Dynamic Impact of Trade Liberalization: Evidence from U.S.-Korea FTA*

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Abstract

This paper studies the dynamic effect of trade liberalization on earnings and consumption, exploiting cross-region variation in the United States at the state level after the U.S.-Korea Free Trade Agreement. A key feature is a theoretically sound measurement of a regional exposure that takes into account the elasticity of substitution and covers all potential channels of tariff impacts. Using the measures for the Local Projection Method, I find that less protection at home is associated with a persistent negative impact: by the 8th quarter, a state at the upper quartile of the barrier cut experienced a decline in wage and consumption that is 1.56 and 1.04 percentage points larger, respectively, than a state at the lower quartile. However, cheaper access to imported inputs has a positive but temporary impact: by the 8th quarter, an upper quartile state experienced an increase in wage and consumption that is 1.62 and 1.45 percentage points larger, respectively. More opportunities to export have little effect.

JEL Classification: E21, E24, F13, F14, F42, F62

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1 Introduction

Does trade liberalization make the U.S. better off? The recent call for protectionism has reheated the long debate over the gains and the losses of free trade. With free trade, the U.S. may benefit from the opportunities to reach new markets abroad and import better inputs. However, it comes at the expense of domestic competition with foreign firms.

This paper provides empirical evidence on the dynamic effects of a free trade agreement (FTA) on earnings and consumption. Using the episode of the U.S.-Korea Free Trade Agreement, I first measure state-level exposures to three channels of the tariff impact: easier exporting, cheaper imported inputs, and a higher degree of local competition with foreign firms. Then, I correlate the cross-state variation in the exposures with those in earnings and consumption over different time horizons using the Local Projection Method (Jordà, 2005).

The immediate challenge to this analysis is measuring the exposures to the changes in tariffs. Although the FTA is a well-defined policy experiment, tariffs are set at a detailed product level (10-digit HS code) and cover thousands of products, so summarizing them in one measure is not straightforward.

In fact, measures of the trade barrier used in the literature are often vaguely defined and lack an economic interpretation (Rodriguez and Rodrik, 2000; Kee et al., 2008). For example, the most common measure of the barrier is the import-weighted average tariff rate, which can be readily calculated by the tariff revenue divided by the total value of imports. However, this measure is likely to be downward biased because products with excessively high tariff rates are not imported and thus are assigned too small weights, although the high tariff rates have a strong prohibitive power. Sometimes shift-share type measures using the average tariff across sectors are used, where the sectoral average is again import-weighted (Topalova, 2010; Kovak, 2013). Still, such an approach is subject to downward bias for a similar reason.

I tackle this challenge with an aggregation procedure that builds on Anderson and Neary (1994, 1996) and Kee et al. (2008, 2009). In particular, I extend their approach of aggregating tariff rates to cover all three channels of tariff impact: barrier to exporting output, importing inputs, and protecting domestic markets. I define each of these barriers–Export Barrier, Input Barrier, or Protective

Barrier–as the uniform rate on all traded products that would induce the same level of *aggregate export*, *intermediate import*, or *domestic sales*, respectively, as the current tariff structure. This new measure is based on the demand structure with Constant Elasticity of Substitution (CES), which is the basis of almost all trade models.

The new measure of exposure is not only well grounded in trade theory, but it also enables much more precise identification of tariff impacts than the trade-weighted average measure. The estimation with the new measures tends to have smaller standard errors. They can also differentiate between the positive and negative impacts of lower import tariffs–cheaper inputs and higher competition, respectively–while the import-weighted average cannot. Still, it is an ad-valorem rate like tariffs and provides convenient and intuitive interpretations.

Another feature of this paper is that it focuses on the dynamic path along the transition. Existing papers are rarely explicit about the transitional effect, and many study only the long-run impact. However, seminal studies of trade theory suggest that when evaluating welfare gains, it is crucial to consider the transition after a reform. For example, Alessandria et al. (2014) show that with a dynamic exporting decision of heterogeneous producers, consumption overshoots early in the transition, and welfare gains differ substantially from what static models predict. Indeed, it would help understand the tension between new opportunities and potential threats because different channels of the tariff may unfold at different timing. Moreover, it may provide suggestive evidence for spatial spillovers or immobility of resources.

The U.S.-Korea FTA, which went into force in 2012, was the largest trade deal for the U.S. after North American Free Trade Agreement (NAFTA) in 1993. It progressively eliminated customs duties on almost all the products traded between the two countries. Within five years of the implementation, over 95 percent of the products were to become duty-free. After the FTA, Korea became the sixth largest trading partner of the U.S., taking 3.5 percent of total U.S. trade as of 2021.

I find fairly similar patterns across wage and consumption in response to lower barriers associated with the FTA. Surprisingly, the Export Barrier cut has little impact on both wages and consumption. On the other hand, the liberalization on the import side has a significant impact once the shocks are realized. Protective Barrier cut, which implies more exposure to the competition with imports from Korea, reduces wages and consumption for at least 12 quarters: for instance, in the

8th quarter, a state at the upper quartile of the barrier cut distribution, compared to a state at the lower quartile, would be expected to experience a 1.56 percentage point larger decline in wage, and it would feed into 1.04 percentage point larger decline in consumption. The Input Barrier cut, which means access to cheaper imported inputs, increases wage and consumption temporarily: an upper quartile state would have a 1.62 percentage point larger wage increase and a 1.45 percentage point larger consumption increase at the 8th quarter than a lower quartile state, but the positive impact soon starts to disappear.

This paper is related to a strand of literature that studies the U.S. 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 provides another perspective on the responses in production and employment. Also, it makes it possible to capture impacts on geographically defined variables such as consumption, labor participation, and unemployment. However, studies on regional variations within the U.S. have mainly focused on manufacturing response to the China Shock or the recent dispute between the U.S. and China (Autor et al., 2013; Benguria and Saffie, 2020; Waugh, 2019). I add to this literature by using the less-studied episode of the FTA and further by providing a picture of the transitional path at a higher time frequency.

