

Measuring Trade Barriers and their Dynamic Impact: Evidence from Regional Exposure to US-Korea FTA*

Soo Kyung Woo[†]

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Abstract

This paper studies the dynamic effects of trade liberalization using regional variation in exposure to the U.S.-Korea Free Trade Agreement. A key contribution is to construct measures of regional exposure that incorporate product-level demand elasticities and capture three channels of trade liberalization: export expansion, import competition, and access to imported intermediate inputs. The measures incorporate product-level demand elasticities and differ from conventional trade-weighted average tariffs. Using the new measures, I find that lower barriers to exports are associated with gradual increases in GDP and employment, while lower protective barriers lead to delayed declines. Changes in input barriers have more muted or mixed effects. These differences are not apparent when conventional measures are used.

JEL Classification: F13, F14, F62

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[†]swoo@sogang.ac.kr Department of Economics, Sogang University

1 Introduction

Protectionist trade policies are back in the spotlight, with many countries raising tariffs and other trade barriers in recent years. While trade liberalization has long been associated with economic growth and welfare gains, its effects operate through multiple channels that may differ in magnitude and timing. In particular, lower barriers can expand export opportunities, increase competition from foreign firms, and reduce the cost of imported inputs. These channels may have distinct and potentially offsetting effects on output and labor markets, especially during the transition following a policy change.

In this paper, I study the dynamic effects of trade liberalization using regional variation in exposure to a bilateral trade agreement. I construct measures of regional exposure that capture three distinct channels of trade liberalization: increased access to foreign markets, greater competition from imports, and changes in the cost of intermediate inputs. Using these measures, I examine how output and labor market outcomes respond over time across U.S. states.

The main contribution of the paper is twofold. First, I develop a theoretically grounded measure of trade barriers that incorporates demand responses and distinguishes between different channels through which tariffs affect the economy. Second, I document that these channels exhibit different dynamic patterns. Reductions in barriers to exports are associated with increases in output and employment, while reductions in protective barriers generate more gradual negative effects, and changes in input costs have more muted or mixed impacts. These differences are not apparent when using conventional trade-weighted tariff measures.

A key challenge in this setting is how to measure exposure to trade barriers. Conventional approaches typically rely on trade-weighted average tariffs. However, these measures tend to understate the true extent of trade distortions, as products with high tariffs receive little weight precisely because they are traded less.¹ To address this issue, I construct measures of

¹Shift-share type measures using the average tariff across sectors are sometimes employed ([Topalova, 2010](#); [Kovak, 2013](#)). However, the sectoral averages are again import-weighted and are also subject to downward bias

trade barriers based on the Armington trade framework. In particular, I build on [Anderson and Neary \(1994, 1996\)](#) and [Kee et al. \(2008, 2009\)](#) to incorporate product-level demand elasticities into the measurement of trade barriers. The resulting measures often exceed conventional averages, indicating that simple average tariffs understate the extent of trade barriers in this setting. I then extend this framework to construct separate measures corresponding to different channels of trade liberalization—exports, import competition, and intermediate inputs. This distinction is important because conventional import-weighted averages combine effects that operate through greater foreign competition and through access to imported inputs. By contrast, the measures developed here allow these channels to be analyzed separately while retaining the interpretation of a tariff-equivalent measure.

When using these measures to estimate the impact of trade liberalization, I focus on the transition dynamics. The literature on trade liberalization has mainly emphasized long-run effects, while being less explicit about how these effects unfold over time. Yet trade adjustment is known to be gradual ([Hooper et al., 2000](#); [Baier and Bergstrand, 2001](#); [Ruhl, 2008](#)), and the labor market response may be even slower when mobility is limited ([Topel, 1986](#); [Glaeser and Gyourko, 2005](#); [Caliendo et al., 2019](#)). Studying these dynamics is important for understanding how the benefits and costs of trade liberalization emerge along the transition. In fact, I find that the effects differ across channels in both magnitude and timing. Reductions in export barriers are associated with gradual increases in output and employment, while reductions in protective barriers tend to generate delayed declines. Changes in input barriers have more muted or mixed effects over time.

I focus on a less-explored episode of trade liberalization: the U.S.-Korea Free Trade Agreement (FTA). The agreement, which went into force in 2012, was the largest trade deal for the U.S. after the North American Free Trade Agreement (NAFTA) in 1993. It progressively eliminated tariffs on almost all products traded between the two countries, with over 90 percent of tariff lines becoming duty-free within five years. This setting provides a useful source of vari-

for a similar reason.

ation, as the magnitude and timing of tariff reductions differ across products and industries, leading to heterogeneous exposure across regions depending on their industrial composition. After its implementation, Korea became the sixth largest trading partner of the U.S., with its share in U.S. gross trade rising from 2.5 percent to nearly 4 percent in 2023.

This paper is related to a strand of literature that studies the regional impact of trade. Taking regions as a unit of analysis provides a complementary understanding to the strand of literature that takes industrial sectors as a unit of analysis (Trefler, 2004; Flaaen and Pierce, 2019). In particular, the approach captures impacts on geographically defined variables such as labor participation and unemployment (Chiquiar, 2008; Topalova, 2010; Kovak, 2013). More recently, studies using regional variations within the U.S. have mainly focused on the impact of trade with China, namely the China shock or the trade war (Autor et al., 2013; Benguria and Saffie, 2020; Waugh, 2019). For example, Autor et al. (2013) use variations at the commuting zone level, while they focus on the effect of Chinese import penetration rather than the tariff changes. This paper is close to Hakobyan and McLaren (2016) who study the distributional effects of NAFTA in that I study the impact of tariffs against a major trading partner at the geographic level. I add to this literature by analyzing the dynamics at a higher time frequency and focusing on how different channels of trade liberalization shape regional outcomes over time.

This paper is also related to growing literature that studies the impact of trade through the global value chain. The role of tariffs on inputs has been studied mostly in the context of production in developing countries (Amiti and Konings, 2007; Topalova and Khandelwal, 2011; Kasahara and Rodrigue, 2008; Halpern et al., 2015). Amiti and Konings (2007), for example, show that in the case of Indonesia, the tariff impact through access to cheaper inputs has a larger impact on firm-level productivity than the impact through the international competition effect. A case for the U.S. has been studied by Handley et al. (2020), who show that producers subject to input tariff shocks during the 2018 Trade War experienced a decrease in their exports. This paper contributes to this literature by constructing a unified measure of

trade barriers that separates export, import competition, and input channels, allowing their effects to be compared within a common empirical framework.

The remainder of this paper is structured as follows. Section 2 introduces the new measures, describes data, and discusses their magnitude across the states after the FTA. I also compare the new barrier measures with the conventional average tariff. Section 3 uses these measures to estimate the dynamic responses, discusses the results, and compares them with those using the conventional measures. Section 4 discusses the robustness of the results. Section 5 concludes.

2 Measures of Trade Barriers

This section describes the measures that quantify the regional trade barriers related to tariffs. I describe the data used, introduce the barrier measures, document the changes in the barrier measures due to the trade agreement, and then compare them with conventional measures.

2.1 Construction of the Measures

A common method for summarizing diverse tariff rates across numerous products is to calculate the weighted average of rates, using trade value as the weight for each product.² Despite its simplicity and widespread usage, this method lacks a solid theoretical foundation and often exhibits a downward bias. This bias arises because excessively high tariffs suppress trade for the affected products, leading to smaller trade flows and underrepresenting their prohibitive impact in the weighted average.

To address these limitations, I introduce measures that leverage the import demand structure of the Armington model. This approach extends the Trade Restrictiveness Index, a measure that evaluates the overall welfare impact of tariffs, based on the theoretical framework of

²This can also be calculated as the ratio of tariff revenue to total import value.

Anderson and Neary (1994, 1996) and the empirical methodology first developed by Kee et al. (2008, 2009), to capture different channels of tariff impacts.

Specifically, using the Armington demand structure, I derive a uniform tariff rate that, if applied uniformly across all imported products, would replicate the same outcomes as the observed tariff structure in the data across three distinct aspects. These aspects represent different channels of tariff impacts: barriers to i) exports to the foreign market, ii) foreign competitors entering the U.S. market, and iii) imports of intermediate inputs. I define each barrier measure as the uniform tariff rate that sustains the observed level of i) aggregate exports, ii) local firms' domestic sales, or iii) imported inputs. In the following, I refer to these barriers as the Export Barrier, Protective Barrier, and Input Barrier.

Beyond being firmly rooted in trade theory, another advantage of the new measures is that they can measure the regional exposure for any pair of trading partners. This means that both national and subnational measures can be obtained directly, without relying on Bartik-style indirect methods, as long as trade and elasticity data for the two partners are available. Additionally, the resulting tariff rates are expressed as ad-valorem equivalents, making its interpretation straightforward.

Export Barrier

The Export Barrier quantifies the distortion in exports resulting from Korea's tariffs on U.S. products. It is defined as an answer to the following question: what is the uniform tariff rate that, if applied to all exported products instead of the observed Korean tariff structure, would maintain the *aggregate export* at its observed level?

To answer this question within a theoretical framework, I start with a demand system of the Armington Model with constant elasticity of substitution (CES). Under the CES structure,

export X_{SK}^i from state S to Korea of product i is given by:

$$X_{SK}^i(\tau_K^i) = \left(\frac{p_S^i(1 + \tau_K^i)}{P_K^i} \right)^{-\varepsilon_K^i} Y_K^i$$

$$P_K^i = \left[\sum_L (p_L^i(1 + \tau_K^i))^{\varepsilon_K^i} \right]^{1/\varepsilon_K^i}$$

where p_S^i is the price of product i from state S , P_K^i is the price index for product i in Korea, τ_K^i is tariff rate imposed by the Korean government on product i from the U.S., ε_K^i is demand elasticity for product i in Korea, and Y_K^i is the total expenditure on product i in Korea. The equation highlights that export X_{SK}^i is a function of the tariff rate τ_K^i , as the tariff raises the price of the product from p_S^i to $p_S^i(1 + \tau_K^i)$ and shifts the demand.

Now consider all products that are exported from state S to Korea. By summing them up, the aggregate export from state S to Korea can be expressed as $\sum_i X_{SK}^i(\tau_K^i)$. Then, the Export Barrier of state S is implicitly defined as B_S^{Export} such that:

$$\sum_i X_{SK}^i(B_S^{Export}) = \sum_i X_{SK}^i(\tau_K^i).$$

That is, B_S^{Export} is the uniform rate at which the aggregate exports under the rate and those under the observed tariff structure are equated.

Totally differentiating with respect to tariff in a partial equilibrium setup,

$$\sum_i dX_{SK}^i \cdot B_S^{Export} = \sum_i dX_{SK}^i \cdot \tau_K^i,$$

and solving for B_S^{Export} , we get

$$B_S^{Export} = \frac{\sum_i X_{SK}^i (1 - X_{SK}^i/Y_K^i) \varepsilon_K^i \tau_K^i}{\sum_i X_{SK}^i (1 - X_{SK}^i/Y_K^i) \varepsilon_K^i}. \quad (1)$$

Thus, the Export Barrier is a weighted sum of tariff rates, where the weights reflect the com-

position of an export value and the demand elasticity of each product.

In particular, the weight is increasing in the export value for most of the products.³ Moreover, it is also increasing in the demand elasticity: if the demand for a product is highly elastic, then the tariff on that product is given a larger weight as it would limit the imports more than a low elasticity product.

Protective Barrier

The U.S. tariff on imports protects a state from competition with Korean firms, helping the state maintain its levels of domestic production and sales. The Protective Barrier quantifies the distortions caused by these protections. It is defined as the uniform tariff rate that, if applied to imports instead of the observed U.S. tariff schedule, would result in the same *sales in the U.S.* as observed under the existing tariff structure.⁴

Similar to the derivation of the Export Barrier, I start with a CES demand of the U.S. for product i from state S :

$$X_{S,US}^i(\tau_{US}^i) = \left(\frac{p_S^i}{P_{US}^i} \right)^{-\epsilon_{US}^i} Y_{US}^i$$

where $X_{K,US}^i$ is the U.S. import from Korea of product i , τ_{US}^i is tariff rate imposed by the U.S. government on product i from Korea, p_S^i is the price of product i from state S , ϵ_{US}^i is the demand elasticity for product i in the U.S., Y_{US}^i is the total expenditure on product i in the U.S., and P_{US}^i is the price index for product i in the U.S.,

$$P_{US}^i = \left[\sum_L (p_L^i (1 + \tau_{L,US}^i))^{\epsilon_S^i} \right]^{1/\epsilon_S^i},$$

³For each i , $w_s^i = X_{SK}^i (1 - X_{SK}^i / Y_K^i)$ is increasing in X_{SK}^i if and only if $X_{SK}^i \leq 0.5Y_K^i$, which means that state S takes less than a half of the product i 's market share in Korea.

