Economic Determinants of Multilateral Environmental Agreements

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Abstract

We examine the economic factors that lead to the formation of multilateral environmental agreements, focusing on the likelihood a pair of countries enters into an agreement as well as the number of agreements they share using a near universe of agreements. Two countries are more likely to have an agreement and have more of them if they are economically larger and of similar economic size, closer in distance, have a preferential trade agreement, and trade more. Results are strongest for agreements involving a small number of countries, consistent with a hypothesis that agreements are formed to manage common pool resources.

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1. Introduction

In recent decades there has been an enormous surge in the number of multilateral environmental agreements that countries use to address transboundary environmental issues they cannot resolve alone (see the first column in Figure 1). From 1950 to 2012 countries negotiated over 1100 such agreements to deal with various environmental issues including global warming, acid rain, degradation of habitats, and overfishing (Mitchell 2002-2015). In this paper we empirically investigate the economic determinants of the formation of multilateral environmental agreements and the number of agreements a pair of countries shares in an attempt to better understand conditions under which countries have demonstrated a willingness to cooperate when dealing with environmental issues.

Previous empirical literature investigating multilateral environmental agreements (MEAs) either mainly focused on factors that influence a single country's decision to ratify a specific environmental treaty (see Fredrikson and Gaston, 2000; Neumayer, 2002; Egger et al., 2011, 2013; Millimet and Roy, 2015) or examined a subset of agreements (Davies and Naughton 2014). General results show that countries that are wealthier, have a more democratic political system, are more open to trade, and are closer to each other are more likely to cooperate and ratify an MEA. Our effort departs from the current literature by examining two countries' cooperation on environmental issues using a near universe of multilateral environmental agreements, rather than focusing on a small number of agreements (usually large ones as in Bernauer et al., 2010) or focusing on a single country's ratification of a particular agreement (such as Fredrikson and Gaston, 2000).

We examine countries' cooperation in solving transboundary environmental issues through the prism of formation of multilateral environmental agreements. Specifically, we ask two questions: which factors determine *the likelihood* of two countries having a multilateral environmental agreement and which factors determine *the number* of multilateral environmental agreements they share? For example, in our data, France has ratified 213 MEAs prior to 1990. Among these agreements, France and Germany are both parties to 179; France and Mexico are parties to 69; and France and Slovakia have no common MEA at all. Instead of focusing on a single country's participation in a given agreements, as done in the previous literature, we investigate why some countries cooperate more on environmental issues (like France and Germany) and why other countries cooperate less (like France and Mexico) or never cooperate (like France and Slovakia).

We use a specification motivated by the gravity equation in international trade to explain the likelihood of cooperation as well as the number of agreements a pair of countries shares. We find that GDP, distance, and preferential trade agreements, variables that usually explain bilateral international trade flows well, are also good predictors of the probability of two countries having a multilateral

environmental agreement as well as the number of agreements they have. Our results indicate that countries trading more with each other are more likely to be parties to at least one environmental agreement. This might not be an intuitive result. Countries that mitigate emissions or protect endangered species may incur economic losses. Probably the most often cited argument in opposition to agreements curbing pollution is that restricting emission of pollutants like carbon dioxide might hurt firm competitiveness in global markets as new regulations increase the cost of production. Moreover, participating in some environmental agreements may result in less trade between countries given new regulations. As a result, countries that trade more with each other might avoid joining MEAs together as it may have a negative effect on their trade.

On the other hand, it may be easier for countries to coordinate their economic and environmental policies when their economic interactions are intense. Two countries can discuss environmental issues and economic issues simultaneously, since such linkage may sustain more cooperation on both issues (Limão, 2005). A country not interested in protecting the environment may be willing to do so if it can enjoy benefits from reduced trade barriers from its trading partners. Countries with extensive economic interactions have more opportunities for such linkages than countries with fewer interactions. In addition, countries may suffer non-environmental costs if they choose not to cooperate on an environmental agreement (Hoel and Schneider, 1997). For instance, a country might be excluded from a future trade agreement if it refuses to cooperate on an environmental agreement. Conversely, it is possible for international trade to increase due to an environmental agreement. This could occur in instances where an agreement is signed by which one signatory agrees to comply with higher environmental standards already in place in the other signatory. In such a setting, one country increases its standards and allows its firms to access a market which used to be closed to them, resulting in increased trade between the two countries.

Our approach is motivated by two observations about multilateral environmental agreements. The first observation is the peculiar nature of environmental agreements that allows a pair of countries to sign a multitude of them. As already discussed, France and Germany are jointly parties to 179 different environmental agreements. This feature sets environmental agreements apart from trade agreements as a pair of countries tends to sign a single trade agreement amongst themselves.[1] The main reason for this is

[1] Technically speaking there is an exception to this principle given that a number of members of the World Trade Organization, which one can consider to be a large trade agreement, have separate agreements governing trade issues pertaining to a subset of WTO members. The North American Free Trade Agreement is one example of such an agreement. It should be noted that most papers examining various aspects of trade agreements tend to focus on the smaller trade agreements and ignore the WTO given that most countries are members of the WTO. Unlike environmental agreements, Canada, the U.S., and Mexico share only one trade agreement, NAFTA. In the case they both sign the same trade agreement with additional countries, the new agreement would replace NAFTA, as would have been the case with the now abandoned (by the U.S.) Trans Pacific Partnership agreement. The only plausible

that environmental agreements tend to focus on relatively narrowly defined environmental issues, while trade agreements tend to be far more encompassing, though not always truly comprehensive. This feature leads us to the second observation on multilateral environmental agreements which is that given their relatively narrow focus they come in all shapes and sizes. Agreements in our data range in size from as few as three to as many as 197 signatories. Figure 1 shows the temporal evolution of new MEAs as well as their cumulative numbers. Given the large range in the number of signatories, the main focus of our investigation is to separately examine agreements with few signatories and those with many signatories as these are qualitatively different types of agreements. Specifically, we examine: 1) MEAs with fewer than the sample median number of signatories (26); 2) MEAs with greater than the 3rd quartile number of signatories (68); and 3) all MEAs in our sample. The evolution of the number of agreements in both groups is also shown in Figure 1.

There are two reasons for separately analyzing MEAs based on the number of signatories. First, theoretical papers exploring the formation of the multilateral environmental agreements predict that self-enforcing environmental agreements could sustain a large number of signatories only when the difference in net benefits between the non-cooperative and fully cooperative outcomes is very small (Barrett, 1994). In a stark theoretical result, Gelves and McGinty (2016) augment the canonical Barrett (1994) model of formation of international environmental agreements by adding consistent conjectures rather than Nash conjectures. They find that large coalitions cannot form, but that small coalitions can lead to substantial increases in abatement over non-cooperative outcomes. Eichner and Pethig (2013) extend the Barrett (1994) model to a general equilibrium setting with a composite consumer good and fossil fuels that are produced and consumed in each country. Allowing for international trade results in large stable self-enforcing environmental agreements, but which result in a small reduction in emissions. In a comparative study of global and regional agreements, Sandler (2017) argues transactions costs of large global treaties are large due to the number of countries involved. Given their lower transaction costs, regional smaller agreements are easier to form. Silva (2017) considers the endogenous formation and stability of agreements in the presence of asymmetric national incomes and nationally determined contributions. While stable coalitions of various sizes are possible under a variety of conditions, they tend to provide too little abatement relative to the first-best outcome. Hovi et al. (2015) argue lack of trust may be an impediment to agreements and discuss ways in which trust may be increased. If lack of trust is an issue, it is more likely to be an issue in larger agreements as more countries need to agree to a common set of

exception of this is the European Union if one treats EU members separately, in which case it may appear that EU members may be parties to multiple trade agreements amongst each other whenever the EU itself enters into trade agreements with other countries. However, whatever concessions the EU may provide in such agreements have no effect on the trade between EU members which is free of any policy intervention due to the nature of the EU itself.

goals and commitments. Agreements with few signatories can overcome issues of trust either because all signatories trust each other or because overcoming trust issues is easier with fewer parties.

Based on these theoretical predictions, we can expect that countries often bear smaller economic costs on average when they ratify large treaties than they do when they ratify small treaties. In addition, some large treaties such as the Framework Convention on Climate Change are signed by almost all countries in the world but have no specific commitments. In other words, such agreements may be an expression of a desire to do something about an issue at some point, but by themselves they entail no immediate commitment to do something. Thus, countries that ratify them bear almost no cost at all. To some extent, given the large transaction costs of setting up large agreements, in order for countries to agree to them, commitments are low as they then tend to keep transaction costs low as well. On the flip side, smaller agreements are more likely to contain binding commitments. Examining the determinants of the likelihood of a pair of countries having an MEA may obscure these nuances if we examine both large and small agreements together. Our results indeed show that such an analysis does obscure important differences between these two types of agreements.

Second, small environmental agreements and large ones often deal with different kinds of environmental issues. Agreements with a few signatories primarily deal with regional environmental issues such as cross-border air pollution or overfishing in regional seas. Agreements with a large number of signatories often deal with global issues such as climate change or endangered species. To be more precise, both of these reasons speak to the central hypothesis we investigate in this paper – that environmental agreements with fewer signatories are signed by countries which desire to deal with common pool resource issues, while larger ones are most likely what one may call "statement" or "preference" agreements in which countries express a desire to deal with an issue but make no strict commitments. Sandler (1997) argues that the smaller the actual commitments, the larger the set of participants. As a result, one might expect that large agreements will have fewer commitments in order to entice more countries to agree to it. Following Sandler (2017) large agreements involving almost all countries may entail significant transaction costs, making them viable usually in cases when commitments of each member are either not large or are not enforceable. With such demarcation of agreements in mind, economic and geographic factors are much more likely to be a driving force behind the formation of smaller agreements. Eichner and Pethig (2015) theoretically examine a setting in which a self-enforcing agreement will consist of at most two countries which will increase their mitigation efforts as they liberalize the bilateral trade relationship. Even though they increase cooperation on both the environmental and trade dimensions, they cannot prevent an increase in emissions and a reduction in aggregate welfare.

We can pursue two strategies to analyze the determinants of the likelihood of a pair of countries being signatories of an agreement. One would entail estimating a dynamic panel model, while the other consists of estimating a number of single-year cross-section regressions. The former approach essentially provides estimates of the effect of variables of interest loosely averaged over the years forming the dynamic panel, while the latter would allow us to examine whether determinants of the formation of agreements change over time. Given the increased recognition and urgency with which environmental issues have begun to be addressed over the years, we find the latter approach of estimating a number of cross-section regressions to be of greater interest and more informative precisely because it allows us to observe whether and how determinants have changed over time.

