Exporting Mass Destruction?
The Determinants of Dual-Use Trade

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ABSTRACT

This study applies well-known arguments on the effect of conflict, alliances, and democracy on international trade to identify the determinants of dual-use trade. Dual-use commodities are those that can be used in weapons of mass destruction (WMD) programs or in legitimate civilian applications. This article advances a theory suggesting that governments seeking to maximize the gains from dual-use trade will promote exports to countries where there are security guarantees and restrict exports to countries where security threats exist. Eight hypotheses are tested using data on licensed dual-use exports from the United States to 128 countries between 1991 and 2001. The results indicate that democracy has a positive and significant effect on dual-use exports while WMD acquisition or pursuit does not necessarily reduce states' access to such commodities. The results vary slightly based on how dual-use exports are measured. In conducting the first systematic analysis on the determinants of dual-use trade, this study contributes to scholarly understanding of WMD proliferation and generally research at the nexus of international trade and international security. In particular, it offers important prescriptions for when states are likely to transfer technology that could be used to build WMD. It also encourages further work that disaggregates trade data to examine relationships between particular types of trade on conflict, alliances, free trade agreements, and other political variables.

INTRODUCTION

Many studies have found that an understanding of international trade cannot be divorced from an understanding of international politics. Three broad arguments dominate this literature. The first is that militarized conflict[1] or the expectation of future conflict reduces trade flows among states because economic actors respond to the risk that conflict adds to their transactions (Pollins, 1989a,b). The second is that democratic states trade more with each other than with non-democratic pairs of states. Given that democracies have limited government, the supposition here is that economic actors are protected from arbitrary and authoritative trade policies (Dixon & Moon, 1993; Bliss & Russett, 1998; Russett & Oneal, 2001). The third is that allies are more likely to trade with one another than non-allies because states fear their trading partners may use the benefits from trade to augment military capabilities (Gowa & Mansfield, 1993; Gowa, 1994; Mansfield & Bronson, 1997; Long, 2003). While the theoretical forces driving these arguments differ, they all connect economics and security in international relations.

It remains an open question whether these same relationships apply to trade in dual-use goods. As the name implies, dual-use commodities have two applications; they can be used in weapons of mass destruction (WMD) programs but also have many legitimate civilian applications.[2] During the Cold War, international trade, particularly dual-use trade, reflected the political/military division of the world along two distinct blocs (Bertsch, 1988; Mastanduno, 1992). The Coordinating Committee for Multilateral Export Controls (COCOM)—the "economic arm" of the North Atlantic Treaty Organization (NATO)—restricted dual-use trade between East and West to stymie the economic and military power of the Soviet Union and its allies. With the Soviet threat

diminished, it is unclear whether the United States still has a strategic incentive to link security and economics (Skålnes, 2000).

This article seeks to uncover the determinants of dual-use trade in the post-Cold War era. It advances a theory that suggests governments seeking to maximize the gains from dual-use trade will promote exports to countries where there are security guarantees and restrict exports to countries posing security threats. Such behavior allows states to reap the benefits of trade while minimizing its potentially damaging side-effects. Side-effects include the potential for a state to employ dual-use technology for military purposes or re-export the technology to a third-state, allowing it to do the same. Both scenarios could undermine the security of the supplier state. Although it draws from several theoretical approaches, this argument builds primarily on literature from the realist perspective, which posits that "security externalities" arise from international trade (Gowa & Mansfield, 1993; Gowa, 1994; Mansfield & Bronson, 1997; Long, 2003). States have no assurances that their trading partners will not use the gains from trade to augment military power and ultimately threaten their security.

Consequently, a government has incentives to promote dual-use trade with military allies and democratic regimes and disincentives to trade such items with states it recently engaged in militarized conflict with, states where the expectation of future conflict is high, and regimes that have acquired WMD or are purported to be pursuing such weapons. The two former variables provide security assurances; the latter four represent security threats. I also expect that the extent to which WMD pursuit or acquisition impacts dual-use trade depends on whether militarized conflict with the state pursuing such weapons is a possibility in the future. To evaluate this theory, this article

analyzes licensed dual-use exports from the United States to 128 countries between 1991 and 2001. Empirical support for many of these expectations is found. The results vary slightly based on whether dual-use trade is measured as the number of approved licenses or the total dollar value of the exports. Some noteworthy findings stand out. Democracy, which is an indicator of security guarantees, has a positive and significant effect on dual-use exports regardless of how they are measured. Interestingly, WMD acquisition or pursuit does not necessarily reduce dual-use exports. Rather, such activity has a negative effect on dual-use trade only when it is undertaken by a potential adversary. The exact magnitude and significance of this effect is dependant on how dual-use exports are measured. This is also true of the alliance and conflict variables.

In considering why and how states transfer WMD-related technology, this study contributes to a growing body of literature on horizontal proliferation (Braun and Chyba 2004; Montgomery 2005; Kroenig 2007). The findings of this research lend some support the realist theory of security externalities (e.g. Gowa, 1994) and generally speaking, arguments positing that security and power influence international trade. The argument put forth here also contributes to the literature on economic statecraft (e.g. Baldwin, 1985) by suggesting that states channel dual-use trade towards states where there are security guarantees and away from states representing security threats in the post-Cold War world. Additionally, this study enhances scholarly knowledge of a topic that is presently scantily understood.[3] Deepening our understanding of dual-use trade serves to uncover important links between international trade, international security, and WMD proliferation.

There are important policy-based reasons for enhancing our understanding of dual-use trade. Virtually every component of a WMD program is a dual-use commodity (Fuhrmann, 2006). Thus, if the international community is to prevent future WMD-related crises, an important first step involves achieving a greater understanding of the determinants of dual-use trade. At present, most governments do not fully appreciate the security implications of dual-use trade and have not done adequate statistical analysis on the topic. For example, a recent report issued by the US Government Accountability Office (2006) revealed that Washington "has not comprehensively analyzed available data to determine what dual-use items have actually been exported."