⁴This measure accounts for sales not only within the state itself but across the entire U.S. market. As a result, it captures foreign competition faced by a firm in a state, even if such competition originates in other states. Unlike the Input Barrier discussed below, this measure includes all types of products, including intermediate goods. Specifically, intermediate goods are considered here as long as they constitute a firm's output and are subject to foreign competition.

where L denotes all countries that the U.S. is purchasing product i from.

The Protective Barrier is B_S^{Prot} such that:

$$\sum_i X_{S,US}^i(B_S^{Prot}) = \sum_i X_{S,US}^i(\tau_{US}^i).$$

Totally differentiating

$$\sum_i dX_{S,US}^i \cdot B_S^{Prot} = \sum_i dX_{S,US}^i \cdot \tau_{US}^i$$

and solving for B_S^{Prot} , we get

$$B_S^{Prot} = \frac{\sum_i (X_{K,US}^i X_{S,US}^i / Y_{US}^i) \epsilon_{US}^i \tau_{US}^i}{\sum_i (X_{K,US}^i X_{S,US}^i / Y_{US}^i) \epsilon_{US}^i}. \quad (2)$$

Thus, the Protective Barrier is a weighted sum of the U.S. tariff rates, where the weights reflect the composition of U.S. consumption of state S products, that of Korean products, and the demand elasticity.

Input Barrier

The Input Barrier summarizes the distortion in the use of imported intermediate inputs that arises due to the U.S. tariff on imports from Korea. The measure is an answer to: what is the uniform tariff rate that, if imposed on all imports instead of the observed U.S. tariff structure, would leave the *intermediate imports from Korea* at their observed level?

Unlike the other measures, here we only consider products that are classified as an intermediate good, assuming that all imports of any intermediate good are to be used as an input for production in that state. The CES demand for intermediate good i from Korea in state S is

given by:

$$m_{KS}^i(\tau_{US}^i) = \left(\frac{p_K^i(1 + \tau_{US}^i)}{P_S^i} \right)^{-\varepsilon_S^i} M_S^i$$

where m_{KS}^i is the import from Korea to state S of intermediate product i , p_K^i is the price for product i from Korea, $\tau_{K,US}^i$ is a tariff rate imposed by the U.S. on imports of product i from Korea, ε_S^i is the demand elasticity of product i in state S , M_S^i is the total use of intermediate product i in state S , and P_S^i is the price index for product i in state S written as

$$P_S^i = \left[\sum_L (p_L^i(1 + \tau_{LS}^i))^{\varepsilon_S^i} \right]^{1/\varepsilon_S^i}$$

where L denotes any country that state S is purchasing product i from.

Input Barrier, the uniform rate at which that aggregate import of inputs is the same as under the observed tariff schedule, is B_S^{Input} such that:

$$\sum_i m_{KS}^i(B_S^{Input}) = \sum_i m_{KS}^i(\tau_{US}^i).$$

Taking total derivatives,

$$\sum_i dm_{KS}^i \cdot B_S^{Input} = \sum_i dm_{KS}^i \cdot \tau_{US}^i,$$

and solving for the uniform tariff rate B_S^{Input} , we get

$$B_S^{Input} = \frac{\sum_i m_{KS}^i (1 - m_{KS}^i/M_S^i) \varepsilon_{US}^i \tau_{US}^i}{\sum_i m_{KS}^i (1 - m_{KS}^i/M_S^i) \varepsilon_{US}^i}. \quad (3)$$

Thus, the Input Barrier is a weighted sum of the U.S. tariff rates, where the weights reflect the importance of Korea as a sourcing market and the product demand elasticity. It takes a similar form as the Export Barrier but with the weights of different subscripts, specifying the

opposite direction of trade flows, and is restricted to intermediate inputs.

Note that a state may be both a user and a producer of a product. For example, Michigan not only utilizes auto parts for automobile production but also manufactures auto parts. Three barrier measures capture these different channels. Specifically, the Input Barrier captures the distortion Michigan faces as a user of auto parts. On the other hand, Export and Protective Barriers take into account the distortion for Michigan as a producer of auto parts when selling its parts abroad, to other states in the U.S., and within Michigan itself.

2.2 Data

Three measures are constructed for each state at the annual frequency. Tariff rates during the period from 2011 to 2017 for both countries are obtained from the official FTA document provided by the Korea Ministry of Trade. The document provides the base tariff rate prior to the FTA for each product. Korea's tariff schedule is defined at the 10-digit HS level, while the U.S. uses the 8-digit level. The analysis, however, uses products at the 6-digit level of the HS code, the finest level of the code that is internationally standardized. For cases where tariff schedules vary within a 6-digit code, I calculate the rate by taking a simple average across the products within the same 6-digit code.⁵

Table 1 presents the base rate statistics for tariffs of the U.S. and Korea. Korea's average tariff rate is substantially higher at 13.1% compared to 4.2% in the U.S. Additionally, the variability in Korea's tariff rates is much greater, with a standard deviation of 52.6% versus 11.2% for the U.S. This difference is further highlighted by the maximum tariff rates: Korea's peak rate reaches 887.40%, while the U.S. maximum is 350%.⁶ The median tariff in Korea (8.0%) is also higher than in the U.S. (2.7%). The interquartile range for the U.S. spans from 0% to 6%,

⁵Ideally, tariffs below the 6-digit level would be aggregated using the same method discussed above. However, the data required to construct the weights—such as import elasticity and consumption—are often unavailable at such a detailed level and are subject to potential measurement errors.

⁶There are 126 products with tariffs exceeding 100% in Korea, most of which are agricultural goods. Excluding these high-tariff products for the construction of barrier measures gives very similar results as the baseline.

Table 1: Base rate statistics

	N	Mean	Std.	Min	p25	Median	p75	Max
US	9,486	4.20	11.18	0.00	0.00	2.70	6.00	350.00
Korea	10,976	13.09	52.63	0.00	5.50	8.00	8.00	887.40

Notes: The table presents statistics for base rates, which correspond to the tariff rates scheduled for imports before the agreement was enacted in 2012. U.S. tariff lines are defined at the HTS8 (8-digit HS) level, while Korea's are defined at the HSK (10-digit HS) level.

whereas Korea's range is narrower, from 5.5% to 8%. These statistics indicate that while Korea generally has higher tariff levels, U.S. tariffs are more dispersed.

The official FTA document also provides the staging category for different products, that indicates the timeline by which tariff reductions are implemented under the FTA. Each product is assigned to a specific category that determines how and when its tariff rate will be reduced, ranging from immediate elimination to phased reductions over a number of years. For example, products in a "Category A" staging schedule become duty-free immediately upon implementation of the agreement, while other categories phase out tariffs over longer periods.

Table 2 shows the distribution of products across staging categories. Products in Category A that became duty-free immediately upon the policy's implementation make up the largest share in both countries: 67% for the U.S. and 45% for Korea. The second-largest category is Category K, also in both countries, covering products that were already duty-free before the agreement took place. Taking these two categories together with categories B, C, D, and Q, over 90% of the products were to be duty-free in both countries within five years of the implementation. In contrast, other products had tariffs phased out over specific periods, varying from 2 years to 20 years.⁷

For the import demand elasticity, I take the value estimated by [Kee et al. \(2008\)](#) each for U.S. and Korea.⁸ Here I assume that that the import elasticity is common across all states in

⁷Among 10,992 products, Korea imposes quotas on 48 (0.44%). However, quota requirements are excluded in my calculation of tariff barrier measures. Also, products in Categories V and W are subject to different tariff rules at different times of the year, although there is only one product in each of these categories. I applied the reduction rule that is mentioned first in the document.

⁸Details on the elasticity estimates are provided in Section 4.1. In that section I compare these elasticity estimates with the those of [Soderbery \(2015\)](#) and [Soderbery \(2018\)](#). I also show the robustness checks using these

Table 2: Staging categories

Category	Staging	Korea		US	
		Count	Share	Count	Share
A	Duty-free immediately	7,392	67.25	4,761	44.72
B	2 equal stages, duty-free year 2	6	0.05	10	0.09
C	3 equal stages, duty-free year 3	752	6.84	360	3.38
D	5 equal stages, duty-free year 5	509	4.63	746	7.01
E	6 equal stages, duty-free year 6	2	0.02	1	0.01
F	7 equal stages, duty-free year 7	41	0.37	91	0.85
G	10 equal stages, duty-free year 10	636	5.79	575	5.40
H	15 equal stages, duty-free year 15	108	0.98	65	0.61
I	Variable reductions, duty-free year 10	24	0.22	12	0.11
J	No change 8 years, then 4 equal stages, duty-free year 12	3	0.03	17	0.16
K	Always duty-free	1,408	12.81	3,990	37.48
L	9 equal stages, duty-free year 9	1	0.01	0	0.00
M	12 equal stages, duty-free year 12	40	0.36	0	0.00
N	Reduced to 30% in 15 equal stages, duty-free year 16	2	0.02	0	0.00
O	18 equal stages, duty-free year 18	7	0.06	0	0.00
P	20 equal stages, duty-free year 20	1	0.01	0	0.00
Q	Annual stages, duty-free 2014	21	0.19	0	0.00
R	Full article value duty, then duty-free year 10	0	0.00	1	0.01
S	Duty-free immediately, selected items duty-free without bond	0	0.00	17	0.16
T	No change 10 years, then 5 equal stages, duty-free year 15	1	0.01	0	0.00
V	Seasonal reductions, 17 or 4 equal stages, duty-free years 5 or 17	1	0.01	0	0.00
W	Seasonal 30% reduction, then 6 equal stages, duty-free year 7	1	0.01	0	0.00
X	No change	13	0.12	0	0.00
Y	No FTA obligations; WTO commitments apply	16	0.15	0	0.00
Z	Reduced to 20%, then 9 equal stages, duty-free year 10	7	0.06	0	0.00
Total		10,992	100	10,646	100

Notes: Category G includes 26 products that are duty-free within a quota, with Category G rules applying once this limit is exceeded.

the U.S. For constructing weights for the three measures, I fix the period to pre-FTA period of 2011. For this year, data on export and import flows to Korea of the corresponding products, used for the construction of Export Barrier, is from the U.S. Census Bureau.⁹ Products are categorized as intermediate inputs according to the Stages of Processing (SoP) classification of United Nations.

As shown in Equation (1), constructing the Export Barrier requires data on the share of state S exports to Korea in Korea's total expenditure, X_{SK}^i/Y_K^i . However, data on the total expenditure Y_K^i in Korea at the 6-digit HS code level is not readily available. To address this data limitation, I decompose the share X_{SK}^i/Y_K^i into three parts:

$$\frac{X_{SK}^i}{Y_K^i} = \underbrace{\frac{X_{SK}^i}{X_{US,K}^i}}_{(a)} \cdot \underbrace{\frac{X_{US,K}^i}{X_{World,K}^i}}_{(b)} \cdot \underbrace{\frac{X_{World,K}^i}{Y_K^i}}_{(c)}$$

where $X_{US,K}^i$ is Korea's import from the U.S. of product i , and $X_{World,K}^i$ is Korea's total import from the world of product i . The term (a) can be obtained using the state's share in the U.S. of exports to Korea of product i , which is available from the Census. The term (b) is the U.S.'s share of imports from Korea of product i and is collected from the UN Comtrade database.¹⁰ Finally, the term (c) is the import's share in total use of the corresponding sector, classified with an IO code. Data on the share is collected from Korea Statistics. The correspondence between IO and HS codes is also from Korea Statistics. This approach allows us to construct an estimate of the share X_{SK}^i/Y_K^i using available aggregate data while maintaining consistency with the theoretical framework.

alternative estimates.

⁹A potential concern with using state-level trade data is that it may not fully capture the actual destinations and sources of U.S. trade. For the Export Barrier measure, the relative size of trade across products within a state is the key factor. If there is significant variation across products in these discrepancies within a state, it could generate noises in the barrier measures. This limitation, however, is not unique to the new measure and is also a challenge inherent in the construction of average tariff measures.

