Trade Policy Shocks and Consumer Prices*

Lerong Li[†]

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Abstract

How do trade policy shocks affect consumer prices? By constructing a novel dataset with both US import prices and barcode-level consumer prices, I examine the pass-through of import prices into consumer prices and its heterogeneity across consumers. I find that the pass-through of import prices to consumer prices is incomplete: a 1% increase in import prices leads to a 0.3 to 0.4% increase in consumer prices. Moreover, the pass-through is heterogeneous: it is higher for consumers with lower income and in markets with higher retail industry competition. To explain these findings, I build on Burstein and Gopinath (2014) to model the retail margin with variable markups and extend it to allow for consumer price heterogeneity. I show that the differential pass-through rates across consumers are largely driven by the differences in expenditure shares across varieties with heterogeneous pass-through rates. In addition to price changes of continuing varieties, the exit of imported varieties reduces the number of varieties in consumption basket and causes an increase in the exact consumer price index. Lastly, I conduct a quantitative exercise to estimate the increase in consumer prices if the U.S imposes a 25% tariff on all consumer goods from China. The tariffs would affect approximately 20% of import expenditures and cause the consumer prices of affected goods to increase 1-2% on average. The increases in consumer prices are almost 50% higher for lower income consumers and higher for consumers living in big cities of the Northeast region and West Coast.

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†University of Maryland. Email: lerongli@umd.edu

1. Introduction

In the past decades, trade barriers have continued to decrease all over the world, thus bringing gains to consumers through lower prices and more varieties. However, in recent years, we have witnessed a reversal of trade policy, through both higher import tariffs and higher policy uncertainty. How do these trade policy shocks affect consumer prices? In particular, how do import price changes caused by such shocks pass on to consumers? Does the import price pass-through vary across consumers, thus generating distributional effect? Answering these questions would help us better understand the welfare implications and the distribution consequences of trade policy shocks. The existing literature has paid little attention to tariff pass-through, possibly due to the lack of variations in tariffs in the past years.[1] However, as the trade barriers increase dramatically in the recent trade war, an emerging literature examines the tariff pass-through into import prices. For example, Amiti et al (2019) and Khandelwal et al (2019) both find that the pass-through of tariffs into import prices at the border is complete, at least in the short-run.[2] However, we do not know how much of that increase in prices at the border is passed through to the prices the consumers pay at retail outlets.

Using a unique dataset that links detailed US import prices with barcode-level consumer prices, I address the question by estimating the pass-through from import to consumer prices during the Great Trade Collapse (GTC). I find that the import price pass-through to consumer prices is incomplete: a 1% increase in import prices would lead to a 0.3 to 0.4% increase in consumer prices. Moreover, the import price pass-through is heterogeneous across consumers. In particular, the pass-through rate is higher for consumers with lower income. Across locations, the pass-through rate is higher to markets with more retail industry competition, which is measured by Herfindahl Index.

To explain the empirical findings, I develop a theoretical framework linking import

[1] One exception is Feenstra(1989), in which he estimated the pass-through of tariffs to prices of Japanese automobiles in 1980s. Other relevant studies mostly focus on how the decline in input tariffs affected manufacturing or export prices (Khandelwal et al (2016); Amiti et al (2018)) during the trade liberalization episodes.

[2] It is a surprising result given that the existing literature has documented incomplete pass-through of exchange rate shocks. It is also inconsistent with the estimated export supply elasticity in Broda, Weinstein and Limão (2008), which implies incomplete tariff pass-through.

prices and consumer prices following Burstein and Gopinath (2014). The framework features nontradable distribution margin and variable markups in the retail/wholesale sector, both of which could lead to incomplete pass-through. Specifically, the pass-through rate of import prices depend on: 1) the distribution margin, as prices of non-tradable goods are insensitive to price shocks at the border; 2) the markup elasticity, which captures how retailers adjust their markups when facing a cost shock.

To explore the heterogeneity in pass-through rates across consumers, I extend the framework to allow for heterogeneity in consumer prices. I first construct a consumer-specific price index by allowing for the differences in expenditure shares and variety-level retail prices. I show that a differential pass-through across consumers could arise through two channels. The first one captures the fact that consumers shop in different retail outlets for the same variety and the pass-through can be different across retail outlets. The second channel focuses on the different expenditure shares across varieties with different pass-through rates. For example, high income consumers spend more on varieties of higher quality, which have different pass-through rates than low-quality varieties.

