Economic Determinants of Multilateral Environmental Agreements

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Abstract

We examine the economic factors that lead to multilateral environmental agreements (MEAs) being formed. We examine the likelihood a pair of countries enters into the same MEA as well as the number of MEAs they both share using a near universe of agreements. Two countries are more likely to have an MEA or 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 MEAs between a small number of countries, consistent indicating that MEAs 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 among others (Mitchell 2002-2014). In this paper we empirically investigate the economic determinants of the formation of multilateral environmental agreements.

Previous empirical literature investigating multilateral environmental agreements (MEAs) mainly focuses 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, 2014). General results show that countries that are wealthier, have a more democratic political system, and most importantly, are more open to trade are more likely to ratify an MEA. Our effort departs from the current literature by examining two countries' cooperation on a near universe of multilateral environmental agreements, rather than focusing on a small number of them or focusing on a single country's ratification of a particular agreement.

We examine countries' cooperation on 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 MEA participation 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 or never cooperate (like France and Mexico or France and Slovakia).

We use a specification motivated by the gravity equation to explain countries' cooperation on multilateral environmental agreements. We find that GDP, distance, and preferential trade agreements, variables that usually explain bilateral trade flows well in the gravity equation literature in international trade, 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 mitigating emissions or protecting endangered species may incur economic losses. For example, restricting emission of pollutants like carbon dioxide might hurt their firms' competitiveness in the global market as new regulation increases the cost of production. Moreover,

cooperating on some environmental agreements may result in less trade between countries. As a result, countries trading more with each other might avoid joining MEAs together as it may have a large negative effect on their trade.

On the other hand, it may be easier for countries to link their cooperation on economic policies to environmental policies when their economic interactions are large. 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 future trade agreements if it refuses to cooperate on an environmental agreement. Trading partners will be more willing to participate in environmental treaties if the benefits they obtain, such as a decrease in tariffs or forming a free trade agreement, are larger than the costs they incur.

We separately examine MEAs with a few signatories and those with a high number of signatories. 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 the MEAs in our sample. Environmental agreements in our data have as few as 3 and as many as 197 signatories. Figure 1 shows the temporal evolution of new MEAs as well as their cumulative number for the three aforementioned groups.

There are two reasons that we separate MEAs based on the number of their 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). A general rule is the smaller the actual commitment, the larger the set of participants (Sandler, 1997). Based on this theoretical prediction, we can expect that countries often bear smaller economic costs on average when they ratify large environmental treaties than they do when they ratify small environmental 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 abatement obligations. This means that countries that ratified them bear almost no cost at all. Since we examine factors that determine the likelihood of two countries having an MEA, the existence of such symbolic large treaties may bias our results.

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 environmental 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. 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.

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 MEAs may affect its GDP, trade, and its cooperation on various trade agreement. 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 (2014). 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, the economic factors have mixed, if any, effects.

Our 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."

2. Related Literature

There are a large number of game-theoretic papers exploring the formation and characteristics of international environmental agreements. Much of this literature focuses on whether a stable coalition forms (Libecap, 2014). Non-cooperative game theory is a very popular approach (e.g. Barrett, 1994, 1997, 2001; Carraro and Siniscalo, 1993, 1998; Hoel, 1992; Hoel and Schneider, 1997; Rubio and Ulph, 2003; Finus et al 2005). This literature mainly uses the concept of internal and external stability. Internal stability means that no coalition member or signatory of an MEA has an incentive to leave the agreement to become a non-signatory. External stability means that no non-signatory party has an incentive to join the MEA.

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, 2014; Davies and Naughton, 2014). Most papers examine the role of trade liberalization in countries' participation decisions. 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 treaty ratification by a country's neighbors, the more treaties the country will ratify itself. In addition, their results are most evident in regional environmental agreements.

Millimet and Roy (2014) 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. To consistently estimate this 'chilling' effect, two econometric issues need to be addressed: self-selection in the GATT/WTO and the difficulty of actually classifying GATT/WTO. The authors use a partial identification approach to tackle these problems. The results show that one cannot exclude the possibility that GATT/WTO has no causal effect on MEA participation for the full sample. WTO does have a negative effect on MEA participation by less developed or non-OECD countries.

Our paper is also related to the literature on formation of international trade agreements. There is a large body of empirical research investigating the formation of free trade agreements (Baier and Bergstrand, 2004; Egger and Larch, 2008; Baldwin and Jaimovich, 2012; Chen and Joshi, 2010; Bergstrand et al., 2014). 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 the two trading partners, the more remote two continental trading partners are from the rest of the world, the jointly economically larger and more similar are the two trading partners, the greater is the difference in capital-labor endowment ratios between the two countries, 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.

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 square 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 the following regression

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

where $\boldsymbol{x}$ is a vector of explanatory variables, $\boldsymbol{\beta}$ is a vector of parameters, and error term $\boldsymbol{e}$ 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 therefore estimate a binary choice model of the following form:

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

where $G(\cdot)$ is the standard normal cumulative distribution function, which ensures that $P(MEA = 1 \mid X)$ lies between 0 and 1. As we noted above, MEA is a binary variable which is unity if two countries jointly participate in an environmental agreement and zero otherwise.