We estimate our specifications annually from 1980 to 2000 allowing us to compare the temporal stability of the determinants. As mentioned above a country's ratification of a MEA may affect its GDP, trade, and cooperation on various trade agreements. All of these factors present potential endogeneity problems in estimation. To deal with these issues, we use the 1970 data on GDP, trade agreements, and bilateral trade flows, similar to the approach used by Bergstrand et al. (2016) who examine determinants of signing of trade agreements. Our results show that two countries are more likely to have an environmental agreement as well as have more environmental agreements if they are economically larger and of similar economic size, are closer to each other in distance, have a preferential trade agreement, and trade more with each other. These results are most robust and consistent over time for MEAs with a small number of signatories. For large treaties, economic factors have mixed, if any, effects over time.

2. Related Literature

There are a large number of game-theoretic papers exploring the formation and characteristics of international environmental agreements (Barrett, 1994, 1997, 2001; Carraro and Siniscalo, 1993, 1998; Hoel, 1992; Hoel and Schneider, 1997; Rubio and Ulph, 2003; Finus et al 2005). Much of this literature focuses on whether a stable coalition forms (Libecap, 2014). Most non-cooperative game theoretic models of MEAs draw a rather pessimistic picture of the prospect of successful cooperation between countries (Finus and Maus, 2008). Basic results show that the number of countries in a stable coalition is likely to be very small and that self-enforcing international environmental agreements with a large number of signatories may not be able to improve substantially beyond non-cooperative outcomes.

A number of papers empirically investigate the formation of multilateral environmental agreements (Fredriksson and Gaston, 2000; Neumayer, 2002; Beron et al., 2003; Murdoch et al, 2003; Egger et al, 2011, 2013; Millimet and Roy, 2015; Davies and Naughton, 2014). Egger et al. (2011) investigate the effect of trade liberalization on countries' participation in multilateral environmental

agreements. They use a linear feedback model to analyze the dynamics of the number of environmental agreements a country ratifies and construct a variable measuring trade liberalization from a non-linear regression model. The results show that a country will ratify more multilateral environmental agreements if it is economically larger and has more liberalized trade and investment policies.

Davies and Naughton (2014) examine whether proximate countries have greater incentives to cooperate than distant ones in the presence of cross-border pollution. They use spatial econometrics to estimate participation in 110 international environmental treaties by 139 countries over 20 years. They find that the higher the number of treaties ratified by a country's neighbors, the more treaties the country will ratify itself. In addition, their results are most evident in the case of regional environmental agreements.

Millimet and Roy (2015) examine whether the World Trade Organization (WTO) and its predecessor the General Agreement on Tariffs and Trade (GATT) have a 'chilling effect' on participation in MEAs. They show that one cannot exclude the possibility that GATT/WTO has no causal effect on MEA participation for the full sample, but it does have a negative effect on MEA participation by less developed or non-OECD countries.

Our paper is also related to the literature on the formation of international trade agreements. There is a large body of empirical research investigating the formation of free trade agreements (Baier and Bergstrand, 2004, 2007; Egger and Larch, 2008; Baldwin and Jaimovich, 2012; Chen and Joshi, 2010; Bergstrand et al., 2016). Baier and Bergstrand (2004) provide one of the first systematic empirical analysis of economic determinants of the formation of free trade agreements. The main conclusions are that the potential welfare gains and the likelihood of a FTA between two countries are higher the smaller is the distance between two trading partners, the more remote two continental trading partners are from the rest of the world, the jointly economically larger and more similar the two are, the greater is the difference in capital-labor endowment ratios between the two, and the smaller is the difference in capital-labor endowment ratios of the member countries relative to that of the ROW.

To analyze the effect of pre-existing preferential trade agreements (PTAs) on non-members' incentives to participate in a PTA, Egger and Larch (2008) test three hypotheses: (1) the formation of a PTA and its enlargement generate incentives for non-members to join an existing PTA; (2) there are also incentives for non-members to establish a new PTA; (3) these interdependencies decrease with distance. By using spatial econometric techniques, they find significant support for their hypotheses.

A more recent strand of the literature on international environmental agreements focuses on ways of dealing with climate change in particular. Nordhaus (2015) shows that a way to deal with free-riding incentives embodied in climate change agreements is to design a regime, a climate club, with small trade penalties on non-participants as it can induce a large and stable coalition with high levels of abatement.

Mason, Polasky, and Tarui (2017) examine conditions which allow for efficient mitigation of greenhouse gas emissions with a large self-enforcing international agreement. Sandler (2017) offers a comparative study of efficient and inefficient agreements on both the global and regional level and provides insights into designing effective international agreements. Eichner and Pethig (2018) show that asymmetry in damage caused by climate change across countries tends to discourage cooperation in large agreements. Finus and Al Khourdajie (2018) show using an intra-industry trade model that only a strong taste for variety on the part of consumers reduces competition among governments to allow for incomplete cooperation on environmental policy.

3. Econometric Model

We use two econometric methods to analyze the economic determinants of multilateral environmental agreements. We estimate a probit model to examine the factors which influence the likelihood of two countries having at least one environmental agreement. We then estimate an ordinary least squares model to examine the factors that influence the number of environmental agreements they have. An observation in our data is a pair of countries in a given calendar year.

The econometric framework used in the first method is the binary choice model. Let y^* denote a latent variable which is the value of a multilateral environmental agreement to a country. We then estimate

$$y^* = \beta_0 + \boldsymbol{x}\boldsymbol{\beta} + e \qquad (1)$$

where $\boldsymbol{x}$ is a vector of explanatory variables, $\boldsymbol{\beta}$ is a vector of parameters, and error term e is assumed to be independent of $\boldsymbol{x}$ and to have a standard normal distribution. Since we don't observe countries' valuation of the MEA, we define an indicator variable which is equal to unity if a country pair has entered into an MEA. We expect countries to form MEAs if the value of the MEA is positive and not to enter into MEAs without benefits. We therefore define the variable $MEA = 1$ if $y^* > 0$ and zero otherwise. We estimate a binary choice model of the following form:

$$P(MEA = 1 \mid X) = G(\beta_0 + \boldsymbol{x}\boldsymbol{\beta}) \qquad (2)$$

where $G(\cdot)$ is the standard normal cumulative distribution function.

In the second portion of our analysis, we examine the determinants of the number of multilateral environmental agreements a pair of countries are a part of in a given year. We estimate the linear regression model given by equation (3). The dependent variable y measures the number of environmental

treaties that both countries have ratified, while the independent variables are the same as those in equation (1).

$$y = \beta_0 + \boldsymbol{x\beta} + e \qquad (3)$$

This specification allows us to examine the degree of environmental collaboration between countries instead of only examining if *any* collaboration exists as in the probit model. For example, France and Germany entered into the first MEA in 1880 but have subsequently signed 179 more MEAs by 2000, whereas Thailand and Vietnam first entered into an MEA in 1950 but have only entered into 47 more by 2000.

For both regressions, we can divide our explanatory variables into several groups: variables used in the international trade gravity equation literature, economic integration variables, and common pool resource variables. For gravity variables, we include: (1) SUM OF GDP: the sum of the logarithm of real GDPs of the two countries; (2) DIFFERENCE IN GDP: the absolute value of the difference between the logarithm of real GDPs of the two countries; (3) DISTANCE: the logarithm of the distance between the two countries; and (4) COMMON LANGUAGE: a dummy variable which is unity if the two countries have the same official language. Our inclusion of the sum and difference in GDPs is motivated by Silva (2017) and Chen and Zeckhauser (2018) who consider the role of country size asymmetry in environmental agreements. We want to measure whether economically larger countries or countries with similar economic size are more likely to join multilateral environmental treaties together. After controlling for other variables such as distance and having a common border, economically larger countries might have more economic interactions with each other. If cooperation in environmental areas fosters cooperation in other economic areas, then larger countries might be more willing to participate in environmental agreements. The variable distance measures the logarithm of distance in kilometers between the two countries. Geographically closer countries are likely to be more familiar and interact more with each other than remote ones. This might foster better cooperation in the environmental arena as well. With the common language variable, we want to examine whether countries that share the same official language are more likely to have an environmental treaty. Shorter distance between countries and common language may both increase trust between countries (Hovi et al. 2015) and reduce transaction costs (Sandler 2017), both of which may facilitate agreements on goals and commitments of agreements.

For economic integration variables, we include: (5) SUM OF IMPORTS: the sum of the logarithm of bilateral trade flows of two countries measured as the sum of imports from each other; and (6) TRADE AGREEMENT: a dummy variable which is unity if two countries have a trade agreement. We expect that countries with a higher level of economic integration will be more likely to cooperate on solving transboundary environmental issues. In addition, when countries ratify trade agreements, they not

only decrease tariffs but also increase cooperation in other areas, like the protection of the environment, as was the case with NAFTA. Trade policy negotiations have been increasingly accompanied by environmental policy measures (Baghdadi, 2013). Barrett (1997, 2005), Nordhaus (2015), and Hovi et al. (2015) discuss how trade sanctions can be used by signatories to induce non-signatories to improve cooperation on environmental issues. The cost of such sanctions will be smaller the less a signatory and a non-signatory trade with each other. Alternatively, countries that trade intensively with each other may be more willing to cooperate on an agreement in order to avoid potentially costly trade sanctions. We expect countries with trade agreements are more likely to have environmental agreements with each other. Kuhn et al (2019) argue that trade liberalization, in the form of a preferential trade agreement, is a highly effective institution in building climate coalitions, leading to increased abatement and more environmentally friendly consumption patterns. Trade agreements can also increase trust among trading partners (Hovi et al. 2015), making it easier to agree on common environmental goals.

For common pool resources variables we include: (7) BORDER LENGTH: equal to logarithm of 1+the length of common border of two countries; (8) SAME REGION: a dummy variable equal to one if the two countries are in the same geographic region as defined by the World Bank; and (9) NEIGHBOR REGION: a dummy variable equal to one if the two countries are located in neighboring geographic regions. Since the MEAs with a few signatories are hypothesized to be primarily used to resolve regional environmental issues, controlling for these variables helps us better identify the effects of economic factors on countries' MEA cooperation.