I then investigate how each channel contributes to the differential pass-through across consumers. A price decomposition shows that the differences in expenditure shares across varieties with heterogeneous pass-through rates account for most of the differential pass-through. That is, consumers with lower income and at more competitive retail market spend more on varieties with higher pass-through rates. For lower income consumers, the higher pass-through rate is possibly due to the fact that lower quality varieties they consume more exhibit lower distribution margin compared with higher quality varieties and thus have higher pass-through rates. For consumers at more competitive retail markets, the higher pass-through might originate from that they spend more on varieties from relatively small retailers which have lower markup elasticity and thus higher pass-through rates.

The impact of trade policy shocks on consumers depends not only on the price changes of continuing varieties, but also on the availability of imported goods. In particular, evidence shows that the increase in trade barriers has led to a sharp decline in the number of imported varieties during the recent trade war (Amiti et al, 2019). To account for the effect of changes in imported varieties on consumer welfare, I derive a relationship between the variety component of the exact consumer price index and the entry and exit of imported varieties. Specifically, the exit (entry) of imported varieties would cause an increase (decrease) in the exact consumer price index and the magnitude of the impact depends on the import share and distribution margin. Using the linked dataset, I show that the exit of imported varieties leads to a decrease in the number of varieties of the same product category in consumption basket, thus causing an increase in the exact consumer price index and additional welfare loss. Particularly, if the number of exiting varieties increases from the 25th to the 75th percentile, the exact price index for this product would be 2.1% larger.

Last, I perform a quantification exercise to estimate the increase in consumer prices if the US imposes 25% tariffs on all consumer goods from China. I find that the increased tariffs would affect approximately 20% of the total expenditures on imported goods and thus cause the consumer prices of affected goods to increase 1-2% on average. The consumer price would increase by 1.07% for high income and 1.53% for low income consumers. Across locations, consumers in the large cities in the Northeast region, which have the most competitive retail market, would experience the largest increases in consumer prices while consumers at the south region, which has more concentrated retail market, have the lowest increases.

A key challenge in identifying the import price pass-through is the endogeneity of import prices. To address this problem, I exploit the exogeneous variations in changes in trade policy uncertainty (TPU) across industries during the GTC. I show that the changes in TPU affected import prices across industries and thus can be used as an instrument for changes in import prices to identify the pass-through.

This paper is related to the literature that examines the tariff or exchange-rate pass-through. Most of the existing literature focuses on how exchange rate shocks affect import prices and consumer prices. As reviewed by Burstein and Gopinath (2014), they find that the exchange rate pass-through is incomplete and the pass-through into consumer prices is well below that into border prices.[3] For tariff pass-through, dating back to 1980s, Feenstra (1989) finds the symmetry of exchange rate and tariff pass-through in the automobiles industry and shows that the tariff pass-through ranges from 0.6 to unity depending on the products. Other studies mostly focus on how the decline in tariffs in trade liberalization episodes have affected prices

[3] For the US, they find that the pass-through is at least twice as high into border prices as it is into retail prices.

(De Loecker et al (2016); Amiti et al (2018); Jaravel and Sager (2019)). For example, Jaravel and Sager (2019) find that the increased import penetration from China leads to a decline in consumer prices in the US, mostly due to the strategic complementarity of pricing decisions of domestic firms. An emerging line of research starts to examine the price effect of US import tariffs during the recent trade war (Amiti et al (2019); Fajgelbaum et al (2019)). They find that the import tariffs are completely passed through into prices paid by US importers, at least in the short run. The results are at odds with previous findings of incomplete pass-through but also raise the question of how much of increases in prices at the border would pass through to the prices at the retail outlets. This paper addresses the question by estimating the import price pass-through into consumer prices using detailed price information. Contemporary to my work, two papers examine the pass-through of US tariffs to consumer prices. Flaaen, Hortacsu and Tintelnot (2019) estimate the price effect of US import tariffs on a specific consumer good: washing machines. They find that the pass-through of tariffs to consumer prices is negative for country-specific duties as multinationals shifted productions to tariff-free countries. However, the tariff elasticity is larger than one for 2018 tariffs that are imposed on all sourcing countries. By exploring the heterogeneous pass-through across consumers, this paper is closely related to Cravino and Levchenko (2017), which study the distributional effect of large exchange rate devaluations on consumers at different income levels. Following their work, this paper also explores how the differences in distribution margin shape the distributional effects across consumers. However, I allow for variable markups, which is an additional margin that would cause distributional effects.