This article proceeds by providing a brief description of how governments control the export of dual-use commodities. Next, a theory of dual-use trade is elucidated that draws from the extant literature and eight hypotheses are put forth. The third section explains the research design and the fourth section presents the results of this analysis. The article concludes by commenting on the implications of these findings and identifies opportunities for future research.

THE CONTROL OF STRATEGIC COMMODITIES

Given the potentially dangerous nature of dual-use goods, most governments place restrictions on their export. In many countries, including the United States, entities seeking to export dual-use technology may have to obtain a license from a governmental agency depending on what the good is and the purported end-user of that good. The channeling of goods in this nature has a lengthy history. The *Corpus Juris Civilis* (Code of Justinian), which was issued by the Byzantine emperor from 529 to 534, makes

reference to controls on "unfinished materials" that could be used in certain types of weapons.[4] This is perhaps the earliest known case of dual-use export control.

The modern system of export control in the United States dates back to World War I when it passed the 1917 Trading with the Enemy Act (TWEA) to institute a naval certification system for exports in cooperation with Great Britain (Cupitt, 2003). Unlike in many other countries, the system for licensing the export of strategic commodities in the United States has two separate components—one for military goods and one for dual-use goods. The focus here is exclusively on the latter. Under the authority of the Export Administration Act of 1979, the United States Department of Commerce (DOC) controls exports and re-exports of dual-use technologies. These controls are maintained primarily for reasons of national security and foreign policy. In particular, they are designed to limit the proliferation of nuclear, chemical, and biological weapons and missile technology.

This process of licensing, which has always been complex, became even more complicated in the post-Cold War era (Beck, Cupitt, Gahlaut & Jones, 2003). In order to fully understand the theory presented in this article, it is important to recognize some specifics of the licensing process. In particular, it is imperative to comprehend that all countries were not subject to the same export control regulations throughout the 1990s.[5] Section 5(b) of the EAA requires the President to create a list of controlled countries for national security purposes. In the early 1990s, this list and related "Country Groups" served as the basis for many licensing decisions. Certain dual-use goods including telecommunication equipment, for example, required a license to be sent to controlled

countries, but a license was not necessarily required to send the same piece of equipment to a close ally.[6]

The nature of these regulations creates some potential roadblocks to any analysis of licensed dual-use trade. As Cupitt (2001: 6) points out, "the ambiguity of the multiple classification schemes always will impose some error into the analysis." My approach to addressing these issues is explained in the methodology section below. For now it will suffice to state that despite measurement issues associated with licensed dual-use trade, these are the best suited available data to test the hypotheses elucidated below.

TOWARDS A THEORY OF DUAL-USE TRADE

The experience of COCOM and the nature of dual-use technology suggest that realism offers an appropriate theoretical foundation. Although realism serves as the theoretical base, I will also draw from the logic of other approaches to put forth a complete theory of dual-use trade. Given the security externalities (Gowa & Mansfield, 1993; Long, 2003) of dual-use trade, a state licensing dual-use technology will seek to minimize the possibility that its exports will be used in a WMD program and mitigate the adverse effects should such materials be used in military applications. A state will want to avoid overly burdensome restrictions that may threaten its own economic wellbeing, while protecting its security interests at the same time. To maintain the appropriate balance between trade interests and security interests, states will seek to: (1) maximize dual-use trade to countries where there are security guarantees; and (2) minimize dual-use trade to countries posing security threats. Security guarantees decrease the likelihood that dual-use technology will be intentionally diverted to a third state and minimize the security risks that would ensue if a state decided to use it to bolster its military capabilities.

Conversely, security threats increase the likelihood that dual-use technology could end up in the wrong hands or be used for unauthorized military purposes. Moreover, the presence of security threats magnifies the damaging effects of WMD program development. Below, I explain the theoretical logic behind each of these expectations and identify the sources of guarantees and threats.

Security Guarantees and Dual-Use Trade

Given the security externalities of trade described above, states have incentives to trade with allies. While enemies may fear what one another might do with the gains from trade, allies are less concerned with this because they typically pursue similar ends. Additionally, alliances decrease the likelihood that states will be taken advantage of. Investors face the risk that a foreign government will engage in opportunistic behavior, meaning that they may impose new or raise existing trade barriers, which would decrease the value of an investment. States are less likely to behave opportunistically towards allies because such behavior could reduce cooperation and ultimately weaken the alliance (Mansfield & Bronson, 1997: 95; Long, 2003).

Based on this logic, predictions can be made regarding the effect of alliances on dual-use trade. First, states are less likely to feel threatened if an ally acquires WMD or significantly augments military capabilities in any other way. Second, allies are more likely to protect the dual-use technology they import than are adversaries. In other words, allies are less likely to intentionally engage in careless re-exports of sensitive technology. Such behavior could threaten the security of the supplier state and if repeated, result in the collapse of the alliance. Since states depend on an alliance to enhance their security, they are unlikely to intentionally jeopardize its existence. The

culmination of these two factors means that allies can exchange dual-use technology with a degree confidence. An alliance substantially increases the likelihood that imported dual-use technology will be used for its stated purpose, and not in a manner that may undermine the supplier state's security interests.