The econometric framework used in the second method is the linear regression model which is shown in equation (3). The dependent variable $\boldsymbol{y}$ 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 301 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 dependent variables, we can divide our explanatory variables into several groups: gravity variables, economic integration variables, and common 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. For variables measuring the sum and difference of the logarithm of real GDPs 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 an environmental agreement together. The variable distance measures the logarithm of distance in kilometers between the two countries. Closer countries might know each other better than remote ones because there might be more economic or non-economic interactions between them. This might foster better cooperation in the environmental arena as well. With the common language variable we want to test whether countries that share the same official language are more likely to have an environmental treaty.

For economic integration variables, we include: (5) SUM OF IMPORTS: the sum of the logarithm of bilateral trade flows of two countries; and (6) TRADE AGREEMENT: a dummy variable which is unity if two countries have a preferential trade agreement. We use these two variables to measure countries' economic integration levels. 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. Trade policy negotiations have been increasingly accompanied by environmental policy measures (Baghdadi, 2013). So we might expect countries with trade agreements are more likely to have environmental agreements with each other.

For common resources variables, we include: (7) BORDER LENGTH: equal to logarithm of (1+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; 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 primarily used to resolve regional environmental issues, controlling for these variables helps better identify the effects of economic factors on countries' MEA cooperation.

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 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.

There are 1,119 agreements, including original agreements, protocols and amendments, from 1950 to 2012. 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 those existing agreements. While one could exclude those 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 in a given year. We then proceed 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 all agreements.

Previewing our results, economic size, distance, and economic integration variables can successfully explain countries' cooperation on MEAs with fewer than 26 signatories, the median number. These factors have mixed effects in different years for MEAs with more than 68 signatories, the 3rd quartile of signatories and for all MEAs.

5.1 Economic determinants of small MEAs, large MEAs, and all MEAs for year 1990

5.1.1 The likelihood of having a multilateral environmental agreement

In Table 1, we present the marginal effects for the likelihood of two countries having an environmental agreement in 1990. Our dependent variable here is dichotomous and is equal to one if two countries have an environmental agreement in a given year and zero otherwise. In addition, we report marginal effects evaluated at means of independent variables on the probabilities of two countries having an environmental agreement.

The first column refers to the results using MEAs with fewer than 26 signatories, the median number. 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% (since the independent variable is the sum of the logged GDPs), 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 with the latter pair holding other things equal. The difference in logged GDPs has a negative effect indicating that countries with 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.[1] Our results support this assertion. Countries with a trade agreement are more likely to have an environmental agreement. In 1990 trade agreements tend to increase 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 together, 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 1 present the results using MEAs with a large number of signatories (68 to be precise) and all MEAs respectively. As we argued above, the results using large agreements and all agreements may be inconclusive. 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 that. This kind of cooperation may lack economic driving forces. As a result, our economic determinants may not work well in explaining countries' cooperation on large MEAs.

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 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.

5.1.2 The number of multilateral environmental agreements

[1] 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.

We show our results on factors influencing the number of MEAs two countries have in 1990 in Table 2. Similar to Table 1, 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 have as they do in explaining the likelihood of two countries having an agreement. Specifically, economically large countries and those with 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 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 have. 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.

5.2 Economic determinants of small MEAs, large MEAs, and all 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 present the results on economic determinants of the likelihood of two countries having an environmental agreement. Figure 3 show the results on the determinants of the number of agreements two countries have.

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 of our estimations. Compared to the results shown in the first column in Table 1, these graphs examine the temporal stability of each determinant. As we can see, the effects of most explanatory variables are rather stable over time. 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. These effects are statistically significant over time.

In Figure 3, we plot similar graphs on factors determining the number of environmental agreements two countries have. Most determinants have statistically significant and consistent effects over time. 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

In this section, we investigate countries' cooperation on MEAs with more than 68 signatories and all MEAs in our sample. 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 other 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 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 have 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 flow 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 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 have.

6. Robustness

We implement several robustness tests to check the sensitivity of our results. We first examine various alternative specifications in Table 3.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.

In Table 3, we present our results using alternative specifications. 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. For the first panel, column 1 is the baseline result which is the same as the first column in Table 1. 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 result. For the second panel, column 5 presents the baseline result which is the same as the first column in Table 2. 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 result. In columns 9 and 10, we employ Poisson and negative binomial estimators to deal with the count nature of our dependent variables. All explanatory variables still have similar effects.

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). To obtain results in early years (before 1980), we have to use explanatory variables in their current-year values since information on GDP and trade flows is missing for many of the earlier years. We compare the results from using current-year values to those using 1970 values by plotting both sets of coefficients in the same figure. Most variables have similar effects when we use their current-year values in estimation. As we can see, most variables of interest have similar effects in the early years.

7. Conclusion

In this paper, we employ a gravity type model to 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.