Our common pool resource variables are potentially crude proxies. Unfortunately, there do not appear to be comprehensive data on specific common pool resources that we could take advantage of. We were able to find only data on two common pool resources: transboundary waters and aquifers.[2] The former are bodies of fresh water, rivers and lakes, that span country borders, while the latter are aquifers that lie underground spanning borders. While we could use both of these variables, they would ignore a myriad of other common pool resources that countries can share without sharing these two, such as forests or other types of productive land, seas, as well as air. To illustrate this point, country pairs that share an aquifer account for 1% of our country pairs, while those that share a lake or a river account for 2.6%. Country pairs that share either an aquifer or a lake or a river account for 2.7% of country pairs. Contrast this with our region dummies, where almost 11% of country pairs belong to the same region and almost as many to neighboring regions. The length of the common border proxies for the multitude of other common pool resources for which precise variables are unavailable. Too examine how good proxies these three variables are, we offer Table 1 in which we estimate the likelihood of a pair of countries

[2] The source for this data is the Transboundary Waters Assessment Programme, http://getwap.org.

sharing an aquifer or a body of fresh water as a function of our three proxy variables using a probit specification. In both cases, the longer the common border, the more likely it is that countries share either of these two types of common pool resources, as is the case if they belong either to the same region or neighboring region. Thus, while imperfect, we believe our proxies do a good job of identifying common pool resources countries share.

We estimate cross-section regressions annually from 1980 to 2000. As mentioned above, countries' cooperation on international environmental issues might foster their economic exchange such as asset cross-holdings and might also impede or promote their bilateral trade flows. To deal with this potential endogeneity issue, we use the 1970 data on GDP variables, bilateral trade flows, and trade agreement dummy.

4. Data

Multilateral environmental agreement data are from Ronald Mitchell's International Environmental Agreement Database Project (2002-2015). Basic information on multilateral environmental agreements includes subject or topic of the agreement, its beginning date, and membership. Treaties are categorized into eight subjects: energy, freshwater resources, habitat, nature, oceans, weapons and environment, pollution, and species. In addition, agreements dealing with pollution are further divided into four categories: pollution related to air, land, ocean, and waste. Agreements dealing with species are also divided into four categories: agriculture, birds, fish, and mammals. Member countries and the date when those members ratified the agreement are identified in the database.

Between 1950 and 2012 there have been 1,119 agreements, including original agreements, protocols and amendments. Countries generally use original agreements to reach major new environmental objectives, use protocols for new but related environmental goals, and use amendments for minor modifications to existing agreements. While one could exclude such modifications, this will understate the number of significant multilateral environmental agreements (Mitchell, 2003). Indeed, there are a number of important protocols and amendments in our data set, such as the Montreal Protocol on Substances that Deplete the Ozone Layer, Kyoto Protocol to the United Nations Framework Convention on Climate Change, and the amendment to the International Convention for the Regulation of Whaling. On the other hand, including all modifications might include some minor, noncontroversial, or technical amendments (Mitchell, 2003). In our paper, we use the broad definition and do not distinguish between these three types of agreements.

Bilateral trade flow data are aggregated from 4-digit SITC UN Comtrade data. Gravity data are from the CEPII gravity database. Economic integration agreement data are from Baier and Bergstrand (2007). Data for the length of common border come from Wikipedia.

5. Results

We begin by comparing the results using MEAs with fewer than the median number of signatories (26), MEAs with greater than the 3rd quartile number of signatories (68), and all MEAs respectively for the year 1990. This gives us a general idea about how economic factors affect countries' cooperation on various agreements. We then proceed to estimate our specifications annually from 1980 to 2000 and plot the coefficients of each explanatory variable over time first using small agreements, followed by large agreements and then pooling across all agreements.

5.1 Economic determinants of MEAs for 1990

Table 2 presents the descriptive statistics for the 1990 samples. The average number of small agreements per country pair is 0.53 with a maximum of 34. Only 16% of country pairs have a small agreement in place in 1990. By contrast, 90% of country pairs are party to a large agreement that involves at least 68 signatories, with the average of 3.34 such agreements per country pair. Taking into account all agreements, 93% of country pairs have at least one agreement in place, with an average of 13.1 agreements.

5.1.1 The likelihood of having a multilateral environmental agreement

In Table 3, we present the marginal effects for the likelihood of two countries having an environmental agreement in 1990. Marginal effects are evaluated at means of independent variables on the probabilities of two countries having an environmental agreement. Our dependent variable here is dichotomous and equal to one if two countries have signed an environmental agreement in a given year and zero otherwise.

The first column refers to the results using MEAs with fewer than 26 signatories, the median number of signatories in our data. For economic size variables, the sum of logged GDPs has a positive effect indicating that economically large countries are more likely to have a small MEA. If we increase the product of two countries' real GDPs by 10%, the probability of them having an environmental agreement increases by about 0.2%. This effect becomes more evident if we compare across country pairs. For example, in 1990, the product of France and Germany's real GDPs is about 4400 times of that of Vietnam and Thailand's. This increases the former pair of countries' probability of having an MEA by

about 21% compared to the latter pair holding other things equal. The difference in logged GDPs has a negative effect indicating that countries of similar economic sizes are more likely to have a small MEA.

Countries trading more with each other are more likely to have an agreement with a small number of signatories. The marginal effect is significant and positive. As mentioned above, trade agreements do not just eliminate trade barriers, they may also foster countries' environmental cooperation.[3] Our results support this assertion. Countries with a trade agreement are more likely to have an environmental agreement. In 1990 having a trade agreement increases the probability of two countries having an environmental agreement by about 5%.

If two countries are close to each other, they are more likely to have an agreement. This result is reasonable because MEAs with a few signatories often deal with regional environmental issues and only nearby countries need to cooperate. In addition, since closer countries might know each other better than remote ones, they are more likely to cooperate on environmental issues. Similarly, countries sharing a longer common border, located within the same region as well as neighboring regions are more likely to have such an agreement. Countries with a longer common border may share more common resources, making them more likely to work together on solving transboundary environmental problems. In addition, countries with the same common official language are also more likely to have an agreement. Results in the first column indicate that economic size, distance, and economic integration variables contribute to countries' cooperation on MEAs with a few signatories.

The second and third columns in Table 3 present the results using MEAs with a large number of signatories (68 to be precise) and all MEAs respectively. As we hypothesized above, the results using large agreements are likely to be different due to MEAs that have many signatories being fundamentally different than those with a smaller number of signatories. Large environmental agreements often have small effects. In addition, some large agreements are signed by almost every country in the world but have no specific binding targets. If there are few economic costs to joining a large agreement, every country will do so. This kind of cooperation may lack economic driving forces. As a result, our economic determinants may not work well in explaining countries' decisions to enter large MEAs. These theoretically different processes based on the size of the agreement mean that specifications including all agreements will muddle these two different effects. This is indeed the case.

As we expect, in column 2, most of our variables of interest have no statistically significant effects or have counter-intuitive effects like the sum of logged GDPs. The only exceptions are economic integration variables. Countries with trade agreements or those having larger bilateral trade flows are

[3] For example, when signing the North American Free Trade Agreement, Canada, Mexico, and the U.S. also signed a side agreement, the North American Agreement on Environmental Cooperation which stipulated that each country must enforce its environmental laws and created a dispute settlement mechanism for enforcement purposes.

more likely to be parties to a large agreement which likely speaks to the fact that more open economies are more likely to cooperate on environmental issues. Similar results are also shown in column 3 in which we examine all agreements where every coefficient is estimated with a smaller magnitude than in column 1, with the exception of the existence of a trade agreement. This reduction in the magnitude of estimated coefficients in the full sample compared to the set of small agreements is a consequence of the lack of economic determinants of formation of large agreements as already hypothesized and discussed.

5.1.2 The number of multilateral environmental agreements

We show our results on factors influencing the number of environmental agreements two countries have signed by 1990 in Table 4. Similar to Table 3, we present the results using MEAs with a few signatories, MEAs with many signatories, and all MEAs from column 1 to 3.

For small MEAs, economic size, distance, and economic integration variables have similar effects in explaining the number of agreements two countries share as they do in explaining the likelihood of two countries having an agreement. Specifically, economically large countries and those of similar economic sizes, those close to each other, and those with trade agreements and having larger bilateral trade flows tend to have more environmental agreements with a few signatories.

For large MEAs, most of our variables of interest work well in explaining the number of MEAs. The reasons are as follows. In the probit estimation, two countries with one hundred environmental agreements are treated the same as those having only one environmental agreement in a certain year. There are some large environmental agreements that most countries in the world have ratified. Many countries join such agreements because they do not need to bear many or any costs as these agreements do not have binding commitments. This may bias our results since we treat as equal country pairs which cooperate a lot and those that cooperate much less. We solve this problem by focusing on small agreements only. In OLS estimation, we compare the number of environmental agreements two countries share. To some extent, this may alleviate some problems caused by large treaties that include almost every country. However, there are some systematic differences between large environmental agreements and small ones. A better way to minimize the bias is to treat these two types of agreements separately in estimation as we have done.

5.2 Economic determinants of MEAs from 1980 to 2000

5.2.1 MEAs with fewer than 26 signatories

In this section we examine countries' cooperation on environmental agreements with fewer than the median number of signatories. Figure 2 presents the results on economic determinants of the likelihood of two countries having an environmental agreement. Figure 3 shows the results on the determinants of the number of agreements two countries have signed.

In Figure 2, we plot the marginal effect and a 95% confidence interval of each explanatory variable year by year from 1980 to 2000. We use the 1970 data on GDPs, trade flows, and trade agreement variables in each estimation. Compared to the results shown in the first column in Table 3, these graphs examine the temporal stability of each determinant. As we can see, the effects of most explanatory variables act in a similar direction across the entire sample period. Our results show that two countries are more likely to have an environmental agreement with a few signatories if they are economically large and are of similar economic size, if they are close in distance, if they have a trade agreement, and if their bilateral trade flows are large. Nearly all of our coefficients show pronounced trends in their size with the marginal effects becoming larger in absolute value over time.

In Figure 3, we plot similar graphs on factors determining the number of environmental agreements two countries have signed. Most determinants have statistically significant effects and exhibit a broadly similar direction and time path to those of the probit estimates. Our results show that economic size, bilateral distance, and economic integration variables have similar effects on the number of environmental agreements as they do on the likelihood of having an agreement.

5.2.2 MEAs with more than 68 signatories and all MEAs

Figure 4 presents the results on the probability of two countries having an agreement with a large number of signatories. Economic size variables have mixed effects over time. The sum of logged GDPs has a positive effect in the early 1980s and after 1992 but has a negative effect in the intervening years. The difference in logged GDPs also has mixed results over time and the estimates are statistically insignificantly different from zero in most years. Distance has a negative effect over time with the effect insignificant in early years. Trade agreements and bilateral trade have significantly positive effects over time.