As Long (2003) has pointed out, there are good reasons to expect different types of alliances to have a different impact on trade. In particular, the potential increase in military power from gains through trade is a positive security externality only when a commitment exists to aid a partner in the event of military conflict. The assurance of protection means that states have a vested interest in augmenting one another's military capabilities prior to the onset of conflict. The same is not necessarily true of neutrality or consultation pledges. Moreover, since the obligation to use force to aid one another in hostilities represents a more solid commitment than either neutrality or consultation, the opportunity costs of re-exporting sensitive dual-use technology are much higher. Defense pacts provide the necessary assurances governments need to exchange dual-use goods with confidence, while other types of alliances may not:

> Hypothesis 1: *States party to a common defense pact exchange more dual-use commodities than states that are not party to a common defense pact.*

Security guarantees can also emerge from regime type. Previous studies have advanced the assertion that democratic partners trade more than non-democratic partners (Dixon & Moon, 1993; Bliss & Russett, 1998). These arguments typically draw from the democratic peace theory (e.g. Doyle, 1983), which suggests that democratic states are unlikely to engage in militarized conflict with one another. As Bliss & Russett (1998: 1128) suggest, this means that democratic leaders are less concerned that another state

will use the gains from trade to threaten their security. Since the likelihood of future conflict is low, a democracy has little to fear from another democracy's increase in power. This logic can be applied to dual-use trade as well. It implies that democratic governments will be more inclined to authorize the export of dual-use technology to other democratic states because the sale of such commodities are unlikely to threaten their security—even if they are employed directly in a military application. A crucial source of fear is mitigated as a result of the peaceful relations that exist among democracies, which enables democratic states to supply dual-use technology to one another with confidence.

There is an additional reason to expect that democratic partners will exchange more dual-use commodities than non-democratic partners. The political institutions in democracies reduce uncertainty and promote confidence among trading partners—both of which facilitate trade. As Morrow, Siverson & Tabares (1998) argue, the rule of law in democracies assures foreign firms' fears that their interests will not be handled capriciously. As far as dual-use trade is concerned, democratic institutions provide assurances that sensitive dual-use technology will not be *intentionally* diverted to a third party. The shared norms and values of democratic states as well as the low expectation of future conflict provide similar assurances; democratic trading partners are less likely to engage in behavior that might undermine one another's security, such as the intentional diversion of technology to a third party.

Hypothesis 2: *Democratic states exchange more dual-use commodities than non-democratic states.*

Security Threats and Dual-Use Trade

Previous studies have demonstrated convincingly that war stops, or substantially reduces, trade because governments forbid trade with enemies and economic actors face too many risks for trade to be profitable (Anderton & Carter, 2001; Glick & Taylor, 2005).[7] Other studies have analyzed the impact of conflict short of war on international trade (Pollins 1989a,b; Morrow, Siverson & Tabares, 1998; Bliss & Russett, 1998; Li & Sacko, 2002). These empirical findings are mixed, in part because of theoretical inconsistencies and measurement issues (Li & Sacko, 2002). Given the nature of dual-use commodities, however, there are strong theoretical reasons to expect that militarized conflict—whether war or conflict short of war—would have an impact on trade. In his innovative study, Pollins (1989a: 738) suggests that economic enterprises will be aware of the political relationship of importing and exporting nations, particularly whether the two are engaged in militarized conflict. I expect this to be especially true when dual-use commodities are being exchanged. Governments are likely to limit the export of dual-use technology to adversaries and may even institute an embargo of such items to punish or shun those that they perceive as foes (Hufbauer, Schott, & Elliott, 1990). Taking this into account, the third hypothesis pertains to the direct effect of conflict and trade:

> Hypothesis 3: *States engaged in militarized conflict exchange fewer dual-use commodities than states not engaged in conflict.*

The threat of future conflict can also exert an indirect influence on trade. Since governments and economic agents forecast the possibility of future political disruptions on trade, the mere prospect of conflict can impact patterns of trade (Morrow, Siverson and Tabares, 1998). Additional studies (Li & Sacko, 2002; Long, 2003) have substantiated the argument that trade is suppressed *ex ante* before conflict actually

occurs. Further, Drezner (1998) finds that states are more likely to initiate economic coercion when the likelihood of future conflict is high, even if it is costly to do so. Based on this logic, I expect a state to be especially wary about licensing dual-use technology to a country it believed the probability of future conflict with was high. Governments should preemptively adjust their trade policies in response to the probability of future conflict. Following Morrow et al. (1998: 650), hypothesis 4 assumes that common interests are an indicator of less conflict in the future. Divergent interests can also reduce trade indirectly by increasing the risk premium to those involved in trade (Dixon & Moon, 1993):

> Hypothesis 4: *Countries with highly dissimilar foreign policies will engage in less dual-use commerce than countries that do not have highly dissimilar foreign policies.*

Security threats may stem from exporting dual-use technology to countries purported to be pursuing WMD programs or states that have acquired WMD. When this is the case it is likely that exported technology would be used directly in military applications, which is something that suppliers seek to avoid. Indeed, states often impose economic sanctions against those that pursue WMD that explicitly limit the export of dual-use technology (Joseph, 2005). There are reasons to believe that WMD would have a different effect on dual-use trade depending on whether a state has actually acquired such weapons or is in the process of pursuing them. In the latter case, states are likely to work extra hard to ensure that this capability is not achieved. Once these weapons are obtained, however, suppliers may be less willing to restrict potentially lucrative dual-use exports.

Hypothesis 5: *States that have acquired WMD receive less dual-use trade than states that have not done so.*

Hypothesis 6: *States pursuing WMD receive less dual-use trade than states that are not doing so.*

Based on the logic above, I expect that WMD pursuit will have a stronger adverse effect on dual-use trade than WMD acquisition.

There are additional caveats to hypotheses 5 and 6. I expect that the United States will be more threatened by WMD in some countries than in others. As Alexander Wendt (1995) notes, Washington worries very little about the large quantities of nuclear weapons held by the British, but the possibility that North Korea has just a few such weapons generates tremendous concern. Based on this logic, I expect that an adversary's alleged WMD program might have a greater impact on dual-use trade than an ally's WMD program. The combination of WMD pursuit and the expectation of militarized conflict provide states with extra disincentives to exchange dual-use commodities. Two related hypotheses flow from this reasoning:

Hypothesis 7: *States possessing WMD and that have highly dissimilar foreign policies engage in less dual use commerce than states that possess WMD and do not have highly dissimilar foreign policies.*

Hypothesis 8: *States that are pursuing WMD and have highly dissimilar foreign policies engage in less dual use commerce than states that are not pursuing WMD and do not have highly dissimilar foreign policies.*

Again, I expect that WMD pursuit among states with highly dissimilar foreign policies will have a stronger negative effect than WMD acquisition among states with highly dissimilar foreign polices.