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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Table 1 The likelihood of two countries having an MEA

VARIABLES	(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)
COMON 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 2 The number of MEAs two countries have

VARIABLES	(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)
COMON 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 3 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					
VARIABLES	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)
COMON 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		
ln(\alpha)										0.744***
										(0.0667)

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

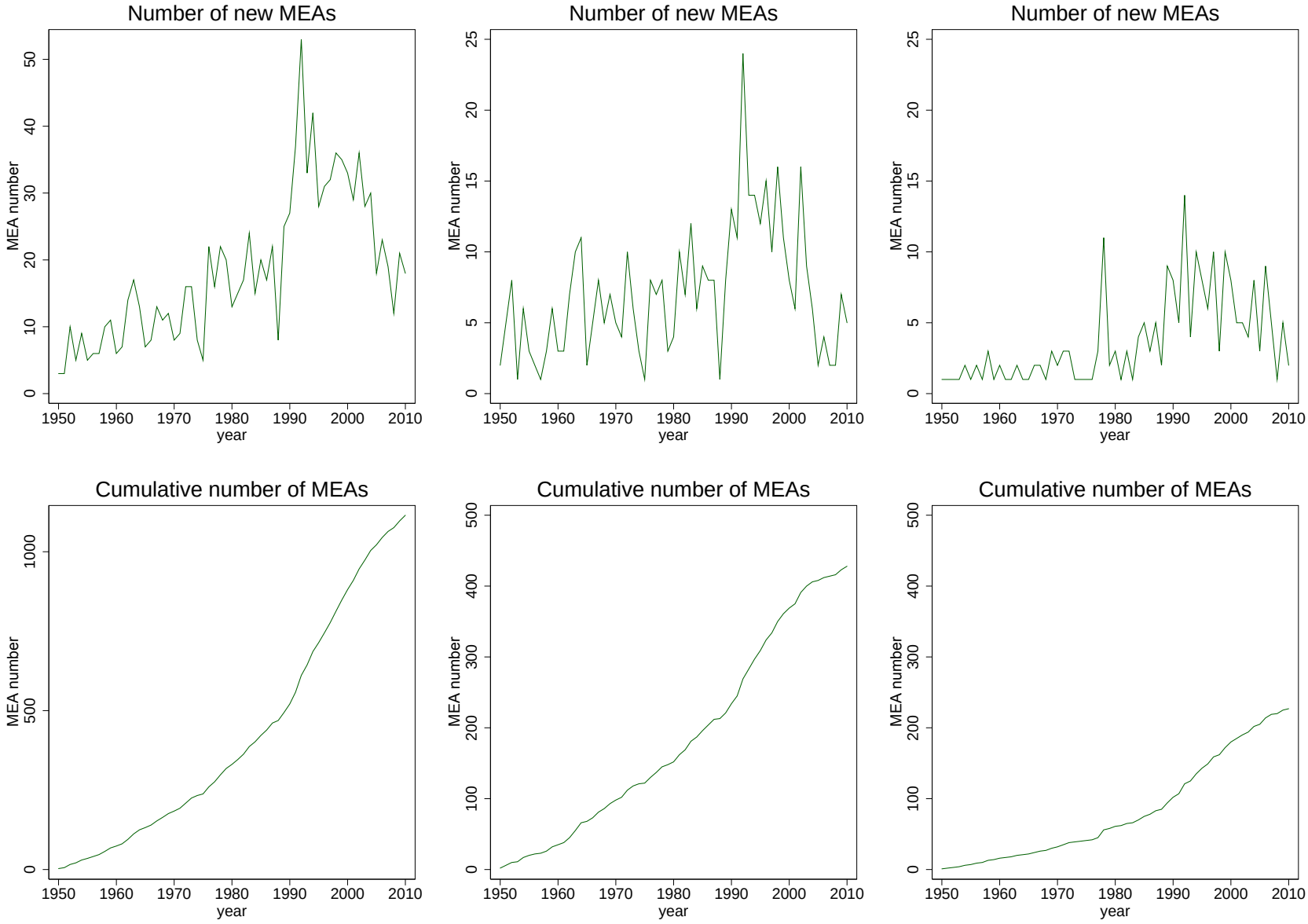
Note: Panel A includes column (1) to (4). Panel B includes column (5) to (10). We use 1970 data on GDP, trade flows, and trade agreements and run regressions

