

Computation and the Theory of Customs Unions *

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Abstract

This paper reports on research that uses computational techniques to assess whether or not various propositions that have been advanced as plausible in the literature on the theory of customs unions actually hold. This research blends theory and numerical simulation to get insights into the likelihood that various theoretical propositions proposed in the customs union literature hold.

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1 Introduction

Despite nearly fifty years of research on regional trade agreements, originating with Viner's (1950) famous book on Customs Unions, few generally accepted propositions regarding the effects of regional trade agreements have yet emerged to guide policy makers and public officials. Whether individual countries necessarily gain by entering a customs union (CU) is unproven¹. Whether world welfare is higher under a CU is also unknown, as is whether customs unions generate higher external tariffs compared to a non-cooperative Nash equilibrium in tariffs. Other propositions are widely thought to be true, but without explicit confirmation; such as that customs unions generally improve the terms of trade of member countries; and that non-member countries prefer that no customs union be formed against them. In this paper, we discuss research that blends theory and numerical simulation, to determine the frequency with which various results hold so as to obtain an indication of which statements are more likely to hold and which not.

The general approach taken considers a three-country, three-good, pure exchange model with CES preferences. To generate our sample set we use both random draws and a grid search over the space defining preference parameters and endowments. We compare both free trade and three-country non-cooperative (Nash) equilibria to partial cooperation regional agreement equilibria where two countries form a regional agreement and play non-cooperatively against the third country (CU). We assume a uniform prior over the parameter space (admittedly a strong assumption) and then calculate the percentage of cases for which certain results hold. The uniform prior assumption means that we do not take a stand about which parameters are more likely to occur than others. We think this is appropriate because we view our work as a substitute for theory. In theoretical research there are no presumptions about parameter values. While we think that it would be interesting to try and run simulations based on actual field data that is not our purpose here. Thus, the sample frequencies we obtain can be interpreted as the probability of particular propositions holding conditional on both the model and the assumed uniform prior.

Taken as a set, our results show that numerical simulation can be an important and useful adjunct to theory in economics. None of the propositions we consider holds unambiguously; some hold over 80% of the time, others considerably less frequently. We also investigate the reasons why particular propositions seem to hold more frequently than others using additional model analyses². Thus, where theory does not yield clear and unambiguous results, numerical simulation can be used to generate insights as to the likelihood of and reasons for particular propositions holding and, we believe, yield significant benefits in many other areas.

¹Kowalczyk (2000) shows that free trade agreements between large and small countries may form if transfer payments can be made.

²See Abrego, Riezman, and Whalley (2001a,2001b) for this analysis.

2 Customs Union Literature

Ambiguous theoretical outcomes have been a constant in the customs union literature since its inception. In 1950 Jacob Viner, the initiator of subsequent customs union literature, pointed out that regional trade agreements do not necessarily result in gains to members, even though some tariffs are eliminated by the agreement. He developed what later became known as the trade creation-trade diversion approach to regional trade agreements to help understand this ambiguity. Following Viner's work, for many years trade creating regional agreements were seen as good, and trade diverting regional agreements were seen as bad.

Viner's work was also the driving force behind later literature that subsequently sought to set out the conditions under which regional trade agreements would either improve or worsen welfare. This work was still based on trade creation-trade diversion considerations; but Meade (1955), Lipsey (1957) and others discovered that preference considerations also enter in trying to make such determinations. This led to Lipsey and Lancaster's (1958) characterization of the general theory of the second best, confirmation that no general customs union results were possible. Dissatisfaction with the trade creation-trade diversion dichotomy resulted in Lipsey (1970), Kemp (1969), Riezman (1979) and others trying to develop other approaches that would yield clear propositions.³ A new approach known as the terms of trade-volume of trade approach became popular, under which the impact of a regional trade agreement can be summarized by its effects on both terms of trade (prices) and trade volumes.⁴ This terms of trade-volume of trade approach uses general equilibrium instead of Vinerian partial equilibrium analysis, and emphasizes the impacts of the union on individual countries as integration occurs, instead of on world welfare.