This paper is also a part of the growing literature that studies the impact of trade through the global value chain. The role of tariffs on inputs has been mostly studied in relation to productivity 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 export.

The remainder of this paper is structured as follows. Section 2 introduces the new measures of the trade barrier, compares them with the conventional import-weighted average tariff, and then discusses their magnitude across the states after the FTA. Section 3 uses these measures to estimate the dynamic responses in earnings and consumption, and Section 4 discusses the results. Section 5 concludes.

2 Measures of Trade Barriers

This section describes the measures I construct to quantify the regional trade barriers. I introduce the concept and the definition of the measures, decompose each of them to make a link to the import-weighted average tariff, and then show the changes in their sizes since the FTA.

A trade barrier is often measured by the average tariff where the weight is given by the trade flow of each product. It is the most common way of summarizing different tariff rates on thousands of products and is easily calculated by dividing tariff revenue by total import value. However, such a convention of aggregating tariff lines lacks a theoretical foundation. Also, it tends to be downward biased, as the excessively high tariffs depress the trade of the corresponding products and they are given too small weights compared to their actual prohibitive power.

Instead, Anderson and Neary (1994, 1996) and Kee et al. (2008, 2009) propose an alternative measure called the Trade Restrictiveness Index (TRI). It is defined as the uniform tariff rate that, if applied to the imported products instead of the current tariff structure, would yield welfare at its current level. Still, the TRI can only capture the overall impact of import tariffs. It does not account for the impact of export tariffs imposed by a foreign government, and moreover, it cannot distinguish the protective impact of import tariffs on foreign products that are competing with home outputs from the distortive impact of import tariffs on inputs.

Accordingly, I take a similar approach as the TRI but consider three different channels of tariff impact: barrier on exports (Export Barrier), barrier on imports of products used as intermediate input (Input Barrier), and barrier on imports of products competing with the local outputs (Protective Barrier). I define each barrier as the uniform tariff rate that yields the outcome–aggregate export, domestic sales, or use of imported inputs–at its current level.

2.1 Definition and Data Sources

Each barrier measure is defined as an answer to each of three different, but similarly formulated, questions. I describe the theoretical background of the measures and derive each in turn.

Export Barrier

Export Barrier summarizes the distortion in export due to Korea's tariffs on U.S. products. It answers the following question: what is the uniform tariff rate that, if applied to exports instead of the current Korean tariff structure, would leave the *aggregate export* at its current level?

To answer this question within a theoretical framework, I start with a demand system with constant elasticity of substitution (CES). It is a simple and versatile structure that constructs a basis of almost all trade theories. Under CES structure, export X^i_{SK} to Korea of product i from state S is given by:

$$X^i_{SK}(\tau^i_K) = \left(\frac{p^i_S(1+\tau^i_K)}{P^i_K}\right)^{-\varepsilon^i_K} Y^i_K$$

$$P^i_K = \left[\sum_L \left(p^i_L(1+\tau^i_{LK})\right)^{\varepsilon^i_K}\right]^{1/\varepsilon^i_K}$$

where p^i_S is the price of product i from state S, P^i_K is the price index for product i in Korea, τ^i_K is tariff rate imposed by the Korean government on product i from the U.S., ε^i_K is demand elasticity for product i in Korea, and Y^i_K is the total expenditure on product i in Korea. The tariff rate τ^i_K raises the price of the product from p^i_S to $p^i_S(1+\tau^i_K)$ and shifts the demand function. Thus, export X^i_{SK} is a function of the tariff rate.

Now consider all products that are exported from state S to Korea. By summing up their exports, the aggregate export from state S to Korea can be expressed as $\sum_i X^i_{SK}(\tau^i_K)$. Then, the Export Barrier of state S is implicitly defined as B^{Export}_S such that:

$$\sum_i X^i_{SK}(B^{Export}_S) = \sum_i X^i_{SK}(\tau^i_K).$$

That is, B^{Export}_S is the uniform rate at which the aggregate export under the rate and that under the current tariff structure is equated.

Totally differentiating in a partial equilibrium setup,

$$\sum_i dX^i_{SK} \cdot B^{Export}_S = \sum_i dX^i_{SK} \cdot \tau^i_K,$$

and solving for B_S^{Export}, we get

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

Thus, the Export Barrier is a weighted sum of tariff rates, where the weights reflect the composition 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.[1] Moreover, it is also increasing in the demand elasticity: a tariff on a high elasticity product that largely restricts the import is given a large weight.[2]

To construct the measure for each state in each year, data are drawn from multiple sources. The classification of the product is at the 6-digit level of HS code, which is the finest level of the code that is internationally standardized. Korea's tariff schedule for U.S. products consists of around five thousand 6-digit lines and comes from the Korea Ministry of Trade. In a rare case that the schedule is segmented into a finer level than the 6-digit HS code, I calculate the rate by taking a simple average within the same 6-digit products. Also, the products with tariff rates over 300% are excluded. Tariff cut on these products does 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. Export flows of each state to Korea of the corresponding products are from the Census. For the demand elasticity of Korea, I take the value estimated by Kee et al. (2008).

On the other hand, data on the total expenditure Y_K^i in Korea at the 6-digit HS code level is not publicly available. Instead, I consider the share X_{SK}^i / Y_K^i and decompose it 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

[1] For each i, $w_s^i = X_{SK}^i \left(1 - X_{SK}^i / Y_K^i\right)$ is increasing in X_{SK}^i if and only if $X_{SK}^i \leq 0.5 Y_K^i$, which means that the product i that comes from the state S takes only a small fraction of Korea's total expenditure on that product.

[2] While this approach allows trade elasticity to vary across products, when using this measure to estimate the tariff impact, I am implicitly assuming that all products equally affect the outcome variable.

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 in the world of imports from Korea of product i and is collected from the UN Comtrade database.[3] Finally, the term (c) is the import's share in total use of the corresponding sector, classified with IO code. Data on the share is collected from Korea Statistics. The correspondence between IO and HS codes is also from Korea Statistics.