Figure 5 presents the results on the number of MEAs two countries have signed using agreements with many signatories. The difference in logged GDPs has a mixed effect over time and the coefficient is not significant in many years. Distance has a positive significant effect over time which means that close countries ratified fewer large environmental agreements than remote ones. This is not at all surprising since in agreements with many signatories, many bilateral pairs of countries will be far apart. The sum of

logged GDPs, existence of a trade agreement, and bilateral trade all have positive and statistically significant effects over time.

Figure 6 and Figure 7 show our results for the likelihood of two countries having an agreement and the number of agreements two countries have signed respectively for all MEAs in our sample. These results show how our independent variables work if we do not separate the small agreements from the large agreements. Similar to the results for large agreements, economic factors perform poorly in explaining the likelihood of two countries having an MEA. On the other hand, economic size, distance, and economic integration variables work well in the OLS regression which examines the number of MEAs two countries share.

5.3 Robustness

We implement several robustness tests to check the sensitivity of our results. We first examine various alternative specifications in Table 5. We only use small agreements which are most interesting and repeat our regressions for the year 1990. Then in Figure 8 and 9 we extend our results for a longer time period from 1965 to 2000 and see how our explanatory variables work in early years.

As before, we use 1970 data on GDPs, trade flows, and trade agreement variables. There are two panels in this table. Panel A (from column 1 to column 4) examines the likelihood of two countries having an environmental agreement. Panel B (from column 5 to column 10) examines the number of environmental agreements two countries have signed. For the first panel, column 1 is the baseline result from the first column in Table 3. In column 2, we exclude all potential endogenous variables and use only geographic ones. These variables have similar effects with those in column 1. In column 3, we exclude trade agreement and trade flow variables and in column 4 we only exclude trade flows. This accounts for the potential concerns that gravity variables may affect countries' participation in preferential trade agreements and bilateral trade flows. As we can see, estimates in columns 3 and 4 have similar signs and magnitudes with those in the baseline specification. For the second panel, column 5 presents baseline results for the number of agreements taken from the first column of Table 4. In the following three columns, we estimate OLS models using similar specifications as those from columns 2 to 4. Our estimates are similar to the baseline results.

OLS estimation implicitly assumes the dependent variable has continuous support whereas our data are a count of the number of agreements a pair of countries have. Since OLS estimates may be biased in this context, in columns 9 and 10 we employ two parametric estimators, Poisson and negative binomial estimators, to deal with the count nature of our dependent variables. All explanatory variables

still have similar effects, with the sole exception of the length of border between two countries no longer having a significant effect suggesting any bias in the OLS estimates is likely to be small.

In Figure 8 and Figure 9, we present the probit results and OLS results from 1965 to 2000 using MEAs with less than the median number of signatories and employing our benchmark specifications given by equations (1) and (3).[4] Our benchmark approach has been to use 1970 data, a ten-year lag from the first year in our sample, of all time-varying variables (GDPs, trade flows, and existence of trade agreements) in order to deal with endogeneity concerns. Following the same strategy in order to estimate our specifications for every year starting with 1965 is difficult as it requires values of the time-varying variables from 1955. While such data are available for a few countries, doing so would inordinately limit our sample and analysis. A different approach we can use to include estimates for earlier years is to use contemporaneous values of the time-varying variables in each of our specifications. Thus, Figures 8 and 9 show the estimates of replicating our main probit and OLS specifications using a sample starting in 1965 with contemporaneous values of our time varying variables. This serves two purposes. Firstly, it allows us to generate estimates for earlier years in our sample when there were fewer agreements. Secondly, by comparing these results with our benchmark results we can obtain some information about the extent to which concerns about endogeneity of contemporaneous time varying variables are warranted.

In Figures 8 and 9 we plot the estimated coefficients and confidence interval for our estimates on the likelihood two countries have an environmental agreement and the number of agreements they share, along with our benchmark estimates which were reported in Figures 2 and 3. Most variables have similar effects when we use their contemporaneous values in estimation. As we can see, most variables of interest have similar effects in the early years. The only significant difference in our results is that using contemporaneous values changes the direction of the effect of trade agreements from a strongly positive one, to a much smaller but negative effect. This is likely due to the change in the composition of countries that are included in the estimating equation when using contemporaneous values. Using 1970 values excludes all countries for which 1970 data are missing.[5]

[4] Analogous results for other specifications are available on request from authors.

[5] In unreported results we estimated our specifications with contemporaneous values but with a balanced panel of countries that are observed in every single year. This also resulted in negatively estimated coefficients for trade agreements. We then split the agreement dummy variable to identify two separate types of trade agreements: one-way agreements, largely Generalized System of Preferences granted by developed countries to developing countries, and reciprocal, two-way agreements in which both parties provide the same concessions and equal market access. Those results reveal that the negative effect of the single trade agreement variable is driven by one-way agreements. One-way trade preferences are rarely granted by countries in close proximity to each other. In other words, they are rarely granted by countries that share common pool resources and are less likely to engage in environmental agreements given the distance that separates them. The estimated coefficient on reciprocal, two-way agreements is always positive and significant. These results are available on request.

5.4 Discussion

The key variables of interest for our analysis are the three variables identifying common pool resources: border length and the same region and neighboring region dummies. Summarizing our results, for the question of the likelihood two countries having either a small or large agreement, our results are quite strong and in the expected direction. All three variables increase the likelihood that a pair of countries are both parties to a small agreement in a statistically significant way (Figure 2). The opposite is true for the pair of countries both being party to a large agreement (Figure 4): with the exception of two or three years in the mid-1990s for border length, these three variables do not have a significant effect on the likelihood of the pair or countries being party to a large agreement.

For the question of the number of agreements countries share, our results are admittedly a bit murkier. Border length and being in the same region increase the number of small agreements a pair of countries share significantly, while being in neighboring regions if anything reduces the number of small agreements. For large agreements, border length plays no role, similar to probit results, while being in the same or neighboring regions increases the number of large agreements countries are a party to. That the results for the number of agreements are weaker is perhaps not a surprise. As we argued at the outset of the paper being party to a large agreement often implies no commitment and no enforcement. As a result, countries can engage in a large number of them as there is no consequence of being a party to such agreements. A full fifth of our country pairs are either in the same or neighboring region, which may account for the significance of the role of both variables in OLS regressions. In addition, as our proxies for common pool resources are proxies at best. Without a better way to capture how many environmental issues countries would have an interest in cooperating on, it is perhaps not a surprise that our results explaining the number of agreements a pair of countries shares are weaker than those explaining the likelihood of sharing an agreement.

Some of the other control variables have similar effects on OLS regressions for small and large agreements. For example, the sum of GDPs and imports have similar effects, as does the existence of trade agreements. On the other hand, larger distance between countries reduces the number of small agreements they are a party to but increases the number of large agreements they are a party to. We are not surprised by these results. Countries will tend to sign more agreements with similar countries and countries they interact with the most. Those will then tend to be economically large countries, countries that are close, and countries they interact with the most proxied by trade links in our analysis. For large agreements, distance starts having a positive effect, but this is not surprising as over time there has been a large increase in the number of large agreements countries are a party to. By definition, large agreements are formed by countries that are far apart, resulting in a positive effect of distance. The fact that some of

these variables have similar effects in the analysis of the number of small and large agreements they share is also not surprising when there are no good ways to capture the number of issues that a pair of countries would have an interest in cooperating on.

The problem with the number of issues a pair of countries would have an incentive to cooperate on is two-fold. For one, there are no good ways of simply counting the issues, other than by using the common pool resource proxies as we argued above. Additionally, countries can sign multiple agreements to deal with one particular issue. For example, it is possible for countries to sign multiple agreements dealing with how to manage a particular resource such as a lake they share. One agreement can deal with polluted waters draining to the lake, one can deal extraction of a particular resource from the lake such as fish or sand, yet another can deal with traffic on the lake. As such, the predictive power of our variables is necessarily weaker and more limited when we try to explain the number of agreements countries share.

6. Conclusion

In this paper, we empirically examine the economic factors that determine countries' cooperation on multilateral environmental agreements (MEAs). We separately examine MEAs with fewer than the sample median number of signatories (26), MEAs with greater than the 3rd quartile number of signatories (68), and all the MEAs in the sample. Our approach is motivated by a hypothesis that environmental agreements with a small number of signatories are more likely to be initiated in order to deal with transboundary environmental issues and common pool resource issues. As such, these agreements are more likely to have binding commitments and, as a result, are more likely to be affected by economic determinants. Larger agreements, such as those signed by virtually all countries in the world, may be agreements largely expressing an intent and desire to deal with an issue, but embody no binding commitments for countries which sign them. The determinants of such agreements may not be economic in nature. We indeed find important differences in economic determinants of small and large environmental agreements.

Our results show that two countries are more likely to have an MEA or have more MEAs if they: 1) are economically large and of similar economic size, 2) are closer to each other in distance, 3) have a preferential trade agreement, and 4) have larger bilateral trade flows. The results suggest that countries' economic interactions may help them overcome potential free-riding problems to work together on transboundary environmental issues. In addition, since the ratification of MEAs often require countries to impose more stringent environmental standards, extensive economic interactions may also help offset the unfavorable "pollution haven effect".