However, even with the adoption of a new approach the same lack of general results has continued to characterize the literature. Indeed, few if any propositions are true for all parameter values even in highly simplified models. In other literature, such as Kennan and Riezman (1990), strategic considerations underlying the formation of regional trade agreements have served to further cloud the picture. Thus, one objective behind the formation of the EU in the late-50s was to enhance joint country bargaining in the GATT with the US; and Mercosur was, in part, an attempt by four countries (Brazil, Argentina, Uruguay, Paraguay) to strengthen their bargaining position for an eventual accession negotiation with NAFTA. Such considerations naturally suggest treating countries as strategic players in a multi-country mixed cooperative - non-cooperative trade policy game, but such considerations have made the search for clear propositions as to the effects customs unions even more difficult.

Our approach is to build on the applied general equilibrium modelling liter-

³See Lloyd (1982), Wooton(1986), Riezman (1985), Kemp and Wan (1976).

⁴Kowalczyk (2000) provides a comprehensive critique of the trade diversion and trade creation methodology, and argues that the terms of trade and volume of trade approach constitutes an attractive alternative.

ature and use numerical simulation methods to investigate the frequency with which various propositions hold. Since Miller and Spencer (1971), Shoven and Whalley (1974) and Whalley (1985), researchers have used numerical equilibrium models to simulate the effects of regional trade agreements as well as to address a range of policy questions. They were used extensively in the WTO Uruguay Round process (see Harrison, Rutherford and Tarr, (1996), and Francois, McDonald and Nordstrom (1996)) as well as in the earlier Tokyo Round. They have also been used to explicitly model the effects of regional trade agreements (Hamilton and Whalley, (1985), Perroni and Whalley, (2000)). These models are richer (more countries, production, more commodities) than the trade models that theorists frequently use. However, propositions of the form we investigate here are not explored.

Our blend of theory and numerical simulation seeks to assess whether propositions hold most of the time, and thus stand as reasonable working hypotheses; or whether they hold seldom, and are thus largely theoretical curiosities. We do this by using numerical simulation techniques to compute equilibria for a large number of model parameterizations, and then to assess the likelihood of a given proposition holding generally by computing sample frequencies.

3 Methodology

3.1 The Economic Model

In investigating customs unions theory the first decision to be made is on the basic modeling approach to follow. The two main existing approaches are the trade creation-trade diversion approach pioneered by Viner (1950) and the terms of trade-volume of trade approach initially developed by Meade (1995), Jones (1969) and Ohyama.⁵

Jacob Viner pointed out that regional trade agreements, although they do eliminate some tariffs, do not necessarily result in gains to members. He developed the trade creation-trade diversion approach to regional trade agreements to help understand how this can happen. These two forces can be explained with a simple example. Suppose two countries, A and B, form a customs union with country C remaining outside the agreement. Suppose that before the customs union forms country A imports clothing from country C, who is the low cost producer of clothing. Further suppose, that as a result of the agreement, A imports clothing instead from B because B has the advantage of tariff-free access to A's market. In this case, trade into A is diverted from low cost producer C to high cost producer B and welfare may be lowered. However, if A formed a union with C, A would import more from low cost producer C and less from high cost producer B; in this case trade would be created and welfare increased. Following Viner's work, for many years trade creating regional agreements were seen as good, and trade diverting regional agreements were seen as bad.

⁵See Kowalczyk (1999, 2000) for a discussion of the terms of trade and volume of trade approach to customs unions theory.

Later work sought to set out the conditions under which regional trade agreements would either improve or worsen welfare. This work, still based on the trade creation-trade diversion approach, (Meade (1955), Lipsey (1957) and others) discovered that preference considerations also enter in trying to make such determinations. This work culminated in Lipsey and Lancaster's (1958) characterization of the general theory of the second best; which states that given distortions exist, the removal of some distortions does not necessarily increase welfare. The implications for customs unions are clear. A customs union removes some distortions (tariffs) but not all of them hence there is no guarantee that customs unions increase economic welfare.

A new approach known as the terms of trade-volume of trade approach became popular, under which the impact of a regional trade agreement can be summarized by its effects on both terms of trade (prices) and trade volumes. This terms of trade-volume of trade approach uses general equilibrium instead of Vinerian partial equilibrium analysis, and emphasizes the impacts of the union on individual countries as integration occurs, instead of on world welfare.

