance Inflation Factors for Multicollinearity Test

| | Total Exports | | High-Tech Exports | | Low-Tech Exports | |
|---|---|---|---|---|---|---|
| Model | DIST | ZDIST | DIST | ZDIST | DIST | ZDIST |
| Intercept | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **Physical Distance Measures** | | | | | | |
| *DIST* | 1.305 | | 1.305 | | 1.305 | |
| *ZDIST* | | 1.276 | | 1.276 | | 1.276 |
| *REMOTE* | 2.221 | 2.222 | 2.221 | 2.222 | 2.221 | 2.222 |
| **Nonphysical and Psychic Distance Measures** | | | | | | |
| *LANG* | 1.625 | 1.629 | 1.625 | 1.629 | 1.625 | 1.629 |
| *ENEM* | 1.309 | 1.309 | 1.309 | 1.309 | 1.309 | 1.309 |
| **State Variables** | | | | | | |
| *GSP* | 4.851 | 4.851 | 4.851 | 4.851 | 4.851 | 4.851 |
| *SPCI* | 9.354 | 9.355 | 9.354 | 9.355 | 9.354 | 9.355 |
| *HCI* | 3.449 | 3.449 | 3.449 | 3.449 | 3.449 | 3.449 |
| *PC* | 4.827 | 4.827 | 4.827 | 4.827 | 4.827 | 4.827 |
| *HDEN* | 4.140 | 4.141 | 4.140 | 4.141 | 4.140 | 4.141 |
| *TAIR* | 3.871 | 3.871 | 3.871 | 3.871 | 3.871 | 3.871 |
| *BTARP* | 2.293 | 2.293 | 2.293 | 2.293 | 2.293 | 2.293 |
| *CO2ER* | 1.790 | 1.790 | 1.790 | 1.790 | 1.790 | 1.790 |
| *SER* | 1.852 | 1.852 | 1.852 | 1.852 | 1.852 | 1.852 |
| *LABW* | 2.456 | 2.456 | 2.456 | 2.456 | 2.456 | 2.456 |
| *SLITR* | 2.663 | 2.663 | 2.663 | 2.663 | 2.663 | 2.663 |
| *TUNDEN* | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| *CPI* | 2.498 | 2.498 | 2.498 | 2.498 | 2.498 | 2.498 |
| *CONTI* | 2.252 | 2.253 | 2.252 | 2.253 | 2.252 | 2.253 |
| **Export Market Variables** | | | | | | |
| *CGDP* | 2.152 | 2.153 | 2.152 | 2.153 | 2.152 | 2.153 |
| *CPCI* | 1.753 | 1.760 | 1.753 | 1.760 | 1.753 | 1.760 |
| *XRAT* | 1.072 | 1.072 | 1.072 | 1.072 | 1.072 | 1.072 |
| *IMPORT* | 1.647 | 1.646 | 1.647 | 1.646 | 1.647 | 1.646 |
| **Trade Agreements** | | | | | | |
| *NAFTA* | 1.216 | 1.182 | 1.216 | 1.182 | 1.216 | 1.182 |
| *BILAT* | 1.047 | 1.046 | 1.047 | 1.046 | 1.047 | 1.046 |
| *APEC* | 1.294 | 1.297 | 1.294 | 1.297 | 1.294 | 1.297 |
| *WTOYR* | 2.798 | 2.797 | 2.798 | 2.797 | 2.798 | 2.797 |
| **Year Dummies** | | | | | | |
| yr1989 | 1.935 | 1.935 | 1.935 | 1.935 | 1.935 | 1.935 |
| yr1990 | 2.094 | 2.094 | 2.094 | 2.094 | 2.094 | 2.094 |
| yr1991 | 2.212 | 2.212 | 2.212 | 2.212 | 2.212 | 2.212 |
| yr1992 | 2.529 | 2.529 | 2.529 | 2.529 | 2.529 | 2.529 |
| yr1993 | 2.820 | 2.820 | 2.820 | 2.820 | 2.820 | 2.820 |
| yr1994 | 3.178 | 3.178 | 3.178 | 3.178 | 3.178 | 3.178 |
| yr1995 | 3.947 | 3.947 | 3.947 | 3.947 | 3.947 | 3.947 |
| yr1996 | 4.657 | 4.657 | 4.657 | 4.657 | 4.657 | 4.657 |
| yr1997 | 5.239 | 5.239 | 5.239 | 5.239 | 5.239 | 5.239 |
| yr1998 | 6.050 | 6.050 | 6.050 | 6.050 | 6.050 | 6.050 |
| yr1999 | 6.643 | 6.643 | 6.643 | 6.643 | 6.643 | 6.643 |
| yr2000 | 7.724 | 7.724 | 7.724 | 7.724 | 7.724 | 7.724 |