¹⁰Multiplication of two shares $(a) \times (b) = X_{SK}^i/X_{World,K}^i$ can be obtained directly by using data of X_{SK}^i and $X_{World,K}^i$. However, since two variables come from separate data sources, I choose to use two shares, each of which comes consistently from one source, in order to keep the consistency and minimize a measurement error.

Similarly, for Protective Barriers, data on the state S sales to the U.S., $X_{S,US}^i$, and U.S. expenditure, Y_{US}^i , in the U.S. at the 6-digit HS code level are not available (see Equation (2)). Instead, I construct the share $X_{S,US}^i/Y_{US}^i$ indirectly by:

$$\frac{X_{S,US}^i}{Y_{US}^i} = \frac{GDP_S^i - X_{S,World}^i}{\sum_S (GDP_S^i - X_{S,World}^i + X_{World,S}^i)}$$

where GDP_S^i is GDP of product i in state S , $X_{S,World}^i$ is the total export of product i from state S to the world, and $X_{World,S}^i$ is the total import of product i from the world to state S . That is, to measure the spending $X_{S,US}^i$ of the U.S. on state S 's product i , I assume that what is produced in state S but not exported to the foreign country was consumed within the U.S. Also, the U.S. expenditure Y_{US}^i is the sum of all states' expenditure, measured by their domestic absorption. Meanwhile, GDP by the state is only available at the sector level, classified with the NAICS code. Thus, I calculate the share at the 4-digit NAICS level using GDP data from BEA and trade data from the Census and then link it to each product using the concordance between HS and NAICS codes from BEA.

For Input Barriers, data on intermediate product use, M_S^i , of state S at the 6-digit HS code level is unavailable. To get the share m_{KS}^i/M_S^i of Equation (3), I resort to its decomposition

$$\frac{m_{KS}^i}{M_S^i} = \underbrace{\frac{m_{KS}^i}{m_{World,S}^i}}_{(a)} \cdot \underbrace{\frac{m_{World,S}^i}{M_S^i}}_{(b)}$$

where $m_{World,S}^i$ is the total import of intermediate product i from the world to the state S . The first term (a) can be obtained using trade data from the Census. For the second term (b), I make use of the Use and Supply Table from BEA to get the national data on the total use of input for each output. Then, I assume that a state's contribution to the national use of input

is proportional to the state's GDP share of output so that

$$m_{World,S}^i = \sum_j m_{World,S}^{ij} \cdot \frac{GDP_S^j}{GDP_{US}^j}$$

$$M_S^i = \sum_j M_{US}^{ij} \cdot \frac{GDP_S^j}{GDP_{US}^j}$$

where $m_{World,US}^{ij}$ is the national imported use of i as an input of j , M_{US}^{ij} is the national total use of i as an input of j , GDP_S^j is the state S 's GDP of j , and GDP_{US}^j is the national GDP of j . I calculate these terms at the 4-digit NAICS level and then link them to term (b) for each product at the 6-digit HS level using the concordance between HS and NAICS.

2.3 U.S.-Korea FTA and Trade Barriers

The negotiations for the U.S.-Korea FTA were first authorized by Congress in 2002, but it took several years of legislative processes and renegotiations until it finally went into effect in March 2012. It required the tariffs between the two countries to be removed within 15 years, either immediately or through equal annual reductions occurring at the start of each year. A significant share of the products were subject to the immediate elimination of tariffs, and most of the products were to be duty-free within five years.¹¹ Before the FTA, Korea was the 7th largest trading partner of the U.S., accounting for around 2.5 percent of gross U.S. trade. As of 2023, Korea became the 6th largest trading partner with almost 4 percent.¹²

Following the procedure described in Section 2.1 and using data from Section 2.2, I quantify the barrier measures around the periods that the FTA was implemented. Table 3 documents the summary statistics of the barrier measures. The Export Barrier tends to be higher than the other two barriers, with its mean, median, minimum, and maximum being larger than the

¹¹Among the 10,992 tariff lines of Korea, 67% became duty-free on the date the treaty entered into force. In the U.S., 45% of 10,646 tariff lines became duty-free on impact. For more details, see Table 2.

¹²There was a renegotiation of the U.S.-Korea FTA that started in July 2017, was signed in September 2018, and went into effect in January 2019. The amendments focused on the automobile sector, including the delays of tariff reductions on Korean trucks. In the analysis I focus on the period until 2017.

Table 3: Barrier statistics

	N	Mean	Std	Min	p25	p50	p75	max
Export Barrier B^{Export}	49	8.02	5.11	1.89	4.88	6.19	10.64	30.04
Protective Barrier $B^{Protective}$	49	2.58	1.49	0.00	1.70	2.26	2.92	7.19
Input Barrier B^{Input}	49	2.70	1.60	0.05	1.60	2.84	3.63	6.42

Notes: The table shows the statistics of three barrier measures during 2011 prior to the FTA, in percents. p25, p50, and p75 denote 25th, 50th, and 75th percentile, respectively. It covers 49 states in the US, including the District of Columbia and excluding Alaska and Hawaii.

others. For example, the medians of the Export Barrier, the Protective Barrier, and the Input Barrier are 7.15, 2.51, and 2.03 percent, respectively. This is because Korea's import tariff rates prior to 2012 were generally higher than the U.S. as discussed above.

Moreover, there are large variations in trade barriers across across different U.S. states. Table 3 shows that the standard deviation ranges from 1.71 (Protective Barrier) to 4.73 (Export Barrier) percent. Figure 1 displays the regional variations of three barrier measures. Export Barrier is highest for Idaho (29.31%), followed by Arkansas (19.15%), Iowa (14.30%), and South Dakota (13.45%). High trade barriers of these states stem from the high tariff on agricultural products including meat and grains. For example, tariff lines that contribute the most for the trade barriers against Idaho's exports include food products such as cheese,¹³ whey,¹⁴ and peas.¹⁵ These products are subject to high tariffs over 30 percents, with relatively high demand elasticity.

Unlike the barriers to exports, Protective Barriers on the import side tend to be higher for states on the eastern states. Top four states are: South Carolina (7.12%), Georgia (6.95%), Vermont (6.47%), and Mississippi (5.87%). South Carolina and Georgia have significant automotive and electronics sectors that import components from Korea. South Carolina, for instance, has a large automotive industry, with manufacturers like BMW relying on Korean parts.

Input Barriers are highest in Oklahoma (5.05%) and Arizona (4.79%). The products con-

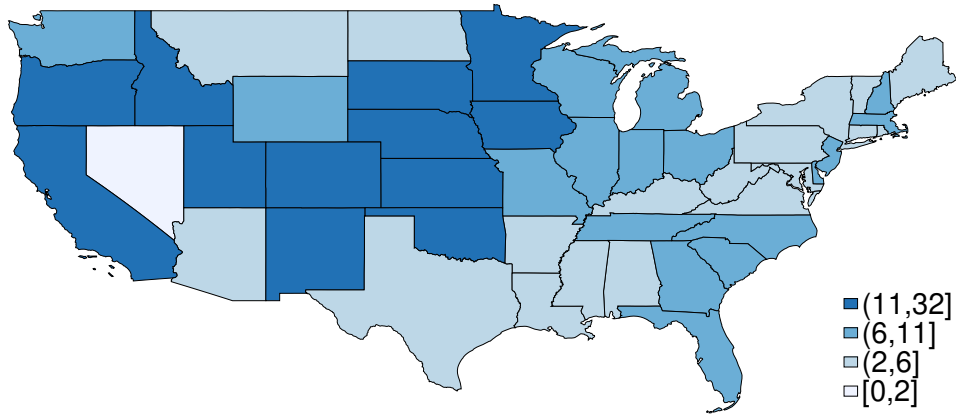
¹³Cheese, not elsewhere specified or included (HS 040690)

¹⁴Whey and modified whey, whether or not concentrated (HS 040410)

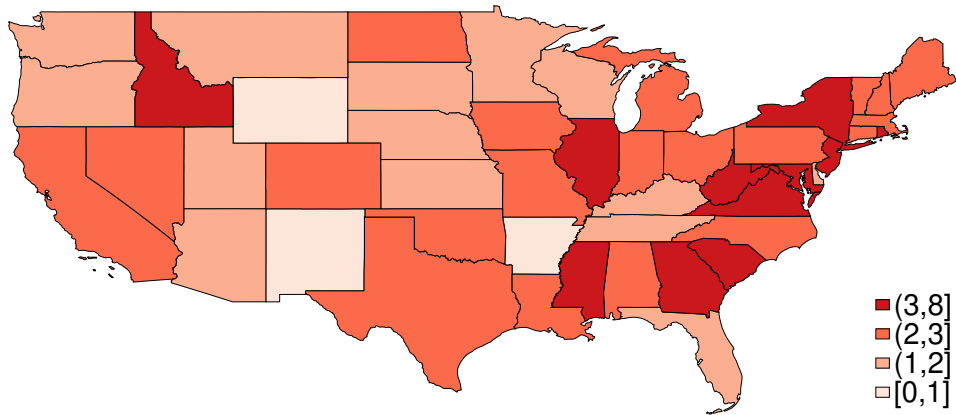
¹⁵Dried peas, shelled (HS 071310)

Figure 1: Regional variations in trade barriers

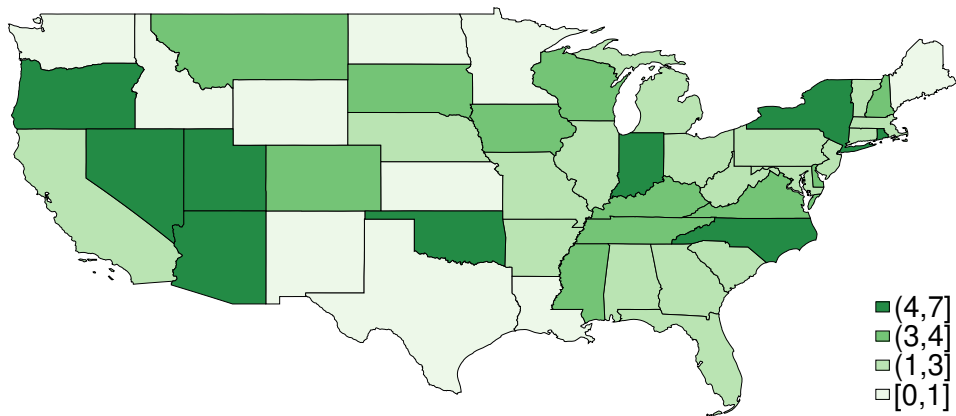
(a) Export Barrier



(b) Protective Barrier



(c) Input Barrier



Notes: The figure shows the measured sizes of three trade barriers faced by different states in 2011, prior to the FTA, expressed in percents. Darker colors indicate higher barriers, with cutoffs determined using the boxplot method.

Table 4: Barrier correlations

	B^{Export}	B^{Prot}	B^{Input}
Export Barrier B^{Export}	1		
Protective Barrier B^{Prot}	-0.21 (0.14)	1	
Input Barrier B^{Input}	-0.07 (0.65)	0.34 (0.02)	1

Notes: The table shows the correlation of barrier measures using the 2011 data.

tributing most to these high input barriers are primarily woven fabrics.¹⁶ Among the intermediates imported by Oklahoma, plastic materials used in construction, piping, and packaging¹⁷ face relatively high tariffs. In Arizona, aluminum products¹⁸ exhibit high demand elasticity.

Table 4 shows the pairwise correlation of the three barriers. The observed correlation is generally low. It is rather surprising that Protective Barriers and Input Barriers are not correlated. While both measures are averages of the common import tariffs, the differences in weighting—driven by each state’s unique industry structure—result in significantly heterogeneous exposure across the different channels of import tariffs. This pattern is also illustrated in Figure 1, where states benefiting from protection against imports do not align with those burdened by high intermediate tariffs.