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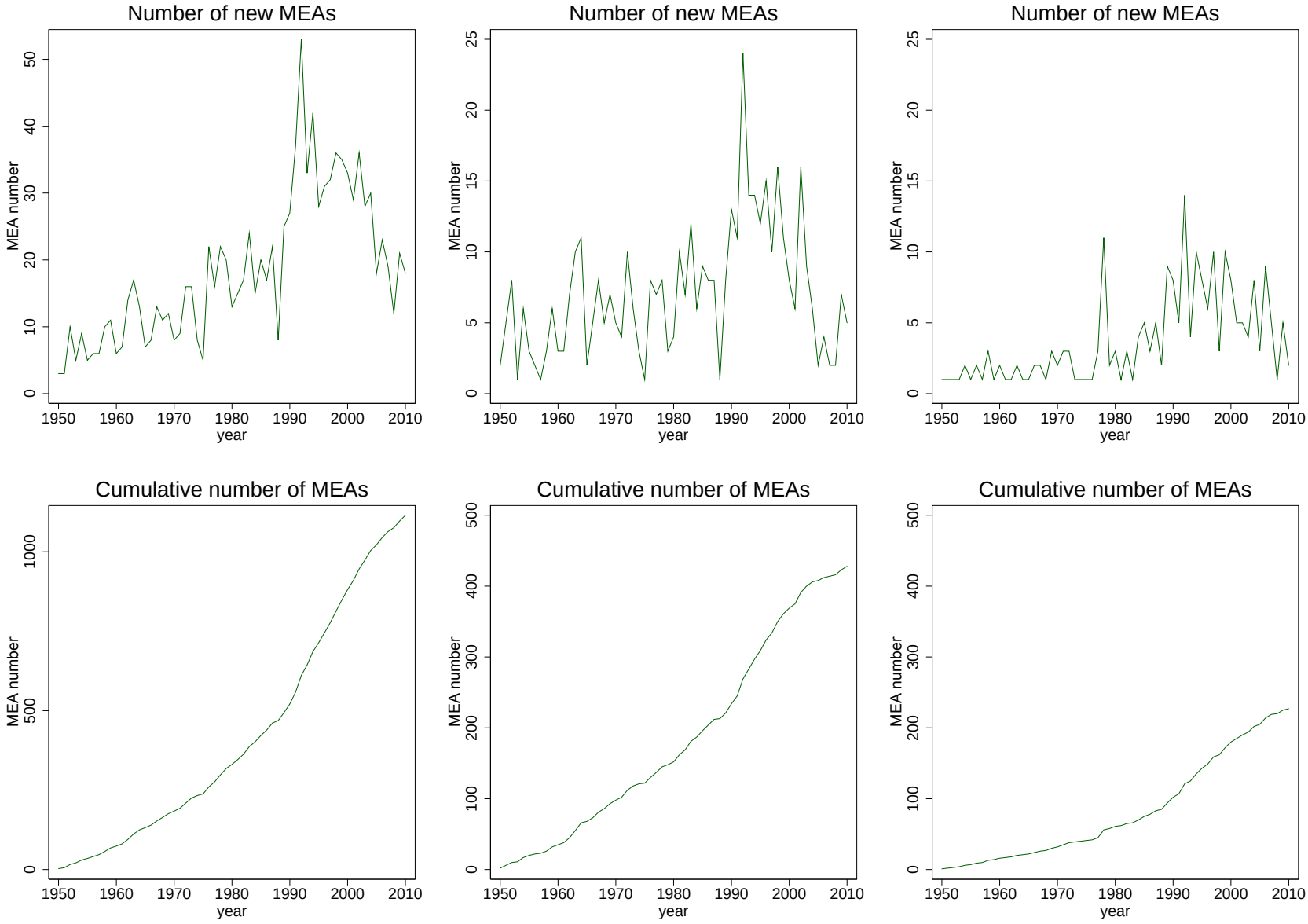
Figure 1 Annual count of multilateral environmental agreements

(1) All agreements

(2) MEAs with fewer than the median number of signatories

(3) MEAs with greater than the 3rd quartile number of signatories



Note: we obtain the graphs in the first column directly from IEA database project (2002-2014). The graphs in the last two columns are calculated using the data in our sample. There are over 1100 MEAs in the IEA database but some of these MEAs lack basic information like who signed the agreement and when they signed. After dropping these agreements, we have 953 MEAs left in our sample with which we calculate the graphs in last two columns.

Figure 2 Probit results using MEAs with fewer than the median number of signatories

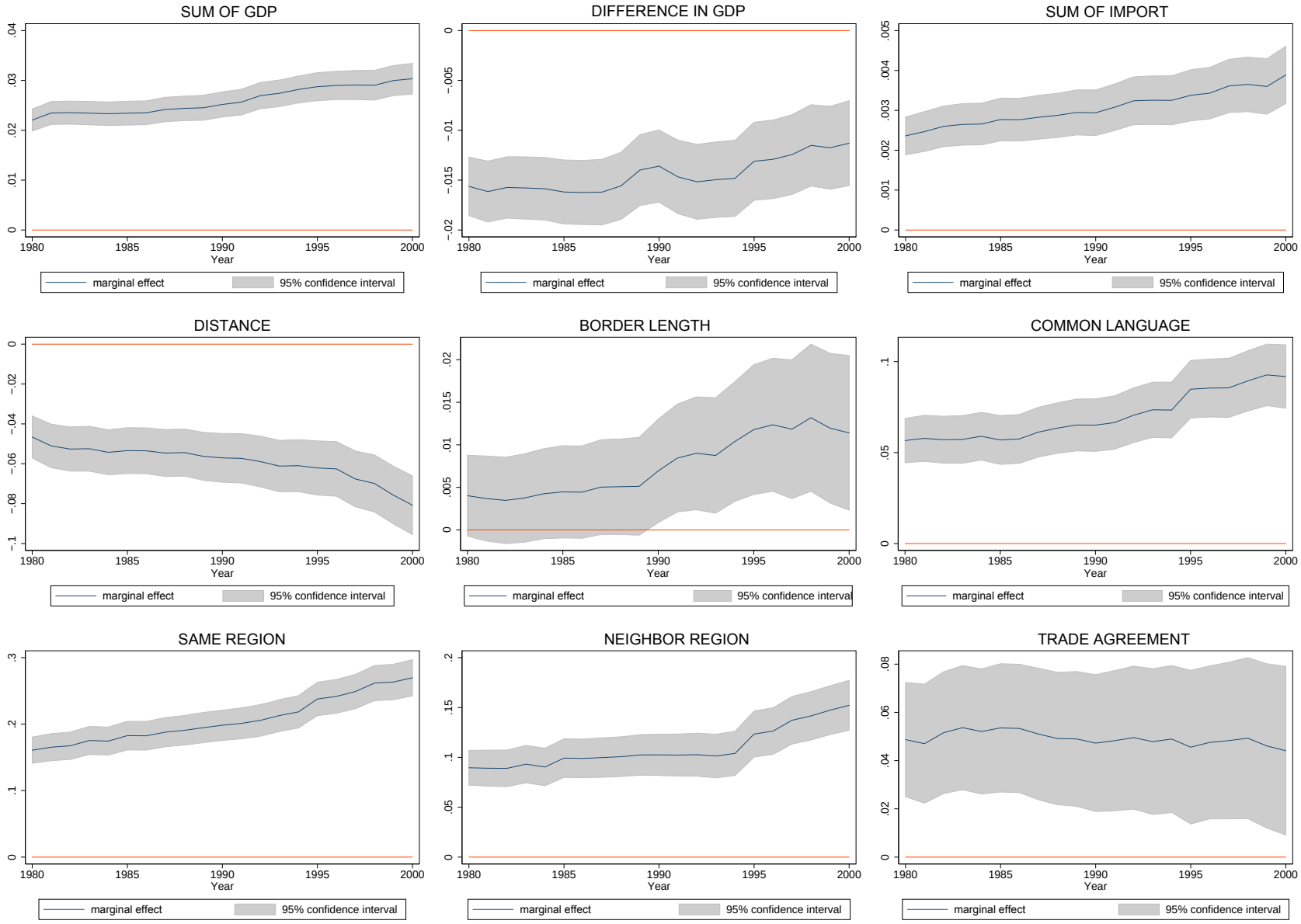


Figure 3 OLS results using MEAs with fewer than the median number of signatories

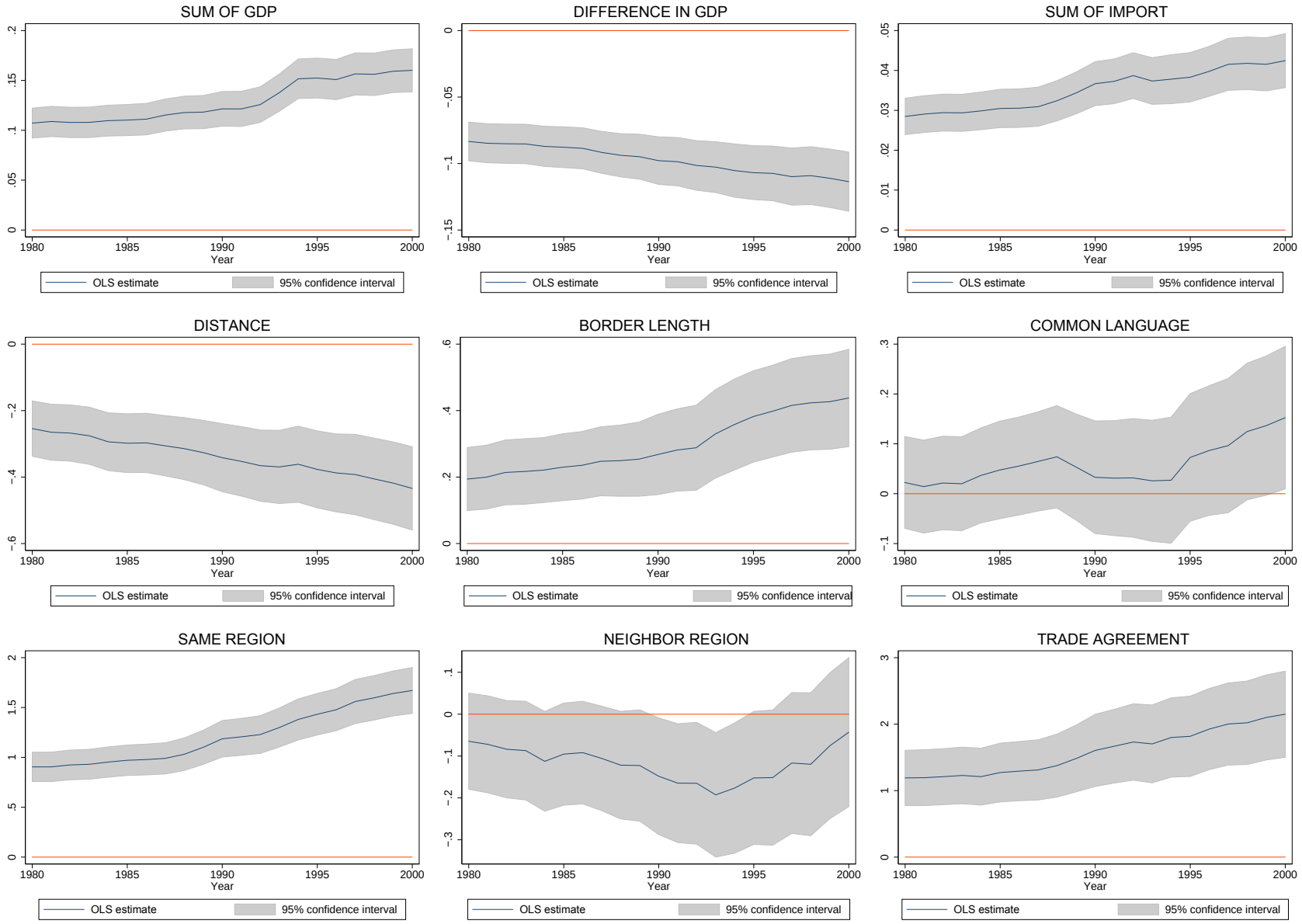


Figure 4 Probit results using MEAs with greater than the 3rd quartile number of signatories