Protective Barrier

U.S. tariff on its imports from Korea protects a state from the competitive threat of Korean firms and thus distorts domestic production and sales. Protective Barrier measures such distortion. It is defined as the answer to the question: what is the uniform tariff rate that, if applied to imports instead of the current U.S. tariff schedule, would induce the same *sales in the U.S.* as its current level?

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

$$X^i_{S,US}(\tau^i_{US}) = \left(\frac{p^i_S}{P^i_{US}}\right)^{-\varepsilon^i_{US}} Y^i_{US}$$

where $X^i_{K,US}$ is the U.S. import from Korea of product i, p^i_S is the price of product i from state S, ε^i_{US} is the demand elasticity for product i in the U.S., Y^i_{US} is the total expenditure on product i in the U.S., and P^i_{US} is the price index for product i in the U.S.,

$$P^i_{US} = \left[\sum_L \left(p^i_L(1+\tau^i_{L,US})\right)^{\varepsilon^i_S}\right]^{1/\varepsilon^i_s},$$

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

The Protective Barrier is implicitly defined as the uniform rate that induces the same level of

[3] Multiplication of two shares $(a)\times(b) = X^i_{SK}/X^i_{World,K}$ can be obtained directly by using data of X^i_{SK} and $X^i_{World,K}$. 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.

aggregate sales of state S to the U.S. as the current tariff structure. That is, it 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

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

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. Note that it takes into account all products traded between the two countries, including both final and intermediate goods, so that it is valid even in the case that a state is producing an intermediate good as its output.

Data used to construct the Protective Barrier also classifies the product at the 6-digit HS code level. The tariff schedule of the U.S. on imports from Korea is drawn from USITC. Import flow from Korea is from the Census, and demand elasticity of the U.S. is again from Kee et al. (2008).

Data on the expenditures $X_{S,US}^i$ and Y_{US}^i in the U.S. at the 6-digit HS code level are not available. 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, I calculate the domestic absorption by the output minus what is exported out of the country, and the U.S. expenditure by the sum of all states' output net of trade. Meanwhile, GDP by the state is only available at the sector level, classified with the NAICS code. The data is provided by BEA. 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.

Input Barrier

The Input Barrier summarizes the distortion on the use of imported intermediates that arises due to the U.S. tariff on imports from Korea. It highlights the role of import tariff that potentially discourages production by increasing the price of inputs. The measure answers the following question: what is the uniform tariff rate that, if imposed on imports instead of the current U.S. tariff structure, would leave the *intermediate imports from Korea* at their current level?

Unlike the other measures above, here we only consider product i that is classified as an intermediate good, assuming that all imports of any intermediate good are used as an input for states' production. The CES demand for intermediate good i from Korea in state S is given by:

$$m^i_{KS}(\tau^i_{US}) = \left(\frac{p^i_K(1+\tau^i_{US})}{P^i_S}\right)^{-\varepsilon^i_S} M^i_S$$

where m^i_{KS} is the import from Korea to state S of intermediate product i, p^i_K is the price for product i from Korea, $\tau^i_{K,US}$ is a tariff rate imposed by the U.S. on imports of product i from Korea, ε^i_S is the demand elasticity of product i in state S, M^i_S is the total use of intermediate product i in state S, and P^i_S is the price index for product i in state S,

$$P^i_S = \left[\sum_L \left(p^i_L(1+\tau^i_{LS})\right)^{\varepsilon^i_S}\right]^{1/\varepsilon^i_s}$$

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

The Input Barrier is defined as the uniform rate such that aggregate import of inputs in state S under the current tariff schedule and those under the rate of the Input Barrier are equated. It is B^{Input}_S such that:

$$\sum_i m^i_{KS}(B^{Input}_S) = \sum_i m^i_{KS}(\tau^i_{US})$$

Taking total derivatives,

$$\sum_i dm^i_{KS} \cdot B^{Input}_S = \sum_i dm^i_{KS} \cdot \tau^i_{US},$$

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

$$B^{Input}_S = \frac{\sum_i m^i_{KS} \left(1 - m^i_{KS}/M^i_S\right)\ \varepsilon^i_{US}\ \tau^i_{US}}{\sum_i m^i_{KS} \left(1 - m^i_{KS}/M^i_S\right)\ \varepsilon^i_S}. \tag{3}$$

Thus, the Input Barrier is a weighted sum of the U.S. tariff rates, where weights reflect the importance of Korea in the intermediate use of a product and its demand elasticity. It takes a similar format as the Export Barrier but with the variables of different subscripts.

Meanwhile, a state may be both a user and a producer of an intermediate product. For example, Michigan not only uses auto parts for automobile production but also produces auto parts as an output. The Input Barrier captures Michigan's new opportunity as a user of auto parts that arises from the lower price of Korean auto parts. However, the lower price of Korean auto parts is also a threat to Michigan as it is a producer of auto parts. Such channel is captured by the Protective Barrier: it captures the effect that the producers in Michigan get to sell fewer car parts domestically within the U.S., including Michigan itself.

Product type classification is from the UN. Data on the U.S. tariff is from USITC. Import flow for all intermediate products from Korea is from the Census. For the import elasticity of each state, I use Kee et al. (2008)'s estimates of the U.S. import elasticity, assuming that the elasticity is the same across all states ($\varepsilon^i_S = \varepsilon^i_{US}\ \forall i\ \forall S$). Data on intermediate product use M^i_S by the state at the detailed 6-digit HS code level is unavailable. Instead, I resort to the decomposition of the share

$$\frac{m^i_{KS}}{M^i_S} = \underbrace{\frac{m^i_{KS}}{m^i_{World,S}}}_{(a)} \cdot \underbrace{\frac{m^i_{World,S}}{M^i_S}}_{(b)}$$

where $m^i_{World,S}$ 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

$$m^i_{World,S} = \sum_j m^{ij}_{World,S} \cdot \frac{GDP^j_S}{GDP^j_{US}}$$
$$M^i_S = \sum_j M^{ij}_{US} \cdot \frac{GDP^j_S}{GDP^j_{US}}$$

where $m^{ij}_{World,US}$ is the national imported use of i as an input of j, M^{ij}_{US} is the national total use of i as an input of j, GDP^j_S is the state S's GDP of j, and GDP^j_{US} 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.