This paper also contributes to the literature that studies the distributional consequences of international trade. This line of research focuses on how international trade causes relative price changes both across sectors and within sectors and relates it to differential price changes across consumers. For example, Fajgelbaum and Khandelwal (2017) incorporates non-homothetic demand in a quantitative model and find that international trade is pro-poor because poor consumers spend more on sectors with a larger trade intensity and a lower elasticity of substitution between domestic and imported goods. Borusyak and Jaravel (2018) relax the assumption on demand structure and use micro-data on expenditure shares across sectors and goods. They show that consumers with various education levels have approximately the same expenditure share on imported goods and the expenditure channel is therefore almost neutral to different education groups. On the other hand, as price and expenditure data at more disaggregated product-level becomes available, some papers start to examine the effect of specific events on consumer welfare using micro-level data. Faber (2014) and Atkin, Faber and Navarro (2016) are two examples using barcode-level data to study separate events (the first one is about NAFTA and the second is on the arrival of foreign retail chains) on Mexican consumers. Similar to these studies, this paper also uses barcode-level price and expenditures. However, these papers did not distinguish between import prices and consumer prices. In contrast, this paper shows that the existence of domestic distribution sector creates a wedge between import and consumer prices and plays a role in generating distributional effects across consumers.

Lastly, this paper is related to recent studies on trade policy uncertainty. Handley and Limão (2017) examine the effect of TPU on imports and import prices from China during its accession to WTO. They find that the decreased TPU led to export entry and technology upgrading of existing exporters, thus pushing down the import prices from China. Carballo et al (2018) focus on the increase in TPU during the Great Trade Collapse and its effect on export dynamics. Following their work, I explore the relationship between TPU and import prices during the GTC and use it as the basis of my empirical strategy.

The rest of the paper is organized as follows. Section 2 presents the theoretical framework linking import and consumer prices. Section 3 introduces data and empirical strategy to estimate the import price pass-through. In section 4, I extend the theoretical framework to allow for heterogeneity in consumers and explore several channels that would lead to differential pass-through. Section 5 provides evidence on differential pass-through across consumers and underlying channels. Section 6 discuss the impact of trade policy shocks on consumer welfare through imported variety. In section 7, I perform quantification exercises to assess the impact of trade war on consumer prices. Section 8 concludes.

2. Theoretical Framework

To examine how the changes in import prices are transmitted to consumer prices, I first develop a theoretical framework linking import prices and consumer prices following Burstein and Gopinath (2014). In this step, I derive a theoretically consistent import price pass-through into consumer prices by focusing on price changes of varieties that exist in both periods.

Suppose there is a retail/wholesale sector that distribute varieties from the port to the destination location. The retail price of variety v at time t is given by[4]

$$p_{vt}^{r} = p_{vt}^{T\,(1-\eta_v)} p_t^{N\,\eta_v} \underbrace{\gamma_{vt}}_{markup} = c_{vt}\gamma_{vt}(c_{vt};\xi_{vt}) \tag{1}$$

where p_{vt}^{T} is the price of variety v at the dock. If it is a domestic variety, it presents the price at the factory gate. The retailer combines the good with distribution services in a Cobb-Douglas way with η_v represents the cost share of distribution service. Distribution service includes domestic transportation cost, marketing cost that uses the non-tradable goods and its price is p_t^N. We call η_v the distribution margin of variety v and assume non-tradable price p_t^N is not responsive to price shocks at the border. The retailer then charges a markup γ_{vt} over its marginal cost c_{vt}. We allow retailers to charge variable markups, which depends on its marginal cost and a demand parameter ξ_{vt}.[5]

Re-write equation (4) in logs:

$$\ln p_{vt}^{r} = (1-\eta_v)\ln p_{vt}^{T} + \eta_v \ln p_t^{N} + \ln \gamma_{vt}(c_{vt};\xi_{vt}) \tag{2}$$

We define variety pass-through as $\rho_v = \frac{\partial \ln p_{vt}^{r}}{\partial \ln p_{vt}^{T}}$, which captures how price shocks at

[4]A variety can be any disaggregated good within a product category. In my empirical analysis, a variety is defined at the barcode level.