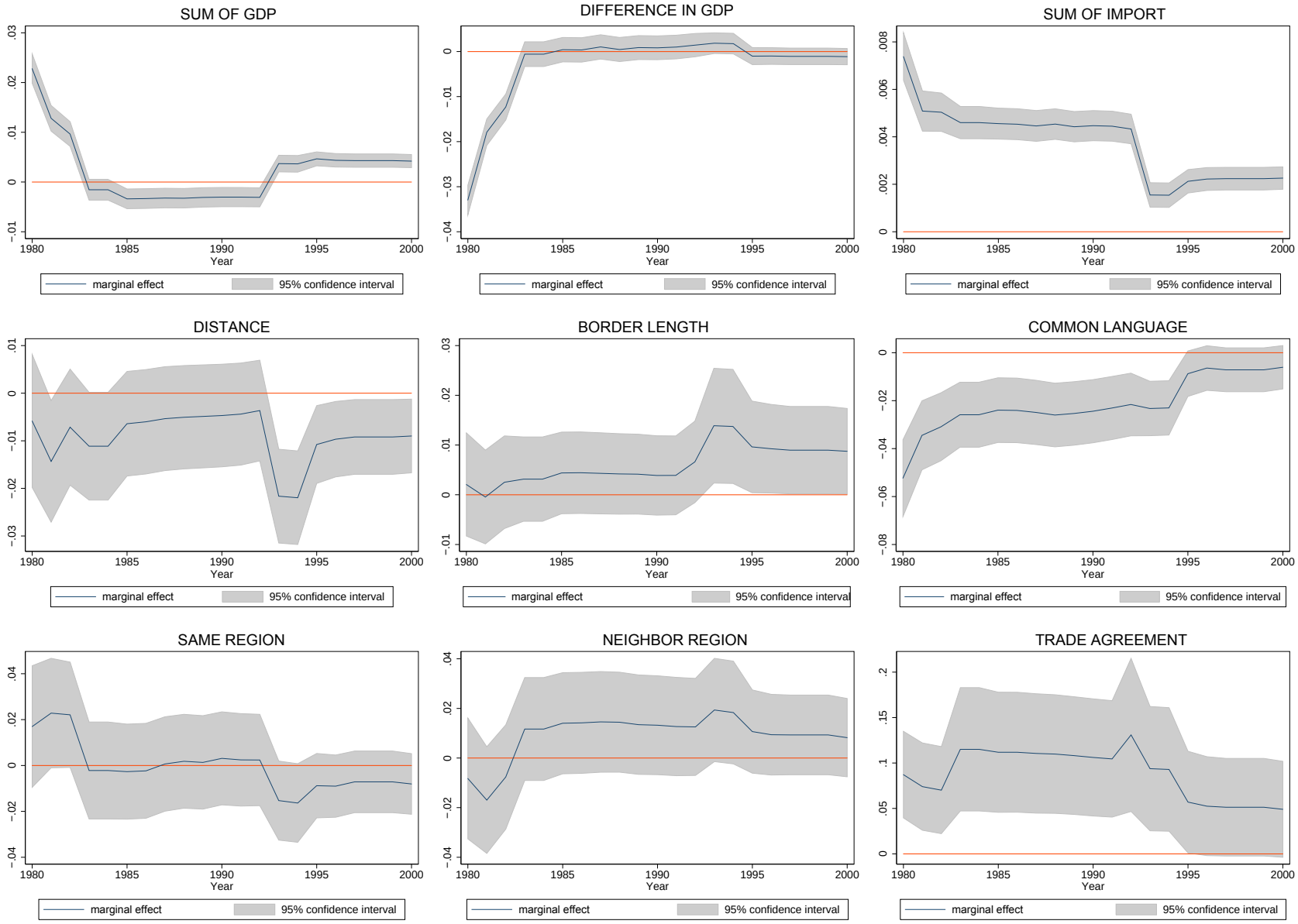


Figure 5 OLS results using MEAs with greater than the 3rd quartile number of signatories

