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Does Exchange Rate Misalignment Mediate the Effect of Tariff on Exports: An Example of US Tariff and Canada Exports in Steel and Aluminum

Zhi Li (41662)

Abstract: Exchange rate is an important price ratio interacting with both real and nominal variables. It is not clear yet how the misalignment of exchange rate can interact with trade policies and affect trade flows. This paper tries to answer the question in the case where Tariff is shortly levied by the US on Canada exports in steel and aluminum. Exchange rate misalignment is hypothesized to partially mediate the impact of the Tariff on Canada steel and aluminum. To test the hypothesis, this paper first estimates exchange rate misalignment from exchange rate and other determinants before using the estimate in turn to detect its influence on exports. No evidence is found in this paper that supports the hypothetical mediation model, although the direct effect of Tariff on its corresponding exports is significantly supported.

Keywords: exchange rate misalignment, exchange rate equilibrium, mediation model, Trump Tariff

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1. Introduction and Motivation to the Question

1.1 Trade and Exchange Rate – Volatility and Misalignment

Since the breakdown of Bretton Woods system in early 1970s, floating exchange rate regime started to gradually take the place of fixed exchange rate system among major industrial economies all over the world. A floating exchange rate is believed to allow for independent monetary policies with the absence of capital controls so that a government can focus on internal goals. In the light of financial shocks, a fixed exchange rate can transmit nominal shocks directly to a real economy, while a floating exchange rate is often considered a buffer to stabilize the real economy[1] (Auboin and Ruta, 2013). As suggested by its name, the floating exchange rate can witness adjustments and fluctuations after absorbing shocks, bringing uncertainty with ambiguous influence on the economy. Such influence is discussed from mainly two perspectives in the field of international trade: exchange rate volatility and exchange rate misalignment[2].

Heated debates on the former can be tracked back in 1973 when Clark brought up a simple theoretical framework describing the negative trade effect of exchange rate volitilaty under strict assumption that, in perfect competition, uncertainty of future exchange rate is the unique determinant of profit earned by a risk-averse export trading company which pays only in foreign currency in the absence of currency hedging tools. In later research, these assumptions, such as risk preference and access to hedging tools, are relaxed and lead to different results of trade based on corresponding assumptions. For example, De Grauwe (1988) argues that, apart from the substitution effect that trade flows fall in exchange rate volatility, there exists an income effect that risk-averse companies tend to export more to offset the fall in their expected utility derived from higher volatility in exchange rate. While a risk-neutral company, whose utility is not correlated with the uncertainty in exchange rate, is usually considered not affected by exchange rate volatility. The subsitition effect, however, could be dominated by the income effect for a company with extremely high level of risk aversion, resulting in a positive relationship between exchange rate volatility and trade to the

[1] Two assumputions are usually stated for nominal exchange rate to function as the transmission belt between nominal shocks and real factors. The first one is price rigidity (at least in a short run) explained by either menu costs or an intention to sustain the price level. The second is trade barrier. Arbitrages do not take place in nontradables, so (the inverse of) nominal price ratio does not always move proportionally with nominal exchange rate even in a long run. Therefore, real exchange rate is not a constant, which partly explains why (relative) PPP is of limited use in actual. Note that real exchange rate is also affected by nonmonetary factors that can cause sustained deviations. (Krugman and Obstfeld, 2009).

[2] Exchange rate misalignment is the departure of true exchange rate from its equilibrium level. Exchange rate equilibrium is achieved when domestic balance and external balance are simultaneously attained (Edwards, 2019). Note that (real) exchange rate equilibrium is not fixed either. There can be no misalignment if a change in exchange rate is totally caused by factors that meanwhile change its equilibrium. It is therefore important to distinguish between a misalignment and a shift in equilibrium. Formal definitions and detailed explanation are given in Study A.

contrary of Clark's model. Sunk cost such as advertising and setting-up, which is the cause of "hysteresis" discussed by Dixit (1989), can also violate the general negative effect described in Clark's model. When it comes to empirical research, the results seem to be even more complicated. Different conclusions arise based on the level of data aggregation, the specific measure or proxy to volatility and among factors (Auboin and Ruta, 2013). In general, the commercial risk and uncertinaty generated from exchange rate volatility is highlighted to influence the decisions on trade and resource allocation (IMF, 1984), but the exact trade effect of exchange rate volatility is still implicit with various theoretical frameworks and nuanced empirical findings.

While debates on exchange rate volatility continued, discussion on exchange rate misalignment gained more attention in early 21st century when global imbalance had doubled since the mid-1990s and current account deficit or surplus had stayed persistent for many economies all over the world. Specifically, the United States witnessed a long run deficit which absorbed up to 75% of world net savings (Bracke et al, 2010). Such imbalance or inequilibriam has become a concern for both researchers and policymakers, and exchange rate misalignment is suspected to be one of the causes. An exchange rate misalignment arises whenever the true level of exchange rate is different from its equilibrium level and is usually caused by factors that have different impacts in the true level and the equilibrium level (Montiel, 2002)[1]. Empirical evidence of the link between exchange rate misalignment and global imbalance can be found in several studies such as the work of Gnimassoun and Mignon (2014). And in the real world, US Department of Treasury designated China as a currency manipulator on August 5th, 2019, claiming that China has a long history of devaluing its currency deliberately to take unfair advantage for competitive purposes in international trade (US Department of Treasury, 2019). In addition to its implications on global imbalance, exchange rate misalignment also indicates the general well-being of an economy itself, especially when the misalignment is in a considerable magnitude. Exchange rate, among other relative prices, is a crucial signal for individual economic agents when making decisions on broad allocations such as the one between consumption and production. It is therefore of great importance to maintain exchange rates at the "right" level (Montiel, 2002). Persistent real exchange rate overvaluation could imply unsustationable macroeconomic conditions within an economy, suggesting its vulnerability to speculative attack and currency crisis (Jongwanich, 2009). Hence, it is often regarded as a precursor to a crisis, for instance the 1997-1998 Asian financial crisis. On the other side, sustainable

[1] The equilibrium level is precisely called "long-run equilibrium real exchange rate (LRER)" and referred to "the right price" by Montiel (2002), who defines real exchange rate misalignment as "the existence of a gap between the (true level of) real exchange rate and the LRER". See Study A for more details.

undervaluation can be a wrong signal and lead to economic overheating which distorts the resource allocation between tradable and nontradable sectors (Jongwanich, 2009). Aguirre and Calderón (2005) show that large real exchange rate misalignment, either undervaluation or overvaluation, can hamper economic growth and the decline in growth is positively associated with the magnitude of misalignment.

Although the discussion on exchange misalignment seems to originate from the concern of global current account imbalance, this paper simply focuses on a trade view and abstracts from the issues of global imbalance and rebalancing, for the factors underlying the emergence of large and persistent current account imbalance are perceived to be macroeconomic and structural distortions which are much broader than the topic of trade (Auboin and Ruta, 2013). Section 1.2 reviews the theoretical frameworks of the trade effect of exchange rate misalignment. Relevant empirical works are reviewed in Section 1.3. The question studied in this paper is brought up in Section 1.4.

Before a deeper dive into the theoretical frameworks of exchange rate misalignment, a few words are noteworthy on the terminologies to be used. First, exchange rate in the remaining context refers to real exchange rate unless otherwise specified and this also works for terms like exchange rate misalignment and exchange rate equilibrium. Second, a nominal depreciation (appreciation) in local currency means that one unit of local currency can be exchanged with less (more) units of foreign currency, suggesting an increased (decreased) nominal exchange rate of local currency per unit of foreign currency (or a bundle of other currencies)[1].While a real depreciation (appreciation) in local currency represents a rise (fall) in its real exchange rate in terms of foreign currency (or the bundle). Third, devaluation and revaluation are often used in a fixed yet adjustable exchange rate regime. However, these terms are in this paper replaced with depreciation and appreciation for consistency of terminology following Auboin and Ruta (2013). Finally, discussion and analysis in the following context is primarily based on the condition of depreciation, for the opposite would be symmetric.

1.2 Trade Effect of Exchange Rate Misalignment – Theoretical Models

Going back to the previous study on exchange rate misalignment, one most important consensus is that governments are unable to determine the real exchange rate directly but can affect the real exchange rate in the short to medium run (Eichengren, 2007). It can usually be achieved by a variety of policy instruments: a moderate fiscal consolidation in the presence of a low level of private absorption; the introduction of capital controls on capital inflows and

[1] Following Uribe and Schmitt-Grohé (2017), (nominal) exchange rate is defined as the price of one unit of foreign currency in terms of domestic currency.

the liberalization of capital outflows; targeted interventions on foreign exchange markets; a nominal depreciation associated with anti-inflationary policies, such as price and wage moderation (Haddad and Pancaro, 2010). Assume the absence of fully capital mobility, it would take mucher longer for arbitrage to take place and close the gap between local real interest rate and foreign real interest rate. If local real interest rate is lower, the demand for local currency would decrease, for foreign investors would be less interested in buying local real and financial assets and need less local currency consequently. This would lead to a nominal depreciation of local currency, i.e., the nominal exchange rate of local currency (per unit of foreign currency) would go up. With the crucial assumption of price rigidity[1] (in the short to medium run), the nominal exchange rate depreciation translates into a corresponding increase in real exchange rate followed by a rise in net exports. It is the direct channel through which trade is affected by exchange rate and is called price signal in standard open macroeconomic models (Krugman and Obstfeld, 2009). Standard models generally assume exported goods and services labelled in the local currency of the exporting country. Hence, a real depreciation in local currency can lead to both a rise in export volume (like an export promotion) and a fall in import volume (like an import restriction), both resulting in an increased trade balance. This scenario is called a perfect pass-through where the nominal depreciation has been totally translated into a real depreciation. The trade impact, however, depends on the invoiced currency. If exported goods and services are priced in a vehicle currency or the buyers' currency, the pass-through would be less than 100% or even disappear (Staiger and Sykes, 2010). For most countries, the unit labeling prices is a combination of local, foreign and vehicle currencies. However, the combination can vary largely across countries. For instance, 100% of exports and 93% of imports are denominated in dollars in the United States, indicating that the trade effect of a real depreciation of dollar (in terms of any one of the other currencies, assumedly) would be mainly from a rise in export volume, following the standard model. The inference is confirmed by Bernard and Jensen (2004). Apart from the invoiced currency, the effect on trade also depends on what the other countries do. One exporter could suffer from the spillover effect where its competitor exporter depreciates its currency against the country of their commen market. And trade can be unaffected should all countries depreciate at the same time (Henry and Woodford, 2008; Mattoo et al., 2012; Auboin and Ruta, 2013).

