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Shapley Value and USMCA

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Abstract

We model the United States-Mexico-Canada Agreement (USMCA) as a cooperative trade game with three national players where Shapley value leads to fair distribution of total trade gains. Based on 2023 figures from International Trade Centre and World Bank, this fair-trade distribution entails annual side payments among the three trading nations, with a total of $118.6 billion accruing to the US based on its large domestic market and greater negotiating power, while retaining the transactional benefits of free trade, unlike actual tariffs. These side payments can be viewed as a form of *international* Trade Adjustment Assistance (TAA) to disadvantaged US citizens and firms via their government. We model USMCA as both a trilateral game and as three separate bilateral games. In terms of total side payments, the results are the same. We conclude that Shapley fair-trade calculations should be an integral part of the upcoming USMCA renewal negotiations.

Keywords

International Trade, Cooperative Game Theory, Shapley Value, USMCA

1. Introduction

In Agnew (2023), we modeled an international trade agreement as a multinational cooperative game and highlighted Shapley value as a device for fair distribution of total trade gains. Here we focus specifically on the United States-Mexico-Canada Agreement (USMCA) which is much in the news these days with an emerging tariff war that threatens its very existence. In any event, this agreement is up for renewal next year and this is an opportune time to put it under the Shapley lens. Current reviews of USMCA are available at
https://www.piie.com/microsites/2025/future-usmca and
https://www.brookings.edu/collection/usmca-forward-2025/.

Recent game theory applications to international trade have been provided by Khurana (2022) and Mughwai (2020). However, these articles are focused on non-

cooperative game theory, particularly on the Prisoner's Dilemma. Krugman and Obstfeld (2003) also highlight Prisoner's Dilemma in the context of trade policy. Kraphol, Ocelik, and Walendek (2021) present results from adaptive Prisoner's Dilemma iterations, but again the focus is on noncooperative strategies. Shanaev (2015) does focus on cooperative game theory and he uses Shapley value as the basis for "fair" pricing across international goods markets. In our view, trade is inherently *cooperative* between national negotiating partners. Cooperative game theory, and particularly Shapley value, can lead to equitable, balanced sharing of total trade gains while preserving the transactional benefits of free trade.

The next section delineates our game structure and details Shapley value for the USMCA game. We use concepts and notation from Owen (2001), a widely referenced game theory textbook; they are also reviewed in Agnew (2023).

2. USMCA Game

We have three national players: (1) United States; (2) Canada; and (3) Mexico. Let $N = \{1,2,3\}$. For each nonempty $S \subset N$, let $g_i(S)$ be the gain from trade in US$ to nation i from inclusion in coalition S, where $g_i(\{i\}) = 0$ since there is no gain from going alone and $g_i(S) = 0$ if $i \notin S$. We define characteristic function $v(S) = \sum_{i \in S} g_i(S)$ as the total gain from trade accruing to coalition S and $y = (y_1, y_2, y_3) = (g_1(N), g_2(N), g_3(N))$ represents the free-trade imputation (payoff vector) associated with the grand coalition, which we assume will ultimately form. Shapley value provides an alternative fair-trade imputation $z = (z_1, z_2, z_3)$ with $z_i = \sum_{\substack{S \subset N \\ i \in S}} \frac{(s-1)!(3-s)!}{3!} \left[v(S) - v(S - \{i\}) \right]$ for $i = 1,2,3$ where $s = |S| =$ number of elements in set S and $\gamma(S) = \frac{(s-1)!(3-s)!}{3!}$ depends only on the size of S. Then $z - y = (z_1 - y_1, z_2 - y_2, z_3 - y_3)$ defines Shapley side payments among the nation players, or *international* Trade Adjustment Assistance (TAA), to achieve trading fairness. These are cash payments, not tariffs; they enable free-trade transactional benefits and existing export structures without tariff distortions.

We define gain from trade as incremental GDP in US$ over a no-trade base. Recall that $GDP = C + I + G + X - M$ defines domestic production of goods and services where C = consumption, I = investment, G = government spending, X = exports, and M = imports. M is included to expunge import content from the other elements of GDP, leaving only domestic production for a particular nation (for further elucidation, see https://www.stlouisfed.org/publications/page-one-economics/2018/09/04/how-do-imports-affect-gdp). We define each nation's trade gain as exports within USMCA beyond a base with no such exports. Since there can be import content in

reported exports, this is an approximation. We also ignore bookkeeping differences between pairwise exports to a particular nation and imports from its exporting partner. Furthermore, we focus on merchandise (goods) exports. Exports of services are therefore baked into base GDP. Pairwise services exports are evidently reported with a significant lag, if at all. Moreover, they are smaller, fairly even (at least between US and Canada), and less contentious.

Table 1 and Table 2 contain our input data. Table 3 and Table 4 contain our computed results.

Table 1. Pairwise 2023 USMCA merchandise exports.

From	To	Exports ($ Billion)
US	Canada	$352.8
US	Mexico	$323.2
Canada	US	$441.0
Canada	Mexico	$6.6
Mexico	US	$472.2
Mexico	Canada	$17.7

Source = https://www.intracen.org/resources/data-and-analysis/trade-statistics.

Table 2. 2023 USMCA GDP, reported and base.

		Base GDP Less
Nation	GDP ($ Billion)	USMCA Exports
US	$27,720.7	$27,044.7
Canada	$2142.5	$1694.9
Mexico	$1789.1	$1299.2
Total	$31,652.3	$30,038.8

Source = https://data.worldbank.org/indicator/NY.GDP.MKTP.CD.