RESEARCH DESIGN

Having identified the article's hypotheses, I turn to the data and methodology employed to analyze dual-use trade. This article analyzes licensed dual-use exports from the United States between 1991 and 2001, in aggregate. These temporal and spatial parameters were driven largely by data restrictions; data on dual-use trade are not readily available. The temporal period was chosen because it allows for an evaluation of dual-use trade in the post-Cold War era, which is different than Cold War dual-use trade when restrictions were comparatively lax and directed towards the former Warsaw Pact countries. While temporally disaggregated data may be ideal (Shellman, 2004), data restrictions do not presently allow this. Aggregating the data does offer some advantages because the value of licensed dual-use trade to the same country can vary substantially from year-to-year. For example, licensed dual-use trade to the United Arab Emirates exceeded $1.2 billion in 1997 but sunk to $3.8 million in 2000 and $6.1 million in 2001.

I chose to analyze dual-use exports from the United States for two reasons. First, the United States represents the most theoretically interesting case. It exports the largest volume of dual-use technologies, and is instrumental in setting international export control standards. Second, data limitations make it difficult to include other countries.

Dependent Variables and Measurement

The dependent variable in this study is the volume of U.S. dual-use exports to country *j,* in aggregate, from 1991-2001. This variable is measured in two different ways. The first

is the total dollar value of licensed U.S. dual-use exports to country *j*. The second is the total number of approved export licenses to country *j*.

These data were obtained from the US Department of Commerce/Bureau of Industry and Security (DOC/BIS) in April 2002. DOC/BIS issues licenses for items that can contribute to nuclear, chemical, and biological weapons programs as well as missile programs. It also issues licenses for reasons of national security, anti-terrorism, regional stability, firearms control, and crime control. Items controlled by DOC/BIS fall into one of eleven categories.[8] Table I lists these categories as well as the amount of dual-use exports corresponding to each from 1991-2001. Some of the exported commodities reflected in these values are controlled for reasons other than WMD proliferation (e.g. night vision goggles, which are restricted for crime control). However, the author's consultations with experts on U.S. export control policy reveal that upwards of 90% of controlled dual-use exports are proliferation-relevant. Although it is impossible to know exactly what percentage of these figures is made up of proliferation-related commodities—at least given the existing data—there is some additional evidence to substantiate this assertion. Consider the group with the largest volume of exports (in terms of dollar value and approved licenses)—materials. Of the 117 export control classification numbers (ECCNs) corresponding to controlled dual-use items in this category, 86 (74%) are controlled for purposes of nonproliferation.[9] Moreover, my interview with a DOC/BIS official (2006) revealed that the Department of Energy (DOE) receives more license referrals than any other agency, suggesting that a significant number of licenses are issued for nuclear-related items.

Insert Table I here.

The study of dual-use trade imposes a number of empirical challenges on researchers. Data on dual-use trade in general are not available. Unfortunately, those who have kept records on trade have not thought in terms of whether a good is dual-use. Thus, this article analyzes licensed dual-use trade—not all dual-use trade. Given the nature of the export licensing system, data on licensed dual-use trade cannot be examined at face value. The key consequence of this is that figures on licensed dual-use exports to the strongest adversaries of the United States are inflated. As Table II reveals, from 1991 to 2001, two adversaries of the United States, Cuba and North Korea received $7.46 billion and $4.39 billion worth of licensed "dual-use" exports, respectively. This is significantly more dual-use exports than the United States approved to most of its European allies. The reason is that a very significant portion of exports to countries like Cuba and North Korea requires a license—no matter what it is. These two countries and a few others routinely appear on the U.S. State Department's list of countries that sponsor international terrorism, which means that any kind of economic assistance, including dual-use exports, is significantly curtailed and may even be prohibited. The bottom line is that while figures for dual-use exports to these countries reflect a significant amount of trade, it is highly unlikely that anything of strategic significance is actually exchanged.

Insert Table II here.

There is a second related, but less severe, problem. Figures on exports to the closest allies, particularly the former COCOM allies, are deflated. For example, the United States licensed $3.14 billion worth of dual-use trade to Canada between 1991 and 2001, making it the fifteenth largest importer of licensed U.S. dual-use commodities during this time period. While this is a significant amount of dual-use trade, it likely does not reflect all relevant sales given that Canada has been the leading destination of U.S. exports since 1946.[10] The nature of the U.S. licensing system allows for some dual-use technology to pass to Canada and other former COCOM countries without the issuance of a license. Thus, some volume of dual-use trade is not reflected in data on *licensed* dual-use trade. However, unlike the countries listed as terrorism sponsors, everything included in the figures on dual-use trade to these countries are in fact strategic commodities.

How can this issues be addressed? The objective is to analyze US exports to as many countries as possible without introducing error in the dependent variable. For the reasons specified above, countries that appeared on Washington's list of terrorism sponsors during the time period under analysis (1991-2001) must be excluded from this analysis.[11] The former COCOM allies must also be excluded.[12] This results in the omission of 23 cases and leaves 128 countries in the sample. Licensed dual-use trade very closely approximates all dual-use trade to this set of countries. Although this approach may not be ideal, it allows us to analyze dual-use trade while deleting only a limited number of observations.

Independent Variables and Measurement

There are a number of independent variables employed to operationalize the security guarantees and threats associated with dual-use trade. With respect to the former, dummy variables measuring whether the importing state shares an alliance with the United States and whether it is a democracy are included. To determine whether a country has an alliance with the United States, I consulted version 3.0 of the Correlates of War Formal Alliance Data (Gibler & Sarkees, forthcoming). Countries are considered allies if they shared a defense pact from 1991 until 2001.[13] Democracy data were obtained from the Polity IVd dataset (Beardsley & Gleditsch, 2003). Polity scores, which range from -10 to 10, are calculated by subtracting the score for the general closedness of political institutions from the score for the general openness of political institutions. A country is considered democratic if it has a score greater than or equal to seven on this scale. Previous studies have identified seven as a "natural cutpoint" and it has become fairly standard to use this threshold (Reiter, 2001).