2.2 Relation to the Conventional Measure

Due to the parallel structure of the way they are defined and derived, three measures (1), (2), and (3) share a similar form. Using this similarity, we can analyze the measures further and draw the link to the conventional import-weighted average tariff.

Recall that all three measures take the form of a weighted average, while the weight of each measure differs from each other. That is, all three measures can be written as $B_S = \frac{\sum_i w^i_S \ \varepsilon^i \ \tau^i}{\sum_i w^i_S \ \varepsilon^i}$ where the weights

$$w^i_S = \begin{cases} \frac{X^i_{SK}\left(1-X^i_{SK}/Y^i_K\right)}{\sum_i X^i_{SK}\left(1-X^i_{SK}/Y^i_K\right)} & \text{for } B^{Export}_S \\ \\ \frac{X^i_{K,US}X^i_{S,US}/Y^i_{US}}{\sum_i X^i_{K,US}X^i_{S,US}/Y^i_{US}} & \text{for } B^{Prot}_S \\ \\ \frac{m^i_{KS}\left(1-m^i_{KS}/M^i_S\right)}{\sum_i m^i_{KS}\left(1-m^i_{KS}/M^i_S\right)} & \text{for } B^{Input}_S \end{cases} \tag{4}$$

are defined differently.[4]

Let the barred variables $\bar{x}$ denote the weighted average of x^i where the weight is given by w^i

[4]Subscripts of ε^i and τ^i are dropped for simplicity. More precisely, B^{Export}_S is with ε^i_K and τ^i_K; B^{Prot}_S is with ε^i_{US} and τ^i_{US}; B^{Input}_S is with ε^i_S and τ^i_{US}.

and the hatted $\hat{x}^i$ be x rescaled by $\bar{x}$. Using these notations, it can be shown that

$$
\begin{aligned}
B_S &= \sum_i w_S^i \ \hat{\varepsilon}_S^i \ \tau^i \\
&= \underbrace{\sum_i w_S^i \ \tau^i}_{\bar{\tau}_S} + \underbrace{\sum_i w_S^i (\tau^i - \bar{\tau}_S)(\hat{\varepsilon}^i - \bar{\varepsilon}_S)}_{cov_S(\tau^i, \hat{\varepsilon}^i)}
\end{aligned} \tag{5}
$$

where $\bar{\tau}_S = \sum_i w_S^i \tau^i$, $\bar{\varepsilon}_S = \sum_i w_S^i \varepsilon^i$, and $\hat{\varepsilon}_S^i = \varepsilon_S^i / \bar{\varepsilon}_S$.[5] This shows that the barrier measure B_S can be decomposed into two parts: weighted average $\bar{\tau}_S$ of tariff and weighted covariance $cov_S(\tau^i, \hat{\varepsilon}^i)$ of tariff and demand elasticity, both with weight w^i.

Now consider the conventional measure of trade-weighted average tariff. The average tariff on exports and imports is formally written as:

$$
T_S = \underbrace{\sum_i \omega_S^i \ \tau^i}_{\bar{\tau}_S} \tag{6}
$$

$$
\omega_S^i = \begin{cases} \dfrac{X_{SK}^i}{\sum_i X_{SK}^i} & \text{for } T_S^{Export} \\[2ex] \dfrac{X_{KS}^i}{\sum_i X_{KS}^i} & \text{for } T_S^{Import} \end{cases} \tag{7}
$$

where X_{SK} is the export from state S to Korea, and X_{KS} is the import from Korea to state S.[6]

Comparing two equations (5) and (6), we can see that the new barrier measure, B_S, differs from the conventional tariff measure, T_S, in two ways. First, B_S has an extra covariance term, $cov_S(\tau^i, \hat{\varepsilon}^i)$, while T_S does not. This is because the barrier measures take demand response into account within the CES structure. The average term, $\bar{\tau}_S$, is common to both the new barrier measures and the conventional tariff measures. Unless the covariance term is zero, B_S will differ from the average term. Covariance term would be zero if all of the products are imposed the same tariff rate or if the elasticities for all products are equated. The difference suggests how the new measure removes the bias found in the conventional measure.

[5] The 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 $\hat{\varepsilon}^i$.

[6] Subscripts of τ^i are dropped for simplicity. More precisely, T_S^{Export} is with τ_K^i; T_S^{Import} is with τ_{US}^i.

Second, the weights are defined differently, as in equations (4) and (7). The weights used in the new measures B_S deliberately reflect the distinct channels through which the tariff affects the local economy, while the weights used in the conventional measures T_S are simply trade flows. Also, in the case of the new measures, two types of weights are used to construct import side barriers: B_S^{Prot} and B_S^{Input}. On the other hand, in the case of the conventional measures, only one type of weight is used on the import side to construct T_S^{Import}, and it cannot separate the tariff impact on competing products from the tariff impact on input products.

2.3 U.S.-Korea FTA and State-level Exposures

The U.S.-Korea FTA was first signed in June 2007, followed by a renegotiated version signed in December 2010. In March 2012, the treaty went into force. At that time, Korea was the 7th largest trading partner of the U.S., accounting for 2.7 percent of total U.S. trade. The treaty required the tariff between the two countries to be removed within 15 years. It eliminated tariffs on the majority of the products immediately,[7] and over 95% of all tariff lines became duty-free within five years. As of today, Korea became the 6th largest trading partner with a trade share of 3.4 percent.

Using the information on the tariff in a given year, along with those on trade flow, GDP, Input-output table, and demand elasticity, we can quantify the barrier measures before and after the FTA. In the empirical exercise, exposure to the FTA is defined as a change in the barrier measures from the previous year during the period of 2012-2016. I exploit state-level variations in the exposure.