[5]Burnstein and Gopinath (2015) and Arkolakis (2017) review several models that would lead to variable markup including non-CES demand such as Kimball demand and oligoplistic competition as in Atkenson and Burnstein (2008). The idea is that heterogeneous firms would charge variable markups as elasticity of demand varies across firms. As shown in Arkolakis (2017) and Amiti et al (2018), firm's markup and cost pass-through depend on the relative price of the firm or the price vector the firm faces.

the border transmit to consumer prices of the same variety.[6] It is straightforward to see that:

$$\rho_v = \frac{\partial \ln p^r_{vt}}{\partial \ln p^T_{vt}} = (1-\eta_v)(1-\theta_v) \tag{3}$$

where $\theta_v = -\frac{\partial \ln \gamma_{vt}}{\partial \ln c_{vt}}$, and we call it markup elasticity. Markup elasticity represents how variety's markup respond to cost shock. In the case of CES with monopolist competition, markup is constant and markup elasticity equals to zero. Thus the variety pass-through only depends on distribution margin. In other scenario, when retailers engage in oligopolistic competition or face non-CES demand, markup elasticity could be positive as retailers absorb part of the cost.

As equation (6) makes clear, variety pass-through can be incomplete (less than one) due to the existence of distribution margin and variable markups. Because the prices of non-tradable goods are insensitive to import price shocks, the higher the distribution margin, the lower the pass-through. As markup elasticity captures how the markup responds to cost shock, the higher the markup elasticity, retailers absorb more of the cost shock, which in term results in lower pass-through.

As we cannot track the same variety from border to retail outlet, we aggregate price changes at variety level to product category level. For the purpose of deriving pass-through, we use varieties that exist in both periods. Log changes in consumer prices of product category g at time t is defined as:

$$\Delta \ln P^R_{gt} = \sum_{v \in g} w_{vt} \Delta \ln p^r_{vt} \tag{4}$$

The weight w_{vt} is the expenditure share of each variety v, which can be fixed or vary over time depending on how we define price index. For example, official CPI use fixed weights, so $w_{vt} = w_v$. Sato-vartia weights vary over time because they take into account the substitution effect in response to price change.

Note that the changes in retail price of variety v can be written as a function of variety pass-through and changes in import price/factory-gate price of variety v:

$$\Delta \ln p^r_{vt} = \rho_v \Delta \ln p^T_{vt} + \eta_v(1+\theta_v)\Delta \ln p^N_t \tag{5}$$

[6] For simplicity, we assume it does not vary over time.

Combining equation (9) and equation (5), we re-write consumer prices of product category g:

$$\Delta \ln P^R_{gt} = \rho_g \sum_{v \in g} w_{vt} \Delta \ln p^T_{vt} + \Delta \ln p^N_t \sum_{v \in g} w_{vt} \eta_v (1 + \theta_v) \tag{6}$$

Here I assume the variety pass-through is the same across varieties in product category g and equals to ρ_g. Then I distinguish between imported goods and domestic goods:

$$\Delta \ln P^R_{gt} = \underbrace{s^I_{gt} \rho^I_g \sum_{v \in g} w^I_{vt} \Delta \ln p^{T,I}_{vt}}_{imported} + \underbrace{(1 - s^I_{gt}) \rho^D_g \sum_{v \in g} w^D_{vt} \Delta \ln p^{T,D}_{vt}}_{domestic} + \tilde{\delta} \Delta \ln p^N_t \tag{7}$$

where $\tilde{\delta} = \sum w_{vt} \eta_v (1 + \theta_v)$. s^I_{gt} is the expenditure share on imported goods in product cateogry g, whereas w^I_{vt} and w^D_{vt} are the expenditure share of a variety v within imported goods and domestic goods separately.