[1] Price is usually assumed to be sticky in a short run for many reasons such as menu costs. Besides, if authorities intend to maintain the price level, in order to restore money market equilibrium, money supply needs to decrease in response to the fall in money demand resulted from a rise in local nominal interest rate and, of course, a rise in local real interest rate considering stable prices and inflation (Krugman and Obstfeld, 2009).

One caveat of the standard model is the absence of market imperfections (information inefficiency, coordination problems and other entry costs), which are spotted more prominent in the tradable sector especially in developing countries. Market imperfections provide a second channel, the indirect one, through which exchange rate affects the allocation of resources between the tradable and the nontradable sectors. For their one-to-one relationship, real exchange rate is sometimes defined as the relative price of nontradable goods in terms of tradable goods (Salter, 1959; Swan, 1960; Uribe and Schmitt-Grohé, 2017). Hence, a real exchange rate depreciation is equivalent to a rise in the relative price of the nontradables, which drives local demand to shift from the nontradable sector to the tradable sector. Apart from the shift in demand, local exporters face lower economic costs generated from market imperfections and are accordingly encouraged to expand their tradable activities. For this reason, a real exchange rate depreciation can lead to a growth in net exports and a shift in resource allocation from the nontradable to the tradable sector (Rodrik, 2008; Freund and Pierola, 2010; Auboin and Ruta, 2013). In short, the indirect channel emphasizes the market imperfections, lead to the conclusion that depreciation in local currency can improve exports and benefit the overall well-being, especially for developing economies.

Both channels suggest that a real exchange rate depreciation (undervaluation) can promote exports and the general well-being of the economy. However, the statement seems to contradict from the view of Washington Consensus (Williamson, 1990) where any exchange rate misalignment, either undervaluation or overvaluation, would impede economy growth by providing a wrong signal to resource allocation.

Two possible explanations for the difference are provided: the length of time and the assumption of perfect competition. The negative impact stated by Washington Consensus usually emerges when the misalignement is both economically significant and persistent enough - suggesting a long run. In the long run, prices together with any other variables are considered fully flexible, and a movement in nominal exchange rate itself is not likely to have any impact on real exchange rate or trade, assuming the absence of market failures and distortions in distortions. On the other hand, the existence of market imperfections can result in structural changes which may not be undone even if real exchange rate equilibrium is restored in the long run, and the economic effect of such structural changes could be ambiguous. Costs would be generated from adjusting resource allocation between the tradable and nontradable sectors, and the cost should be taken into consideration jointly with the growth in net exports and the part of market imperfection costs alleviated by real exchange rate depreciation. Unless the market imperfections are empirically profound and extremely important enough, the relevant growth in net exports can be overwhemlmed by the adjusting costs (Auboin and Ruta, 2013), as is supported by Haddad and Pancaro (2010).

They find that effect of real exchange rate depreciation becomes negative on economic growth in the long run, and the effect of real exchange rate depreciation on exports becomes statistically insignificant for countries with all income levels in the long run. It is not impossible that real exchange rate can be maintained at a value different from its equilibrium intentionally by the government, in which case inefficiencies can be expected from resource misallocation in the long run. The idea of structural changes caused by market imperfections is somehow similar to the case brought up by Edwards (1989) where "modifications of fundamentals[1]" (some of which are the changes in structural factors) can give rise to a shift in the equilibrium level of real exchange rate over time and further affect trade. Hence, it could be challenging but crucial to find out the cause of a change in the true level of real exchange. It could represent a departure from equilibrium, while the equilibrium may also change but in a different direction or magnitude. It could imply a simultaneous shift in both true and equilibrium level, which suggests no misalignment. The equilibrium path needs to be estimated to distinguish the two. Study A comes back to the issue with more details and a practice in estimating the equilibrium path and calculating the misalignment.

To sum up, a nominal exchange rate misalignment can in theory lead to a deviation of real exchange rate away from its equilibrium level in a short term. Theoretical models suggest a positive effect of real exchange rate deprecition on trade balance in the short run, with price signals and market imperfections being the main channels. Misalignments of real exchange rate, whether restored later or not, can result in resource reallocation or misallocation, and have impacts on trade in a long run. Next section reviews some empirical works related to the theories discussed above.

1.3 Exchange Rate Misalignment and Trade – Empirical Findings

Apart from presenting empirical evidence for or against the theoretical models, it is also necessary to summarise prevalent strategies measuring exchange rate misalignment in preparation for the empirical approach applied later in this paper. While this section only provides a brief overview of the empirical research on the trade effect of exchange rate misalignment. Readers are kindly introduced to Study A for measuring approaches to exchange rate misalignment.

First, the positive relationship between exchange rate depreciation and export growth has been generally confirmed by a batch of research focusing on a single economy. For example, Arslan and van Wijnbergen (1993) investigated the Turkish export miracle over the 1980–1987 period. With time series regression and simulation, they found real depreciation of the

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[1] Montiel (2002) uses "Fundamentals" to refer to determinants of exchange rate equilibrium.

Turkish currency contributed by far the most to real export growth rate among other factors such as export incentives and import growth in the Middle East. Bernard and Jensen (2004) found similar evidence examining sources of the manufacturing export boom in the United States from 1987 to 1992, where that they used a positive change in exchange rate to indicate an appreciation of the US currency. They found that real depreciation in US dollar is strongly and significantly positively associated with increase in export volume, especially on the intensive margin. In other words, the increase of export volume primarily comes from a higher export intensity among existing exporters instead of those who newly entried the exporting market, which further provides substantial indirect evidence of the existence of sunk costs to exporting as existing exporters showed greater responses to favorable exchange rate and demand shocks.

Second, Cross-country analysis has also provided empirical support for the positive relationship. By examining 92 episodes of export surges, i.e., significant increases in manufacturing export growth that are sustained for at least 7 years, Freund and Pierola (2012) found that a large real depreciation in local currency is usually a precursor to export surges in developing countries. It does not only provide evidence for the positive relationship, but also confirms that it is currency depreciation that affects trade and vaguely denies the opposite, which is important for the mediation model to be brought up in Section 3. They also found that the role of the exchange rate becomes less pronounced in developed countries and that the difference could be explained by new market entries stimulated by depreciation in developing countries. The new export is shown to account for more than 40% of export growth, supporting the theoretical positive trade effect of depreciation through new entries. Haddad and Pancaro (2010) find a positive effect of exchange rate depreciation on export expansion only for developing economies with per capita income no more than 2,500 US dollars in the short-to-medium term, while the association becomes statistically insignificant for all income levels in the long run. They also examine the effect of exchange rate depreciation on economic growth, and evidence implies a short-to-medium-term positive relationship for all income levels except developing economies with per capita income between 2,500 to 6,000 US dollars. The relationship becomes negative for all income levels in the long run. The findings are in line with other empirical research, indicating that the positive effect of the real exchange rate on economic growth is at least partly through export expansion. The effect being strong for developing economies and weak for developed economies particularly, supporting the market imperfection channel proposed by Rodrik (2008).

1.4 Motivation to the Question

One question at the forefront of research debate is whether and how exchange rate misalignment interacts with trade policy and ultimately have an impact on trade. It was just presented in the last two sections that, in a short-to-medium term, exchange rate depreciation stimulates export growth, thus trade balance, especially for developing economies. But question remains whether trade balance can in turn affects exchange rate. Implicit answers are found in Edwards (1989) and Montiel (2002). International transfers, which is usually proxied as net capital inflows (the opposite of net exports), is classified as one of the long-run external fundamentals of exchange rate equilibrium, so the answer is yes unfortunately. However, the disappointing answer somehow ignites this paper. What if trade balance is replaced by exports in a couple of industries? That exchange rate is endogenous to aggregate trade balance sounds just like exchange rate is endogenous to aggregate demand. That different industries have different properties can be a reminder of that each consumer has her own preference. In this sense, can exchange rate work exogenously for each industry just as it works for individual agents? For the reason, this paper implicitly assuming the endogeneity and causality of exchange rate misalignment on industry-level exports.

And as suggested by its name, trade policy is designed for specific trade targets so its impact on trade is unquestionable. Trade policy consists of too many measures from antidumpting investigation to subsidies. In this study, we choose Trump Tariff on Canadian steel and aluminum industries, partly because it aims on only two industries and is unlikely to have a systematic impact on aggregated trade flows, which could in turn affect exchange rate, thus reassuring the causality of exchange rate misalignment on trade. Another reason is that Trump Tariff is not likely to be commonly considered directly resulted from exchange rate misalignment or trade balance. At the very least, neither exchange rate misalignment nor trade balance seems to be precursors of Trump Tariff in the short run, which suggests the causality of Trump Tariff on Trade. In addition, the bilateral trade of steel and aluminum, among most kinds of goods and services traded between US and Canada, had been exempted from tariff under North American Free Trade Agreement (NAFTA)[1] until Trump Tariff kicked in and made Canada became subjective to the tariff. Trump Tariff on Canada was lifted on May 17, 2019 and imposed again on August 6, 2020 (“Steel and aluminum”, 2022). Trump Tariff on Canada can thus be regarded as a shock to both exchange rate and trade if observations are collected before the Covid shock in early 2020, which probably answers

[1] A US steel tariff took place from March 5, 2002 to December 4, 2003 and Canada was exempted under NAFTA (Proclamation No. 7529, 2002; Proclamation 7741, 2003).

why Trump Tariff on Canada could be a good example to examine the interaction between exchange rate misalignment and trade policy, and their effects on trade[1].