Table 1 documents the distribution of the barrier measures before the FTA and their changes initiated by the FTA. The first column displays the barriers in 2011 before the FTA was implemented. The medians of the Export Barrier (B^{Export}), the Protective Barrier (B^{Prot}), and the Input Barrier (B^{Input}) are 6.98, 2.64, and 2.03 percent, respectively. The distribution of the Export Barrier is further away from zero than the other measures, due to the fact that the tariff rates of Korea were generally higher than those of the U.S.

The remaining columns display changes in the barrier measures realized in the following years. Since the FTA eliminated the tariff on almost all products, the size of tariff cuts was almost entirely

[7] Among the 5,087 tariff lines of Korea, 64% became duty-free on the date the treaty entered into force. In the U.S. case, 24% of 4,316 tariff lines became duty-free on impact.

determined by the rates before the FTA. Indeed, the change in the Export Barrier (ΔB^{Export}) tends to be larger than that in other measures. The changes in the Protective Barrier (ΔB^{Prot}) and the Input Barrier (ΔB^{Input}) were of similar size.

Looking at the changes across time, the drops in the measures are largest in 2012, reflecting that most tariff concessions happened in the first year of the FTA. In the first year, the Export Barrier dropped by 3.76 percentage points for a median state. On the import side, median sizes of the Protective Barrier and the Input Barrier drops were 0.72 percentage points and 0.62 percentage points respectively. Also, there is a sizable dispersion in the drops. A state at the 75th percentile of barrier cuts experienced drops that were 3.31 percentage points (Export Barrier), 1.28 percentage points (Protective Barrier), and 1.84 percentage points (Input Barrier) larger than those faced by a state at the 25th percentile.

The distributions of the barrier changes shift toward zero as time develops. By 2016, the barrier cuts are close to zero in most states. It might seem surprising that some states face higher barriers than the previous year after the implementation of the FTA. However, even with lower tariff rates for individual products, each is assigned a different weight every year and the increase is possible due to the compositional effect.

3 Estimation

Given the exposure to the FTA every year during the period of 2012-2016 in each state, I now estimate the dynamic response of earnings and consumption to these changes. The choice of the sample period is motivated by the observation in Table 1 that most of the tariff cuts were realized within the first 5 years. The response at time horizon h can be defined as a difference between the forecast path for the outcome variable and its counterfactual:

$$\beta^h = E(\Delta_h\ y_{S,t+h}|\Delta B_t = 1\%p, \mathcal{X}) - E(\Delta_h\ y_{S,t+h}|\Delta B_t = 0, \mathcal{X}) \tag{8}$$

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 period. In other words, β^h is the average cumulated response across states and across time of the outcome variable y, at h periods in the future, in response to 1 percentage point change in a barrier, conditional on the information available at the initial time t.

I estimate β^h using the Local Projection Method of Jordà (2005). In particular, I estimate the following equation:

$$\Delta_h\, y_{s,t+j} = \mu_s^h + \mu_{t+h}^h + \beta_X^h \Delta B_{st}^{Export} + \beta_I^h \Delta B_{st}^{Input} + \beta_P^h \Delta B_{st}^{Prot} + \sum_{k=1}^{4} \gamma_k^h \Delta_1\, y_{s,t-k} + \varepsilon_{t+h}. \tag{9}$$

The horizon estimated ranges up to 12 quarters after a shock in trade barriers ($h = 0, 1, \cdots, 12$). I also check for the existence of any anticipatory movement by looking at the horizons before the shock ($h = -1, \cdots, -12$). I estimate all three barrier impacts in one regression, so we can identify each channel controlling for the others, which helps the case that output is also an input in a state.

4 Result

4.1 Dynamic Responses in Earnings and Consumption

Figure 1 provides a visual representation of the estimates of equation (9). Each panel of the figure displays the cumulative response in logged GDP, employment, income, and consumption to 1 percentage point cut in three barrier measures at time horizons $h = -12, \cdots, 12$. To show responses to reductions, rather than increases, in the barriers ($-\Delta B^{Export}, -\Delta B^{Prot}, -\Delta B^{Input}$), signs of the estimates are flipped ($-\hat{\beta}_X, -\hat{\beta}_P, -\hat{\beta}_I$). The shaded area show 90 percent confidence intervals of the coefficient estimates for each time horizon.

Similar patterns are found across the responses in GDP, employment, income, and consumption. Before the tariff cut is realized ($h < 0$), there is not much movement in all variables. That is, the variables do not move in anticipation of the scheduled tariff changes. After the realization of the shocks ($h \geq 0$), the barrier impacts are consistent across all variables. First, the Export Barrier cut has little effect, as shown in blue with circle markers. The significant impact of the Export Barrier cut is observed only in employment. Second, the Protective Barrier cut has a negative and statistically significant relationship with all variables, as shown in yellow with diamond markers. This implies that a state with lower protection from foreign competitors experiences a decrease in production and employment, and thus fewer earnings which feed into less consumption. The decrease happens gradually: the impact is significant only starting a quarter after the shock, and it continues to be negative for 8 quarters and longer. Finally, the Input Barrier cut has a positive but rather transitory impact, as shown in green with square markers. In other words, access to cheaper inputs due to tariff concessions has a positive but temporary effect on production and employment and thus on earnings and consumption. The responses reach their peaks around the 8th quarter.

While the responses in four variables roughly resemble each other, that of the income slightly deviates from the common pattern. In particular, its response to the Export Barrier cut is significantly negative for a period of time, although small. Given that the Export Barrier cut implies an opportunity to expand, such contraction is rather unintuitive. Also, the response to the Input Barrier cut is small and insignificant unlike the other variables, which show a significantly negative response.

To explore this further, I look at the components of personal income by its source.[8] Figure 2 displays responses in each component of personal income. Interestingly, wages and salaries in Panel (a) shows a clear pattern that is very similar to what is found in Figure 1: little impact of the Export Barrier cut, persistently negative impact of the Protective barrier cut, and temporarily positive impact of the Input Barrier cut. On the other hand, the component driving the overall response in personal income is proprietors' income: it responds with a much larger magnitude in a similar pattern as personal income. Thus, while other types of income may move differently, employed workers are subject to typical tariff impacts via changes in the labor market, and the shock is also transmitted to consumption response.