Figure 2 presents the distribution of the barrier changes initiated by the FTA. Since the FTA requires the tariff rates to eventually reach zero, the extent of changes in the initial years primarily reflects the pre-FTA tariff levels. As the Export Barrier is larger than the other barriers prior to the FTA (Table 3), significant reductions in Export Barriers were observed immediately after the FTA. On the other hand, Protective and Input Barriers experienced smaller and more gradual reductions compared to Export Barriers, with some states showing negligible or

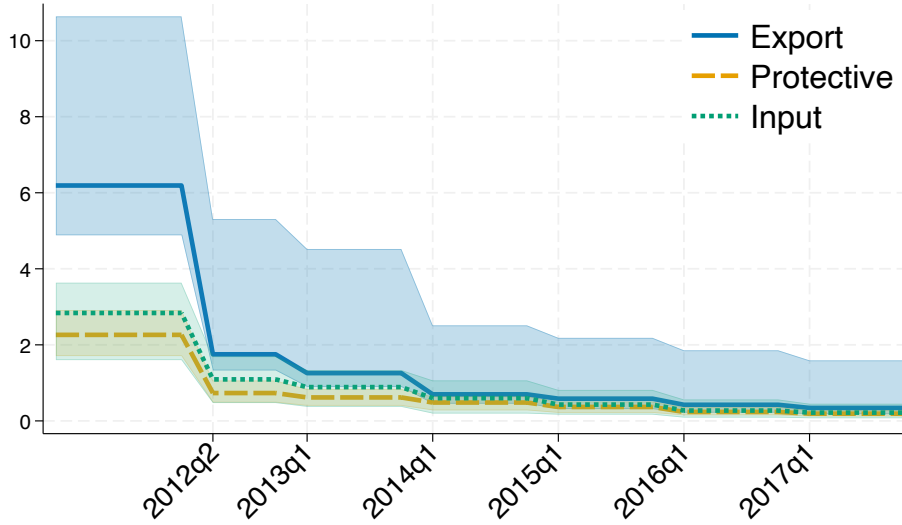
¹⁶Woven fabrics of cotton, containing >85% cotton by weight, dyed, plain weave (HS 520852); Woven fabrics of synthetic filament yarn, containing >85% polyester, unbleached or bleached (HS 540761); Woven fabrics of synthetic filament yarn, containing >85% nylon or polyamides, dyed (HS 540742).

¹⁷Polyvinyl chloride (PVC), not mixed with other substances (HS 390410).

¹⁸Aluminum structures and parts of structures, not elsewhere specified or included (HS 761090).

no changes by 2016. The sharp reduction in the first year reflects the fact that a large share of products are in staging category A (Table 2). For all of the barriers, there is considerable heterogeneity in the size of reductions across states, though this difference narrows over time as the barriers converge to zero.

Figure 2: Barrier changes after the FTA



Notes: The figure shows distribution of barrier measure changes following the implementation of the FTA. The lines show the median across states, and the shaded area represents the interquartile range. It covers 49 states in the US, including the District of Columbia and excluding Alaska and Hawaii.

2.4 Limitation of Conventional Measures

The most commonly used measure of trade barriers is the trade-weighted average tariff. Although simple and widely used, this measure may understate the true extent of trade distortions. Products subject to high tariffs are often traded less because those tariffs are restrictive, and therefore tend to receive little weight in the average. In such cases, the conventional measure puts too little weight on the products for which tariffs have the strongest effects on trade. This issue is particularly relevant in the present setting, where tariffs vary substantially across

highly disaggregated products.

The measures proposed here differ from conventional averages in two respects. First, they incorporate product-level demand elasticities, allowing tariffs on goods that are more responsive to price changes to receive greater weight. Second, they distinguish between different channels through which tariffs affect the economy. On the export side, tariffs restrict access to foreign markets. On the import side, they matter both through protection from foreign competitors and through access to imported intermediate inputs. Conventional trade-weighted averages do not separate these effects. By contrast, the barrier measures developed in this paper provide a common framework for quantifying each channel separately while retaining the interpretation of a tariff-equivalent measure.

Denoting the conventional average tariff on exports and imports by T_S^{Export} and T_S^{Import} , respectively, these measures can be written as

$$\begin{aligned} T_S^{Export} &= \sum_i \omega_S^{Export,i} \tau_K^i & \omega_S^{Export,i} &= \frac{X_{SK}^i}{\sum_i X_{SK}^i} \\ T_S^{Import} &= \sum_i \omega_S^{Import,i} \tau_{US}^i & \omega_S^{Import,i} &= \frac{X_{KS}^i}{\sum_i X_{KS}^i} \end{aligned} \quad (4)$$

where X_{SK}^i is the export from state S to Korea of product i , and X_{KS}^i is the import of state S from Korea of product i .

On the other hand, the three measures derived in Equations (1), (2), and (3) can be rewritten as

$$\begin{aligned} B_S^{Export} &= \frac{\sum_i w_S^{Export,i} \varepsilon_K^i \tau_K^i}{\sum_i w_S^i \varepsilon_K^i}, & w_S^{Export,i} &= \frac{X_{SK}^i (1 - X_{SK}^i/Y_K^i)}{\sum_i X_{SK}^i (1 - X_{SK}^i/Y_K^i)} \\ B_S^{Prot} &= \frac{\sum_i w_S^{Prot,i} \varepsilon_{US}^i \tau_{US}^i}{\sum_i w_S^i \varepsilon_{US}^i}, & w_S^{Prot,i} &= \frac{X_{K,US}^i X_{S,US}^i / Y_{US}^i}{\sum_i X_{K,US}^i X_{S,US}^i / Y_{US}^i} \\ B_S^{Input} &= \frac{\sum_i w_S^{Input,i} \varepsilon_{US}^i \tau_{US}^i}{\sum_i w_S^i \varepsilon_{US}^i}, & w_S^{Input,i} &= \frac{m_{KS}^i (1 - m_{KS}^i/M_S^i)}{\sum_i m_{KS}^i (1 - m_{KS}^i/M_S^i)}. \end{aligned} \quad (5)$$

Each barrier measure takes the form of a weighted average, with the weights varying by chan-

nel. This common structure makes it possible to compare the barrier measures directly with the conventional trade-weighted average tariff.

To make this comparison precise, let \bar{x} denote the weighted average of x^i where the weight is given by w^i , and let the hatted \hat{x}^i denote x normalized \bar{x} . Then each barrier measure can be expressed as

$$B_S = \sum_i w_S^i \hat{\varepsilon}_S^i \tau^i = \sum_i w_S^i \tau^i + \sum_i w_S^i (\tau^i - \bar{\tau}_S)(\hat{\varepsilon}^i - \bar{\varepsilon}_S) \quad (6)$$

where $\bar{\tau}_S = \sum_i w_S^i \tau^i$, $\bar{\varepsilon}_S = \sum_i w_S^i \varepsilon^i$, and $\hat{\varepsilon}_S^i = \varepsilon_S^i / \bar{\varepsilon}_S$.¹⁹ This shows that any barrier measure B_S can be decomposed into two components: the weighted average of tariff and the weighted covariance of tariff and the demand elasticity.²⁰

Equation (6) highlights two ways in which the barrier measure B_S differs from the conventional tariff average T_S . First, the weights differ across measures and depend on the channel being considered. For example, while both the Export Barrier and the conventional average export tariff place greater weight on products with larger export values, the Export Barrier also incorporates the demand response through the export share in total expenditure Y_K^i . On the import side, the conventional trade-weighted average tariff uses a single weight based on import flows and therefore combines distinct effects of import tariffs. By contrast, the Protective Barrier and the Input Barrier separate the role of tariffs in shielding domestic firms from foreign competition from their role in affecting access to imported intermediate inputs.

Second, the barrier measure includes an additional covariance term between tariffs and demand elasticity. This term captures the extent to which tariffs are imposed on products for which trade is more responsive to price changes. When products with higher demand elasticity are also subject to higher tariffs, the covariance is positive, and the barrier measure exceeds the conventional average tariff. In this case, conventional averages understate the restrictive

¹⁹The first equality follows from the definition of $\hat{\varepsilon}^i$, and the second uses the equation $\sum_i w_S^i \hat{\varepsilon}^i = 1$, which is again evident from the definition of $\hat{\varepsilon}^i$.

²⁰Both the average and covariance being assigned a weight w^i .

Table 5: Base tariff rate and demand elasticity

	(1)	(2)	(3)	(4)	(5)
Elasticity	0.019*** (0.003)	0.020*** (0.003)	0.037** (0.017)		
Elasticity#US				0.003*** (0.000)	0.013*** (0.004)
Elasticity#Korea				0.062*** (0.012)	0.091* (0.053)
Korea	3.909*** (0.146)	3.862*** (0.145)	8.252*** (0.671)	3.377*** (0.139)	7.615*** (0.647)
Constant	0.773*** (0.052)	0.791*** (0.051)	3.448*** (0.257)	1.012*** (0.025)	3.751*** (0.152)
Observations	93,320	93,320	8,295	93,320	8,295
R-squared	0.009	0.022	0.019	0.024	0.020
Year FE	NO	YES	Pre-FTA	YES	Pre-FTA

Notes: The dependent variable is the base tariff rate at the HS-6 product level in 2011 prior to the FTA. Sector fixed effect is at HS2 level. For Time FE, 'Pre-FTA' denotes that only base rate prior to the FTA is used. Robust standard errors, clustered at HS2 is sector FE is used, in parentheses. *** p<0.01, ** p<0.05, * p<0.1

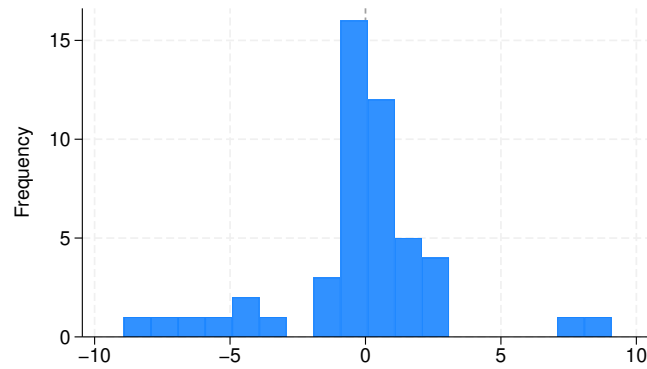
effect of tariffs because they place too little weight on the products for which tariffs have the strongest trade effects.

The importance of this covariance term is not only conceptual but also empirically relevant in the present setting. Table 5 examines the relationship between base tariff rates, set prior to the FTA, and import demand elasticity at the HS-6 product level. In column (1), the coefficient on elasticity is positive and significant, suggesting that countries tend to impose higher tariffs on products with higher import demand elasticity. This relationship remains positive when time fixed effects are included, as shown in columns (2) and (3). Columns (4) and (5) further show that the positive relationship is present for both the U.S. and Korea, although it is stronger for Korea. These results imply that the covariance term in Equation (6) is positive on average, so that conventional trade-weighted average tariffs tend to understate the true extent of trade barriers in this setting.

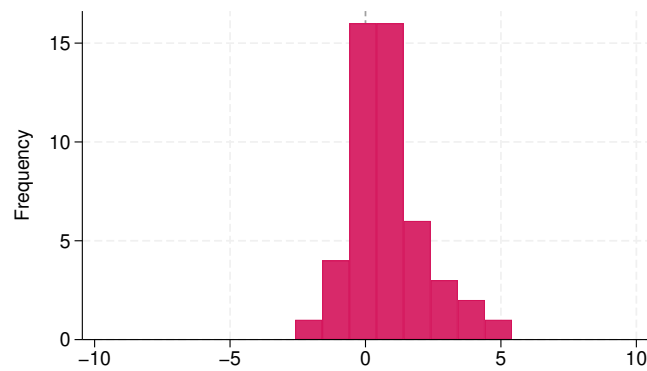
Figure 3 illustrates this implication at the state level by presenting the distribution of the

Figure 3: Barrier measures vs. trade-weighted average tariff

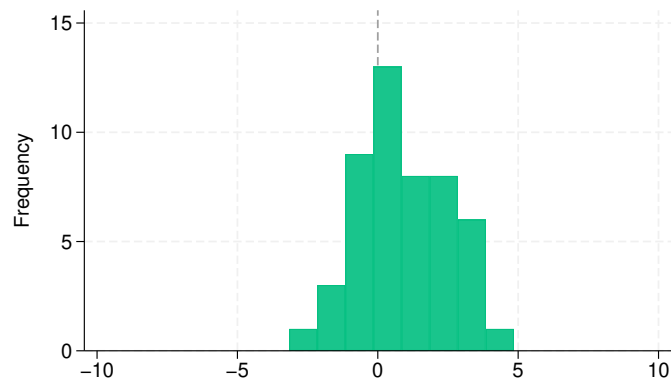
(a) Export Barrier



(b) Protective Barrier



(c) Input Barrier



Notes: The figures show the histogram of the weighted covariance between tariffs and rescaled demand elasticities, calculated using the corresponding weights of each barrier measure. Base rates prior to the FTA are used. The gray dashed line represents a covariance value of zero.

weighted covariance term.²¹ While there is heterogeneity across states, the distribution is skewed toward positive values. In other words, the barrier measures tend to exceed the corresponding trade-weighted average tariffs, indicating that conventional averages place too little weight on highly restrictive products. This pattern is especially pronounced on the import side. Even when import tariffs are lower on average than export tariffs, they may still represent substantial trade barriers once demand responses are taken into account.