Table 6a: Variable Sources

| | |
|---|---|
| **Dependent Variables** | |
| *Total* | http://www.wisertrade.org |
| *H-tech* | http://www.wisertrade.org |
| *L-tech* | http://www.wisertrade.org |
| **Independent Variables** | |
| **Physical Distance Measures** | |
| *DIST* | Centroids for country *j* and the *i* th state from CIA fact book |
| *ZDIST* | GIS Centroid Data |
| *REMOTE* | Port Data from National Transportation Atlas Database 1999 |
| **Nonphysical and Psychic Distance Measures** | |
| *LANG* | Eff (2004) |
| *ENEM* | Eff (2004) |
| **State Variables** | |
| *GSP* | Bureau of Economic Analysis |
| *SPCI* | Bureau of Economic Analysis |
| *HCI* | CFED Development Report Card Index |
| *PC* | CFED Development Report Card Index |
| *HDEN* | National Transportation Atlas Database 1999 |
| *TAIR* | National Transportation Atlas Database 1999 |
| *BTARP* | http://www.taxfoundation.org/bp45.pdf |
| *CO2ER* | http://www.epa.gov/cleanenergy/egrid/pdfs/state.pdf |
| *SER* | Bureau of Economic Analysis |
| *LABW* | Bueau of Labor Statistics |
| *SLITR* | http://www.instituteforlegalreform.org/pdfs/2004%20full%20report.pdf |
| *TUNDEN* | Unionstats.com |
| *CPI* | Bureau of Labor Statistics |
| *CONTI* | http://www.marad.dot.gov/MARAD_statistics/Con-pts-02.htm |
| **Export Market Variables** | |
| *CGDP* | U.S. Energy Information Administration |
| *CPCI* | U.S. Energy Information Administration |
| *IMPORT* | U.S. Energy Information Administration |
| *XRAT* | International Financial Statistics |
| **Trade Agreements** | |
| *BILAT* | U.S. Trade Representative (USTR) website (http://www.ustr.gov) |
| *APEC* | U.S. Trade Representative (USTR) website (http://www.ustr.gov) |
| *NAFTA* | U.S. Trade Representative (USTR) website (http://www.ustr.gov) |
| *WTOR* | Word Trade Organization website (http://www.wto.org) |

# Appendix B

Table 1b: Summary of Proximity Matrices

| Category | Name | Equation | Data Year | Description |
|---|---|---|---|---|
| **Distance** | | | | |
| | *CONT* | Eq. (1) | 2004 | Contiguous States |
| | *DIST* | Eq. (2)-(3) | 2004 | Inverted Squared Great Circle Distance |
| **Culture** | | | | |
| | *PRELEC* | Eq. (13) | 2004 | Inverse Euclidean Distance, Presidential Elections |
| | *CONS* | | 2004 | Inverse Euclidean Distance, Average Voting Pattern of State Senate |
| **Level of** | | | | |
| | *HDI* | Eq. (17) | 2000 | Inverse Euclidean Distance Life expectancy PCI, College Attainment Rate |