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

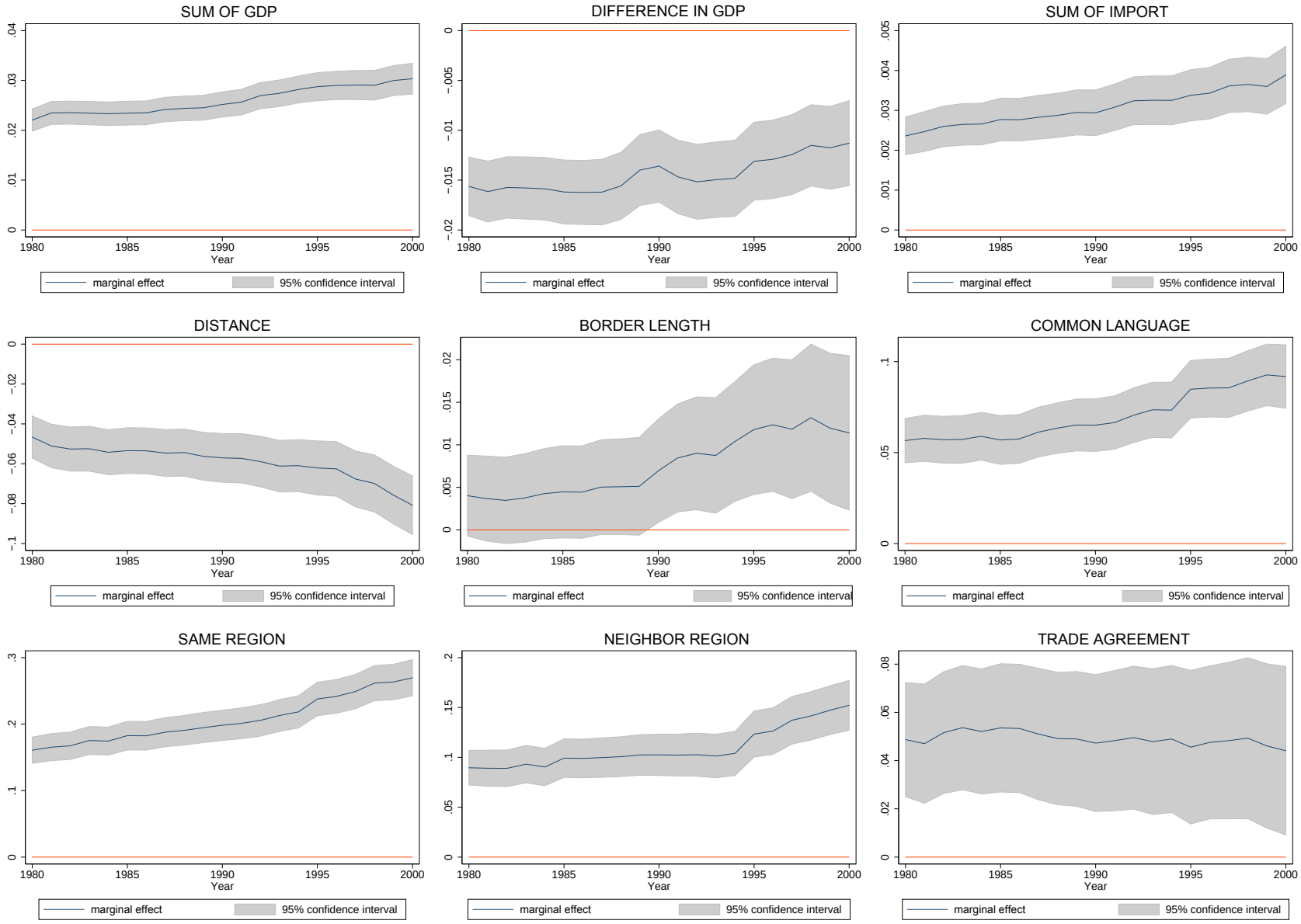


Figure 3 OLS results using MEAs with fewer than the median number of signatories

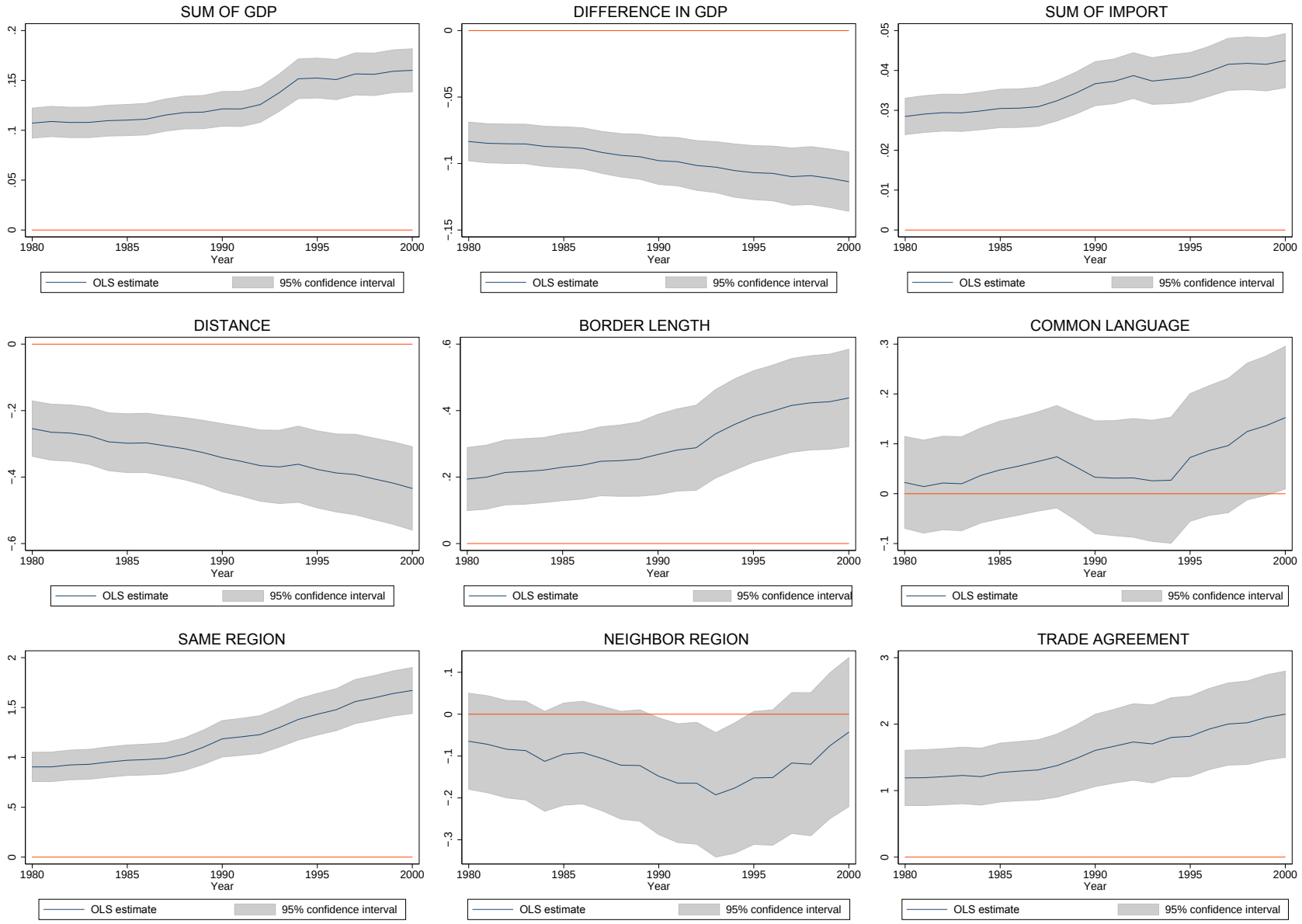