Security threats emanate from militarized conflict, WMD pursuit, WMD acquisition, and expectations of future conflict. To operationalize militarized conflict, I consult data compiled by Richard Grimmett (2002) that lists all uses of U.S. armed forces abroad from 1789 to 2001. The instances of force deployment listed in this database can be classified as: combat operations; humanitarian crises; transportation of troops; evacuation of American citizens; offensive compliance monitoring; and peacekeeping. Two of these categories—combat operations and offensive compliance monitoring—stand out as particularly aggressive measures. Theoretically, there is reason to believe that these types of operations are the type of conflict that should suppress dual-use trade. Thus, states are coded as being engaged in conflict with the United States if the latter

country deploys troops to: 1) engage in combat against the state; or 2) engage in offensive compliance monitoring such as no-fly zones or embargoes.

To measure the likelihood of future conflict, I include a variable measuring the dissimilarity of foreign policy interests between the importing state and the United States. The spatial model of foreign policy similarity, *S,* which ranges from negative one for entirely divergent interests to positive one for completely convergent interests, is employed here (Signorino & Ritter, 1999). Given that this study analyzes exports from a major power, I include the global, weighted S-score to appropriately measure common interests.[14] Theoretically, there is reason to believe that this variable should be dichotomous rather than continuous. The expectation is that the United States will be particularly concerned about exporting dual-use technology to a country where the probability of future conflict is high, but will not be more worried by an *S*-score of -.9 than an *S*-score of -.8. The likelihood of future conflict is considered high if the average *S*-score between 1991 and 2001 falls in the lowest tenth percentile.[15]

Data on states pursuit of acquisition of nuclear weapons are obtained from Singh and Way (2004).[16] Similar data relating to chemical and biological weapons were obtained from estimates compiled by the Center for Nonproliferation Studies (2002).[17]

The Models

To evaluate the effect of the independent variables on dual-use exports I begin with a modified gravity model, which describes trade flows in terms of factors that influence the supply of exports, factors that affect the demand for imports, and factors the facilitate or restrict the flow of trade between them. Gravity models have a long history of providing a base empirical model of dyadic trade (Aitken 1973; Anderson 1979; Deardorff 1998).

Although different variants of the model have been advanced, it remains widely accepted that a state's capacity to supply exports as well as a state's demand for imports is directly related to its GDP (Anderson, 1979; Deardorff, 1998). Population is typically included in the model as a proxy for a country's market size (Aitken, 1973: 882). Distance is included to capture the transportation and transaction costs associated with trade. These costs are expected to rise as the distance between two countries increases.[18]

In addition to the standard measures, I add one additional control variable—the total value of regular trade—to set the proper baseline for comparison between regular and dual-use trade.[19] As well, I include the independent variables that operationalize the security guarantees and security threats of dual-use trade. I take the natural log of all interval level variables to make the equation linear. The final model is semi-logarithmic due to the inclusion of dummy variables. Thus, the model estimated is:

$$\ln X_{i(t)} = \beta_0 + \beta_1 \ln(GDP_{j(t)}) + \beta_2 \ln(POP_{j(t)}) + \beta_3 \ln(DIST_{j(t)}) + \beta_4 ln(EXPORTS_{j(t)}) + \beta_5 ALLY_{j(t)} + \beta_6 DEMOCRACY_{j(t)} + \beta_7 DISSIMILARITY_{j(t)} + \beta_8 CONFLICT_{j(t)} + \beta_9 WMD\_AQUISITION_{j(t))} + \beta_{10} WMD\_PURSUIT_{j(t))} + \beta_{11} DISSIMILARITY_{j(t)} \; X \; WMD\_ACQUISITION_{j(t)} + \beta_{12} DISSIMILARITY_{j(t)} \; X \; WMD\_PURSUIT_{j(t)} \quad (1)$$

The dependent variable is measured in two ways. The first is the natural logarithm of the value of dual-use exports from the United States to country *j* in aggregate from 1991-2001. The second is the natural logarithm of the number of approved licenses to country *j* in aggregate from 1991-2001. The independent variables are defined as follows:

ln$GDP_{i(t)}$ is the natural logarithm of the average GDP, measured in current US dollars, of country *j* from 1991-2001;

ln$POP_{j(t)}$ is the natural logarithm of the average national population in country *j*, measured in thousands, from 1991-2001;

ln$DIST_{i(t)}$ is the natural logarithm of the geographical distance between the United States and country *j* that equals 0 if a country shares a land border with the United States;

ln$EXPORTS_{i(t)}$ is the natural logarithm of the value of all exports from the United States to country *j* from 1991-2001;

$ALLY_{j(t)}$ is a dummy variable that equals one if country *j* is part of a defense pact with the United States between 1991 and 2001 and zero otherwise;

$\text{DEMOCRACY}_{i(t)}$ a dummy variable that equals one if the average Polity score for country *j* from 1991-2001 is seven or greater;

$CONFLICT_{i(t)}$ is a dummy variable that equals one if U.S. troops were deployed to take up aggressive operations against country *j* at least once between 1991 and 2001, and zero otherwise;

$DISSIMILARITY_{i(t)}$ is a dummy variable that equals one if the average compatibility of country *j's* foreign policy with the United States from 1991-2001 is in the lowest tenth percentile, and zero otherwise;

$WMD\_ACQUISITION_{i(t)}$ is a dummy variable that equals one if country *j* acquired nuclear, chemical, or biological weapons at any point from 1991 to 2001 and zero otherwise.

$WMD\_PURSUIT_{(t)}$ is a dummy variable that equals one if country *j* was pursuing or exploring chemical or biological weapons at any point from 1991 to 2001 and zero otherwise.

The two interaction terms are included to test the hypothesized effect of WMD pursuit and acquisition on dual-use trade.