Table 2b: State Human Development Index Score and Ranking

| Rank | State Name | Index | Rank | State Name | Index |
|---|---|---|---|---|---|
| 1 | Connecticut | 0.96106 | 26 | Nevada | 0.77026 |
| 2 | Massachussetts | 0.95320 | 27 | Florida | 0.76473 |
| 3 | Colorado | 0.92844 | 28 | North Carolina | 0.76463 |
| 4 | New Jersey | 0.91764 | 29 | Missouri | 0.76411 |
| 5 | Maryland | 0.91289 | 30 | Wyoming | 0.76341 |
| 6 | Virginia | 0.86487 | 31 | Ohio | 0.76327 |
| 7 | California | 0.86242 | 32 | Georgia | 0.76188 |
| 8 | New York | 0.85784 | 33 | Iowa | 0.75965 |
| 9 | New Hampshire | 0.84790 | 34 | Oklahoma | 0.73246 |
| 10 | Minnesota | 0.84609 | 35 | Montana | 0.72884 |
| 11 | Washington | 0.84502 | 36 | South Dakota | 0.72780 |
| 12 | Illinois | 0.83991 | 37 | Maine | 0.72738 |
| 13 | Vermont | 0.83031 | 38 | Idaho | 0.72529 |
| 14 | Kansas | 0.81360 | 39 | New Mexico | 0.72375 |
| 15 | Delaware | 0.81139 | 40 | Arizona | 0.72275 |
| 16 | Rhode Island | 0.80785 | 41 | Indiana | 0.71997 |
| 17 | Utah | 0.80666 | 42 | North Dakota | 0.71965 |
| 18 | Oregon | 0.80479 | 43 | South Carolina | 0.71069 |
| 19 | Alaska | 0.80364 | 44 | Tennessee | 0.70144 |
| 20 | Hawaii | 0.79817 | 45 | Kentucky | 0.69671 |
| 21 | Pennsylvania | 0.78705 | 46 | Alabama | 0.69580 |
| 22 | Nebraska | 0.78472 | 47 | Louisiana | 0.69142 |
| 23 | Texas | 0.77338 | 48 | Mississippi | 0.65900 |
| 24 | Michigan | 0.77204 | 49 | West Virginia | 0.64396 |
| 25 | Wisconsin | 0.77149 | 50 | Arkansas | 0.64331 |

Table 2b indicates that Connecticut, Massachusetts, Colorado, New Jersey, Maryland, Virginia, California, New York, New Hampshire, and Minnesota are the top 10 states in terms of human development. The lowest-ranked states in terms of human development as calculated by this study include North Dakota, Indiana, South Carolina, Tennessee, Kentucky, Alabama, Louisiana, Mississippi, West Virginia, and Arkansas.

Table 3b: Ranking of Normalized Conservative Index

| Rank | State Name | COIND | Rank | State Name | COIND |
|---|---|---|---|---|---|
| 1 | Oklahoma | 1.000 | 26 | Wisconsin | 0.544 |
| 2 | Wyoming | 0.984 | 27 | Illinois | 0.528 |
| 3 | Idaho | 0.944 | 28 | Florida | 0.527 |
| 4 | Utah | 0.874 | 29 | South Carolina | 0.514 |
| 5 | Alaska | 0.844 | 30 | New Mexico | 0.508 |
| 6 | New Hampshire | 0.839 | 31 | Michigan | 0.501 |
| 7 | Kansas | 0.826 | 32 | California | 0.493 |
| 8 | Alabama | 0.809 | 33 | Louisiana | 0.492 |
| 9 | Arizona | 0.787 | 34 | Maine | 0.482 |
| 10 | Colorado | 0.785 | 35 | Nevada | 0.472 |
| 11 | Kentucky | 0.775 | 36 | Washington | 0.452 |
| 12 | Nebraska | 0.752 | 37 | New Jersey | 0.418 |
| 13 | Mississippi | 0.724 | 38 | Oregon | 0.416 |
| 14 | Georgia | 0.696 | 39 | Maryland | 0.391 |
| 15 | Tennessee | 0.673 | 40 | New York | 0.353 |
| 16 | North Carolina | 0.642 | 41 | Virginia | 0.345 |
| 17 | Ohio | 0.630 | 42 | West Virginia | 0.338 |
| 18 | Indiana | 0.616 | 43 | South Dakota | 0.337 |
| 19 | Vermont | 0.607 | 44 | Delaware | 0.328 |
| 20 | Iowa | 0.597 | 45 | Rhode Island | 0.324 |
| 21 | Missouri | 0.564 | 46 | Connecticut | 0.310 |
| 22 | Texas | 0.560 | 47 | Arkansas | 0.275 |
| 23 | Minnesota | 0.553 | 48 | Massachussetts | 0.254 |
| 24 | Pennsylvania | 0.547 | 49 | North Dakota | 0.232 |
| 25 | Montana | 0.544 | 50 | Hawaii | 0.201 |