Figure 4 Probit results using MEAs with greater than the 3rd quartile number of signatories

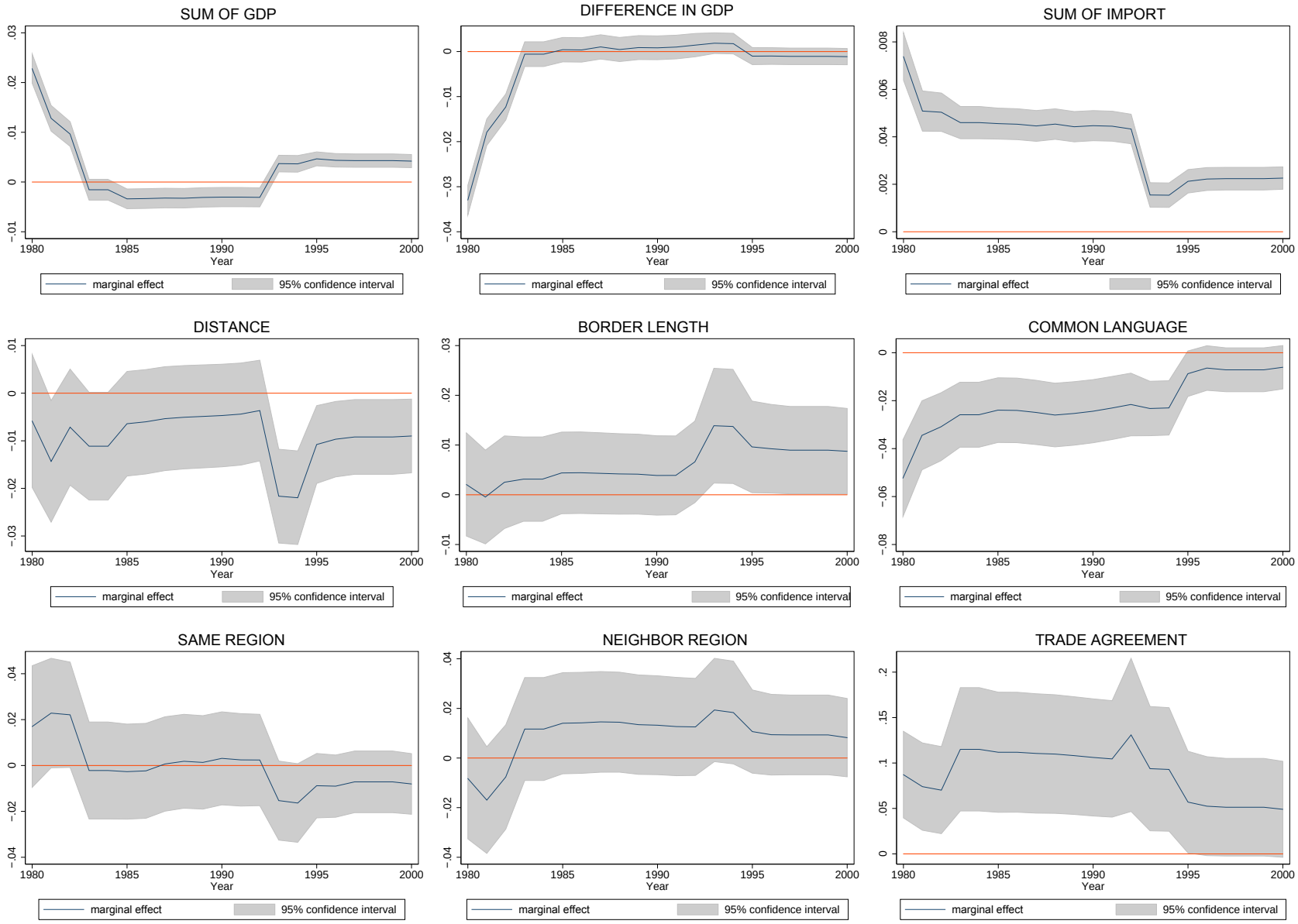


Figure 5 OLS results using MEAs with greater than the 3rd quartile number of signatories