Define import price index of product g as $\Delta \ln P^I_{gt} = \sum_{v \in g} w^I_{vt} \Delta \ln p^{T,I}_{vt}$. Here I assume the same weight in consumption basket and in imported bundle, which is reasonable given the goods we focus on are mostly final goods. Similarly, I define domestic price index of product g as: $\Delta \ln P^D_{gt} = \sum_{v \in g} w^I_{vt} \Delta \ln p^{T,D}_{vt}$.[7] I can rewrite the above equation (7) as:

$$\Delta \ln P^R_{gt} = s^I_{gt} \rho^I_g \Delta \ln P^I_{gt} + (1 - s^I_{gt}) \rho^D_g \Delta \ln P^D_{gt} + \tilde{\delta} \Delta \ln p^N_t \tag{8}$$

As we can see in equation (8), the import price pass-through into consumer prices of the same product category depends on the interaction of the import share s^I_{gt} and variety pass-through ρ^I_g. The latter one is a function of distribution margin and markup elasticity. As both factors are less than one, the import price pass-through into consumer prices is incomplete at product category level. Next, I discuss how I take equation (8) into data.

[7]Note that the changes in domestic price $\Delta \ln P^D_{gt}$ might be a function of changes in import prices because of the strategic complementarities in pricing decisions of domestic and foreign exporters (Feenstra and Weinstein(2017); Amiti, Itskhoki and Konings(2018)).

3. Empirical Analysis

3.1. Data and Measurement

To estimate the import price pass-through to consumer prices, I use a merged dataset from two data sources. The first one is the US quarterly import data during 2004Q1-2011Q4, which is available through US Census Bureau. This dataset contains customs value, quantity and unit value for each HS10-country combination. Our sample has 68 exporting countries, which include all US major trading partners and account for over 80% of total imports into the US.

The second dataset is the Consumer Panel from AC Nielsen company during the same period and is available through Kilts marketing center of University of Chicago. Nielsen Consumer Panel (Nielsen data hereafter) contains transaction-level information such as price, quantities on barcoded goods from a representative sample of households in the US. In addition, it includes detailed household demographic and geographic information such as household income, size, zip-code etc. The products in Nielsen data are mostly consumer packaged goods, which account for about 30% of all expenditures on goods in CPI (Broda and Weinstein (2010)).

To merge the two dataset, I use a concordance developed by Bai and Stumpner (2018) which matches HS-6 digits in trade data with product codes (“product module") in Nielsen data. The concordance covers 1175 HS6-digit codes and 1246 product modules, generating 359 new product categories.[8] The matched HS6s accounts for approximately 20% of total import value and mostly are final goods imports.

I calculate consumer price index for each product category using information in Nielsen data. The consumer price index is defined as a weighted average of price changes of continuing varieties:

$$\Delta \ln P_{gt}^{R} = \sum_{v \in g} w_{v0} \Delta \ln p_{vt}^{r} \tag{9}$$

where a variety is defined as a barcode (UPC). The price changes are calculated as the difference of (log) unit value at time t relative to that in the corresponding quarter

[8]For example, the new product category “plain pasta" include 10 product modules ranging from Spaghetti to Lasagna, and 2 HS6s which are “unstuffed pasta that made with or without eggs".

of 2004. I use the expenditure share at base periods as weight. Import price index is calculated for the same product category using detailed import data, with a variety is defined as a HS10-country. As the variety is more aggregated in import data than in the Nielsen data, I assume: $\Delta \ln p^{T,I}_{Vt} = \sum_{v \in V} w^{V}_{v0} \Delta \ln p^{T}_{vt}$. That is, the import price of a HS10-country combination V is the weighted average of the import prices at (unobserved) barcode-equivalent level (v).

Table 1 reports the summary statistics of changes in import prices and consumer prices during the sample period. Column 1 is for pre-crisis period (2005Q1-2008Q3) and column 2 is for crisis period (2008Q4-2011Q4). As we see, both import and consumer prices increases during this period and the increase is larger during the crisis period. In addition, the import prices exhibit more variation than consumer prices.