However, even with the adoption of a new approach the same lack of general results has continued to characterize the literature. Indeed, few if any propositions are true for all parameter values even in highly simplified models. Consider the conjecture: "In a 3-country pure exchange economy, any pair of countries can benefit by forming a regional trade agreement". In a world where countries are of the same size this conjecture is true, but as Riezman (1999) shows, this conjecture fails to hold more generally. In a world with one large and two smaller countries, a regional trade agreement between the large country and either smaller country can result in the large country doing worse than in the initial equilibrium. In the initial equilibrium, the large country benefits from its use of tariffs against both countries, while small countries lose. When the large country forms a customs union it shares some of its tariff advantages with the other union partner, but foregoes the opportunity to play strategically against the small partner. Thus, even in a very simple model there are still no general results even for a more restricted set of questions⁶.

Kennan and Riezman (1990) introduce strategic considerations into the problem of customs union formation. Thus, one objective behind the formation of the EU in the late-50s was to enhance joint country bargaining in the GATT with the US; and Mercosur was, in part, an attempt by four countries (Brazil, Argentina, Uruguay, Paraguay) to strengthen their bargaining position for an eventual accession negotiation with NAFTA. Such considerations naturally suggest treating countries as strategic players in a multi-country mixed cooperative-non-cooperative trade policy game. However, such considerations have made the search for unambiguous customs unions propositions even more difficult.

In this paper, we derive results using the same type of three country-three good pure exchange model considered by Kennan and Riezman (1990.) We use

⁶There has nonetheless been intense recent policy debate over whether or not regional trade agreements are desirable in which strong positions are advanced (Bhagwati and Panagariya (1996), Summers (1991), Riezman (1999)).

numerical methods based on the applied general equilibrium modelling literature. We discuss what can be learned using numerical methods about the effects of customs unions and which customs unions are likely to form. Whether individual countries benefit, whether trade volumes expand, whether terms of trade turn in favor of member countries, whether tariffs rise globally, which customs unions are likely to form, and whether trade agreements affect patterns of trade will all be discussed below.

3.2 Computation

The basic methodology we use is to compute sample frequencies for various propositions we are interested in. For example, if we want to know how likely it is that customs unions will increase external tariffs when they form, we use sampling techniques to generate parameterizations that we can use to make that determination. In fact, we have used two different procedures for generating alternative model parameterizations. One is a randomization technique in which we randomly select both preference parameters (both shares and elasticities) and endowments. We consider CES preferences and generate share and substitution parameters in preferences for all three countries as well as endowments normalized to lie in a unit interval for each good for each country. For each model parameterization we compute all possible equilibria and then use that data to analyze the likelihood of the various propositions of interest.

Our central case involves randomizing over both preference parameters and endowments. Table 1 sets out the key features of the procedures we use in computing equilibria on which our sample frequencies are based.

Table 1
Model Structure and Other Details of Experiments used to Assess the Frequency of Trade Pattern Changes

Dimensionality:	3 countries, 3 goods
Preferences:	CES, with parameter values generated by random draws
Endowments:	Preference parameters and endowments are randomly drawn from a unit interval
Number of cases:	We consider 2000 different model specifications in our central case, with an equilibrium computed for each
Equilibria computed for each case:	Competitive equilibria, three-country Nash equilibria, Customs Union equilibria (the sum of member utilities is maximized)

An alternative, and perhaps simpler method uses a search over a grid. In our work we have only used the grid search method on endowment configurations since the dimensionality of the grid becomes unworkably large if we also include preference parameters. The grid search procedure we consider involves all possible symmetric endowment configurations across the three countries with single digit decimals; a total of 769 cases. Table 2 indicates how a case of (0.1, 0.3, 0.4) translates into the endowment array by good by country given in Table 2. Cases which by construction are symmetric are excluded (e.g.(0.2, 0.4, 0.6) gives the same equilibrium solution as (0.4, 0.2, 0.6)). What we are able to show is that the grid search method yields essentially the same results as randomization provided the same parameters are varied. We assume that the global endowment of each good is 1 by choice of units, and consider own country endowments of goods that range between .1 and .9. We consider off diagonal elements of the endowment array to be symmetric.

Table 2
An Example of a Model Parametric Specification Generated by the
Grid Search Procedure

Endowment of Goods	Country		
	1	2	3
1	0.10	0.45	0.45
2	0.35	0.30	0.35
3	0.30	0.30	0.40

For more detail about the computations see our earlier paper Abrego, Riezman and Whalley (2001b).