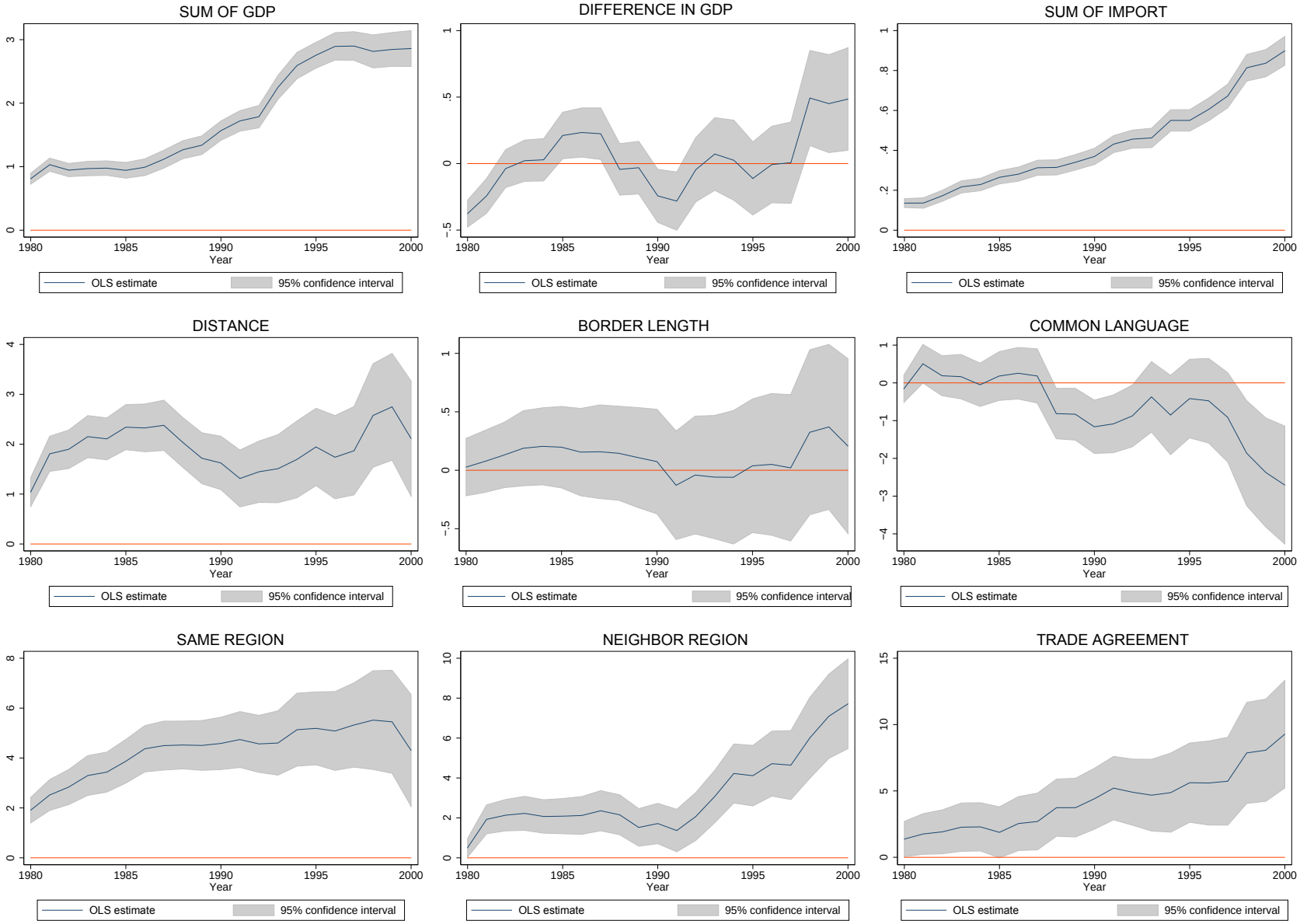


Figure 6 Probit results using all MEAs

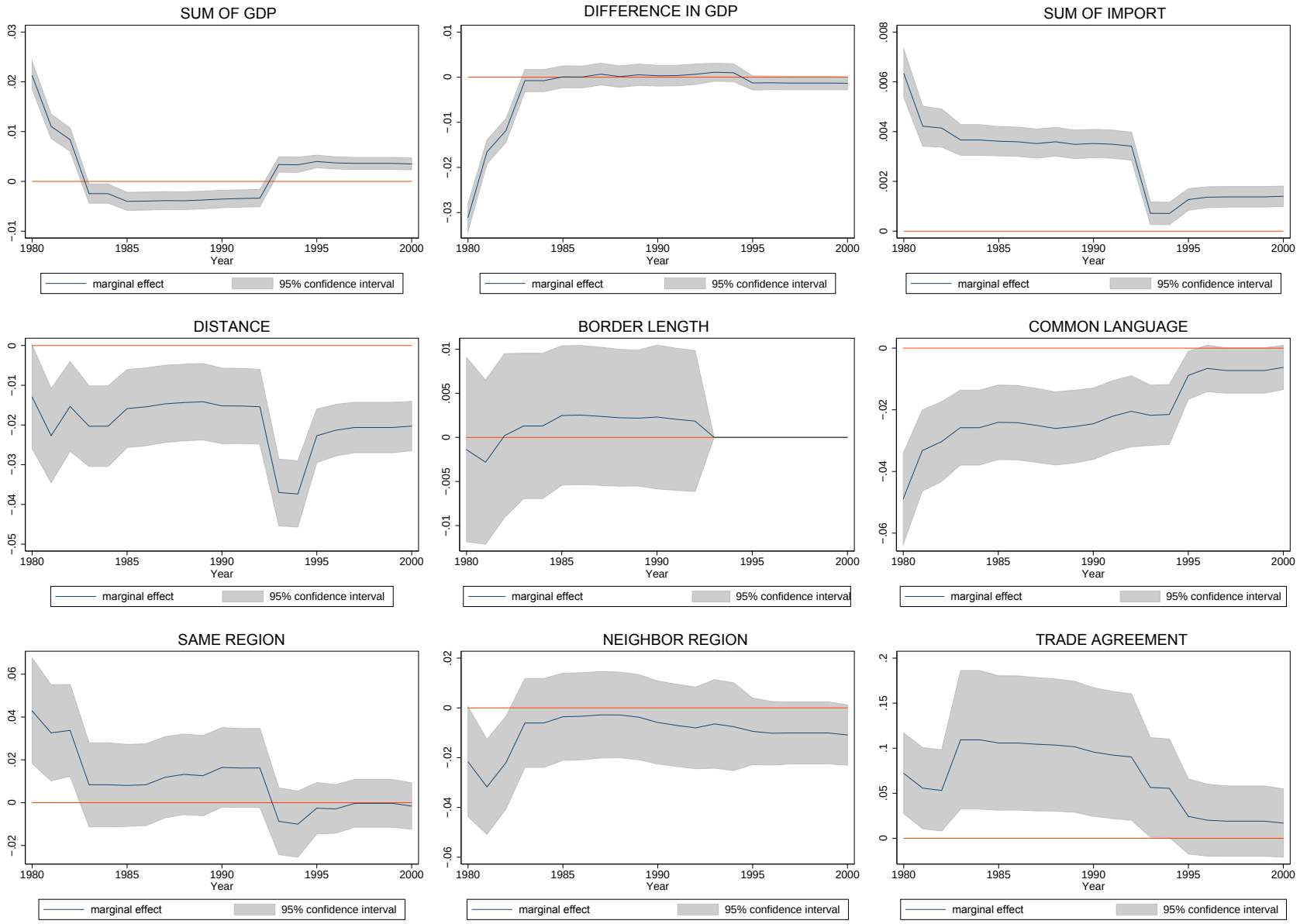