Table 1: Summary Statistics of Import and Consumer Prices

	Pre-Crisis	Crisis	Overall
Changes in Consumer Prices ($\Delta \ln P^{R}_{gt}$)	0.044	0.146	0.090
	[0.117]	[0.173]	[0.154]
Changes in Import Prices ($\Delta \ln p^{I}_{gt}$)	0.057	0.224	0.133
	[0.580]	[0.655]	[0.621]
Observations	3,577	2,971	6,548

Notes: Standard deviations are reported in the bracket.

3.2. Identification Strategy

Equipped with price indices, I take equation (8) into data by estimating the following equation:

$$\Delta \ln P^{R}_{gt} = \alpha + \beta \Delta \ln P^{I}_{gt} + \gamma \Delta \ln P^{D}_{gt} + \delta_t + \epsilon_{gt} \tag{10}$$

where $\Delta \ln P^{R}_{gt}$ and $\Delta \ln P^{I}_{gt}$ are changes in consumer prices and import prices of product category g respectively. I control for changes in domestic prices using US industrial PPI. In doing so, I build a concordance between 359 product categories and 262 NAICS 6-digit industries.[9] The industrial PPI at NAICS level is obtained from two data sources. The first one is from NBER-CES database, which is reported yearly, while the second

[9] I first use the concordance between NAICS6 and HS6 by Pierce and Schott(2009) and then link HS6 with product categories.

one is quarterly-based PPI from BLS. In the baseline, I report the results using PPI from NBER-CES database. I do robustness check using BLS PPI and the results are reported in Appendix C. I add time fixed effects to capture the changes in prices of non-tradable goods and other macro economic shocks that could affect all products equally. Because all price indices are calculated as price changes, the product fixed effects are differenced out. To address the concern that there might be product-specific trend in prices, I control for department fixed effects in the robustness check. The results are reported in Appendix.

One key challenge to identify the pass-through is the endogeneity of import prices. The event of Great Trade Collapse (GTC) provides us a unique setting to identify the import price pass-through as it generates exogeneous variation in trade policy uncertainty across industries.

During the 2008 financial crisis, as the economic condition worsened, there was widespread discussion of a possible trade war (Carballo et al, 2018). Though eventually the trade war didn't happen, it caused substantial increase in trade policy uncertainty during this period. Figure 1 plots the news-based trade policy uncertainty index constructed by Carballo et al (2018) and the average applied tariffs during this period. As we see, though the applied tariffs barely changes, trade policy uncertainty increased substantially, especially in 2008Q4.

More importantly, the increase in TPU was heterogeneous across industries and affected the industrial import prices. The basic idea is that in the case of trade war, the U.S. might switch to non-cooperative tariffs, which are product-specific and can be proxied by Column-2 tariffs.[10] Column-2 tariffs were set in Smoot-Hawley Act of 1930 and thus exogeneous to product-level shocks during the financial crisis. Furthermore, recent studies document that TPU affected imports and import prices. In particular, Handley and Limão (2017) find that the import prices from China decreased more in industries with higher initial TPU during China's accession to WTO. Following their work, I show the increased TPU has affected import prices across industries during GTC using US quarterly import data during 2004Q1-2011Q4. Specifically, I find that industries that experienced larger increase in TPU have lower import prices, which is mainly driven by the lower prices of existing varieties. The results are reported in

[10]Broda, Weinstein and Limão (2008) show the relationship between optimal non-cooperative tariffs and column-2 tariffs are positive.