In randomization cases we limit our parametric specification to the relevant range for each parameter, e.g. 0.1 for share parameters. We consider 2000 draws in our central case analysis. For all the specifications generated by both methods we compute free trade, three-country Nash, and customs union equilibria and compare across these to assess sample frequencies as to how often the propositions we list above hold in the cases we consider. Assuming a uniform prior, we can interpret the computed sample frequencies in probabilistic form as the likelihood of whether or not any particular proposition holds. As noted above, an important difference between the randomization and grid search procedures is that the grid search is limited to endowments, while the randomization is over all model parameters.

In three-country Nash cases, we encounter difficulties in computing equilibria reflecting a lack of monotonicity in the individual country utilities when they are maximized with respect to their own tariff vector. Such problems are confined

to the three-country Nash cases (and occur in between 17 and 20% of cases in our central case) and do not arise with customs union or free trade equilibrium computations. These problems manifest themselves by the GAMS optimization code we use cycling between local equilibria. They are more common in cases where trade patterns change.⁷

4 Results

We have used computational methods to investigate many different aspects of customs unions. For purposes of discussion we can divide these into four categories. The first category is what are the effects of customs unions on tariffs, prices, and trade volumes. Secondly, we also consider the welfare effects of customs unions. Next, we look at whether the formation of customs unions is likely to change the pattern of trade. Finally, using these results, the fourth category of results looks at questions regarding the likelihood of customs union formation.

4.1 Tariffs, Prices and Trade Volume

We begin by discussing what we can learn from computational methods about the effects of customs unions. The first question we consider is whether the formation of customs unions will lead to more protectionist pressure because of the desire of the member countries desire to increase their external tariffs. For example, in Krugman (1991) customs unions always increase their external tariffs. Is this result generally true? Our computations suggest that in 72.2% of the cases, customs unions raise common external tariff rates relative to three-country Nash levels. This means that one quarter of the time customs union reduce external tariffs so the result in Krugman is not generally true. This result is consistent with Bond and Syropoulos (1996) who find that the external tariff of the customs union might increase or decrease. Syropoulos (1999) provides intuition for why customs unions lower tariffs some of the time. He argues that when two countries form a customs union there are two effects working against each other in determining the optimal external tariff for the union. First, there is a tariff reduction effect. As customs unions members eliminate tariffs between them the optimal external tariff falls. Second, there is an effect that leads to increased tariffs as the customs union internalizes the tariff externality that occurs when members import the same good. Thus, two forces work in opposite directions. This intuition suggests that the external tariffs of a customs union can fall when the tariff externality is small which would happen when the customs union members do not import much of the same good. Thus, computational methods tell us that customs unions raise tariffs about three quarters of the time and want to lower them one quarter of the time.

⁷In the cases in which we cannot compute Nash equilibrium we drop all results for that endowment and preference specification.

Next we consider customs unions' effects on terms of trade. There are two possible points of comparison. We first could think about whether a customs union improves its terms of trade with respect to the non-member countries as compared to the three country Nash equilibrium. What we find is that in 88.6% of cases the terms of trade do improve. To see the intuition for these results think about the problem from the third country's point of view. The formation of the customs union means that they face a tariff war with one larger opponent instead of two smaller ones. This usually means that the terms of trade will be worse for them, better for the customs union. We have not done the calculations for the comparison to free trade, but we expect that the results would be similar.

Theory tells us that for a country joining a customs union there are two effects on trade volumes. Trade with the other customs union member increases while trade with the rest of the world decreases. Which effect dominates depends on the initial conditions. If we use free trade as our initial equilibrium then our computations show that moving from free trade to a customs union reduces customs union members' overall trade volume most (72.9%) of the time. However, if the initial comparison is three country Nash equilibrium, our results show that trade volumes for member countries increase most (86.9%) of the time. Thus, initial conditions determine which effect usually dominates. Using these results as a guide we now turn to a discussion of the welfare effects of customs unions.

4.2 Welfare

Traditionally, the customs union literature has focused on the world welfare effects of customs unions. This question has been traditionally analyzed using the trade creation-trade diversion approach. We however, can compute world welfare effects directly. In our framework, the question becomes, starting at Nash equilibrium, in what percentage of cases does moving to a customs union increase world welfare?⁸ Computations show that over three-quarters (76.0%) of the time world welfare improves moving from Nash equilibrium to a customs union. Here we are comparing two distorted equilibria. Moving from a Nash equilibrium to a customs union gives some tariff reduction, however, members of the customs union coordinate their external tariffs which usually leads to higher external tariffs. The results therefore, indicate that from a global point of view the benefits of tariff reduction outweigh the costs of better tariff coordination, with a sample frequency of 76%.