Two models are estimated below. Model 1 measures dual-use exports as the natural logarithm of the dollar value of such exports. Model 2 measures dual-use exports as the natural logarithm of the number of approved licenses. Each model is estimated using Ordinary Least Squares (OLS) regression with robust standard errors.[20] In each case, a Breusch-Pagan / Cook-Weisberg test for heteroskedasticity was conducted and the null hypothesis of constant variance was easily rejected ($p<.0001$). This provides reason to believe that estimating this model using standard OLS regression may violate the assumption of homoskedastic error variances across all observations.

RESULTS

The hypotheses stated above suggest that states should export more dual-use technology when security guarantees are provided and less dual-use technology in the presence of security threats. The results provide some support for these expectations. Table III and Table IV display the results of the OLS regression.[21] From the information available in Table III, I can examine the effect of alliances, democracy, conflict, and the control variables on dual-use exports.

The coefficient on the variable measuring democracy is positive and statistically significant in Model 1. Substantively, the results indicate that democratic states receive 193% more dual-use exports from the United States than non-democracies.[22] This finding provides support for Hypothesis 2 and the argument that democracy and trade are positively correlated (Dixon & Moon, 1993; Bliss & Russett, 1998). Contrary to expectations, the coefficient on the variable measuring whether a state is an ally of the

United States is not statistically significant in Model 1. Also in contrast to theoretical predictions, the coefficient on the variable representing militarized conflict is not statistically significant in this model. Most of the control variables do not behave as expected in Model 1. Only the coefficient on the variable measuring all exports is significant and in the expected direction. This may be in part because overall exports are highly correlated with GDP, population, and distance.

More information is needed to interpret the WMD and Dissimilarity variables. I expect that the effect of WMD on dual-use exports differs based on Dissimilarity, which is a proxy for the likelihood of future conflict. To interpret the effect of these variables, I follow the advice of Brambor, Clark, and Golder (2005) and present the marginal effect of each variable when the modifying variable is present and absent as well as the corresponding standard errors.[23] This information is presented in Table IV. Interestingly, the estimates of Model 1 lend support to the hypothesized effect of WMD pursuit and acquisition on dual-use exports. Both WMD pursuit and WMD acquisition have a substantively strong, statistically significant, and negative impact on dual-use exports when Dissimilarity is high and an insignificant effect when Dissimilarity is not high. These results suggest that states may not be particularly concerned if a friendly nation pursues or acquires WMD. The same actions by a potential adversary would likely leave a supplier feeling threatened enough to adjust dual-use trade accordingly. This lends support to Wendt's (1995) assertions regarding threats posed by WMD pursuit and acquisition.

Insert Table IV here.

Like other studies assessing the political determinants of international trade (Long, 2003; Long & Leeds, 2006), I find an insignificant relationship between the Dissimilarity variable and trade in most cases. In Model 1, the coefficient representing this variable is statistically insignificant among states that are pursuing or have acquired WMD. Dissimilarity does, however, have a positive and statistically significant effect on dual-use trade among states that are not pursuing and have not acquired WMD.

The estimates of Model 2 reveal some different results. Unlike in Model 1, the estimates for Model 2 show that a military alliance has a positive and statistically significant effect on dual-use trade. Specifically, military allies receive 134% more dual-use exports from the United States than non-allies. This provides some evidence in support of the first hypothesis and arguments that link military alliances and trade (Gowa & Mansfield, 1993; Long, 2003). Like in Model 1, the coefficient on the variable measuring democracy is positive and statistically significant in Model 2. Based on these estimates, democracies receive 34% more dual-use exports from the United States than non-democracies. This lends further support to arguments that democracy and trade are linked (Dixon & Moon, 1993; Bliss & Russett, 1998).

The coefficient on the variable representing militarized conflict is statistically significant and in the hypothesized direction in Model 2. The estimates indicate that conflict with the United States reduces the dual-use exports a state receives by 83%. This lends some support to the fourth hypothesis and arguments that militarized conflict reduces trade (Pollins, 1989a,b). In Model 2, Dissimilarity does not produce a statistically significant effect on dual-use exports. However, the coefficient on the

variable measuring WMD acquisition is statistically significant and positive both when Disimilarity is high and when Dissimilarity is not high. The coefficients measuring WMD pursuit are statistically insignificant in both cases. The divergent effects of WMD acquisition and WMD pursuit support the expectation that states will worry more about the latter than the former. The positive coefficients for WMD acquisition were not expected, however. A post-hoc explanation for this may be that states that have acquired WMD have a greater demand for dual-use commodities. These mixed results warrant cautious conclusions regarding the effect of WMD pursuit or acquisition on dual-use exports.

The control variables behave largely as expected in Model 2. The coefficients on the variables representing GDP, population, and all exports are statistically significant and in the expected direction. The coefficient on the variable representing distance is statistically significant but is positive, counter to theoretical expectations.

As the previous discussion illustrates, there are some noteworthy differences between Model 1 and Model 2. These differences may shed light on which measure of dual-use trade is more appropriate. More of the coefficients on the variables are statistically significant and in the anticipated direction in Model 2 than in Model 1. Further, the R^2 of Model 2 is slightly greater (.89) than the R^2 of Model 1 (.80), suggesting that the variables in the former model collectively explain more of the variation in dual-use exports. The only explanatory variable that has a statistically significant effect in the hypothesized direction in both models is democracy. Alliances, militarized conflict, and most of the control variables behave as expected in Model 2 but not in Model 1. The WMD variables have the expected effect on dual-use trade in Model

1 but not in Model 2. This is, however, the only case where a variable behaves as expected in Model 1 but not in Model 2. Collectively, a comparison of these results suggests that the number of approved licenses may be a more appropriate measure of dual-use exports than the total dollar value. This may be in part because the dollar value of dual-use trade is not necessarily proportional to the proliferation risk of the exported items.[24] In other words, there are commodities that can be purchased relatively cheaply but that are integral components of a WMD program. This conclusion is not definitive, however. Future research on dual-use trade should use both measurements and explore this matter further.