What remains in examining the pairwise interactions of these three variables is the relationship between exchange rate misalignment and trade policy. It is far from enough just detecting a statistically significant relationship between trade policy and exchange rate misalignment, for correlation does not suggest causality and is unable to further tell whether the exchange rate misalignment leads to trade policy response or vice versa. Recall that both variables are endogenous to an economy in the long run, the intertwined connection of the two could end up rather complicated, as is pointed out by Auboin and Ruta (2013) that currency undervaluation and trade restrictions can escalate in a vicious cycle and ultimately result in long-term trade effects. Hence, detection of the relationship is limited to a short term[2], in conformity with previous sections. Then the question of concern now becomes if trade measures respond to currency misalignment, or the contrary, in a short term.

In most developing countries, the real exchange rate is largely determined by economic policies rather than market fluctuations. The real exchange rate depends on the balance between savings and investment and the balance between expenditures and income (Haddad and Pancaro, 2010). Hence, it could be perceived that it is fiscal policy rather than trade measure that alter real exchange rate and that trade policy is at least not at the origin of the three-factor system composed of trade exchange rate misalignment and trade except for itself. This perceiption is of course rather implicit and is very limited to developing countries. Another perception prevailing among economists is that, compared with exchange rate, tariffs have a stronger and more persistent impact on trade flows and is therefore believed more likely to have a more direct and closer connection with trade balance (Auboin and Ruta, 2013), assuming a full mediation model[3]. This perception is supported by Fitzgerald and Haller (2018). They use micro data for Ireland to estimate how aggregate exports (participation and revenue) respond to tariffs and real exchange rates and find exports respond more to tariffs, with the elasticity (between -3.8 and -5.4) nearly 10 times greater than that of exports with respect to real exchange rates (between 0.45 and 0.6).

The question on short term causality is also studied from a historical perspective. For example, Eichengreen and Irwen (2010) find substantial cross-country variation in the

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[1] More background information can be found in Section 2.

[2] A short term here does not refer to a short time span across sample. For example, for any time spot, we are interested in the effect of present policy on exchange rate misalignment at the following next time spot. The number of time spots does not have to be limited. The interval between the earliest and the latest spots does not necessarily have to be a short term.

[3] Section 2 provides more details on mediation models.

movement to protectionism during the Great Depression in 1930s. Countries that remained on the gold standard resorted to more restrictive trade policies (tariffs, import quotas, and exchange controls) than countries that went off gold. Recall the impossible trinity that a fixed exchange rate and free capital movement cannot be reached simultaneously with an independent monetary policy. Restrictive trade policies (capital controls) were then implemented in coutries who wished to maintain the gold standard (fixed exchange rate). The inability of a country to use the exchange rate as a policy instrument may create an incentive to impose protectionist measures (Auboin and Ruta, 2013), in which sense trade policies respond to exchange rate movement. Some other research provides answers from the perspective of business cycle. Bagwell and Staiger (1995) propose a theoretical framework explaining the countercyclical nature of trade barriers repeatedly documented in empirical studies. It is implied that protectionism (contingent trade policies) responds to macroeconomic shocks. Bown and Crowley (2013) suggest one such shock could be a real currency appreciation. They find historical evidence for the EU and US from 2008Q4 to 2010Q4 that real currency appreciations led to more import protection through temporary trade barriers, i.e., the relatively substitutable import restrictions under antidumping, countervailing duty, global safeguards, and the China-specific safeguard policies. Nicita (2013) finds similar positive effect of exchange rate appreciation on the number of antidumping investigations using panel data across 100 countries from 2000 to 2009. Broz and Werfel (2014) capture the demand for trade protection with the initiation of trade restrictive regislation in the US parliament and find a positive relationship between exchange rate appreciation and the demand for protectionism for industries with high pass-through even in a long run. Pass-through is defined as the elasticity of import and export prices to changes in the real exchange rate. The positive association between appreciation and demand is highly convincing evidence that trade measures react to exchange rate shocks in the first place. An overvalued exchange rate is often the root cause of protection (Shatz and Tarr, 2000).

Despite rich empirical research, the question of causality between exchange rate misalignment and trade policy can hardly be answered in a general way, for trade policy can take too many forms and the causality can not be detected unless knowing the exact trade policy. Even if knowing the specific trade policy does not guarantee an answer of some pattern. For instance, a broad protectionism trade policy of country A targeting at all its main trading partners could be triggered by currency manipulation of country B, but country C which has a sustainable bilateral exchange rate with country A could face the protectionism trade policy as well. Apparently, the trade policy on country C does not result from the exchange rate between country A and C. Therefore, the only way to handle the question is to answer it under a very specific circumstance. As mentioned above, since Trump Tariff is not perceived as a typical trade policy initiated from bilateral trade or exchange rate between US and Canada[1], it makes little sense to put exchange rate misalignment at the origin of the aforementioned three-factor system. Besides, considering Canada Dollar a floating exchange regime and susceptible to shocks, it would be reasonable to assume that Trump Tariff is at the origin, and it can give rise to exchange rate misalignment, if any, theoretically. Even if Trump Tariff is restricted to only two industries in Canada and exchange rate is assumed exogenous to single industry at the beginning of this section, the influence of Trump Tariff is unlikely limited to only exports of the two industries. It can probably still serve as a signal to affect expectation of the market including nominal exchange rate.

So far, the existence and direction of pairwise causality has beem discussed for any two variables in the three-factor system, as has been done in most of the relevant research. However, to the best of the author's knowledge, there is not yet a study detecting the three-factor system in a comprehensive manner. In the three-factor system where exchange rate misalignment is perceived to be a channel through which Trump Tariff affects trade flows, and one might wonder how much trade effect (on Canada exports) of Trump Tariff is precisely through the channel (indirect effect) and how much is not through the channel (direct effect). The question can be broken down into three sub-tasks. The first task is to compare the three-factor system with a standard mediation model to see exactly how indirect effect and direct effect is estimated in general and in this case. The second task is to find out whether a misalignment exists in the real exchange rate of Canadian Dollar against US Dollar and calculate the misalignment if it does exist. The third task is to apply the value of misalignment calculated in the second task, together with proxies for other relevant covariates, to conduct the procedures illustrated in the first task. The first task is done in Section 2. The second and third task are finished in Section 3 by Study A and Section 4 by Study B respectively. Results and Discussion are presented in Section 5.

2. Background and a Mediation Framework

In the three-factor system brought up in Section 1.4, exchange rate misalignment is assumed to mediate on the effect of Trump Tariff on trade. To describe the three-factor system as precisely as possible, an introduction to a general mediation model is given in Section 2.1, together with relevant definitions and possible issues. Section 2.2 starts with economic backgrounds on Trump Tariff and Canada, then shows how a basic mediation model is nested in the scenario of Trump Tariff.

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[1] US and Canada can correspond to country A and C mentioned above.

2.1 Introduction to Basic Mediation Model

Mediation analysis is often used in empirical studies to test exactly how dependent variable Y is affected by independent variable X. A simplest mediation is a causal system where X is proposed as influencing Y through a single intervening variable M (Hayes, 2017). The simplest form of mediation model is shown in Figure 1.

Arrows in Figure 1 suggest there are two channels through with X can possibly have effects on Y. The one passing though M is known as the indirect effect (IE) of X on Y. X is hypothesized to influence M with effect a, and M in turn influences Y with effect b. IE equals $a * b$ in magnitude. The other channel is called the direct effect (DE) of X on Y with effect c. The total effect of X on Y is the sum of direct effect (DE) and indirect effect (IE). It is possible that X affects Y totally through either IE or DE. The former is called full mediation (in contrast to partial mediation where both channels are of use), while the latter is simply no mediation. In a mediation model, M is called a mediator variable (Hayes, 2017).

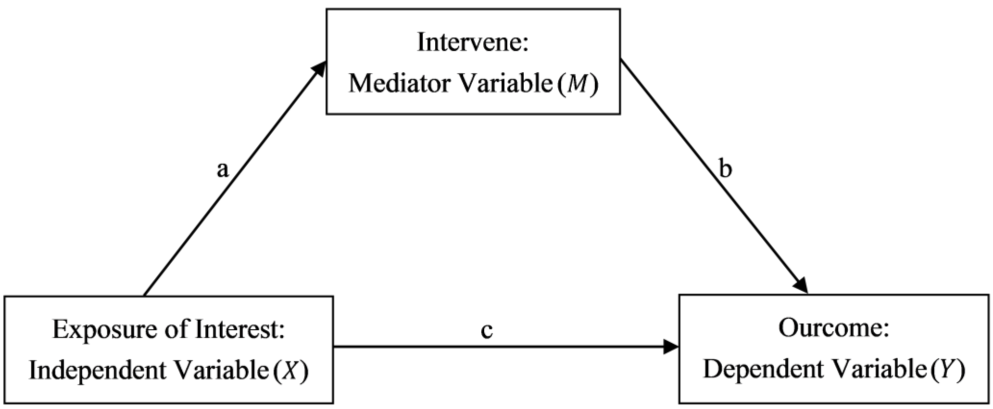

Figure 1. Basic Mediation

In estimating IE and DE, the procedure consists of two steps. First, regress M on X. If the effect of X on M is not statistically significant or equals to zero, it can be told from this step that there is no IE in the mediation model proposed, or M is not the true mediator at the very least. Second, regress Y on X and M. Again, if either effect b or c is statistically insignificant or equals to zero in amount, the corresponding channel does not exist. To support the existence of IE, effect a and b must be simultaneously statistically significant and different from zero. Formally, the procedure is:

$$M = const_1 + aX + resid_1 \tag{1}$$

$$Y = const_2 + bM + cX + resid_2 \tag{2}$$

Above is the simplest mediation model where omitted variable can be a severe problem. Apart from X, if there are some other mutual determinants of M and Y, named C, C should enter the second step of the procedure. Otherwise, the residuals from equation (2) and M are correlated through omitted variable C (endogeneity), and the estimation of effect b is therefore biased. Other determinants of M, named D, enters the first step of the procedure especially when D is with strong theoretical support.