The next welfare question we consider is when *both* members of a customs union could do better with a customs union than at free trade. The importance of this issue lies in the fact that it gives an indication of the stability of free trade. To see this consider the finding from Abrego, Riezman and Whalley (2001b) that in 22.9% of cases both member countries prefer a customs union to free trade. This means that if the world economy were at free trade, more

⁸We measure world welfare by summing each individual country's welfare.

than 20% of the time there would be a customs union that would benefit both member countries. In those cases, free trade would not be very stable in the sense that there would be a tendency to defect and form a customs union. This number jumps to almost 50% (47.6%) when the comparison is to Nash equilibrium rather than free trade. So, half the time at Nash equilibrium there would be an incentive for a pair of countries to form a customs union.

Moving from a Nash equilibrium (or free trade) to a customs union improves the union member's bargaining power and the members should gain *vis-a-vis* the non-member. From Johnson (1953), Kennan and Riezman (1988) and Syropoulos (2002) we know that only where there are significant asymmetries of size in a two-country case will a country gain in Nash equilibrium relative to free trade. The same logic applies to the union-non union distinction and in our computations both members gain (i.e. the customs union is big enough) about 20% of the time.

To understand the intuition for these results it helps to decompose the change into a terms of trade effect and a volume of trade effect. Moving to a customs union from either free trade or a Nash equilibrium will usually improve the terms of trade of union members with respect to the rest of the world (88.6% of cases.) However, within the customs union one country will see its terms of trade improve at the expense of the other member.⁹ So, for one member the terms of trade improve with respect to all trading partners, while for the other the change in overall terms of trade is ambiguous and will depend on what percentage of its trade is within the customs union. The volume of trade will usually (72.9% of the time) fall moving from free trade to customs union and increase moving from Nash equilibrium to customs union (86.9% of the time.) Combining these effects it follows that welfare gain for both members of a customs union is more likely when the comparison is to a Nash equilibrium rather than to free trade.

4.3 Trade Patterns

In Abrego, Riezman and Whalley (2001a) we investigate whether the formation of customs unions influences trade patterns. What we do is rather than imposing a trade pattern on equilibrium, as is usually done in the literature, we allow it to be endogenously determined as part of each equilibrium computation. In this way we can determine if trade pattern changes are common or unusual. If we compare free trade with customs union equilibrium we find that in around 35% of cases the equilibrium trade pattern changes. If the comparison is customs union with three-country Nash equilibrium in around 40% of cases the trade patterns change. Finally, comparisons between free trade and three country Nash reveal that the trade pattern changes in about 20% of cases. Therefore, we find that, despite assumptions made in theoretical analysis to the contrary, changes in the pattern of trade are surprisingly likely to occur in three or more country trade models that compare various tariff equilibria and free trade. And

⁹Riezman (1979) stresses the importance of this effect.

thus we conclude that the assumption of unchanged trade patterns, widely used in theoretical literature on geographically discriminatory trade agreements, has weak computational support.¹⁰

4.4 Equilibrium Outcomes

We next turn to a discussion of which international trade equilibria are viable. We do this by considering when a country or group of countries could block an existing agreement. This concept was first introduced in international trade equilibria by Riezman (1985). The general idea of blocking is that trade agreement A *blocks* trade agreement B if all members of A do better under A than they do under trade agreement B .

Therefore, free trade blocks Nash equilibrium only if all countries do better at free trade than at the Nash equilibrium. Previous theoretical work suggests that this is likely to occur in cases when the endowments are relatively symmetric. Free trade blocks a particular customs union if the members of the customs union are better off at free trade than at the customs union equilibrium. A customs union blocks free trade or Nash equilibrium if the member countries do better under the customs union. A customs union can also block another customs union. This occurs if one member of the customs union can do better by joining in a customs union with the non-member. A single country can also block free trade if a country can guarantee themselves higher utility by going it alone than participating in a free trade agreement. Also, a single country can block a customs union of which it is a part if it does better by itself than as a member of the customs union.