We are using Base GDP as a device for analyzing fairness within existing trading relationships. If USMCA exports were actually removed, there would obviously be significant adjustments within the three national economies. Furthermore, we are assuming each year's export results would be analyzed in turn, thus allowing for export shifts within USMCA.

Table 3. Trilateral USMCA trade game. All coalitions and alternative total gain distributions.

Nation	Base GDP ($ Billion)	Description
1	$27,044.7	United States
2	$1694.9	Canada
3	$1299.2	Mexico
Total	$30,038.8	

Continued

National GDP Gain ($ Billion) from Exports				
Coalition S	1	2	3	Total $v(S)$
None	$0.0	$0.0	$0.0	$0.0
{1}	$0.0	$0.0	$0.0	$0.0
{2}	$0.0	$0.0	$0.0	$0.0
{3}	$0.0	$0.0	$0.0	$0.0
{1,2}	$352.8	$441.0	$0.0	$793.8
{1,3}	$323.2	$0.0	$472.2	$795.4
{2,3}	$0.0	$6.6	$17.7	$24.3
{1,2,3} Free Trade	$676.0	$447.6	$489.9	$1613.5
% of Total	41.9%	27.7%	30.4%	100.0%
% GDP Gain	2.5%	26.4%	37.7%	5.4%
Shapley Fair Trade	$794.6	$409.1	$409.9	$1,613.5
% of Total	49.2%	25.4%	25.4%	100.0%
% GDP Gain	2.9%	24.1%	31.5%	5.4%
Side Payments	$118.6	−$38.6	−$80.1	$0.0

To illustrate the Shapley calculation for Nation 1 (US), we note that $\gamma(S) = \frac{1}{6}$ when $|S| = 2$ and $\gamma(S) = \frac{1}{3}$ when $|S| = 3$. Then, focusing on the Total column in Table 3 and ignoring irrelevant zeros, we have

$$z_1 = \frac{v(\{1,2\}) - v(\{2\})}{6} + \frac{v(\{1,3\}) - v(\{3\})}{6} + \frac{v(\{1,2,3\}) - v(\{2,3\})}{3}$$
$$= \frac{793.8 + 795.4}{6} + \frac{1613.5 - 24.3}{3}$$
$$= 794.6$$

The trilateral balance indicates side payments to the US of $38.6 billion and $80.1 billion from Canada and Mexico respectively to achieve fairness. These aren't tariffs. They are simply annual cash payments. Actual tariffs would have other impacts. They would raise US prices and diminish import demand. They would also disrupt cross-border supply chains. Nonetheless, there is a place for import tariffs in the real world, both reciprocal tariffs to match those imposed by others and strategic tariffs to bolster industries that are advantageous or critical for national defense, long-term growth, and future prosperity. This case is made emphatically by Fasteau and Fletcher (2024). The US has been significantly disadvantaged over the past several decades by unbalanced, open-door trade with many nations. Our point is that balancing adjustments are even necessary within a free-trade agreement to achieve fairness and stability. Side payments can be viewed as entrance fees to the US market which balance trade benefits within USMCA. They are also an international form of TAA to compensate US citizens and firms that are disadvantaged by free trade.

We can also examine the impact of three separate bilateral trade agreements as an alternative to trilateral USMCA. In this case, Shapley value simply splits total bilateral trade gains 50-50. In a two-player cooperative trade game, we have $N = \{1,2\}$, $\gamma(N) = \frac{(2-1)!(2-2)!}{2!} = \frac{1}{2}$, and Shapley values $z_1 = z_2 = \frac{v(N)}{2}$, an even split of total trade gain. This makes sense since there is no gain at all unless the two parties agree, as in many 50-50 business joint ventures. It also corresponds to the Nash bargaining solution in Chapter IX of Owen (2001).

Table 4. Three separate bilateral trade games.

	USA	Canada	Mexico	Total
Exports ($ Billion)	$352.8	$441.0		$793.8
Shapley 50-50 Split	$396.9	$396.9		$793.8
Side Payments	$44.1	−$44.1		$0.0
Exports ($ Billion)	$323.2		$472.2	$795.4
Shapley 50-50 Split	$397.7		$397.7	$795.4
Side Payments	$74.5		−$74.5	$0.0
Exports ($ Billion)		$6.6	$17.7	$24.3
Shapley 50-50 Split		$12.2	$12.2	$24.3
Side Payments		$5.6	−$5.6	$0.0
Total Side Payments	$118.6	−$38.6	−$80.1	$0.0

In terms of total side payments, there is no difference between the trilateral game in Table 3 and three separate bilateral games in Table 4. Pairwise bilateral side payments are simply netted out in Table 3. This equivalence would not be true for more generally calibrated games, but it is for this export driven formulation.

3. Conclusion

Shapley value is utilized for fair apportionment of value in a wide variety of economic and political settings. In the international trade setting, it yields a sensible split of total gains from trade, but it requires ongoing side payments among the parties to an agreement, unlike free-trade which is essentially open-door and hands-off. Dissecting the trilateral USMCA agreement in 2023, we conclude that Shapley value apportionment would entail annual side payments of $38.6 billion and $80.1 billion to the US from Canada and Mexico respectively. This Shapley fairness adjustment results from either a trilateral game structure or alternatively from three separate bilateral games. The bottom line is that Shapley fair trade can balance the scales while still enabling global competition and development. Shapley estimates and calculations should be an integral part of every international trade negotiation, including the upcoming USMCA renewal. Negotiated Shapley

side-payments can ensure ongoing fairness and stability to resulting agreements on a year-by-year basis as export structures shift.

Conflicts of Interest

No potential conflict of interest was reported by the author.

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