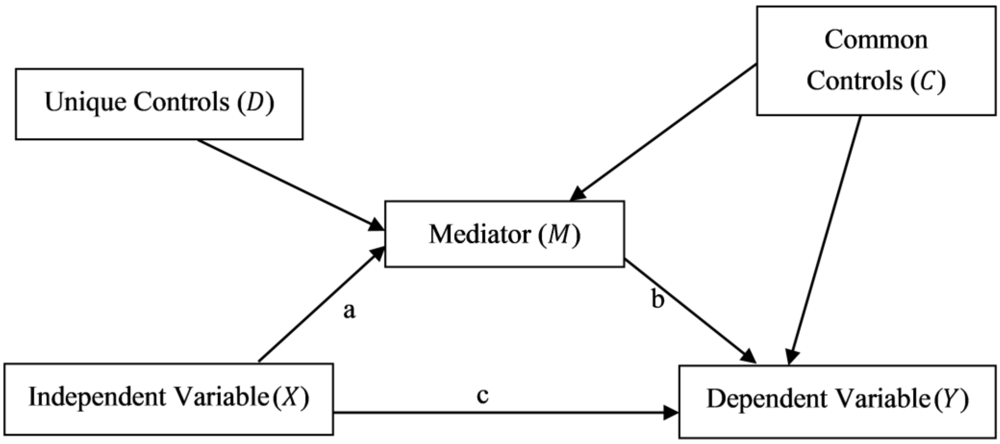

Figure 2. Mediation with Controls

The updated procedure for the mediation model in figure 2 is formally:

$$M = \alpha_0 + \alpha_1 X + \alpha_2 D + \alpha_3 C + u \tag{3}$$

$$Y = \beta_0 + \beta_1 X + \beta_2 M + \beta_3 C + v \tag{4}$$

Next section links equation (3) and (4) to the scenario of Trump Tariff.

2.2 Trump Tariff in a Mediation Model

Before putting a mediation framework into the case of Trump Tariff, this section reviews some data on the economic and political backgrounds of the case.

First, it should be stated the exchange rate regime in Canada has been floating since 1970 (Thiessen, 2000). One could therefore infer at least the nominal exchange rate of Canadian Dollar (CAD) in terms of United States Dollar (USD) is likely to be responsive to trade policies.

Second, according to data from the world bank, US takes up to more than 70% of Canada export partner share and more than 50% of Canada import partner share for over 20 years, apart from 49.53% of import partner share in 2011 (WITS, 2022a, 2022b). About 90% of primary aluminum production is exported from Canada to US (Government of Canada, 2022), and 89% of its steel exports are sent to US in 2019 by Canada (US Department of Commerce, 2020). In other words, almost all Canda exports of steel and aluminum end up in US. Since US is the biggest partner and main destination for Canada exports (especially steel and aluminum), the spillover effect of Trump Tariff through other countries on Canada exports (at least in these two industries) would be insignificant. And CAD-USD exchange rate would have exceptionally important impact when jointly studied Canada exports to US in steel and aluminum and Trump Tariff levied precisely on the two industries.

Third, steel and aluminum are "key contributors to Canadian economy", and Canada and the US have shared for years a "highly integrated market" on steel and aluminum (Government of Canada, 2022) under NAFTA until Canada suddenly became subject to a 25% tariff on steel and 10% tariff on aluminum placed by President Trump on June 1, 2018. The tariff was not lifted until May 17, 2019, and part of it came back shortly from August 6, 2020 to September 15, 2020 (Government of Canada, 2022). For this reason, the tariff levied from 2018 to 2019 could serve as some sort of abrupt shock to Canada exports on steel and aluminum[1].

A mediation framework can be established in the light of Trump Tariff scenario. Apparently, the independent variable (X), the mediator variable (M) and the dependent variable (Y) are respectively Trump Tariff, CAD-USD exchange rate misalignment and Canada exports (on steel and aluminum).

[1] The period of interest in this paper is set before December 2019 considering the worldwide outbreak of Covid-19 pandemic and its massive shock on various aspects of world economics. Hence, the partial comeback of Trump Tariff in 2020 is out of discussion in this paper.

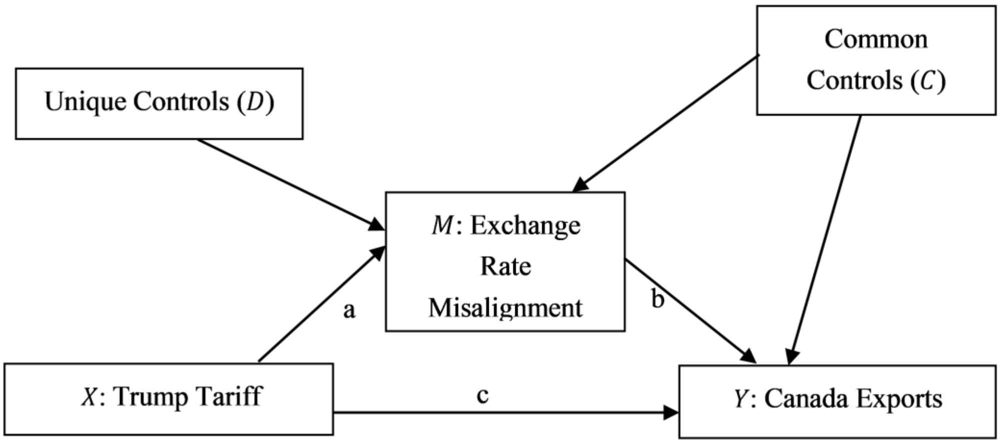

Figure 3. Mediation in Trump Tariff Scenario

With the same two steps to estimate direct/indirect effect:

$$M = \alpha_0 + \alpha_1 X + \alpha_2 D + \alpha_3 C + u \tag{3}$$

$$Y = \beta_0 + \beta_1 X + \beta_2 M + \beta_3 C + v \tag{4}$$

The estimates of β_1 would be the direct effect with formal hypothesis H1: The effect of Trump Tariff on Canada exports is statistically significant and different from 0 (H1).

The product of α_1 times β_2 equals the indirect effect with formal hypotheses H2 and H3: The effect of Trump Tariff on exchange rate misalignment is statistically significant and different from 0 (H2). The effect of exchange rate misalignment on Canada export is statistically significant and different from 0 (H3).

To test these hypotheses, it should be clear a) what variables are included in control C and control D; b) what is the value of exchange rate misalignment; c) what proxies are used to represent these variables; d) what monotonic transformation and econometric methods are required to run the two regressions. These problems are first tried to be solved in Study A with a review of definition and calculating methods to exchange rate equilibrium and misalignment.

3. Study A: Calculating the Misalignment of CAD-USD

3.1 Definition of Misalignment and Equilibrium

The intuition of exchange rate misalignment is informally presented above as the departure of exchange rate from its equilibrium level. However, every true exchange rate actually spotted in real life is in equilibrium itself. To distinguish exchange rate equilibrium from the broad concept of equlibrium, formal definition is given below (Montiel, 2002).

Real exchange rate is defined as the relative price of foreign goods and services adjusted by nominal exchange rate (Krugman and Obstfeld, 2009). Nominal exchange rate and price levels are what can be observed directly, and real exchange rate can be directly calculated from the observations. The true level of real exchange rate at any time spot is linked to the contemporary nominal exchange rate and prices. Montiel (2002) points out that the true level of real exchange rate is determined by both long-run factors and short-run factors. And the equilibrium level of real exchange rate is defined as a path only affected by long-run factors. For this reason, the equilibrium level of real exchange rate is not static or a certain value, and Montiel (2002) uses "long-run equilibrium real exchange rate" to stand for the equilibrium level of real exchange rate to distinguish the equilibrium level from a general definition of equilibrium[1].Short-run factors determine only the true level of real exchange rate without affecting the equilibrium level of real exchange rate[2]. Thus, it is the short-run factors (and unobservable disturbance) that drive the true level up and down around the equilibrium level. The discrepancy between the true level of real exchange rate and its equilibrium level is referred to as real exchange rate misalignment.

To measure real exchange rate misalignment (ERM), which is the gap between the true level of real exchange rate (RER) and the equilibrium level of real exchange rate (ERE), ERE should be estimated beforehand once RER is transferred from nominal exchange rate (NER) and price levels. Next section focuses on approaches to estimate ERE.

3.2 Estimation of Equilibrium and Calculation of Misalignment

3.2.1 Review to Empirical Approaches

In general, there are two types of approaches to estimating ERE. The first type is simpler and rooted in concepts and definitions themselves without much estimation. Two typical examples are Purchasing Power Parity (PPP) approach and Black-Market Premium (BMP) approach. The second type yields more robustness in outputs and is regressed based on theoretical frameworks usually presented by either Fundamental Equilibrium Exchange Rate (FEER) model or Behavioral Equilibrium Exchange Rate (BEER) model. This section

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[1] This paper follows the definitions in Montiel (2002) but uses different terms. Exchang rate equilibrium (ERE) is used to represent the equilibrium level of real exchange rate, i.e., "long-run equilibrium real exchange rate" in Montiel (2002).

[2] Montiel (2002) refers to the true level of real exchange rate as "short-run equilibrium real exchange rate", because "the economy is presumably in some kind of equilibrium at any given moment."

reviews these four approaches. Their mechanism, advantages, and disadvantages are briefly discussed.

The measurement of RER is based on PPP rate as is shown in the last section. RER is at equilibrium when internal balance (when markets for nontraded goods and labor are both in equilibrium) and external balance (when the current account deficit is equal to the value of the sustainable capital inflow) are simultaneously achieved (Williamson, 1983; Montiel, 2002). Following this, ERE equals RER, which is proxied by PPP rate, in a certain year with the simultaneous achievement of both balances. Set the year as a base year, and RER in this year can work as ERE for some periods. Hence, ERM is the difference of contemporary RER and base-year RER. This approach is called PPP approach because PPP rate is used to represent RER (Cottani et al., 1990). Although PPP approach makes it easy to measure ERE and compare it with RER, the caveat of PPP approach is obvious: ERE is assumed to be constant over time. BMP approach assumes it is contemporary black market exchange rate that reflects the true ERE, for which reason, BMP, defined as the gap between black-market price and official price, reflects ERM (Huh et al., 1987). This approach, however, lacks support from empirical evidence to verify the correlation between black market exchange rate and ERM is robust (Zhang, 2001).