Given the importance of the labor market impact such as employment and wage of employed workers, we might want to learn more about the context of these changes. I further look at two other labor market variables: labor force and unemployment. In Panel (a) of Figure 3, the pattern of the response of the labor force is almost identical to that of employment, which is shown in

[8]Personal income consists of the following where the share is based on the 2012-2016 average: Wages and salary 50%, Dividends, interest, and rent 20%, Proprietors' income 10%, and Transfer 17%.

Panel (b) of Figure 1. Specifically, response to the Export Barrier cut induces a gradual increase up to 0.4% in the 12th quarter, while the response to the Input Barrier cut peaks around 0.4% in the 5th quarter. Meanwhile, in Panel (b) of Figure 3, the estimates for unemployment responses show roughly opposite directions of large magnitude, although most of them are statistically insignificant. This implies that movements in employment are mainly driven by both factors: more/fewer people willing to work and less/fewer people unable to find jobs.

In terms of the economic significance of these estimates, the impact that a state faces is determined by the size of its barrier changes, presented in Table 1 column 2. For the discussion on economic significance, I use the barrier changes in 2012 when the FTA was first implemented. Also, I focus on the impact on wages and consumption. The estimates of wage from Figure 1 Panel (d) and that of consumption from Figure 2 Panel (a) are presented again in Table 2.

Comparing two states, one at the 75th percentile of the Export Barrier change and the other at the 25th percentile, the state with the larger barrier cut would be expected to experience a 0.40 percentage point larger decline in wage[9] and a 0.13 percentage point larger increase in consumption in the 4th quarter. The magnitude of the impacts are similar in the 8th and 12th quarter. However, these estimates are not statistically significant.

In the case of the Protective Barrier cut, a state at the 75th percentile would be expected to experience a 0.91 percentage point larger decline in wage and a 0.73 percentage point larger decline in consumption in the 4th quarter. The magnitude of the impacts continues to build up at least until the 12th quarter: wage decline of 1.56 and 1.32 percentage points and consumption decline of 1.04 and 0.87 percentage points in the 8th and the 12th quarter, respectively, are expected.

An interquartile move of the Input Barrier change yields a modest increase in wages of 1.01 percentage points in the 4th quarter, which grows up to 1.62 percentage points in the 8th quarter and then shrinks to 0.25 percentage points in the 12th quarter. In terms of consumption, the move would bring increases of 1.03, 1.45, and 1.58 percentage points in the 4th, 8th, and 12th quarters, respectively.

[9] Noting that the interquartile range in the state-level Export Barrier changes in 2012 is (-2.27)-(-5.58)=3.31 percentage points (Table 1 column 2), the differential change between states at the upper and lower quartile of the barrier change is expected to be 3.31*(-0.12)=-0.40 (2). The rest of the discussion is obtained in a similar way using the two tables.

4.2 Comparison with the Conventional Measures

In order to highlight the use of the new barrier measures, I provide the results estimated with the conventional tariff measures, as defined in equation (6). Figure 4 compares the result with that of the new measures. The left panel (a) and right panel (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 are displayed in Figure 1 and are reproduced here.

First, the new barrier measures give a much more precise estimate than the conventional measures. In the first row, the estimate with the new measures (solid blue) has a much narrower confidence interval than that with the conventional measures (dotted red), even though the sizes of the two are similar to each other. It is also the case found in the third row, where the comparison is again between the confidence interval of the new measures (solid green) and that of the conventional measures (dotted red).

Second, the new barrier measures allow us to disentangle two opposite forces of import tariffs. If we use the conventional measures, we only see a combined effect of lower import tariffs on output and input, which is estimated to be positive (red dotted line in the second or the third row). However, by using the new measures, we can disentangle the negative impact of lower import tariff on output (Protective Barrier cut, yellow solid line in Panel (b)) and the positive impact of lower import tariff on input (Input Barrier cut, green solid line in Panel (c)).

5 Conclusion

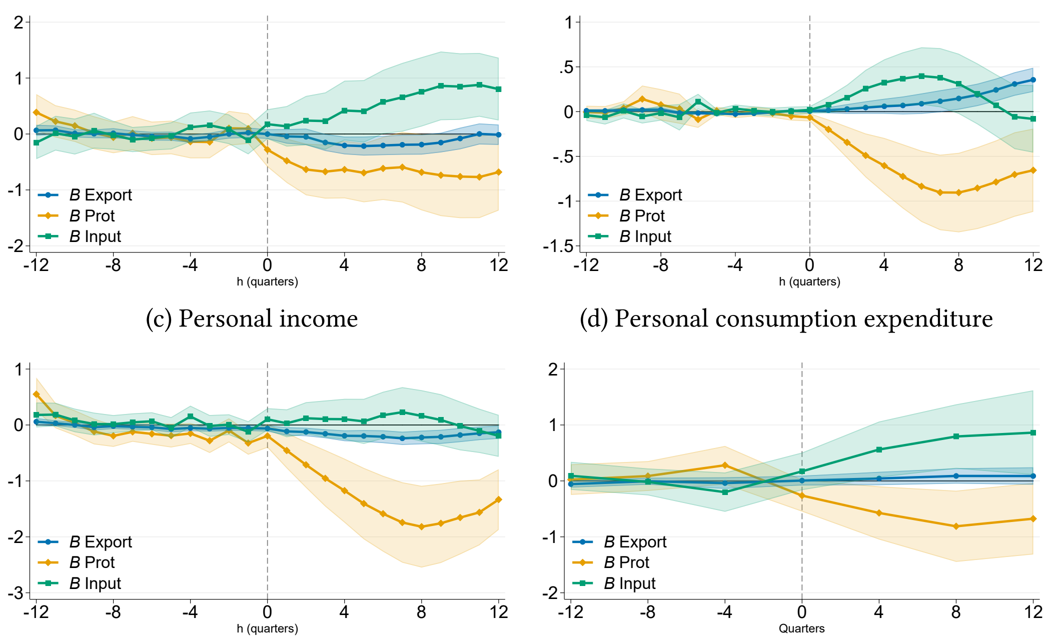
This paper examines the effect of tariff cuts that accompanied the U.S.-Korea FTA on earnings and consumption along the transitional path. I first introduce a procedure to aggregate Korean tariffs on U.S. exports, U.S. tariffs on imported inputs, or U.S. tariffs on Korean exporters in order to quantify each state's exposure to the Export Barrier, Input Barrier, or Protective Barrier. Using differential changes in these measures across states in the U.S., I estimate the relationship between the barrier cuts and GDP, employment, income, and consumption over the time horizon that ranges from 12 quarters before to 12 quarters after a shock.