Figure 7 OLS results using all MEAs

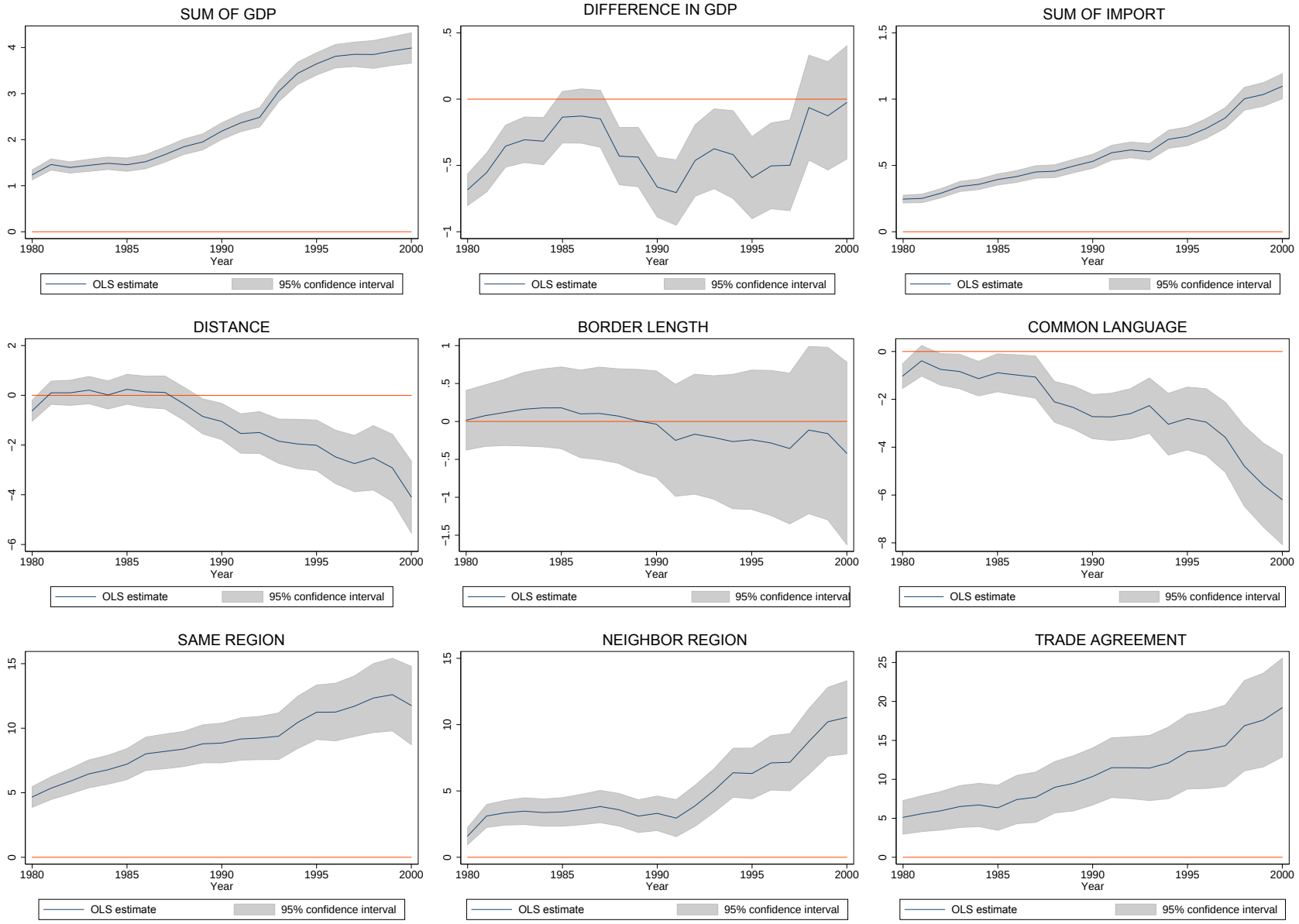


Figure 8 Probit results using MEAs with less than the median number of signatories