CONCLUSION

The primary objective of this study was to take a first-cut attempt at identifying the determinants of dual-use trade. Given the limitations of this analysis, I am only able to make relatively modest conclusions: the results of this study can be viewed as preliminary support for the assertion that states channel dual-use trade towards destinations where security guarantees exist and away from targets where security threats are present to minimize its potentially negative security externalities.

The most robust finding relates to the effect of joint democracy on dual-use trade. Regardless of how dual-use exports are measured, democratic states received more dual-use exports from the United States than non-democratic states. This suggests that democracy may be a stronger indicator than alliances of the security guarantees of dual-use trade. Alliances and militarized conflict had a significant effect on dual-use exports in only one of the models. This lends some support to realist arguments (e.g. Gowa & Mansfield, 1993) and the notion that conflict reduces trade (e.g. Pollins 1989, a,b). The

findings relating to the WMD variables are particularly interesting. When it comes to WMD the results indicate that it is *who* and not *what* that matters (Cirincione, Wolfsthal & Rajkumar, 2005), which lends support to notions about the importance of context (Wendt, 1995). Collectively, the results of this analysis suggest that it may be necessary to take a theoretically integrative approach to analyzing dual-use trade that draws from the logic of realism (e.g. Gowa & Mansfield), liberalism (e.g. Russett & Oneal 2001), and constructivism (e.g. Wendt 1995). The conclusions reached here are by no means definitive. Whether some of this study's inconsistent findings are due to the way dual-use trade is measured or some other factor is a question that future research should address. Future work should also determine whether other countries channel dual-use trade to the same degree as the United States.

These findings offer theoretical and substantive contributions. In the immediate post-Cold War period, Mastanduno (1992: 344) questioned whether globalization and the onset of a new world order would lead the United States to "adjust the balance between economic and national security interests." The evidence presented here hints that the United States continues to have a "strategic need" (Skålnes, 2000) to link security and economics in the post-Cold War era. This tells us something about when states are likely to transfer technology that can be used to build WMD and contributes to a growing body of literature on *how* states acquire WMD (Braun & Chyba, 2004; Montgomery, 2005; Kroenig, 2007). Further, the results encourage disaggregating trade data to examine relationships between particular types of trade on conflict, alliances, free trade agreements, and other political variables. As Dorussen (2006: 87) argues, there are

"good theoretical arguments to suspect that trade in some goods should have a bigger impact on the likelihood of conflict than trade in others."

The findings have important policy implications as well. Recent evidence suggests that Washington has not conducted systematic analysis on this issue (GAO, 2006). Empirical investigation of dual-use trade is important because it sheds light on which states are most likely to have access to the technology needed to construct WMD. The findings of this study suggest that adversaries of Washington may have a difficult time acquiring such components from the United States—especially if they are pursuing WMD. Other democracies, however, are likely to have less restricted access to dual-use technology.

Table I: Approved Licenses by Commodity Group

Group #	Commodity Group	Approved Licenses	Value ($Million)
1	Materials	41,539	72,878
2	Materials Processing	6,250	4,122
3	Electronics	14, 468	7,729
4	Computers	24,839	24,370
5	Telecommunications and Cryptography	17,930	25,505
6	Sensors	6,734	3,217
7	Avionics and Navigation	3,106	10,086
8	Marine Technology	144	143
9	Propulsion Systems and Transportation Equipment	5,003	27,482
0	Nuclear Materials	14, 900	6,134
EAR99	Items Subject to EAR Not Elsewhere Specified	4,624	5,569

Source: U.S. Department of Commerce

Table II: The Highs and Lows of U.S. Dual-Use Exports, 1991-2001

Favorite Destinations

	Total Dollar Value (Million USD)	*Number of Approved Licenses*
1.	Colombia (30,790)	China (10836)
2.	China (12,590)	Taiwan (9791)
3.	United Kingdom (9,333)	Israel (7854)
4.	Mexico (9,199)	India (5699)
5.	Taiwan (7,783)	Brazil (5686)
6.	South Korea (7,652)	Mexico (5290)
7.	Cuba (7,460)	South Korea (5193)
8.	Brazil (6,875)	Japan (5153)
9.	Japan (6,192)	United Kingdom (4426)
10.	Singapore (5,159)	Singapore (3713)
11.	France (5,049)	Germany (3586)
12.	North Korea (4,391)	South Africa (3549)
13.	South Africa (3,532)	Russia (2962)
14.	Israel (3,230)	France (2923)
15.	Canada (3,145)	Argentina (2653)

Undesirable Destinations

	Total Dollar Value (USD)	*Number of Approved Licenses*
137.	Burundi (852,326)	Equatorial Guinea (7)
138.	Uganda (767,684)	Moldova (7)
139.	Equatorial Guinea (453,616)	Tajikistan (6)
140.	Moldova (409,852)	Lesotho (6)
141.	Madagascar (384, 328)	Benin (5)
142.	Rwanda (311,749)	Chad (4)
143.	Liberia (285,469)	Djibouti (4)
144.	Lesotho (246,631)	Liberia (4)
145.	Benin (216,409)	Somalia (3)
146.	Togo (177,075)	Burundi (3)
147.	Burkina Faso (21,800)	Iraq (3)
148.	Afghanistan (20,356)	Togo (3)
149.	Central African Republic (12,001)	Burkina Faso (2)
150.	Comoros (1900)	Afghanistan (1)
151.	Iraq (3)	Central African Republic (1)

Source: U.S. Department of Commerce

Table III: OLS Regression with Robust Standard Errors of the Impact of Independent Variables on U.S. Dual-Use Exports, 1991-2001