FEER approach defines ERE as "the real effective exchange rate that is consistent with macroeconomic balance" (Clark and MacDonald, 1998). Macroeconomic balance here refers to simultaneous internal balance (full employment and low inflation) and external balance (sustainable current account when countries are in internal balance)[1]. FEER approach abstracts from short-term factors and focuses on medium-term factors. The basic idea is that the current account position (CA) is a function of ERE, local output under full employment, foreign economies, and other determinants. At medium-run equilibrium, CA equals equilibrium (the negative of) capital account (CAP). Thus, CA could be replaced with the negative value of CAP and be put back into the function to derive medium-term fundamental ERE (Clark and MacDonald, 1998). FEER is rather straightforward for the estimation is based directly on the definition of ERE, but it is not perfect. Apart from the complications resulting from a considerable amount of parameter estimation (Zhang, 2001), other flaws of FEER approach are a) defining external balances is controversial; b) the value of the trade elasticities, which determine FEER, relies on the form of CA function and could be of low

[1] Note the definition of internal and external balances are different between Montiel (2002) and Clark and MacDonald (1998). Unlike Clark and MacDonald, Montiel does not introduce the concept of "medium term", but the framework is alike. Jongwanich (2009) incorporates the little nuance by grouping medium-term factors and long-term factors into "lasting fundamentals" and thus distinguishs short-term factors. This paper follows Moniel and Jongwanich and uses "long-term" and "non-transitory" to represent non-short term unless otherwisely specified.

accuracy; c) the application of FEER approach often relies on a full-blown multicountry macroeconomic model (Jongwanich, 2009). Clark and Williamson (1998) emphasize that FEER is a "medium- to long-run concept" and is unable to "explain cyclical movements in the real exchange rate". This caveat is solved by BEER.

Being also model-based, BEER greatly differs from FEER in the notion of equilibrium it adopts (Clark and MacDonald, 1998; Zhang, 2001). In a word, short-run factors can also be included and listed together with medium-run factors and long-run factors as regressors of RER in a reduced-form equation. Hence, RER is determined by a bundle of explaninng variables that are not necessarily subject to simultaneous internal and external balance[1]. The bundle of explaining variables is composed of transitory and lasting component of economic fundamentals[2] that are found related to true RER. If the shift in true RER is fully explained by changes in medium- to long-run fundamentals, then true RER equals ERE "in a behavioral sense" (Clark and MacDonald, 1998; Zhang, 2001). Specifically, BEER approach can be broken into two steps. First, regress the true RER on fundamental determinants to estimate the coefficients. Next, use relevant estimates (that is, coefficients of medium- to long-run factors) from last step, together with the actual level of fundamental determinants, to calculate ERE that reflects the changes in fundamental determinants, and the equilibrium path for the RER is simply the time series of ERE. Jongwanich (2009) groups the fundamentals are into three categories, namely, short-run (transitory) fundamentals, medium-run fundamentals, and long-run fundamentals, with the last two together considered as lasting (or non-transitory) fundamentals. BEER approach becomes the standout among other prevalent methods because it captures short-run dynamics.

The core of BEER approach is the selection of fundamental determinants, where four key components are often included according to abundant literatures. The four components are fundamentals that reflects domestic supply, domestic fiscal policy, international economies, and trade barriers (Hinkle and Montiel, 1999; Zhang, 2001). Note that all these four components are all lasting fundamentals, yielding the participation of transitory fundamentals if one is interested in detecting short run ERE[3]. Following sections puts BEER into application.

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1 Some of the variables are still related to both balances, just like what is done in FEER.

2 "Fundamentals" and "determinants" can be used interchangeably.

3 The inclusion of short-run fundamentals captures ERM more precisely than just medium- to long-run ERE, in the sense of taking omitted variables (short-run factors) out of residuals. However, the frequency of macro data such as government expenditure is limited to quarter. Quaterly data may not be appropriate to be applied in estimation together with short-term fundamentals. Therefore, this paper transfers quarterly data monotonically into monthly data to include short-term fundamentals and follows the reduced-form structure in BEER to estimate ERE directly.

3.2.2 Variable Selection and Data Description

In order to estimate ERE with BEER method, proper variables for the four groups of fundamentals should be selected. A suitable price index should also be found to translate NER into RER.

Since most macro data is available at most in monthly frequency, data used in this paper is all converted into the frequency. For few variables no more frequent than quarterly data, such as the government spending of Canada, the quarterly amount is divided equally and filled into the corresponding three months. Note that NER are in the unit of Canadian Dollar per United States Dollar (CAD-USD) and other variables are measured in CAD wherever relevant.

Start with RER, which is the domestic-foreign ratio of price index adjusted for NER. The "most common choice" for the domestic price index is domestic CPI, in this case Canada CPI. And the foreign price index is usually a trade-weighted CPI in domestic currency (CAD), weights being the share taken up by a trading partner country in the sum of Canada exports and imports (Montiel, 2002). The trade-weighted CPI is approximated into US CPI in CAD, since US is the biggest trading partner taking up 75.37% export partner share and 50.73% import partner share of Canada between 2015 and 2019 (WITS, 2021). Monthly data of NER is available from OECD (2021) and monthly data of Canada CPI and US CPI is available from IMF (2021). Note that CPI base year is 2002 for Canada and 2010 for USA, and the true level RER should theoretically be adjusted by a parameter which equals the ratio of 2002 Canada CPI bundle price (in CAD) over 2010 US CPI bundle price (in USD), yet this would not be a problem and it is not necessary to be adjusted. The series of CPI ratio can be regarded scaled by the parameter simultaneously. CPI itself is composed of different goods and services across different countries, and the importance of RER (NER adjusted CPI ratio) lies more in its growth and trend than its value in this paper. To avoid confusion, RER will not take its log form until entering regression. RER is computed formally as:

$$RER = \frac{NER * CPI_{US}}{CPI_{CA}}$$

Next comes to fundamentals and their proxies. Based on Clarks and MacDonald (1998) and Montiel (2002), below lists some determinants ("fundamentals") of medium- to long-run ERE that are commonly used[1]. The list is rooted in the theoretical framework established by Edwards (1988), who develops internal and external balances to a broader sense. This paper abstracts from the framework due to space limitation and applies empirical practice directly

[1] They are not listed by the four components in last section, but all four components are covered in the list.

on it. Following Edwards and Montiel, one can immediately derived that these are also determinants for ERM[1]. External fundamentals are international prices (that is, external terms of trade); international transfers, including foreign aid flows; world real interest. Policy-related domestic fundamentals are import tariffs, import quotas, and export taxes; exchange and capital controls; other taxes and subsidies; the composition of government expenditure (on tradeables and nontradeables). Non-policy-related domestic fundamentals is technological progress. Chowdhury (1999) suggest RER affected by both real and nominal variables, with real variables overlapping with those listed above. Nominal variables are expansionary macroeconomic policies and nominal devaluation. Based on the principle that fundamentals should represent four components from last section and with reference to Chowdhury (1999), from these listed above this practice chooses:

Terms of trade (ToT) is the relative unit price of exportable good in terms of importable good (Montiel, 2002). It captures changes in the international economic environment and represents the international economy component (Zhang, 2001). ToT monthly data is available in various forms from Canada government (Statistics Canada, 2021a), among which customer-based data is chosen against balance of payment data, and Laspeyres fixed weight is chosen against Paasche current weight[2]. This practice chooses seansonal adjusted data wherever possible following Statistics Canada Quality Guidelines (Statistics Canada, 2021d). The data is originally provided as export/import volume/price index and monotonically converted with a value of 100 in base year 2012 from datasource, with inflation adjusted for. Price index for exports and imports are selected to calculate ToT follows the definition above in Montiel (2002). Log form of the ratio is taken following Clark and MacDonald (1998).

Net capital inflow (NCI) equals the opposite of net exports (NX) by the nature of accounting identity (Krugman and Obstfeld, 2009). Intuitively, foreign currencies earned from NX must end up somewhere other than the market of goods and services. Therefore, (the opposite of) NX is the proxy of NCI in this paper. NCI is universally incorporated into fundamentals for it reflects capital control of domestic government (Chowdhury, 1999) and represents changes in international economic environment (Zhang, 2001). NCI also links to the external balance attained at ERE (Clark and MacDonald, 1998). Monthly data is available

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[1] ERM is the difference of RER and ERE. The determiants of RER (“short-run equilibrium”), is composed of the determinants of ERE (“long-run equilibrium”) and short-run fundamentals (with disturbances) that determine RER but not ERE (Montiel, 2002).

[2] “The major difference between customs and balance of payments concepts is that customs data reflect trade crossing from one economic territory to another whereas balance of payment data reflect changes of ownership between residents and non-residents of Canada” (Statistics Canada, 2021b). Laspeyres fixed weight is chosen as is done in reports of Canada government (Statistics Canada, 2021c).

for Canada exports and imports in the unit of 1 million CAD and adjusted for inflation with base year 2012[1] (Statistics Canada, 2021e, 2021f).

Government expenditure (GEX) captures changes in domestic fiscal policy and is measure by the ratio of government spending (Gov) to GDP. Monthly GDP and Quarterly Gov are in the unit of 1 million CAD and adjusted for inflation (Statistics Canada, 2021g, 2021h). Gov is assumed equally distributed across three months in a quarter for monthly frequency due to the lack of monthly Gov data. Technological progress (TPR) is the non-policy-related domestic fundamental and reflects domestic supply (Zhang, 2021). Following Chowdhury (1999), the proxy of TPR is growth rate of real GDP. Note GDP monthly data shows real GDP, for the inflation is adjusted (Statistics Canada, 2021g). The degree of openness (OPEN) captures trade barriers and is measured by the GDP share taken up by the sum of imports and exports. Nominal devaluation (NDV), measured by the change in NER, stands for short-run nominal fundamentals that draws RER back to ERE (Chowdhury, 1999). Thus, NDV enters the regression on RER together with non-transitory fundamentals but refrains from calculating ERE given its short-run property. The other short-run fundamental is the excessive supply of domestic credit (XCR) measured by the gap between domestic credit growth (GCR) and real GDP growth. Bank of Canada provides monthly data of credit measures (Statistics Canada, 2021i). Domestic credit (DCR) implies the expansion in domestic credit which can be resulted from unsustaionable expansionary policies (Chowdhury, 1999). XCR together with NDV explains (part of) the discrepancy of RER and ERE and does not engage in the calculation of ERE.