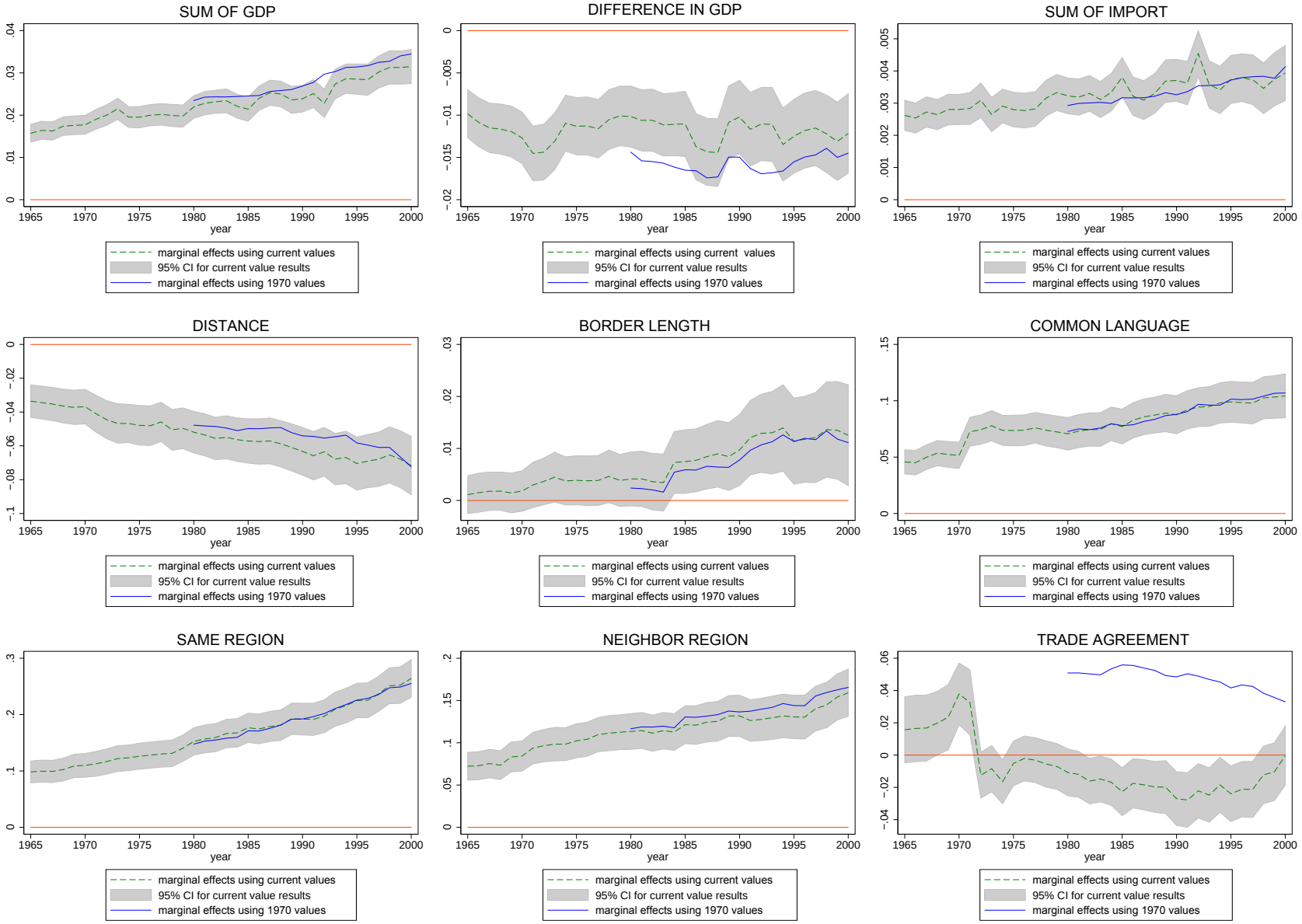


Figure 9 OLS results using MEAs with less than the median number of signatories