3 Dynamic Responses to Barrier Changes

In this section, I use the three barriers from Section 2 to estimate their dynamic impact on output and labor market outcomes. I discuss the estimation strategy, present the results, and then compare them with those obtained using the conventional trade-weighted average tariff.

3.1 Estimation

Given the exposure to the FTA during the period of 2012-2016 in each state, I now estimate the dynamic response to these changes.²² The response at time horizon h can be defined as a difference between the forecast path for the outcome variable and its counterfactual:

$$\beta_h = E(\Delta_h y_{S,t+h} | \Delta B_t = -1\%p, \mathcal{X}) - E(\Delta_h y_{S,t+h} | \Delta B_t = 0, \mathcal{X}) \quad (7)$$

where $\Delta_h y_{S,t+h} = y_{S,t+h} - y_{S,t-1}$ is growth in logged outcome variable y of state S between periods $t - 1$ and $t + h$, $\Delta B_t = B_t - B_{t-1}$ is a change in the barrier measure at time t , and \mathcal{X} is a vector of controls including lags of the outcome and all other barrier cuts during the sample

²¹While Table 5 compares the tariff and elasticity at the product level, Figure 3 presents the weighted covariance at the state level. The weighted covariance is same as the difference between the barrier measures and the average tariffs, or the last term in Equation (6).

²²The choice of the sample period is driven by the observation that the majority of tariff reductions occurred within the first five years. This can be seen also be seen in Table 3.

period.²³ In other words, β_h is the average cumulative response across states and across time of the outcome variable y at h periods ahead in response to a 1 percentage point decrease in a barrier, conditional on the information available at the initial time t . Because the tariff schedule was announced in advance, the empirical design does not interpret tariff changes as unanticipated shocks. Instead, it estimates how local outcomes evolve around scheduled changes in trade barriers.

In specific, I use the Local Projection Method (Jordà, 2005) and estimate β_h^{Export} , β_h^{Input} , and β_h^{Prot} in the following equation:²⁴

$$\begin{aligned} \Delta_h y_{s,t+h} = & -\beta_h^{Export} \Delta B_{st}^{Export} - \beta_h^{Input} \Delta B_{st}^{Input} - \beta_h^{Prot} \Delta B_{st}^{Prot} \\ & + \sum_{k=-8}^4 \omega_{t+k}^h \Delta B_{st+k} + \gamma^h \Delta_1 y_{s,t-1} + \mu_s^h + \mu_{t+h}^h + \varepsilon_{t+h}. \end{aligned} \quad (8)$$

where μ_s^h and μ_{t+h}^h are state and time fixed effects. It is a set of estimations of a direct forecasting model for each forecast horizon h . It provides with multi-step predictions and enables us to find the responses to a shock at h without reference to the data generating process.

Note that the regression includes all three barriers simultaneously, which helps isolate the role of each channel by exploiting variation across common tariff lines within a state. This is particularly useful because many states use products as inputs that are also produced locally. For example, Michigan is both a producer and a user of auto parts.

Also, because tariff changes were scheduled and announced in advance, the specification includes leads and lags of the barrier changes. This helps absorb predictable movements associated with the announced tariff path and allows me to assess whether outcomes respond prior to implementation.

Because the tariff schedule was predetermined and the empirical variation comes from dif-

²³For construction of barrier measures, the weights are fixed using data from pre-FTA period, while dependent variable changes over time.

²⁴The negative signs are used in front of the coefficients for the barriers in Equation (8). This is to interpret the estimates as the impact of liberalization, instead of pure changes in the barriers. Note that β_h is defined as a response to a tariff reduction in Equation 7.

ferential regional exposure to those scheduled changes, the estimates should be interpreted as state-level differential responses to tariff phase-outs under the FTA, rather than as fully model-free causal effects of trade liberalization. In addition, the barrier measures are constructed using several allocation assumptions, since the relevant bilateral state-product expenditure and input-use data are not directly observed. The empirical design also cannot fully rule out persistent state-level factors correlated with pre-FTA industrial composition. For these reasons, the estimates are best read as evidence on differential regional adjustment associated with scheduled liberalization.

The horizon estimated ranges up to 12 quarters after a shock in trade barriers ($h = 0, 1, \dots, 12$). I also check for the existence of any anticipatory movement by looking at the horizons before the shock ($h = -1, \dots, -4$).

3.2 Results

This section reports the main results on the dynamic effects of trade liberalization. A key finding is that the effects differ across channels in both magnitude and timing. Reductions in export barriers lead to gradual increases in output and employment, while reductions in protective barriers are associated with delayed declines in manufacturing employment and more persistent regional adjustment.

Figure 4 presents the estimation results for GDP responses. Panel (a) shows the cumulative response of log GDP to a 1 percentage point cut in each of the three trade barriers at horizons $h = -2, \dots, 12$. Before the tariff cut is realized ($h < 0$), GDP shows little movement, suggesting that it does not respond in anticipation of the scheduled tariff changes. Once the policy is implemented ($h \geq 0$), GDP moves in economically intuitive directions: easier access to the export market gradually increases GDP, reaching 0.8 percentage points by the 12th quarter (Export Barrier, solid blue). Lower protection from foreign firms slightly raises GDP in the short run, but the effect turns negative over longer horizons (Protective Barrier, dashed

yellow). The effect of lower input barriers is instead negative on average (Input Barrier, dotted green). However, when I focus only on durable sectors, cheaper inputs increase GDP, as expected. Lower import tariffs have two opposing effects: they reduce GDP growth by intensifying competition in the domestic market, but they also support production by lowering input costs. Similar patterns, with larger magnitudes, appear when I restrict the analysis to durable-goods production (Panel (b)).

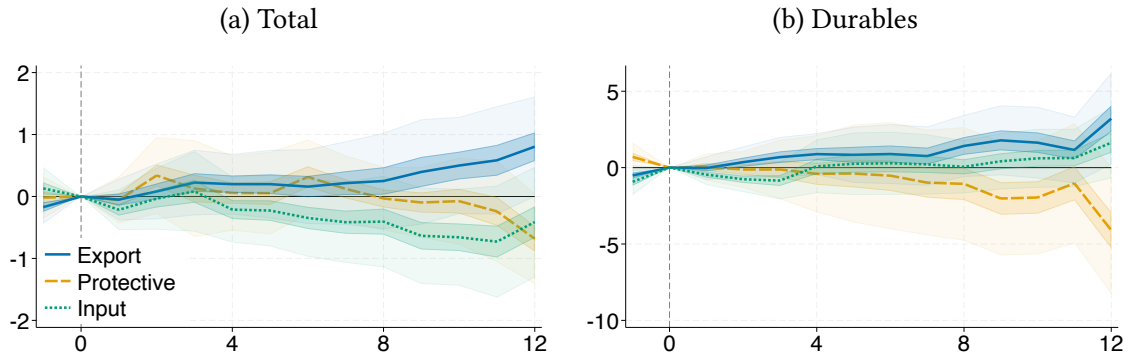
Using the interquartile variation in state exposure, the estimates imply nontrivial differences in GDP across states. For the Export Barrier, the implied GDP difference between states at the 25th and 75th percentiles of exposure reaches 1.42 percentage points by the 12th quarter.²⁵ Similar calculations for the other barriers also indicate economically meaningful heterogeneity in the effects of the FTA across states.

These magnitudes should be interpreted with care. The estimates do not measure the aggregate effect of the FTA on the U.S. economy. Instead, they capture differential responses across states with different exposure to the tariff changes. In this sense, the estimates are closer to state-level exposure effects than to the aggregate counterfactuals typically reported in quantitative trade models.

I further study the labor market outcomes. Figure 5 shows that the employment response is broadly similar to that of GDP, although the adjustment is somewhat more delayed. A cut in the Export Barrier gradually raises employment, reaching 0.41 percentage points by the 12th quarter, whereas a lower Protective Barrier reduces employment by 0.14 percentage points over the same horizon. Interestingly, the labor force moves closely with employment, both in timing and in magnitude (Figure 5, Panel b). Part of this adjustment reflects changes in population: a cut in the Export Barrier is associated with gradual population growth, whereas a cut in the Protective Barrier leads to population decline (Panel d). Labor force participation,

²⁵The interquartile range in the state-level Export Barrier changes in 2012 is $(-1.85)-(-3.55)=1.78$ percentage points (Figure 2). The differential change between states at the upper and lower quartile of the barrier change is calculated by multiplying the interquartile range by the point estimate at the 12th quarter (Table 9), which results in $1.78 \times 0.80 = 1.42$. The rest of the discussion is obtained in a similar way.

Figure 4: GDP



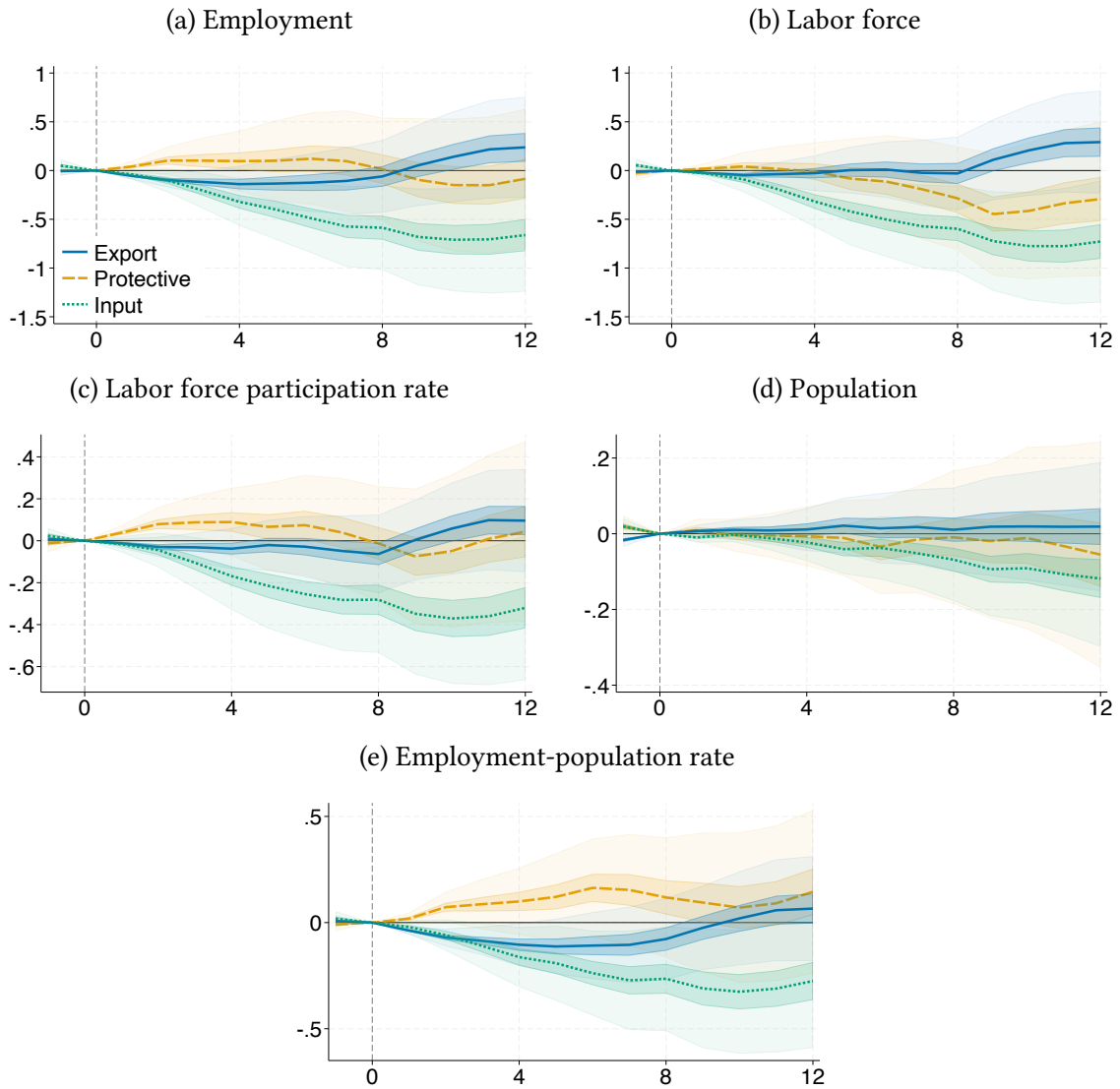
Notes: The figure displays cumulative responses to 1%p barrier cuts in GDP, i.e. the estimates of β_h^{Export} , β_h^{Prot} , and β_h^{Input} over the horizon of $h = -2, \dots, 12$ (quarters). The light and dark shaded areas display 90% and 68% confidence intervals, respectively. All dependent variables are logged and multiplied by 100.

measured as the labor force share of population, also moves in the same direction (Panel c). Taken together, these findings suggest that the employment effects of trade liberalization operate importantly through entry into and exit from the labor force, with part of the adjustment reflecting migration across states.