Among the fundamentals selected above, NDV and XCR are short-run ones, while the others are commonly seen as lasting fundamentals.

Figure 4 shows real GDP of Canada from January 2007 to September 2020. The trend is quite gentle in general except two falls. The first dive between 2008 and 2009 reflects Global Financial Crisis. The second plunge in early 2020 can be explained by COVID-19 pandemic. The lastest sample is in December 2019 to exclude the interference of the Covid-19 pandemic. To avoid systematic interference caused by the two worldwide shocks. Data is set from January 2010 to December 2019 in this paper. This also rules out the effect of the re-imposition of 10% Trump Tariff on Canada aliminum from August 2020 to September 2020.

[1] All data provided by Statistics Canada is adjusted for inflation with base year 2012, unless otherwisely specified.

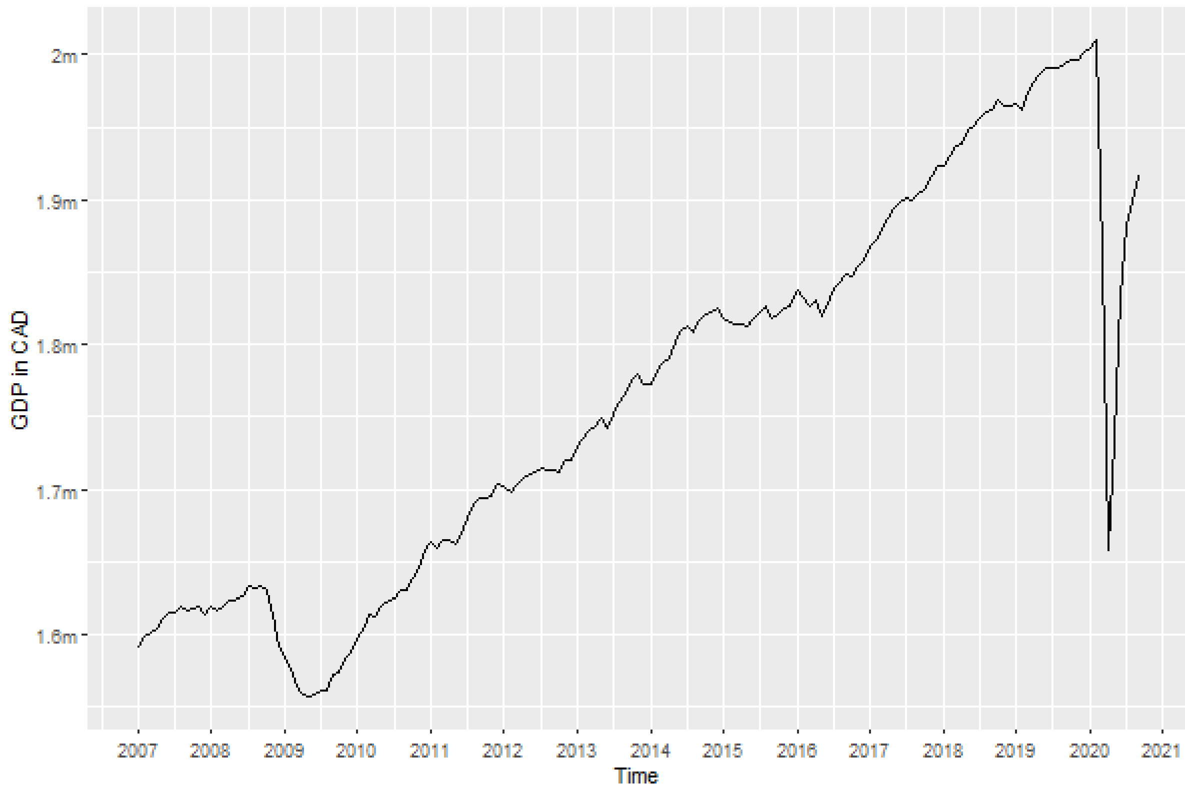

Figure 4. Real Canada GDP (in Canadian Dollar)

So far, all four components are covered by the variables selected above. Recall Trump Tariff scenario yields one more determinant: a dummy variable named Trump. It takes equals 1 for months between (and including) June 2018 and June 2019, during which the tariff is levied on steel and aluminum industries in Canada[1]. For the remaining time it equals 0.

Figure 5 presents nominal exchange rate and real exchange rate between Canada and US. A surge immediately followed by a plunge from 2008 to 2009 suggests Global Financial Crisis starting in US, in line with Figure 4. It is hard to recognize by eye the potential effect of Trump Tariff on NER and RER mentioned in Section 2.4. In answering the question, next section detects the potential effect with BEER method.

[1] Canada became subject to Trump Tariff on June 1, 2018. Trump Tariff was eliminated by a joint statement by Canada and US on May 17, 2019 and was reimposed from August 6, 2020 to September 15, 2020, effective August 16, 2020 to September 1, 2020 ("Steel and aluminum", 2022).

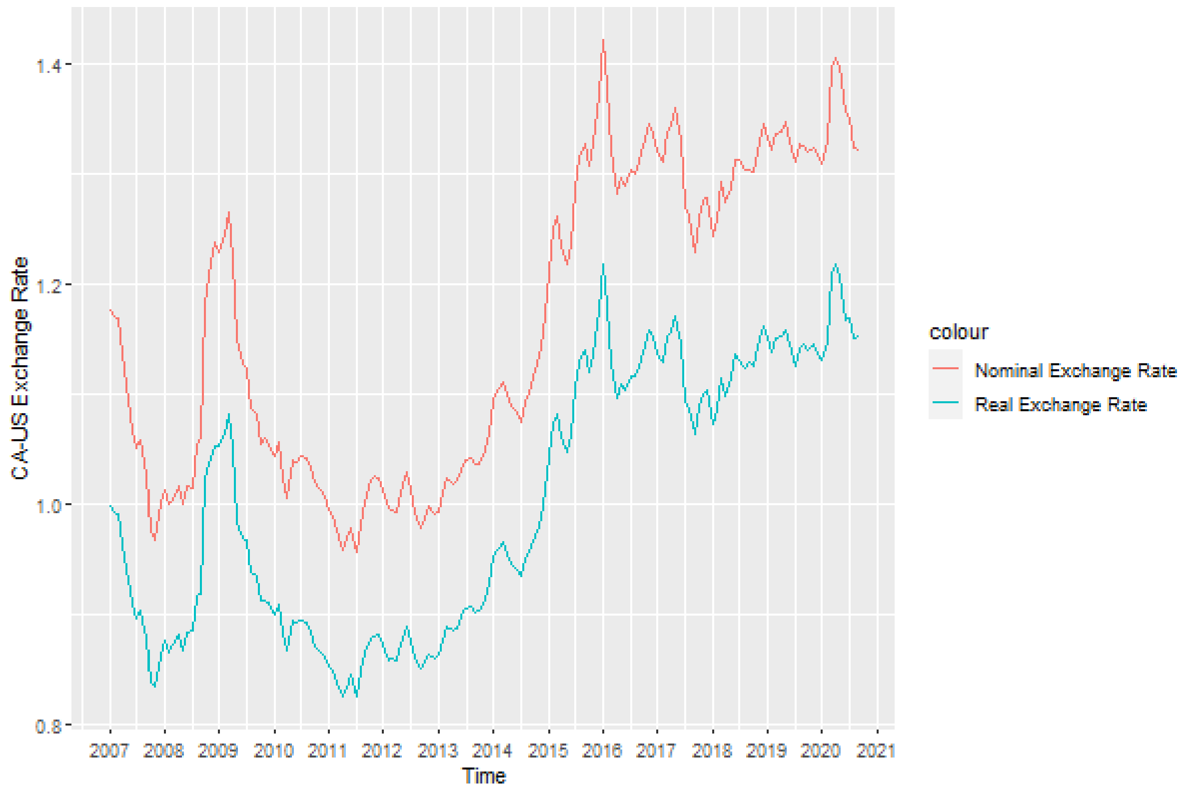

Figure 5. Nomianl and Real Exchange Rate (Canada to US)

3.2.3 Estimation with a Revised BEER Approach

This section begins with the standard theoretical model of BEER approach (Clark and MacDonald, 1998):

$$RER_t = \theta_1^T LR_t + \theta_2^T MR_t + \theta_3^T SR_t + \varepsilon_t \tag{5}$$

$$ERE_t = \theta_1^T LR_t + \theta_2^T MR_t \tag{6}$$

$$ERM_t = RER_t - ERE_t = \theta_3^T SR_t + \varepsilon_t \tag{7}$$

LR_t, MR_t, SR_t refer to a vector of long-run fundamentals, medium-run fundamentals, and short-run fundamentals respectively.

Total ERM (TERM) is defined when medium- to long-run fundamentals are at their sustainable level:

$$TERM_t = RER_t - \left(\theta_1^T \overline{LR}_t + \theta_2^T \overline{MR}_t\right) \tag{8}$$

$$TERM_t = (RER_t - ERE_t) + \left[ERE_t - \left(\theta_1^T \overline{LR}_t + \theta_2^T \overline{MR}_t\right)\right] \tag{9}$$

$$TERM_t = (RER_t - ERE_t) + [(\theta_1^T LR_t + \theta_2^T MR_t) - (\theta_1^T \overline{LR}_t + \theta_2^T \overline{MR}_t)] \quad (10)$$

$$TERM_t = \theta_3^T SR_t + \varepsilon_t + [\theta_1^T (LR_t - \overline{LR}_t) + \theta_2^T (MR_t - \overline{MR}_t)] \quad (11)$$

The righthandside of quation (11) are transitory effects, random disturbance, and lasting effects. The sustainable value of lasting fundamentals is sometimes represented by their mean value (Zhang, 2001). It is noticeable that equation (11) resembles a vector equilibrium correction model (VECM), but it can only be confirmed by testing the existence of cointegration between lasting fundamentals and the dependent variable. Intuitively, the test is likely to support the cointegration, for medium- to long-run fundamentals determines RER more tham one period. To some extant, the stochastic process of RER is explained by the stochastic process of lasting fundamentals. After the cointegration is confirmed, equation (11) is transferred slightly into the standard form of VECM to proceed estimation. This is what is done in prevailing empirical practice of BEER method (including Clark and MacDonald, 1998; Chowdhury, 1999; Zhang, 2001).