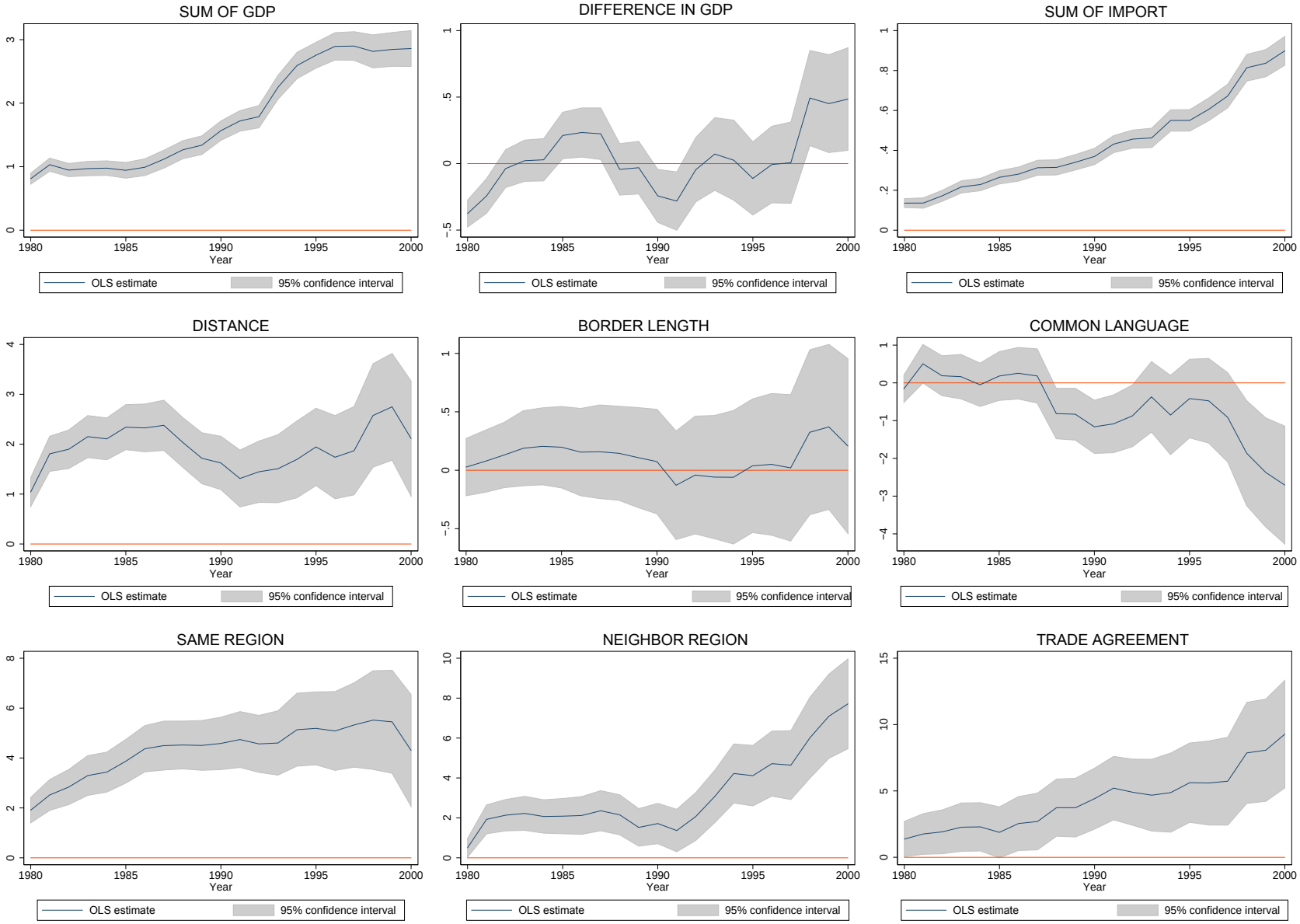


Figure 6 Probit results using all MEAs

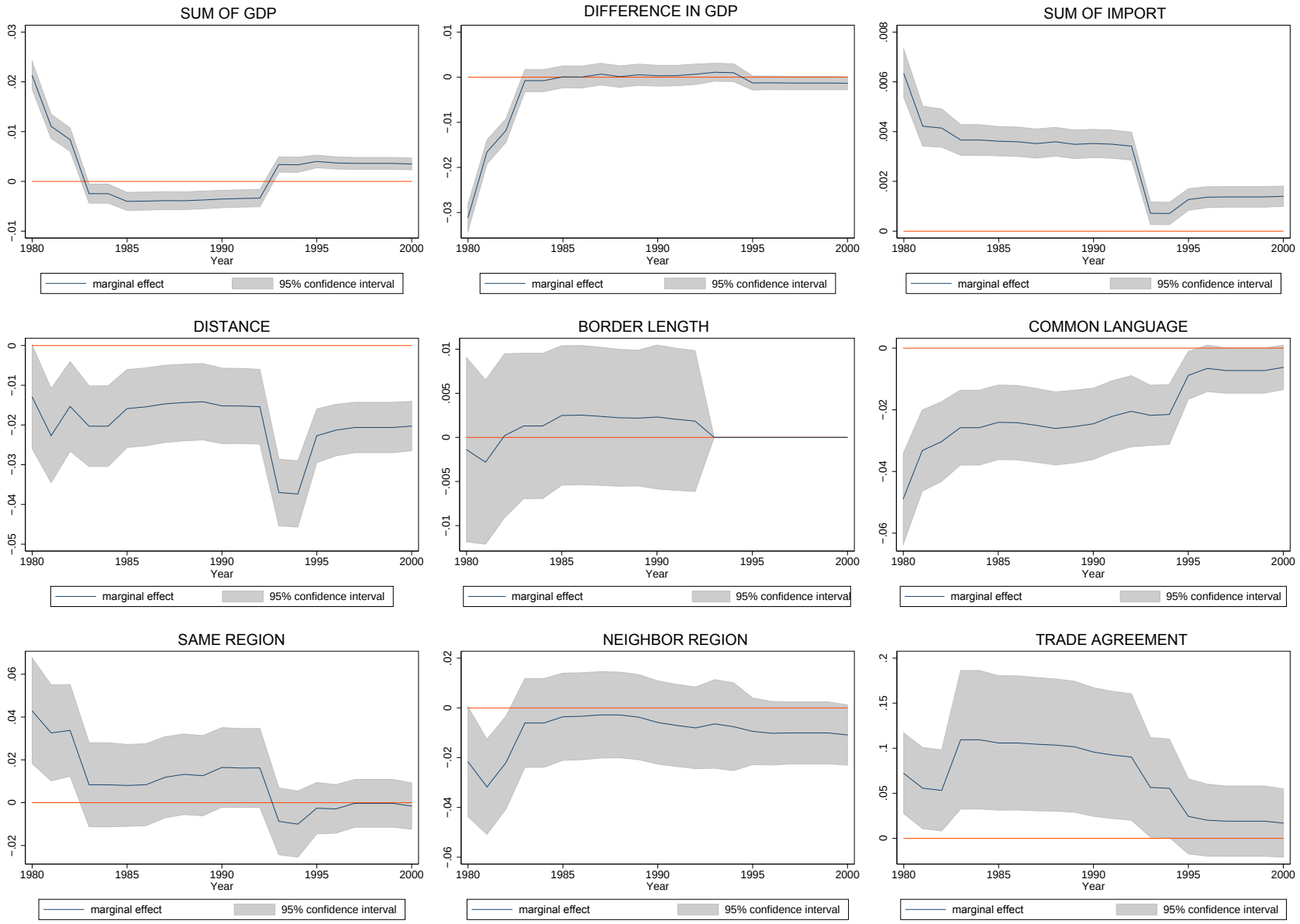


Figure 7 OLS results using all MEAs

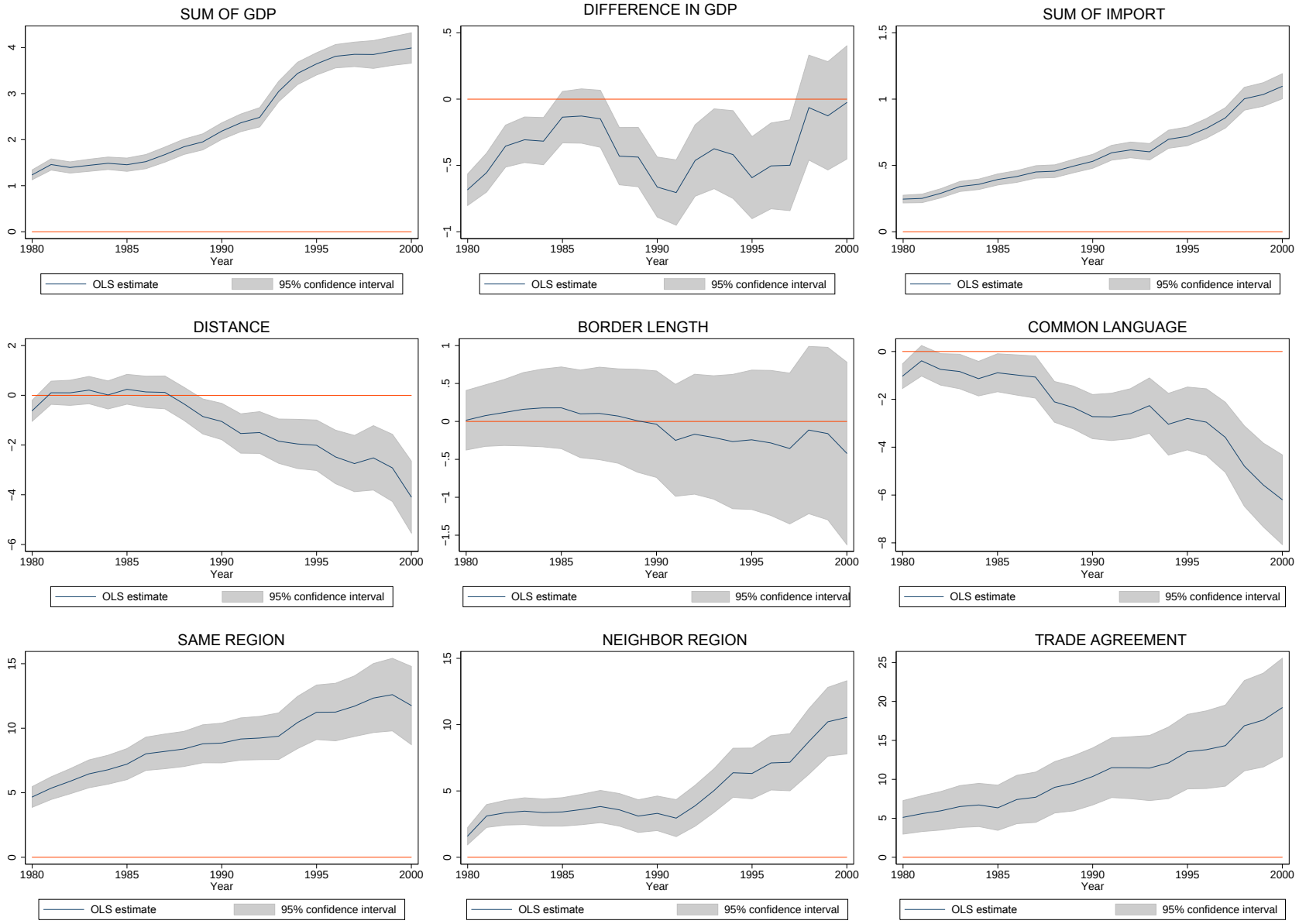


Figure 8 Probit results using MEAs with less than the median number of signatories