Variable	Estimated Coefficient (Robust Standard Error)	
	Model 1 ($ value)	Model 2 (licenses)
Security Guarantees		
Military Alliance	-.13	.87***
	(.41)	(.21)
Democracy	1.16**	.31*
	(.42)	(.17)
Security Threats		
Conflict	-.62	-1.56**
	(1.17)	(.61)
Dissimilarity	1.93***	.21
	(.49)	(.18)
WMD Pursuit	.072	.54
	(.58)	(.36)
WMD Acquisition	1.25	1.78***
	(.78)	(.40)
WMD Pursuit X Dissimilarity	-2.34**	-.67*
	(.72)	(.38)
WMD Acquisition X Dissimilarity	-3.13**	-.60
	(1.03)	(.48)
Control Variables		
Gross Domestic Product	-.069	.45***
	(.23)	(.12)
Population	.34**	-.14*
	(.14)	(.075)
Distance	.15	.12**
	(.11)	(.051)
Regular Exports	1.03***	.47***
	(.17)	(.10)
Constant	-7.8**	-15.9***
	(2.66)	(1.26)
N	128	128
R^2	.80	.89

Note: Asterisks denote tests of statistical significance: * indicates $p<.05$ while ** and *** indicate $p<.01$ and $p<.001$, respectively. All tests are one-tailed.

Table IV: The Effect of Weapons of Mass Destruction and Dissimilar Foreign Policies on Dual-Use Exports, 1991-2001

Variable	Estimated Coefficient (Robust Standard Error)	
	Model 1 ($ value)	Model 2 (licenses)
WMD Acquisition		
Among states with non-dissimilar foreign policies	1.25 (.78)	1.78*** (.40)
Among states with dissimilar Foreign policies	-1.88** (.78)	1.18*** (.36)
WMD Pursuit		
Among states with non-dissimilar foreign policies	.073 (.58)	.54 (.36)
Among states with dissimilar Foreign policies	-2.26*** (.49)	-.13 (.17)
Dissimilarity		
Among states that have acquired WMD	-1.20 (.87)	-.39 (.43)
Among states that are pursuing WMD	-.40 (.46)	-.46 (.32)
Among states that are not pursuing and have not acquired WMD	1.93*** (.53)	.21 (.18)

Note: Asterisks denote tests of statistical significance: * indicates $p<.05$ while ** and *** indicate $p<.01$ and $p<.001$, respectively. All tests are one-tailed.

NOTES

[1] The terms conflict and militarized conflict are used interchangeably throughout this paper.

[2] For example, the same valve that is required to enrich uranium is also widely used in the semiconductor industry.

[3] Noteworthy attempts to analyze dual-use trade include Cupitt (2001).

[4] I thank an anonymous reviewer for pointing this out.

[5] Although, the questions considered by the government when determining whether to approve or deny a license remained the same. See Beck et al (2003).

[6] Space does not permit a detailed explanation of U.S. export control policy. For an excellent account of U.S. policy in this area, see Cupitt (2000, 2003).

[7] Barbieri & Levy (1999) find that war does not have a significant impact on trading relationships. Their study, however, is based on only seven dyads.

[8] A list of all items on the Commerce Control List is available at: http://www.access.gpo.gov/bis/ear/ear_data.html.

[9] This includes commodities controlled for reasons of chemical and biological weapons proliferation (CB), the chemical weapons convention (CW), missile technology proliferation (MT), nuclear proliferation (NP), and items subject to approval by the Nuclear Regulatory Commission.

[10] According to the Canadian embassy in Washington: <http://www.dfait-maeci.gc.ca/can-am/washington/trade_and_investment/wltr-en.asp>.

[11] This excludes Cuba, Iran, Iraq, North Korea, Libya, Sudan, and Syria.

[12] I also estimate models with former COCOM countries included. I discuss some of these results in note 22. Former COCOM states include: Australia, Belgium, Canada, Denmark, France, Germany, Greece, Italy, Japan, Luxembourg, Netherlands, Norway, Portugal, Spain, Turkey, and the United Kingdom

[13] This includes three countries that joined the North Atlantic Treaty Organization in 1997—Poland, Hungary, and the Czech Republic.

[14] These data were also acquired using the EUGene program (Bennett & Stam, 2000).

[15] Different cutoff points were tested and similar results were obtained.

[16] Singh and Way code all such cases between 1945 and 2000. If a country was exploring, pursuing, or had acquired nuclear weapons in 2000, the author assumes the same is true in 2001.

[17] The CNS dataset classifies states' pursuit of CB weapons as "possible," "probable," or "known."

[18] In this analysis, GDP is measured in current US dollars. These data were obtained from the International Monetary Fund's (IMF) *World Economic Outlook Database,* September 2005, and can be accessed at <http://www.imf.org/external/pubs/ft/weo/2005/02/data/index.htm>. Missing data for six cases was obtained from Gleditsch (2002). Following previous work, distance is the "great circle" distance between the capitals of the states. Border countries (in this case Mexico and Canada) are coded as one mile (Fitzpatrick & Modlin, 1986). These data were acquired using the EUGene program (Bennett & Stam, 2000). Population data were collected from version 3.0 of the Correlates of War Project's National Military Capabilities data (Singer, Bremer & Stuckey, 1972).

[19] These data come from the United States International Trade Commission (USITC) and are measured in actual U.S. dollars (http://dataweb.usitc.gov/).

[20] Stata 8.2 was used to run all statistical models. At first glance, an event count model (King, 1989) seems well suited for analyzing the number of approved licenses. However, after taking the natural logarithm of the number of approved licenses the dependent variable is almost normally distributed, which means that OLS is an appropriate estimation technique.

[21] I also estimate these models with the former COCOM states included. Not surprisingly, this changes the effect of a military alliance and other explanatory variables on dual-use trade—but not the effect of democracy, which remains statistically significant and in the expected direction. In the interest of space, I do not report these results here.

[22] Interpreting the substantive effect of a dummy variable in a semi-logarithmic model requires a transformation of the coefficient by a formula equal to roughly 100 * ($e^{coefficient} - 1$). The resulting values represent the percentage change in the dependent variable as the dummy variable changes from zero to one (Halvorsen and Palmquist 1980). This was done in Stata 8.2 by using the logdummy command.

[23] The Stata command lincom is used to generate these values.

[24] I thank an anonymous reviewer for this insight.

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