The personal income shows more intuitive responses. Figure 6 presents the responses of personal income. Income for all sectors, both in aggregate and on a per capita basis, increases following a cut in the Export Barrier (Panels a and b). When the analysis is restricted to the nonfarm sector, however, the response becomes more similar to those of GDP and employment (Panels c and d). This pattern suggests that the nonfarm sector plays an important role in driving movements in the aggregate economy. Because the agreement with Korea involved substantial tariff changes in the farming sector, and because this sector appears to behave differently from the rest of the economy, combining farm and nonfarm income may mask important sectoral differences in the income response.

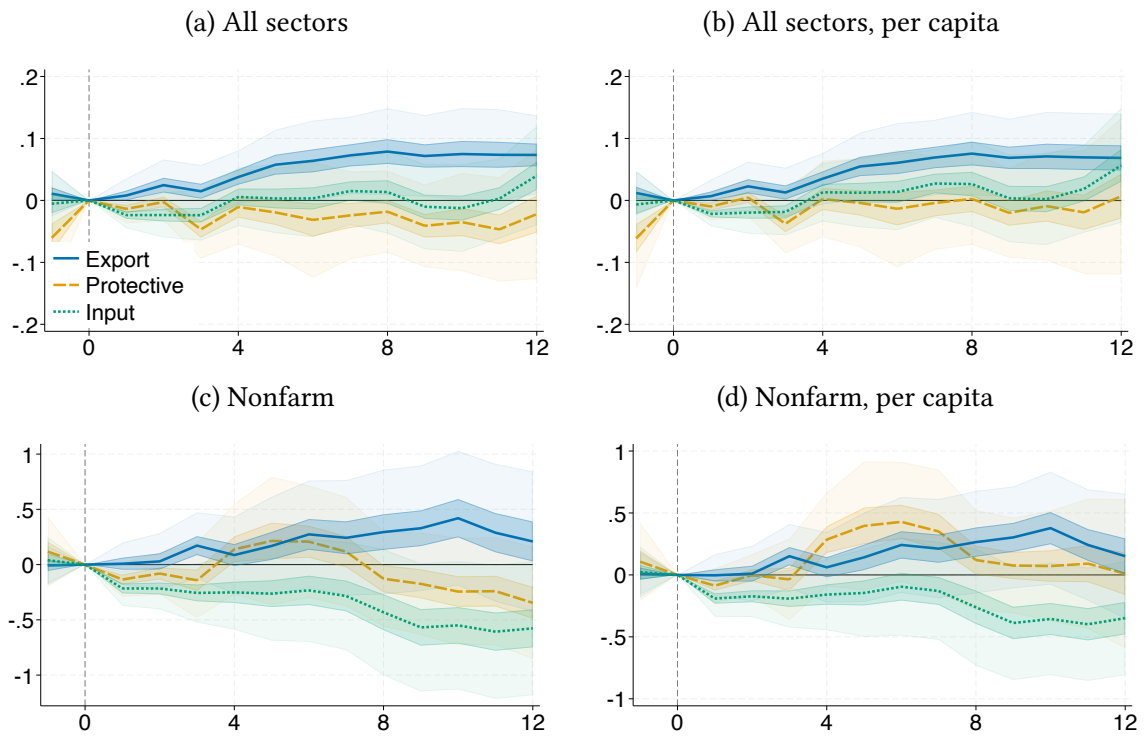
To explore these patterns further, I decompose personal income into its sources and examine the response of each component. Figure 7 presents the responses of the different components of personal income. Wages and salaries respond positively and gradually to the Export

Figure 5: Labor market responses



Notes: The figure displays cumulative responses to 1%p barrier cuts in the labor market variables, i.e. the estimates of β_h^{Export} , β_h^{Prot} , and β_h^{Input} over the horizon of $h = -2, \dots, 12$ (quarters). The shaded areas display 90% and 68% confidence intervals. Dependent variables in (a)-(d) are logged and multiplied by 100.

Figure 6: Personal income



Notes: The figure displays cumulative responses to 1%p barrier cuts in different components of personal income, i.e. the estimates of β_h^{Export} , β_h^{Prot} , and β_h^{Input} over the horizon of $h = -2, \dots, 12$ (quarters). The shaded areas display 90% and 68% confidence intervals. All dependent variables are logged and multiplied by 100.

Barrier cut, show little response to the Protective Barrier cut, and decline following the Input Barrier cut (Panel a). Since wages and salaries account for the largest share of personal income,²⁶ this component appears to be the main driver of the overall income response for U.S. residents.

Income from other sources also tends to respond positively to lower Export Barriers. For example, proprietors' income increases as well, with a much larger magnitude (Panel c). By contrast, a lower Input Barrier is associated with an increase in proprietors' income, especially in the long run. This suggests that much of the benefit from cheaper inputs accrues to proprietors rather than wage workers. The responses of dividends, interest, and rent, as well as transfers, are mostly insignificant (Panels b and d). These differences likely reflect the fact that wages are more directly tied to production within the state, whereas these other income sources are more closely linked to economic activity outside the region. For example, interest income is influenced by financial markets, where the local effect of trade barriers is less direct. As a result, these income sources respond more weakly and less systematically to changes in state-level trade conditions.

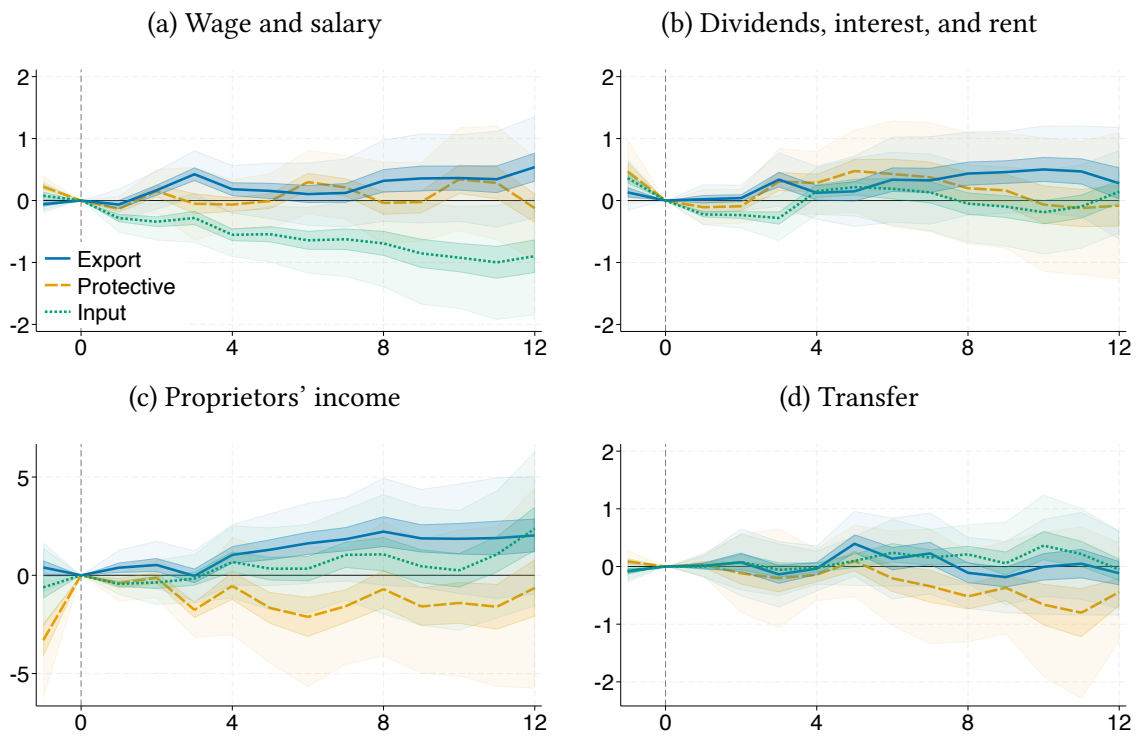
3.3 Comparison with Results using Conventional Measures

To highlight the use of the new barrier measures, I provide the results estimated with the conventional tariff measures of Equation (4). Figure 8 compares the result with that of the new measures. The panels in the left column (a) and right column (b) represent separate regressions, where the red dotted lines show the estimates when regressed on the conventional average tariff, while blue, yellow, and green solid lines are estimates of the new measures that have been displayed in Figure 4. The results in fact are very different, suggesting that using conventional measures to evaluate the effect of the agreement can be problematic.

First, using the Barrier measure clearly reveals the effects of the agreement, whereas the

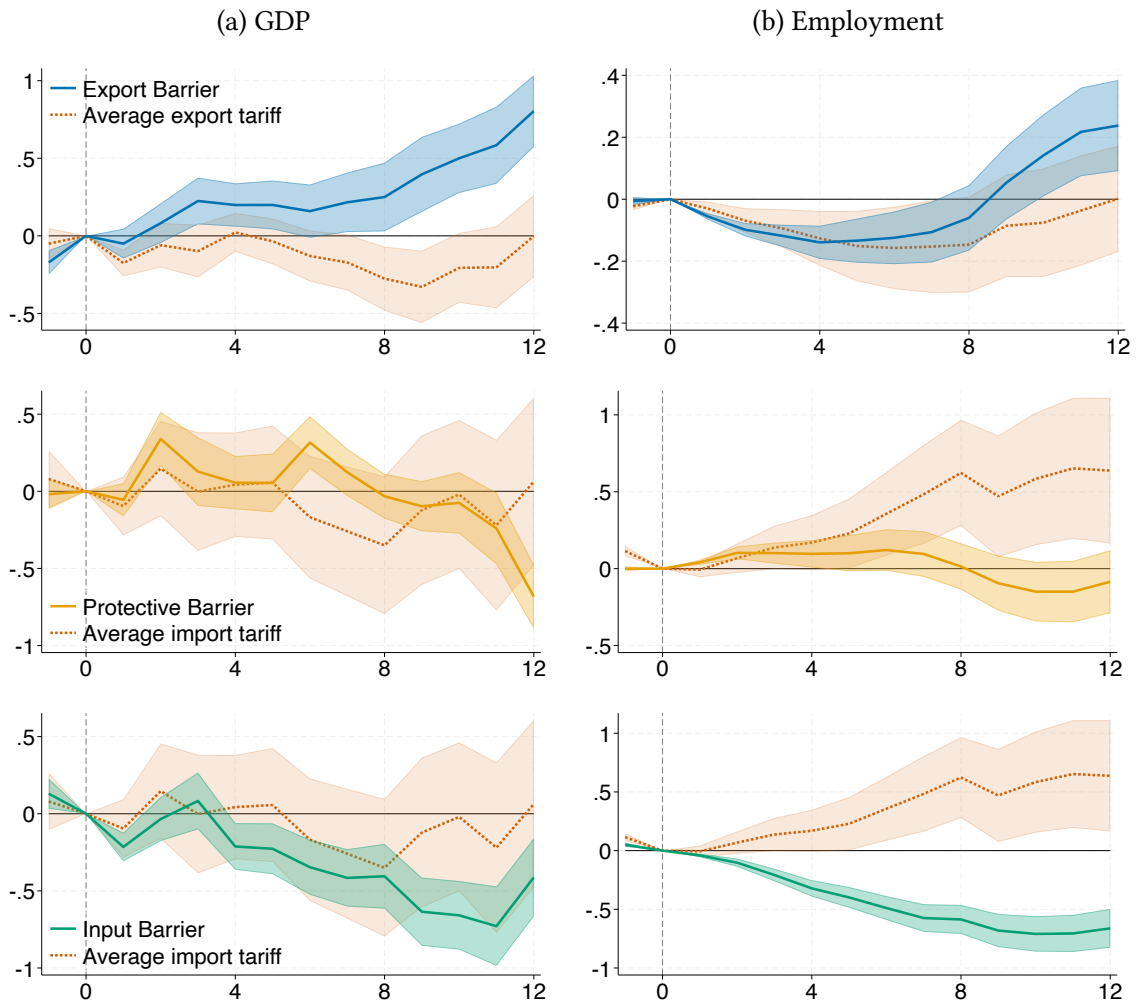
²⁶Personal income consists of the following components: Wages and salaries (50%), Dividends, interest, and rent (20%), Proprietors' income (10%), and Transfers (17%) based on the 2012–2016 average.