Given these definitions of blocking the next step is to determine the likelihood that each of the three possible equilibria are blocked. For each draw of preferences and endowments we have calculated the welfare for each country under free trade, Nash equilibrium, and for any of the three possible customs unions. Using this information we apply the above definitions to determine which equilibria are blocked.

Our results indicate that 45.0% of the time multilateral free trade cannot be blocked by any customs union. That is, almost half the time there does not exist any viable customs union that makes both members better off than they are at free trade. In addition, 37.9% of the time free trade cannot be blocked by a single country acting alone. If we combine these two measurements we find that in 17.4% of cases neither a customs union nor any country acting alone can block free trade. Putting together these numbers it means then, that 82.6% of the time free trade can be blocked by either a customs union or a single country acting alone. Since $45.0 + 37.9 = 82.9$ this implies that in .3% of cases *both* a customs union and a single country can block free trade. Another interesting implication of these results is that in the cases when free trade is blocked it

¹⁰We have checked for multiple equilibria by starting the calculations from very different initial conditions. We are not able to find any examples of multiple equilibria, but that of course, does not mean that they do not exist.

is slightly more likely that it is blocked by a customs union than by a single country. We next turn to consideration of when customs unions can be blocked.

It turns out that customs unions are much less likely to be blocked than free trade. In 40.4% of cases customs unions are unblocked compared to 17.4% for free trade. We have to be a bit careful here because there are three possible customs unions that could form. The numbers in the table hold for at least one customs union. So, this means that for 40.4% of preference and endowment draws there is *at least one* customs union that cannot be blocked by any option (including the other two possible customs unions.)

For some of these 40.4% of cases there may be more than one customs union that is unblocked. We know that most of the time, nearly ninety percent, a customs union cannot be blocked by one of the other two possible customs unions. Customs unions are never blocked by free trade, and they can be blocked by a single country 67.5% of the time. Here, when customs unions are blocked it is more likely blocked by a single country (32.5%) than by another customs union (10.6%.) This implies that since customs unions are blocked 40.4% of the time then in 2.7% of cases both a single country *and* a customs unions block customs unions.

Next consider Nash equilibrium. Nash equilibrium is much more likely to be blocked than a customs union and is about equally likely to be blocked as free trade. A customs union blocks Nash equilibrium 87% of the time and Nash equilibrium is blocked in total only 87.6% of the time. This means that in almost every case in which Nash equilibrium is blocked there is a customs union that blocks it. Free trade blocks Nash in 26.7% of cases but in all but .6% of those there is also a customs union which can block Nash equilibrium as well.

Taken together these preliminary results suggest that customs unions are the most likely outcome to occur in the sense they are least likely to be blocked by some other trading arrangement. Free trade is the next most likely with Nash equilibrium being the least likely trading arrangement to arise. These results are only suggestive and await more careful analysis, but nonetheless are quite intriguing.

5 Sensitivity Analysis

5.1 Grid Search versus Randomization

In performing these computations we use two distinct methods. One method systematically searches a grid computing equilibria for all possible values of the relevant variables. An alternative to the grid search method is a randomization procedure that randomly selects values of the relevant variables then computes the corresponding equilibria. In Abrego, Riezman and Whalley (2001b) we report results which compare grid search and randomization procedures. We find that the method used to generate sample frequencies may be less important than the restrictions placed on the search made, independent of the method used. In other words, it may not make much difference whether grid search or

randomization is used, but inclusion of different variables appears to have an important effect on the outcome. For a more detailed discussion of these issues the reader is directed to Abrego, Riezman and Whalley (2001b).

5.2 Number of Draws

We choose for our central case the randomization method. With this method the issue is how much sampling to do. Our central case uses 2000 randomizations. To see how sensitive our results are to the size of the sample we also report results for 500, 1000 and 3000 randomizations in Abrego, Riezman and Whalley (2001b). Results indicate minor variations in results across these different sampling procedures. This suggests that the frequencies obtained using 2000 randomizations have small standard errors.

6 Conclusions and Future Challenges

We believe this body of work demonstrates that computational techniques can be used effectively to gain insights on theoretically intractable problems. The main challenge that remains is characterize the parts of the parameter space where propositions hold or do not hold. In this way, we can hopefully gain insight into what is happening in these models and this will in turn point the way forward to future theoretical work.

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