The new measures provide not only a theoretically sound quantification of trade barriers, but also a more precise identification. Specifically, using the measures, we can disentangle the negative impact of Protective Barrier cut and the positive impact of the Input Barrier cut. Moreover, the impact of the Export Barrier cut, which is small, is more precisely estimated with a smaller standard error.

Also, the estimates of dynamic impact along the transitional path enable a richer understanding of how trade liberalization shapes the local economy. I observe that each barrier impact differs in terms of not only the magnitude and the direction but also its gradualness and persistence. Protective Barrier cut tends to affect the economy for a longer time horizon at least for 12 quarters, while the response to the Input Barrier cut 8 quarters after the shock overshoots its longer-run estimates. One might find it surprising that earnings and consumption do not move much in anticipation of barrier changes. This might be specific to the episode studied or to the identification procedure. More careful analysis of the anticipatory effect is left as future research.

Finally, the results have implications for evaluating the effect of import tariffs. It is often considered that "conceding" import tariff generates a loss for the country by lowering its guard against import competition. However, the result of this paper suggests that there exists an important positive channel of import tariff cut: lower import tariff reduces the cost of imported inputs. It is of a similar size to that of the import competition effect. In fact, the negative impact may be dominated by the positive impact, at least in the short run, depending on the size of each barrier cut that a state faces.

Figure 1: Cumulative response to 1%p barrier cuts



(a) GDP (b) Employment

(c) Personal income (d) Personal consumption expenditure

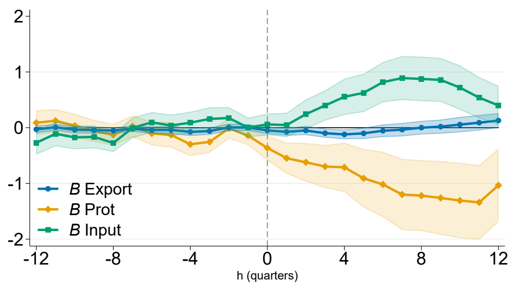
Notes: The figure displays the estimates of $-\beta_X^h$, $-\beta_P^h$, and $-\beta_I^h$ over the horizon of $h = -12, \cdots, 12$ for each outcome variable. The shaded areas display 90% confidence intervals. All dependent variables are logged and multiplied by 100. Frequency for personal consumption expenditure shown in Panel (d) is annual due to data availability.

Table 1: Barriers before and after the FTA

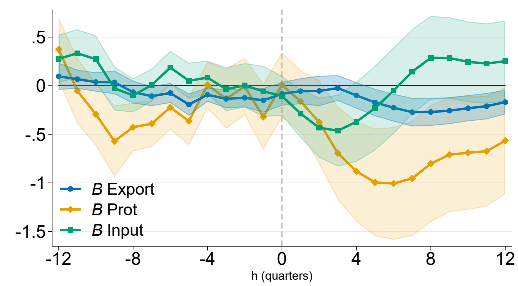
	B (%)	ΔB since FTA (%p)				
	2011	2012	2013	2014	2015	2016
Export Barrier B^{Export}						
25th percentile	4.73	-2.27	0.18	0.02	0.43	0.22
50th percentile	6.98	-3.76	-0.65	-0.58	0.17	-0.08
75th percentile	10.06	-5.58	-1.30	-1.35	-0.43	-0.55
Protective Barrier B^{Prot}						
25th percentile	1.74	0.04	-0.02	0.31	0.24	0.04
50th percentile	2.64	-0.72	-0.43	-0.09	-0.17	-0.18
75th percentile	4.11	-1.24	-0.80	-0.40	-0.51	-0.46
Input Barrier B^{Input}						
25th percentile	0.87	-0.05	0.19	0.17	0.07	0.15
50th percentile	2.03	-0.62	-0.03	-0.11	-0.01	-0.06
75th percentile	3.30	-1.89	-0.42	-0.45	-0.53	-0.41