Figure 7: Personal income by source



Notes: The figure displays cumulative responses to 1%p barrier cuts in GDP, i.e. the estimates of β_h^{Export} , β_h^{Prot} , and β_h^{Input} over the horizon of $h = -2, \dots, 12$ (quarters). The shaded areas display 90% and 68% confidence intervals. All dependent variables are logged and multiplied by 100.

Figure 8: Estimation with different measures



Notes: Each of two columns is from a separate regression. The solid blue, yellow, and green lines are a reproduction of those in Figure 6 Panel (a) and Figure 4 Panel (d). Red dotted lines labeled as T Export and T Import denote estimates for the conventional measures defined in Equations (4). The shaded areas display 90% confidence intervals. All dependent variables are logged and multiplied by 100.

average export tariff does not. For example, only with the Barrier measure do we find a positive effect of lower export tariffs on GDP and employment. Similarly, a delayed negative effect on GDP following an import tariff reduction is observed only when using the new measure. In contrast, conventional measures yield insignificant results across all tariff channels. Thus, relying on conventional methods may understate the impact of the new agreement.

Second, the new barrier measures give a much more precise estimate than the conventional measures a narrower confidence interval. The estimate with the new measures (solid lines) has a narrower confidence interval than that with the conventional measures (dotted red), especially in the case of the Protective and Input Barriers in comparison to the average import tariff.

Finally, the new barrier measures allow us to disentangle two opposite forces of import tariffs. If we use conventional measures, we only see a combined effect of lower import tariffs on output and input (red dotted line in the second or the third rows). However, by using the new measures, we can disentangle the impact of lower import tariff via protection channel (Protective Barrier cut, yellow solid lines) from those via input channel (Input Barrier cut, green solid lines).

4 Robustness

This section assesses the robustness of the main results using several alternative specifications. I first consider alternative estimates of import demand elasticities. I then replace scheduled tariffs with applied tariffs in constructing the tariff measures. Finally, I re-estimate the local projections using different lag lengths. The main results remain broadly similar throughout.

These exercises address several measurement and specification choices, but some limitations of the empirical design remain. In particular, the analysis is still based on state-level exposure, known policy changes, and a limited set of state-time controls. The robustness results should therefore be interpreted as showing that the main findings are not driven solely

Table 6: Elasticity Statistics

	N	p01	p25	p50	p75	p99	Mean	Sd
Soderbery (2018)	1820	1.55	2.49	2.91	3.59	10.00	21.16	610.45
Soderbery (2015)	14230	1.01	1.45	1.91	3.38	131.05	5.89	16.96
Kee (2008)	6997	0.08	0.90	1.19	3.29	171.19	8.65	30.53

Notes: The table shows the statistics of import demand elasticity for the US and Korea. N is number of observations, p01-p99 denote percentiles, and Sd is standard deviation.

by the particular construction of the trade barriers or by a specific choice of lag length.

4.1 Elasticity Estimates

This section compares different estimates of product-level demand elasticity. Namely, I consider the estimates of [Soderbery \(2018\)](#) and [Soderbery \(2015\)](#) along with those of [Kee et al. \(2009\)](#) that I use in the baseline analysis.

[Kee et al. \(2009\)](#) examines 117 countries during the period of 1988–2002, focusing on products at the HS6 level. They extend the GDP function approach ([Kohli, 1991](#); [Harrigan, 1997](#)), which accounts for general equilibrium effects arising from exogenous changes in prices or endowments. They modify this framework to estimate import price elasticities at the tariff line level. On the other hand, [Soderbery \(2018\)](#) studies a larger set of 192 countries during 1991–2007, providing bilateral estimates for 1,243 products at the HS4 level. He estimates both import demand and export supply, leveraging variations in prices and quantities in bilateral trade data. [Soderbery \(2015\)](#) focuses on the U.S. for the period 1993–2007, providing more granular estimates at the HS10 level. He extends the methods of [Feenstra \(1994\)](#) and [Broda et al. \(2008\)](#) using limited information maximum likelihood to correct for small sample biases and constrained search inefficiencies.

Table 6 shows summary statistics of these demand elasticity estimates. The average of [Soderbery \(2018\)](#) estimate is exceptionally high, even exceeding its 99th percentile. This is driven by a few extreme outliers in the right tail. Looking at these outliers, however, many of them are associated with large standard errors.

For a clearer comparison, Table 7 presents the relationship between different estimates. The upper panel compares the demand estimates of the U.S. from Kee et al. (2009) and Soderbery (2015). Interestingly, there is not much correlation between these two sources. In the lower panel, when comparing both U.S. and Korean estimates from Soderbery (2018), we do not find similarities either. This is true even if I exclude the estimates with large standard errors (column 3). However, once I exclude outliers above 99th percentiles, as in columns 4 and 5, the coefficient becomes positive and significant.

Table 7: Elasticity regressions on Kee et al. (2009)

	(1)	(2)	(3)	(4)	
Soderbery (2015)	0.014	-0.000	0.013	0.013	
	(0.016)	(0.001)	(0.015)	(0.015)	
Constant	6.946***	1.309***	4.829***	4.829***	
	(0.295)	(0.013)	(0.153)	(0.153)	
Observations	9,037	6,699	8,839	8,839	
R-squared	0.000	0.000	0.000	0.000	
Trim	None	SE	Percentile	Percentile	

	(1)	(2)	(3)	(4)	(5)
Soderbery (2018)	-0.002	-0.004	0.012	0.543***	0.489**
	(0.004)	(0.004)	(0.020)	(0.198)	(0.196)
Constant	7.433***	7.441***	1.240***	3.369***	3.535***
	(0.346)	(0.344)	(0.060)	(0.626)	(0.621)
Observations	6,282	6,282	3,820	6,155	6,155
R-squared	0.000	0.010	0.000	0.001	0.015
Country FE	NO	YES	YES	NO	YES
Trim	None	None	SE	Percentile	Percentile

Notes: 'SE' trim indicates that elasticity estimates with standard errors below the 75th percentile are used, while 'Percentile' trim indicates that only the elasticity estimates below the 99th percentile are included. The upper panel only uses the US data. Standard errors are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

For the robustness check, I redo the analysis by constructing the barrier measures using the demand elasticity estimates from Soderbery (2015). In this exercise, extreme values above the 99th percentile are excluded. The results, presented in Figure 9, are broadly consistent with

the baseline analysis. In particular, the lower Protective Barrier consistently shows a delayed, negative effect. Moreover, the Input Barrier results are similar to the baseline. On the other hand, the Export Barrier cut now has a slightly different effect on GDP (Panel a), employment (Panel b), and labor force (Panel c), while it still shows a positive effect on personal income (Panel d).

I use the estimates from [Kee et al. \(2008\)](#) in the baseline analysis for two reasons. First, relative to the alternatives, they are better suited to the medium-run object of interest in this paper. Estimates such as [Soderbery \(2015, 2018\)](#) are often closer to short-run substitution responses, whereas my barrier measures are intended to capture the broader effective incidence of tariffs along the adjustment path. Second, the framework in [Kee et al. \(2008\)](#) is more closely aligned with the theoretical structure underlying my measures. Kee et al. derive import demand elasticities within a GDP-function framework that incorporates general equilibrium considerations, which matches more naturally with my construction of uniform tariff-equivalent barriers.

4.2 Applied Tariff

In the baseline analysis, I use scheduled tariff rates from the FTA document, which provide base tariff rates along with their scheduled reductions across different staging categories. Alternatively, product-level tariff rates can be derived from actual applied tariffs, calculated as the ratio of tariff revenue to total import value.²⁷

Data on applied tariffs and scheduled tariffs differ in several ways. First, their availability varies. Our dataset includes scheduled tariff rates only for those expressed in ad valorem terms, excluding tariffs listed as a dollar amount per unit weight or volume, as well as those combining ad valorem and specific dollar values.²⁸ Applied tariff data, in contrast, are only available for

²⁷Specifically, the applied tariffs used in this analysis are calculated as the share of calculated duty in customs value for 2010 and 2011, based on data from the U.S. Census Bureau.

²⁸Out of 10,333 U.S. tariff lines, 1,099 products (10.6 percent) are expressed in dollar-per-unit terms or combinations of ad-valorem and per unit terms. Among these, applied rates are available for 268 of these and the rest

Figure 9: Elasticity estimates



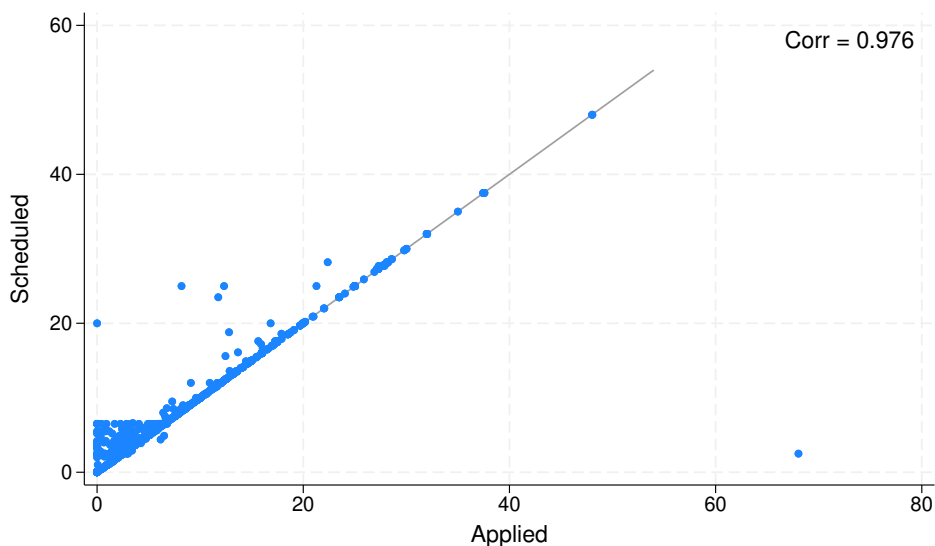
Notes: The figure displays cumulative responses to 1%p barrier cuts in GDP, i.e. the estimates of β_h^{Export} , β_h^{Prot} , and β_h^{Input} over the horizon of $h = -2, \dots, 12$. The light and dark shaded areas display 90% and 68% confidence intervals, respectively. All dependent variables are logged and multiplied by 100.

products with actual transactions. When tariffs are prohibitive and prevent imports, those products are omitted from the data, resulting in fewer observations overall.

Table 8 compares the summary statistics of two datasets on tariff rates. Among the 9,486 tariff lines in the scheduled tariff dataset, 4,440 lines (42.97%) appear only in the scheduled data, and these products lack corresponding applied rates due to the absence of transactions and tariff revenue. The other 5,046 tariff lines (45.75%) are present in both datasets. On the other hand, 730 tariff lines appear exclusively in the applied tariff dataset, often due to Special Tariff Treatments, Temporary Tariffs, or Duties. Scheduled and applied tariff rates exhibit similar mean and median values, along with comparable interquartile ranges. However, products with the extremely high scheduled rates, such as the maximum of 350%, are likely not to be

of the products have no transaction during our sample period.

Figure 10: Comparison of Scheduled and Applied Rates



Notes: Each observation show the scheduled and applied tariffs for different products at the HS8 level. The black line is a 45 degree line.

traded and thus are not reflected in the applied tariff data.