However, the prevailing procedures are not followed in this practice for mainly two reasons. First, 120 observations are far from enough to be regressed based on VECM. Second, Augmented Dickey–Fuller (ADF) test, Phillips–Perron (PP) test and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test are applied to RER and every single fundamental. Test results suggest a few of them probably with a stationary process I(0) while the others with a unit root process I(1). It is not impossible to let I(0) enter VECM should one insist, for "occasionally it is convenient to consider systems with both I(1) and I(0) variables. Thereby the concept of cointegration is extended by calling any linear combination that is I(0) a cointegration relation, although this terminology is not in the spirit of the original definition because it can happen that a linear combination of I(0) variables is called a cointegration relation" (Lütkepohl and Krätzig, 2004). Hence, VECM is not the best approach for the practice. Then what steps should be taken next?

The answer seems to be found in the noted work of Edwards (1988), although he probably does not run into the same issue. Recall that VECM is constructed (specifically, reparameterized) from autoregressive distributed lag (ADL) model conditioning the hypothesis of cointegration in ADL is not rejected. The basic idea is that Edwards first decomposes factors that affects the intertemporal RER change this period into three parts: the last-period departure of RER itself, the contemporary departure of lasting fundamentals, the comteporary intertemporal change in transitory fundamentals. Just like equation (11), the decompose is based on similar theoretical models and has a “mean-reversion-ish" form. Unlike Clark and MacDonald (1998), what he does is somehow in the opposite direction: the

“VECM-ish” decompose is converted back into a “ADL-ish” form which later extends to incorporate all relevant fundamentals. Since it is not a “real” VECM, no tests for cointegration are needed in the conversion.

The technique is rather exquisite. Not only are the desired properties of regular BEER (incorporation of short-run fundamentals) retained, but also do I(0) fundamentals in this practice enter the regression in a proper way. Following the exact procedure of Edwards (1988) with some reference to Chowdhury (1999), the final equation to be estimated in this practice is:

$$\Delta logRER_t = \gamma_1 ToT_t + \gamma_2 logGEX_t + \gamma_3 logOPN_t + \gamma_4 NCI_t + \gamma_5 TPR_t + \mu_1 logRER_{t-1} + \mu_2 XCR_t + \mu_3 NDV_t + \mu_4 Trump_t + \delta_t \quad (12)$$

Regression output is shown in Table 1.

	Dependent variable:	
	log(RER) - log(lag(RER))	
	default	robust
	(1)	(2)
ToT	-0.023* (0.013)	-0.023* (0.013)
log(GEX)	0.003 (0.015)	0.003 (0.013)
log(OPN)	0.014 (0.009)	0.014 (0.009)
NCI	-0.00000 (0.00000)	-0.00000 (0.00000)
TPR	0.218 (0.172)	0.218 (0.142)
log(lag(RER))	-0.016** (0.008)	-0.016** (0.007)
XCR	0.185 (0.154)	0.185 (0.116)
NDV	0.953*** (0.013)	0.953*** (0.012)
Trump	-0.0004 (0.001)	-0.0004 (0.001)
Constant	0.069 (0.060)	0.069 (0.054)
Observations	119	119
R^2	0.984	0.984
Adjusted R^2	0.982	0.982
Residual Std. Error (df = 109)	0.002	0.002
F Statistic (df = 9; 109)	728.796***	728.796***
Note:		*p**p***p<0.01

Table 1. Estimation of Real Exchange Rate

Several issues can be spotted on Table 1, among which the most obvious one could be over-fitting. Noticed both R^2 and adjusted R^2 are too close to 1. The auto-correlation function (ACF) and the partial auto-correlation function (PACF) of residual suggests the residual is unlikely to follow a white noise process. The value of coefficient of log(lag(RER)) is negative and very close to 0, and the coefficient is statistically significant, suggesting the RER in last period may not be a good regressor. The issue is tried to be explained with several potential causes, such as proxies being not good enough for variables, limited sample size, endogeneity of regressors. It is also possible that the identical model in Edwards (1988) can not very well describe Trump Tariff Scenario, and the remaining part of the section tries to rule out the problem of equation specification. In doing so, the core idea of Edwards (1998) remains but the measurement approach is revised. The revision to approach starts with careful detection to the stochastic properties of every single variable involved.

Except binary variable Trump, there are eight variables remained to be examined, namey RER, ToT, NCI, GEX, TPR, OPN, NDV and XCR. In the first step, ACF and PACF suggest RER, ToT, NCI, GEX, OPN are likely to follow an AR(1) process. TPR, NDV and XCR are probably stationary. The second step looks closely into the variables regarded non-stationary in step one, for ACF and PACF are not precise enough. Step two uses Akaike information criterion (AIC), Bayesian information criterion (BIC), Hannan–Quinn (HQ) information criterion and Final Prediction Error (FPE) criterion simultaneously on every one of the eight variables to roughly determine the optimal number of lags assuming they follow some auto-regressive stochastic process. With the optimal number of lags, the third step run ADF, PP and KPSS test on all eight variables, with conclusions that a) RER, ToT, GEX reject stationary tests and do not reject unit-root tests; b) the others are the opposite and are accordingly accepted as stationary I(0). Step four takes first difference of RER, ToT and GEX (namely dRER, dToT and dGEX) and repeat the previous three steps regarding dRER, dToT and dGEX. Conclusion is that dRER, dToT and dGEX are all considered stationary.

Now that the stochastic process is clarified, run the regression below where RER, ToT and GEX enter the estimation equation in terms of dRER, dToT and GEX[1].

$$\begin{aligned} dRER_t = \; & \rho_1 dToT_t + \rho_2 dGEX_t + \rho_3 OPN_t + \rho_4 NCI_t + \rho_5 TPR_t + \tau_1 XCR_t + \tau_2 NDV_t \\ & + \tau_3 Trump_t + \epsilon_t \end{aligned} \tag{13}$$

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[1] ToT, GEX, OPN, TPR, XCR and NDV are originally defined as ratios. In theory, they should be scaled up by 100 times so that their coefficients correspond to a 1% increase. A more common approach would be taking log forms, which is not applicable here with negative data. However, this monotonic transformation is not applied in this paper in order to make coefficients more readable. In other words, coefficients of the above variables are presented to be 100 greater in tables and figures below.

	Dependent variable:	
	dRER	
	default	robust
	(1)	(2)
dToT	-0.017 (0.031)	-0.017 (0.030)
dGEX	-2.199* (1.296)	-2.199** (1.054)
OPN	0.058 (0.087)	0.058 (0.091)
NCI	-0.00000 (0.00000)	-0.00000 (0.00000)
TPR	0.206 (0.269)	0.206 (0.218)
XCR	0.256 (0.221)	0.256 (0.172)
NDV	0.993*** (0.019)	0.993*** (0.024)
Trump	-0.0001 (0.001)	-0.0001 (0.001)
Constant	-0.004 (0.005)	-0.004 (0.005)
Observations	119	119
R^2	0.968	0.968
Adjusted R^2	0.966	0.966
Residual Std. Error (df = 110)	0.003	0.003
F Statistic (df = 8; 110)	416.776***	416.776***
Note:		*p**p***p<0.01

Table 2. Revised Estimation of Real Exchange Rate

Only very slight improvement is seen in the output. It could be the same problem of sample size, proxies and endogeneities. Recall figure 2 and equation (3), even though independent variables are carefully selected to cover every possible source of determinants of RER, endogeneity and omitted variable bias are not guaranteed to be ruled out. Although distortion in following calculation can result from this step. This practice continues and leave the problem open for future discussion. Note that the coefficient of Trump is insignificant both statistically and economically. Hypothesis 2 is not supported. Since there is no evidence for the existence of the first half of indirect effect, there is no need to test Hypothesis 3 because the existence of indirect effect requires H2 and H3 simultaneously supported.

3.2.4 Calculation of Misalignment

Figure 2 shows transitory and lasting effects on the intertemporal shift in RER. Previous theories suggest the exact lasting effect can fully explain the contemporary intertemporal shift in ERE. And the exact transitory effect with disturbance in the error term is equivalent to the contemporary intertemporal shift in ERM. Recall the transitory fundamentals are XCR and

NDV, the other independent variables in table 2 are all non-transitory fundamentals. ERE at any period equals the initial level of ERE in the first period plus the sum of all intertemporal shift in ERE until current period. Each intertemporal shift in ERE equals to the corresponding non-transitory effect, which equals the true level of non-transitory fundamentals multiplying their coefficient estimated in Table 2. Following the same logic for RER, formally:

$$RER_t = RER_0 + \sum_{i=1}^{t} dRER_i \tag{14}$$

$$ERE_t = ERE_0 + \sum_{i=1}^{t} dERE_i \tag{15}$$

Deduct equation (15) from equation (14) simultaneously on both sides, by definition:

$$ERM_t = ERM_0 + \sum_{i=1}^{t} (dRER_i - dERE_i) \tag{16}$$

Denote:

$$dERM_i = dRER_i - dERE_i \tag{17}$$

$$SumERM_t = \sum_{i=1}^{t} dERM_i$$

Since ERM can be fully explained by transitory fundamentals and disturbances, ERM is not likely to sustain around a certain level significantly different from zero. Hence, the average true ERM (true ERM equals ERM shift sum plus initial ERM) can equal zero in a medium- to long- period. If the inference holds, initial ERM equals the opposite of the average of ERM shift sum. In other words, the true ERM can be measured as the ERM deducted its average during the sample timespan. Assume no sustainable ERM in the long run for simplicity, i.e., $E(ERM) = 0$. Given n the sample size, take expectation on both sides of equation (16):

$$0 = E(ERM) = ERM_0 + E(SumERM)$$

$$ERM_0 = -E(SumERM) = -\frac{1}{n}\left(\sum_{t=1}^{n} \sum_{i=1}^{t} dERM_i\right) \tag{18}$$

Plug equation (17) and (18) back into equation (16):

$$ERM_t = -\frac{1}{n}(\sum_{t=1}^{n} \sum_{i=1}^{t} (dRER_i - dERE_i) + \sum_{i=1}^{t} (dRER_i - dERE_i) \tag{19}$$

$dRER_t$ is directly from RER_t, and $dERE_t$ is computed as the actual level of non-transitory variables times the estimate of their corresponding coefficients in table 2.