Figure 2: Responses in income by its source

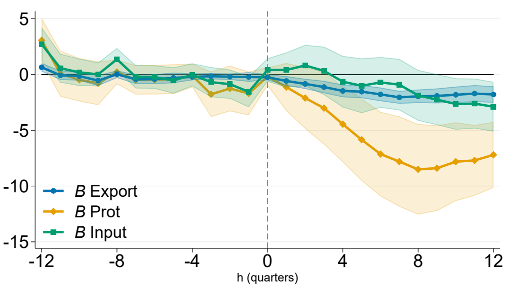
(a) Wage and salary



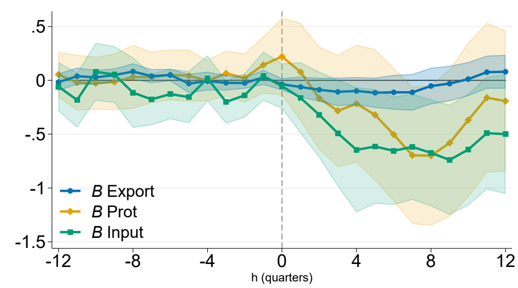
(b) Dividends, interest, and rent



(c) Proprietors' income



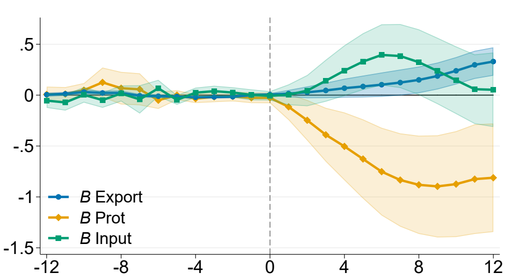
(d) Transfer



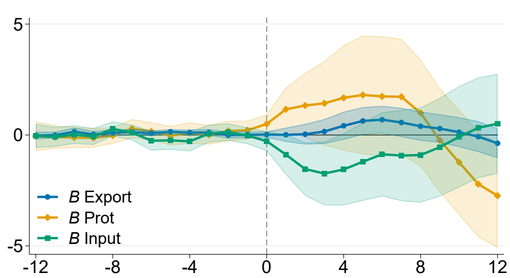
Notes: The figure displays the estimates of $-\beta_X^h$, $-\beta_P^h$, and $-\beta_I^h$ over the horizon of $h = -12, \cdots, 12$ for each outcome variable. The shaded areas display 90% confidence intervals calculated with robust standard error. All dependent variables are logged and multiplied by 100.

Figure 3: Response in labor market

(a) Labor force



(b) Unemployment

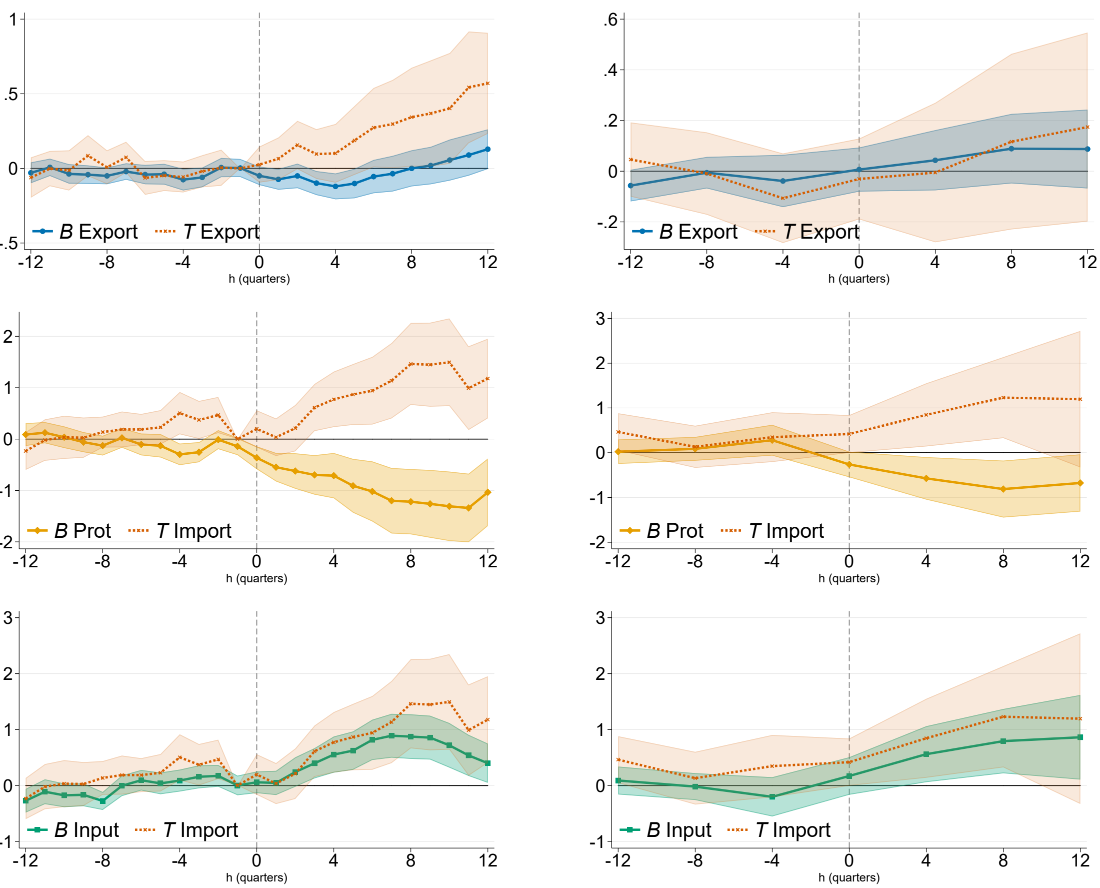


Notes: The figure displays the estimates of $-\beta_X^h$, $-\beta_P^h$, and $-\beta_I^h$ over the horizon of $h = -12, \cdots, 12$ for each outcome variable. The shaded areas display 90% confidence intervals. All dependent variables are logged and multiplied by 100.

Figure 4: Estimation with barrier measures vs. trade-weighted average tariff

(a) Wage and salary

(b) Personal consumption expenditure



Notes: Each of two columns is from a separate regression. The solid blue, yellow, and green lines are reproduction of those in Figure 2 Panel (a) and Figure 1 Panel (d). Red dotted lines labeled as T Export and T Import denote estimates for the conventional measures defined in equations (6) and (7). The shaded areas display 90% confidence intervals. All dependent variables are logged and multiplied by 100.

Table 2: Point estimates of cumulative response

	Wage and Salary			Consumption		
	Quarter 4	Quarter 8	Quarter 12	Year 1	Year 2	Year 3
ΔB^{Export}	-0.12**	0.00	0.13	0.04	0.09	0.09
	(0.05)	(0.07)	(0.08)	(0.07)	(0.08)	(0.09)
ΔB^{Prot}	-0.71***	-1.22***	-1.03***	-0.57**	-0.81**	-0.68*
	(0.27)	(0.39)	(0.40)	(0.29)	(0.39)	(0.39)
ΔB^{Input}	0.55***	0.88***	0.40*	0.56*	0.79**	0.86*
	(0.20)	(0.24)	(0.21)	(0.30)	(0.35)	(0.46)
Time FE	YES	YES	YES	YES	YES	YES
State FE	YES	YES	YES	YES	YES	YES
R^2	0.654	0.717	0.870	0.747	0.795	0.861
Observations	969	969	918	254	254	204

Notes: See equation (9) in the text. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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