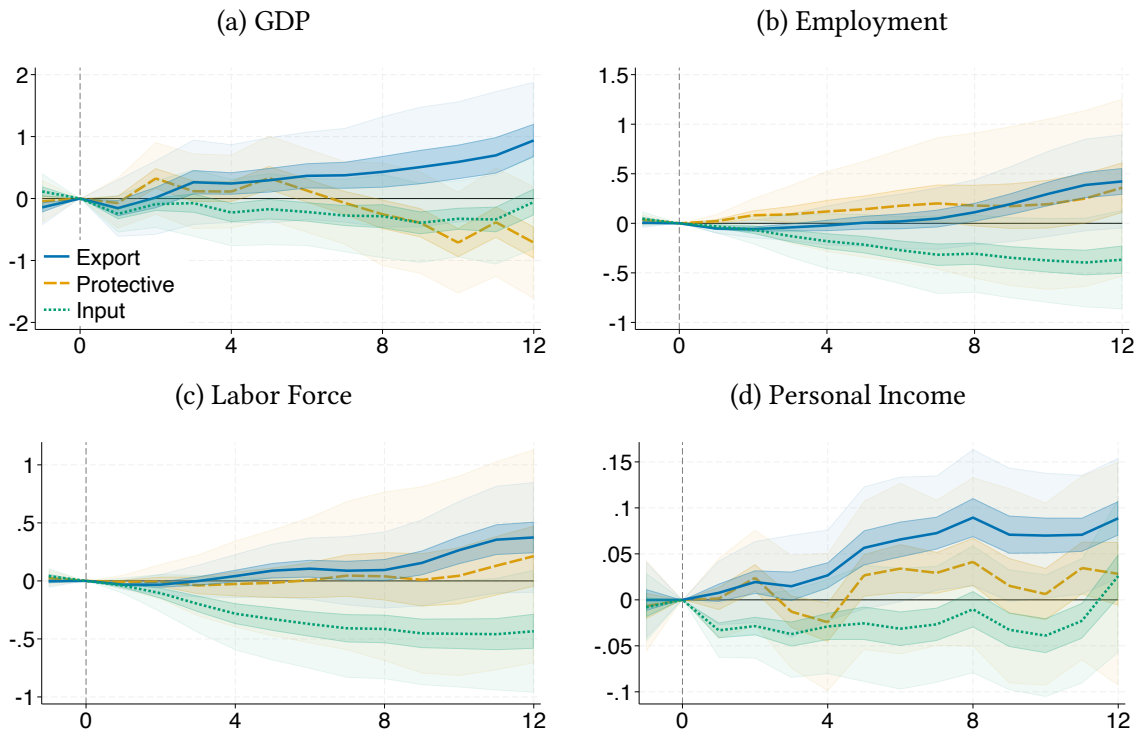
Figure 10 shows that for the tariff lines that appear in both datasets, scheduled and applied rates generally align closely. However, some discrepancies exist. When the rates differ, applied tariffs tend to be lower than scheduled tariffs. This discrepancy could be due to exemptions, reductions, or waivers that are temporarily applied by the U.S. government.

Figure 11 presents the estimation results when applied tariffs are used for barrier constructions. The differences in the rates yields slight differences in the results. Overall, negative effect of Protective Barrier cut becomes insignificant for employment (Panel b), labor force (Panel c), and personal income (panel d). On the other hand, effects of Export and Input Barrier cuts persist in this alternative specifications.

Table 8: Statistics of scheduled and applied rates

	N	Mean	Std.	Min	p25	Median	p75	Max
Scheduled	9,486	4.20	11.18	0.00	0.00	2.70	6.00	350.00
Applied	5,792	4.10	5.87	0.00	0.00	2.71	5.80	68.04

Figure 11: Applied tariff



Notes: The figure displays cumulative responses to 1%p barrier cuts in GDP, i.e. the estimates of β_h^{Export} , β_h^{Prot} , and β_h^{Input} over the horizon of $h = -2, \dots, 12$ (quarters). The shaded areas display 90% and 68% confidence intervals. All dependent variables are logged and multiplied by 100.

4.3 Number of Lags

In the baseline analysis, a lag in the response variable of one period is used. I redo the estimation using two and four lags. The results are provided in Table 9. The response estimates are almost unchanged, in terms of signs and significance. Specifically, the response to the Export Barrier cut is nearly identical to the benchmark case. Furthermore, the Protective Barrier cut also shows very similar results, with the response being positive on impact and becoming significantly negative by the 12th quarter. Finally, the Input Barrier cut does not seem to have a significant impact as in the benchmark case, either in the cases of 2 or 4 lags.

4.4 Individual Channels

The agreement with Korea differs significantly from the China shock or the early periods of the U.S.-China trade war in that it was bilateral, bringing changes to both inward and outward trade barriers. Therefore, it is crucial to consider changes in both directions to correctly identify the impact of each channel. Moreover, both the Protective Barrier and the Input Barrier measure inward barriers and are constructed from U.S. tariffs on imports from Korea. For these reasons, I include all barriers—Export, Protective, and Input Barriers—in the baseline regression (Equation 8).

Consider instead running regressions on each barrier measure separately, rather than including them jointly in a single regression. Specifically, I estimate:

$$\Delta_h y_{s,t+h} = -\beta_h^i \Delta B_{st}^i + \sum_{k=-8}^4 \omega_{t+k}^h \Delta B_{st+k}^i + \gamma^h \Delta_1 y_{s,t-1} + \mu_s^h + \mu_{t+h}^h + \varepsilon_{t+h} \quad (9)$$

where B_{st}^i is one of B_{st}^{Export} , B_{st}^{Prot} , or B_{st}^{Input} .

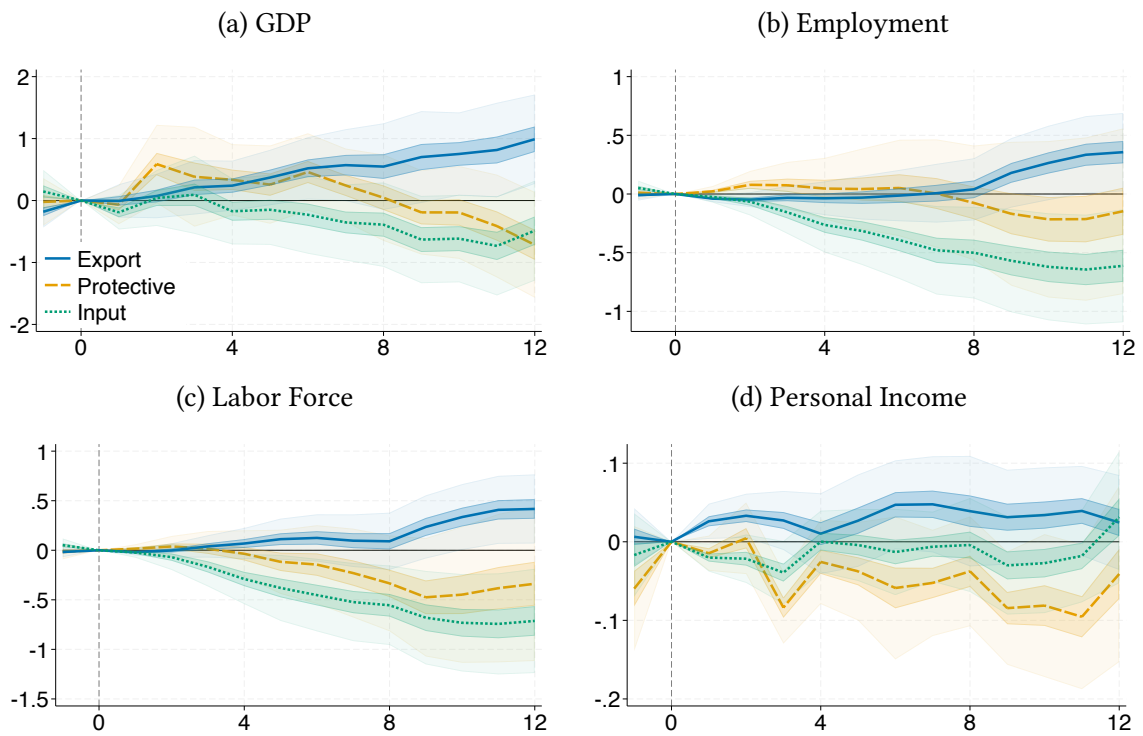
Figure 12 presents the results for GDP, employment, labor force, and personal income, with each channel estimated separately and combined into a single graph. Compared to Panel a of Figure 4, the Export Barrier continues to show a positive, though slightly smaller, response in

Table 9: GDP, lags

	$L = 2$				$L = 4$			
	Quarter 0	Quarter 4	Quarter 8	Quarter 12	Quarter 0	Quarter 4	Quarter 8	Quarter 12
ΔB^{Export}	-0.04 (0.16)	0.29 (0.29)	0.56 (0.47)	0.80** (0.40)	-0.16 (0.28)	0.29 (0.42)	0.51 (0.59)	1.02** (0.50)
ΔB^{Prot}	0.00 (0.20)	0.32 (0.41)	-0.05 (0.37)	-0.61 (0.49)	-0.07 (0.25)	0.33 (0.42)	-0.39 (0.50)	-0.80 (0.55)
ΔB^{Input}	-0.19 (0.19)	-0.17 (0.35)	-0.58 (0.46)	-0.32 (0.45)	-0.25 (0.18)	-0.17 (0.35)	-0.39 (0.39)	-0.01 (0.45)
Time FE	YES	YES	YES	YES	YES	YES	YES	YES
State FE	YES	YES	YES	YES	YES	YES	YES	YES
R^2	0.491	0.587	0.647	0.765	0.391	0.553	0.618	0.784
Observations	441	441	392	343	294	294	294	294

Notes: See Equation (8) in the text. Robust standard errors in parentheses. Clustered at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 12: Individual regressions



Notes: The figure displays cumulative responses to 1%p barrier cuts in GDP, i.e. the estimates of β_h^{Export} , β_h^{Prot} , and β_h^{Input} over the horizon of $h = -2, \dots, 12$ (quarters). The shaded areas display 90% and 68% confidence intervals. All dependent variables are logged and multiplied by 100.

GDP. The Protective Barrier maintains a delayed but negative effect on GDP, consistent with the baseline results. The Input Barrier also demonstrates a consistent result. For employment and labor force outcomes (Panels b and c of Figure 12 vs Panels a and c of Figure 5), the Export and Input Barrier results remain similar to the baseline. However, the Protective Barrier now shows insignificant results.

These findings suggest that, to understand the role of input barriers, the other channels of import tariffs need to be properly controlled. Considering all channels jointly is crucial to accurately capture the multifaceted effects of changes in trade policy.

5 Conclusion

There remains substantial uncertainty about the effects of trade policy changes. This paper revisits the issue by studying the dynamic effects of the U.S.-Korea FTA. I first introduce theoretically grounded measures of trade barriers that incorporate demand responses and better capture the effective incidence of tariffs. This matters particularly when tariffs are higher on more demand-elastic products, as appears to be the case for U.S. imports.

The new measures reveal clearer dynamic patterns than conventional ones. Reductions in Export Barriers are associated with gradual increases in GDP and employment, whereas reductions in Protective Barriers are associated with gradual declines in these variables. These findings highlight the importance of measuring trade policy in a way that reflects both its incidence and its multidimensional nature.

More broadly, the results show that the effects of trade liberalization differ not only in magnitude and direction but also in timing and persistence. In this sense, the paper provides new evidence on how trade liberalization shapes local economies along the transition path, and may offer useful discipline for quantitative models with spatial adjustment and labor mobility frictions in the spirit of [Caliendo et al. \(2019\)](#).

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A Data

- **Products:** The product is defined at the HS-6 level. Although the tariff rates are defined at the finer level of HS-10 in both countries, HS-10 is not harmonized across countries, making it hard to link the tariffs to trade flows and other variables. In fact, in most of the cases, the tariff rates do not differ within the HS-6 level. In a few cases where the schedule is segmented into a finer level into the 10-digit HS code, I calculate the rate by taking a simple average within the same 6-digit products. The correspondence between the product code HS and IO is taken from Korea Statistics, while the correspondence between HS and NAICS is from BEA.
- **Tariff rates:** The tariff schedules of both the U.S. and Korea are digitized from Chapter 2 of the official Agreement, downloaded from the Korea Ministry of Trade. The tariff revenue of the U.S. on imports from Korea is drawn from USITC. The tariff lines with rates over 300% are excluded. Tariff cuts on these products do not fully reflect the changes in protection for these products, because these are mostly agricultural products that are protected by quotas or safeguards even after the FTA. These products account for 0.5% of the total number of tariff lines.
- **Trade flows:** Bilateral export and import of each state to Korea of the corresponding products are from the Census. Korea's aggregate import from the U.S. and the world is collected from the UN Comtrade. Data on the use of imports in each sector in Korea is collected from Korea Statistics.
- **Income and labor market variables:** State-level GDP, income, and expenditure are from BEA. Employment and wages are from QCEW. Labor participation related variables are from BLS.
- **Input share:** I use the Use and Supply Table from BEA.
- **Demand elasticity:** The product level elasticity of both the U.S. and Korea are estimated values from [Kee et al. \(2008\)](#).