4. Study B: Detecting Mediating Effect of ERM

Considering Figure 2 together with Table 2, all fundamentals of ERM can also have effect on Canada exports of Steel and Aluminum, except XCR and NDV which go to control D because of their collinearity with ERM. Thus, control C is composed of the other seven fundamentals, and ERM works as the mediator M. Still, it can not guarantee the absence of endogeneity and omitted variables.

Data on Canada exports is from Governmant of Canada (2021a, 2021b, 2021c). Trump Tariff was levied on several sub-industries within the industries of Steel and Aluminum (Mohawk Global, 2018) and exports data are at the level of these sub-industries. These sub-industries subject to Trump Tariff are labelled in 6-digit HTS code, so 6-digit HTS code is used to filter these sub-industries from all Canada export (EuroStat, 2017). All relevant sub-industries are added up on the monthly basis to calculate monthly exports in (the affected part of) Steel and Aluminum industries.

Both industries suffered plunge from May 2018 to May 2019, perfectly overlapped with the period during which they are subject to Trump Tariff.

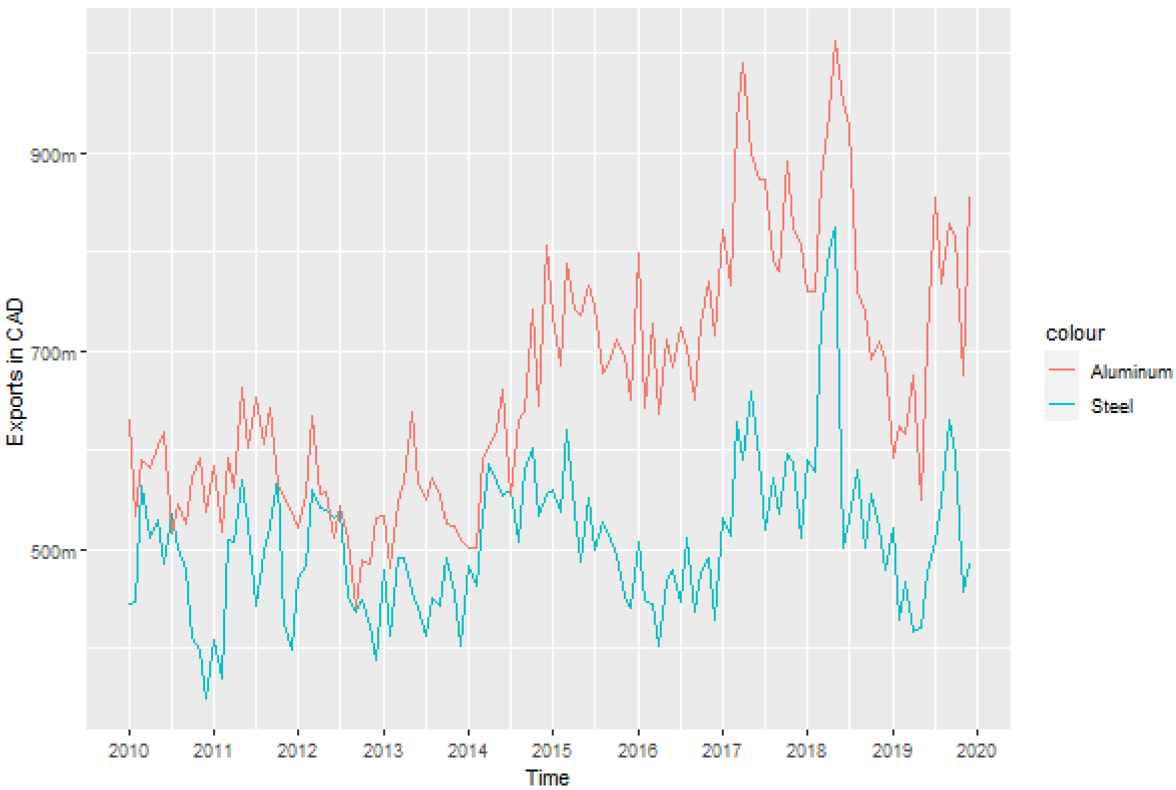

Figure 6. Canada Exports in Aluminum and Steel (in Canadian Dollar)

Just like what is done before the second regression in Study A, stochastic properties of the two exports are examined in the same four-step procedure, so that all variables entering the regression equation are (converted to be) stationary. Results suggest steel export is I(0) while aluminum export is I(1), so dALM enters estimation equation. Also check for ERM. I(1) is supported against I(0). Estimation equations and results are presented below.

$$STL_t = \pi_1 dToT_t + \pi_2 dGEX_t + \pi_3 OPN_t + \pi_4 NCI_t + \pi_5 TPR_t + \omega_1 Trump_t + \omega_2 dERM_t + r_t \tag{20}$$

$$dALM_t = \varphi_1 dToT_t + \varphi_2 dGEX_t + \varphi_3 OPN_t + \varphi_4 NCI_t + \varphi_5 TPR_t + \sigma_1 Trump_t + \sigma_2 dERM_t + s_t \tag{21}$$

	Dependent variable:	
	STL	
	default	robust
	(1)	(2)
dToT	-1,219,458,538.000* (641,758,283.000)	-1,219,458,538.000** (579,529,328.000)
dGEX	22,936,074,700.000 (27,269,132,936.000)	22,936,074,700.000 (31,601,502,597.000)
OPN	9,344,446,819.000*** (1,845,607,836.000)	9,344,446,819.000*** (2,208,040,897.000)
NCI	5,896.981 (4,681.901)	5,896.981 (4,565.118)
TPR	4,065,105,003.000 (3,118,684,884.000)	4,065,105,003.000 (3,156,783,872.000)
Trump	-80,290,817.000*** (23,528,439.000)	-80,290,817.000*** (23,161,666.000)
dERM	196,647,690.000 (382,464,543.000)	196,647,690.000 (364,829,841.000)
Constant	-57,364,549.000 (106,378,875.000)	-57,364,549.000 (129,867,159.000)
Observations	119	119
R^2	0.268	0.268
Adjusted R^2	0.222	0.222
Residual Std. Error (df = 111)	67,308,524.000	67,308,524.000
F Statistic (df = 7; 111)	5.801***	5.801***
Note:		*p**p***p<0.01

Table 3. Estimation of Steel Export

	Dependent variable:	
	dALM	
	default	robust
	(1)	(2)
dToT	-286,794,010.000 (663,708,427.000)	-286,794,010.000 (649,045,239.000)
dGEX	7,228,876,026.000 (28,201,822,714.000)	7,228,876,026.000 (26,431,350,857.000)
OPN	3,092,300,255.000 (1,908,733,406.000)	3,092,300,255.000 (2,033,438,859.000)
NCI	-1,848.867 (4,842.037)	-1,848.867 (4,510.504)
TPR	3,336,526,967.000 (3,225,353,678.000)	3,336,526,967.000 (3,292,203,846.000)
Trump	-64,263,003.000*** (24,333,185.000)	-64,263,003.000** (25,110,141.000)
dERM	73,907,425.000 (395,546,029.000)	73,907,425.000 (420,018,393.000)
Constant	-173,871,894.000 (110,017,366.000)	-173,871,894.000 (112,084,414.000)
Observations	119	119
R^2	0.077	0.077
Adjusted R^2	0.019	0.019
Residual Std. Error (df = 111)	69,610,686.000	69,610,686.000
F Statistic (df = 7; 111)	1.320	1.320
Note:		*p**p***p<0.01

Table 4. Estimation of Aluminum Export Growth

For both industries, Trump Tariff has significantly impact on the increase of exports to US. At least Hypothesis 1 is supported. Based on Table 3 and Table 4, Hypothesis 3, the second half of indirect effect, is not supported in either industry. There is no evidence that Trump Tariff has any influence on exchange rate misalignment. Neither is there any empirical findings supports the hypothesis that exchange rate misalignment actually determines the steel and aluminum Canada exports to US. The two estimation results in this section do not describe the effcts on exports in a good way, looking at the low values of R^2 and adjusted R^2. The low values are quite straightforward, for covariates in the model are chosen primarily to alleviate potential endogeneity. Variable selection is based on how it would interact with exchange rate misalignment. Unique controls of exports are not considered as long as they are believed to have no correlation with exchange rate misalignment. Hence, the low values of R^2 and adjusted R^2 truthfully reflects independent variables in this model do not explain much.

5. Conclusion and Discussion

The question of interest is whether exchange rate misalignment mediates the effect of Trump Tariff on Canada exports in Steel and Aluminum, and this paper says no. In answering the question, empirical part first computes exchange rate misalignment from real exchange rate and its determinants. The estimation at the meantime denies the hypothesized impact of Trump Tariff on exchange rate misalignment, and therefore invalidates the mediation framework immediately even before estimating the direct effect of Trump Tariff on Canada steel/aluminum exports.

However, the empirical output is highly questionable itself. Although it is tried to collect data from as few datasources to avoid statistical error, the sample size is rather limited, and it gives rise to a few following problems. The selection of determinanats to exchange rate is based on previous literature and intended to represent different markets and balances in theoretical model. But very few of them are with data already available. Proxies are used to represent several determinanats, and it is no surprise that some features of original determinants important to the framework is dropped by using proxies. Not only do proxies distort the original model, but also can they correlate with one another and lead to endogeneity. The handling of cointegration and stochastic process is over-simplified given the limit of data. In reviewing this paper, some assumptions could be too weak in the first place. For example, exchange rate is simply assumed exogenous for single industry, which lacks theoretical and empirical support. Future revision on this paper can be perfomed from at least three perspectives: the first would be the selection of variable. With limited data, the number of explanatory variables should be paid close attention to, especially when the effect of lag or lead is considered of potential importance. The second would be model specification. All scenarios can not be applied to standard model and should be adjusted on scenario-specific conditions. The third relates to techniques such as estimation method and monotonic transform especially when the stochastic process is highlighted.

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