Table 3b above indicates that, while Oklahoma, Wyoming, Idaho, Utah, and Alaska are the five most conservative states, Connecticut, Arkansas, Massachusetts, North Dakota, and Hawaii are the five least conservative states in the U.S. If cultural values affect productivity and thus export performance, and also if the calculated conservative index proxies a state's cultural values very well, holding all other factors constant, it is the expectation of this study that Oklahoma and Wyoming will perform at similar levels on the international export markets and, North Dakota and Hawaii will also perform at similar levels. However, Massachusetts and Wyoming are expected to perform at dissimilar levels on the export market due to the big difference in their cultural values.

# Appendix C

## C.1 List of Countries Used in the Study by Region

**Africa**

Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo (Brazzaville), Congo (Kinshasa), Cote d'Ivoire (Ivory Coast), Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Saint Helena, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Western Sahara, Zambia, and Zimbabwe.

**Asia and Oceania**

Afghanistan, American Samoa, Australia, Bangladesh, Bhutan, Brunei, Burma, Cambodia, China, Cocos (Keeling) Islands, Cook Islands, Fiji, French Polynesia, Guam, Heard and McDonald Islands, Hong Kong, India, Indonesia, Japan, Kiribati, North Korea, South Korea, Laos, Macau, Malaysia, Maldives, Mongolia, Nauru, Nepal, New Caledonia, New Zealand, Niue, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Taiwan, Thailand, Tonga, Vanuatu, Vietnam, and Wake Island.

**Central and South America**

Antarctica, Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bolivia, Brazil, Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Falkland Islands, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Montserrat, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Saint Kitts and Nevis, Saint Lucia Saint Vincent/Grenadines, Suriname, Trinidad and Tobago, Turks and Caicos Islands, Uruguay, and Venezuela.

**North America**

Bermuda, Canada, Greenland, Mexico, and Saint Pierre and Miquelon.

**Eastern Europe**

Albania, Armenia, Azerbaijan, Belarus, Bulgaria, Czech Republic, Estonia, Former Czechoslovakia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Poland, Romania, Russia, Slovakia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.

**Western Europe**

Austria, Belgium, Bosnia and Herzegovina, Croatia, Denmark, Faroe Islands, Finland, France, Germany, Gibraltar, Greece, Iceland, Ireland, Italy, Luxembourg, Macedonia, Malta, Netherlands, Norway, Portugal, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and Yugoslavia (Serbia and Montenegro).

**Middle East**

Bahrain, Cyprus, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, and Yemen.

## C.2 Trade Agreements and Member Countries

**North American Free Trade Agreement**

Canada, and Mexico.

**Bilateral Trade Agreements**

Israel, and Jordan.

**Asian Pacific Economic Cooperation**

Table 1c: Apec Member Ecnomies and Year of Membership

| Country | Year of Membership |
|---|---|
| Australia | 1989 |
| Brunei | 1989 |
| Canada | 1989 |
| Chile | 1989 |
| China | 1991 |
| Hong Kong | 1991 |
| Indonesia | 1989 |
| Japan | 1989 |
| Republic of Korea | 1989 |
| Malaysia | 1989 |
| Mexico | 1993 |
| New Zealand | 1989 |
| Papua New Guinea | 1993 |
| Peru | 1998 |
| Philippines | 1989 |
| Russia | 1998 |
| Singapore | 1989 |
| Chinese Taipei | 1991 |
| Thailand | 1989 |
| United States | 1989 |
| Vietnam | 1998 |