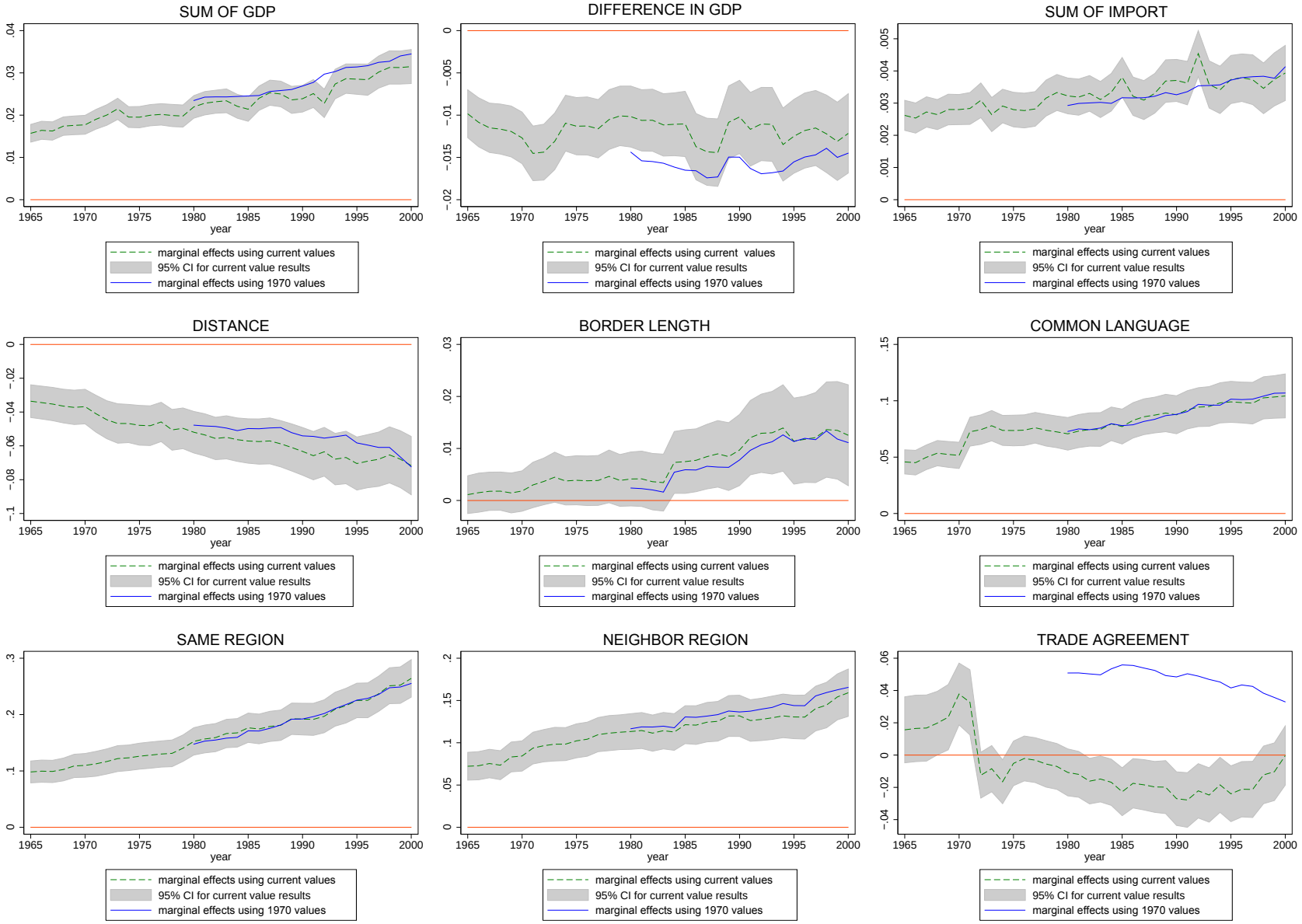


Figure 9 OLS results using MEAs with less than the median number of signatories

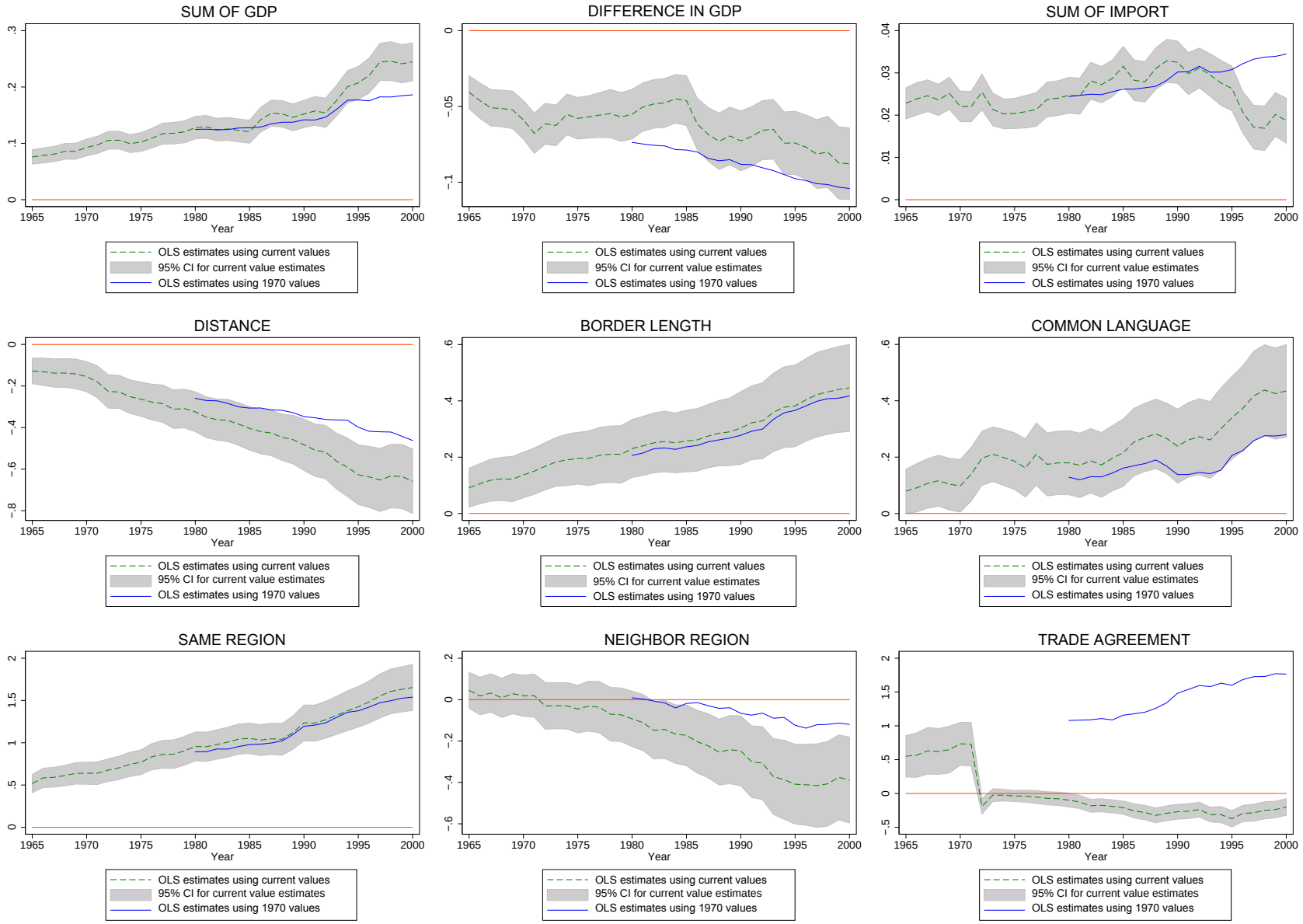


Table 1: Common pool resources

	Aquifers	Transboundary waters
BORDER LENGTH	0.00398***	0.01612***
	(0.000)	(0.001)
SAME REGION	0.02069***	0.05383***
	(0.003)	(0.003)
NEIGHBOR REGION	0.01421***	0.03941***
	(0.003)	(0.003)
Observations	22,791	22,791

Standard errors in parentheses, ***, **, and * denote p-value less than 0.01, 0.05, and 0.1.
NOTE: All results we present are marginal

Table 2: Descriptive Statistics for 1990 regressions

Variable	Obs	Mean	Std. Dev.	Min	Max
Dependent Variable					
Number of Small Agreements	9,216	0.5377	2.0507	0	34
Small Agreement Dummy	9,216	0.1623	0.3688	0	1
Number of Large Agreements	9,216	3.3421	4.1595	0	17
Large Agreement Dummy	9,216	0.9027	0.2964	0	1
Number of All Agreements	9,216	13.1248	20.5409	0	185
All Agreement Dummy	9,216	0.9352	0.2461	0	1
Independent Variable					
SUM OF GDP	9,216	17.9863	3.0377	8.2842	29.3126
DIFFERENCE IN GDP	9,216	2.4468	1.8336	0.0001	11.0490
SUM OF IMPORT	9,216	7.7679	11.2142	0	45.7842
DISTANCE	9,216	8.7758	0.7486	4.7418	9.8925
BORDER LENGTH	9,216	0.1238	0.8947	0	9.0931
COMMON LANGUAGE	9,216	0.1918	0.3938	0	1
SAME REGION	9,216	0.1268	0.3328	0	1
NEIGHBOR REGION	9,216	0.1082	0.3106	0	1
TRADE AGREEMENT	9,216	0.0341	0.1814	0	1

Table 3: The likelihood of two countries having an MEA in 1990

	(1) small agreements	(2) large agreements	(3) all agreements
SUM OF GDP	0.0252***	-0.00303***	-0.00354***
	(0.00129)	(0.000987)	(0.000892)
DIFFERENCE IN GDP	-0.0136***	0.000835	0.000326
	(0.00185)	(0.00135)	(0.00117)
SUM OF IMPORT	0.00294***	0.00447***	0.00352***
	(0.000292)	(0.000324)	(0.000290)
DISTANCE	-0.0570***	-0.00470	-0.0152***
	(0.00622)	(0.00550)	(0.00485)
BORDER LENGTH	0.00695**	0.00389	0.00231
	(0.00310)	(0.00407)	(0.00416)
COMMON LANGUAGE	0.0651***	-0.0244***	-0.0245***
	(0.00737)	(0.00672)	(0.00590)
SAME REGION	0.198***	0.00311	0.0165*
	(0.0117)	(0.0103)	(0.00948)
NEIGHBOR REGION	0.103***	0.0132	-0.00586
	(0.0105)	(0.0102)	(0.00852)
TRADE AGREEMENT	0.0473***	0.106***	0.0958***
	(0.0145)	(0.0329)	(0.0364)
Observations	9,216	9,216	9,216

Standard errors in parentheses, ***, **, and * denote p-value less than 0.01, 0.05, and 0.1.
NOTE: All results we present are marginal effects. We use 1970 data on GDP, trade flows, and trade agreements and run regressions for 1990

Table 4: The number of MEAs two countries have in 1990

	(1) small agreements	(2) large agreements	(3) all agreements
SUM OF GDP	0.121***	1.567***	2.185***
	(0.00887)	(0.0777)	(0.0916)
DIFFERENCE IN GDP	-0.0978***	-0.243**	-0.663***
	(0.00914)	(0.102)	(0.115)
SUM OF IMPORT	0.0367***	0.370***	0.531***
	(0.00281)	(0.0207)	(0.0267)
DISTANCE	-0.342***	1.625***	-1.052***
	(0.0522)	(0.273)	(0.372)
BORDER LENGTH	0.268***	0.0739	-0.0365
	(0.0616)	(0.228)	(0.358)
COMMON LANGUAGE	0.0330	-1.163***	-2.722***
	(0.0576)	(0.360)	(0.470)
SAME REGION	1.186***	4.585***	8.851***
	(0.0932)	(0.535)	(0.784)
NEIGHBOR REGION	-0.148**	1.718***	3.312***
	(0.0711)	(0.515)	(0.664)
TRADE AGREEMENT	1.605***	4.418***	10.37***
	(0.277)	(1.172)	(1.866)
Observations	9,216	9,216	9,216

Standard errors in parentheses, ***, **, and * denote p-value less than 0.01, 0.05, and 0.1.
NOTE: All results we present are marginal effects. We use 1970 data on GDP, trade flows, and trade agreements and run regressions for 1990

Table 5: Alternative specifications

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Panel A: The likelihood of having an MEA				Panel B: The number of MEAs two countries have					
	Baseline results	No GDP, PTAs, or trade flows	No PTAs or trade flows	No trade flows	Baseline results	No GDP, PTAs, or trade flows	No PTAs or trade flows	No trade flows	Poisson	Negative binomial
SUM OF GDP	0.0252***		0.0296***	0.0324***	0.121***		0.196***	0.199***	0.247***	0.301***
	(0.00129)		(0.00102)	(0.00116)	(0.00887)		(0.0110)	(0.0115)	(0.0123)	(0.0118)
DIFFERENCE IN GDP	-0.0136***		-0.0108***	-0.0133***	-0.0978***		-0.0746***	-0.0967***	-0.124***	-0.157***
	(0.00185)		(0.00161)	(0.00184)	(0.00914)		(0.00770)	(0.00919)	(0.0179)	(0.0216)
SUM OF IMPORT	0.00294***				0.0367***				0.0281***	0.0330***
	(0.000292)				(0.00281)				(0.00238)	(0.00302)
DISTANCE	-0.0570***	-0.0341***	-0.0654***	-0.0652***	-0.342***	-0.259***	-0.491***	-0.436***	-0.330***	-0.637***
	(0.00622)	(0.00258)	(0.00554)	(0.00626)	(0.0522)	(0.0261)	(0.0536)	(0.0551)	(0.0515)	(0.0703)
BORDER LENGTH	0.00695**	0.0101***	0.00557**	0.00542*	0.268***	0.329***	0.309***	0.257***	-0.0104	0.00579
	(0.00310)	(0.00144)	(0.00280)	(0.00319)	(0.0616)	(0.0506)	(0.0630)	(0.0628)	(0.0159)	(0.0208)
COMMON LANGUAGE	0.0651***	0.0372***	0.0697***	0.0712***	0.0330	0.102***	0.212***	0.110*	0.523***	0.739***
	(0.00737)	(0.00324)	(0.00648)	(0.00738)	(0.0576)	(0.0268)	(0.0504)	(0.0572)	(0.0772)	(0.0718)
SAME REGION	0.198***	0.0825***	0.174***	0.198***	1.186***	0.664***	1.207***	1.185***	1.417***	1.473***
	(0.0117)	(0.00509)	(0.0106)	(0.0118)	(0.0932)	(0.0531)	(0.0978)	(0.0969)	(0.104)	(0.127)
NEIGHBOR REGION	0.103***	0.0446***	0.0757***	0.0958***	-0.148**	-0.138***	-0.355***	-0.221***	0.499***	0.456***
	(0.0105)	(0.00474)	(0.00938)	(0.0106)	(0.0711)	(0.0356)	(0.0736)	(0.0735)	(0.0955)	(0.118)
TRADE AGREEMENT	0.0473***			0.0676***	1.605***			1.862***	0.186**	0.234*
	(0.0145)			(0.0142)	(0.277)			(0.285)	(0.0887)	(0.129)
Observations	9,216	22,791	10,153	9,216	9,216	22,791	10,153	9,216	9,216	9,216
R-squared					0.316	0.121	0.262	0.291		

Standard errors in parentheses, ***, **, and * denote p-value less than 0.01, 0.05, and 0.1.

Note: Panel A includes column (1) to (4). Panel B includes column (5) to (10). We use 1970 data on GDP, trade flows, and trade agreements and run regressions for