## World Trade Organization

Table 2c: WTO Member Countries and their Year of Membership

| Country | Year | Country | Year | Country | Year |
|---|---|---|---|---|---|
| Albania | 2000 | Gabon | 1995 | Netherlands Antilles | 1995 |
| Angola | 1996 | Gambia, The | 1996 | New Zealand | 1995 |
| Antigua and Barbuda | 1995 | Georgia | 2000 | Nicaragua | 1995 |
| Argentina | 1995 | Georgia | 2000 | Niger | 1996 |
| Armenia | 2003 | Germany | 1995 | Nigeria | 1995 |
| Armenia | 2003 | Ghana | 1995 | Norway | 1995 |
| Australia | 1995 | Greece | 1995 | Oman | 2000 |
| Austria | 1995 | Guinea | 1995 | Pakistan | 1995 |
| Bahrain | 1995 | Guinea-Bissau | 1995 | Panama | 1997 |
| Bangladesh | 1995 | Guyana | 1995 | Papua New Guinea | 1996 |
| Barbados | 1995 | Haiti | 1996 | Paraguay | 1995 |
| Belgium | 1995 | Honduras | 1995 | Peru | 1995 |
| Belize | 1995 | Hong Kong | 1995 | Philippines | 1995 |
| Benin | 1996 | Hungary | 1995 | Poland | 1995 |
| Bolivia | 1995 | Iceland | 1995 | Portugal | 1995 |
| Botswana | 1995 | India | 1995 | Qatar | 1996 |
| Brazil | 1995 | Indonesia | 1995 | Romania | 1995 |
| Brunei | 1995 | Ireland | 1995 | Rwanda | 1996 |
| Bulgaria | 1996 | Israel | 1995 | Saint Kitts and Nevis | 1996 |
| Burkina Faso | 1995 | Italy | 1995 | Saint Lucia | 1995 |
| Burma | 1995 | Jamaica | 1995 | Saint Vincent/Grenadines | 1995 |
| Burundi | 1995 | Japan | 1995 | Senegal | 1995 |
| Cambodia | 2004 | Jordan | 2000 | Sierra Leone | 1995 |
| Cameroon | 1995 | Kenya | 1995 | Singapore | 1995 |
| Canada | 1995 | Korea, South | 1995 | Slovakia | 1995 |
| Central African Republic | 1995 | Kuwait | 1995 | Slovenia | 1995 |
| Chad | 1996 | Kyrgyzstan | 1998 | Solomon Islands | 1996 |
| Chile | 1995 | Kyrgyzstan | 1998 | South Africa | 1995 |
| China | 2001 | Latvia | 1999 | Spain | 1995 |
| Colombia | 1995 | Latvia | 1999 | Sri Lanka | 1995 |
| Congo (Brazzaville) | 1997 | Lesotho | 1995 | Suriname | 1995 |
| Congo (Kinshasa) | 1997 | Lithuania | 2001 | Swaziland | 1995 |
| Costa Rica | 1995 | Lithuania | 2001 | Sweden | 1995 |
| Cote d'Ivoire (IvoryCoast) | 1995 | Luxembourg | 1995 | Switzerland | 1995 |
| Cuba | 1995 | Macau | 1995 | Tanzania | 1995 |
| Cyprus | 1995 | Madagascar | 1995 | Thailand | 1995 |
| Czech Republic | 1995 | Malawi | 1995 | Togo | 1995 |
| Czech Republic | 1995 | Malaysia | 1995 | Trinidad and Tobago | 1995 |
| Denmark | 1995 | Maldives | 1995 | Tunisia | 1995 |
| Djibouti | 1995 | Mali | 1995 | Turkey | 1995 |
| Dominica | 1995 | Malta | 1995 | Uganda | 1995 |
| Dominican Republic | 1995 | Mauritania | 1995 | United Arab Emirates | 1996 |
| Ecuador | 1996 | Mauritius | 1995 | United Kingdom | 1995 |
| Egypt | 1995 | Moldova | 2001 | Uruguay | 1995 |
| El Salvador | 1995 | Moldova | 2001 | Venezuela | 1995 |
| Estonia | 1999 | Mongolia | 1997 | Yugoslavia (Serbia and Montenegro) | 2003 |
| Estonia | 1999 | Mozambique | 1995 | Yugoslavia (Serbia and Montenegro) | 2003 |
| Fiji | 1996 | Namibia | 1995 | Zambia | 1995 |
| Finland | 1995 | Nepal | 2004 | Zimbabwe | 1995 |
| France | 1995 | Netherlands | 1995 | | |