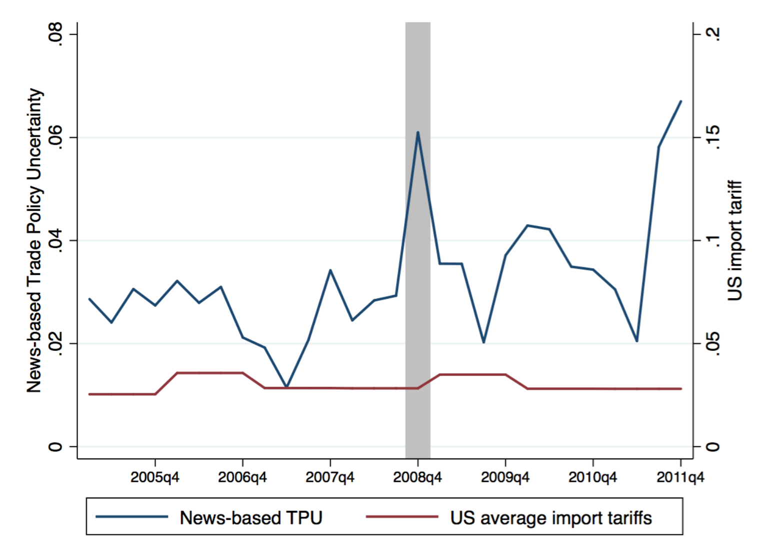

Figure 1: US Import Tariffs and Trade Policy Uncertainty

Notes: The news-based TPU index is constructed by Carballo et al (2018) and represents the mentions of "uncertainty" or "uncertain" in the set of articles about international trade or trade policy in major US newspapers. The US average imported tariffs are calculated as the weighted average of applied MFN tariff rates.

Appendix.

I therefore measure the increase in TPU each industry experienced during the crisis following Handley and Limão(2017). That is, I calculate the potential profit loss for each industry if high protection state realizes using the differences between column-2 tariff rates and Most Favored Nation (MFN) tariff rates, which are the tariffs US actually applied. Specifically, the increase in TPU in industry i is:

$$TPU_i = 1 - (\frac{\tau_2^i}{\tau_m^i})^{-\sigma} \tag{11}$$

where τ_2^i and τ_m^i are Column 2 and MFN tariff rate for industry i respectively.[11] Specifically, I use the interaction of industrial TPU and crisis dummy to capture the industry by time variations of TPU and use it as an instrument for the changes in import prices.

[11]In the baseline, the column 2 and MFN tariff rates for each industry are calculated as the simple average of HS8-level tariff rates. The elasticity of substitution σtakes the value of 3 following Handley and Limão(2017). In the robustness check, I try alternative TPU measures including $\ln(\frac{\tau_2^i}{\tau_m^i})$. The results are reported in the Appendix C.

The crisis dummy equals to one during 2008Q4-2011Q4, and zero otherwise. To better capture the overall TPU level over time, I also interact the industrial TPU with news-based TPU index. As shown in Figure 1, the news index is quarterly based and measures the overall sentiment of trade policy uncertainty over time. It has an average of 0.026 before the crisis and 0.040 during the crisis. Especially, it increased by almost three-fold from 2008Q3 to 2008Q4.

Due to similar reasons, the changes in domestic prices are also endogeneous. I therefore instrument industrial PPI with one plausibly exogeneous cost shock: the changes in energy prices. To do so, I interact the prices of five major energy sources with their corresponding cost shares in each industry.[12] Their annual price information is obtained through SEDS (State Energy Data System) of EIA. I use the average prices per BTU across the US to avoid any endogeneity issue. The expenditures data is available through Manufacturing Energy Consumption Survey (MECS), which reports each manufacturing industry's expenditures (in Million US dollars) on these five sources of energy every 4 years. I use the data from 2006.

Table 2: Import-Consumer Price Pass-through

	(1) OLS	(2) IV	(3) IV
Changes in Import Prices	0.014***	0.366***	0.338***
	(0.003)	(0.097)	(0.088)
Industrial PPI	0.180***	0.524***	0.486***
	(0.014)	(0.107)	(0.078)
Instrument		TPU $\times$ *Crisis*	TPU $\times$ *News*
Time FE	Yes	Yes	Yes
N	5819	5635	5635

Notes: ***p<0.001, **p<0.005, *p<0.01. In both IV regressions, I instrument industrial PPI with changes in energy prices. The Cragg-Donald F statistics is 8.30 for column 2, which exceeds Stock and Yogo (2005) critical value of 7.03 (10% significance level) for two endogeneous variables and two instruments. The Cragg-Donald F statistics is 7.98 for column 3.

Table 2 reports the results from the OLS and IV estimations. As we can see in Column 1, the coefficient is significant but small. However, after we instrument changes in import prices and domestic prices, the magnitude of coefficient increases substantially. Based on our IV estimates, the pass-through is between 0.3-0.4, suggesting that a one percent increase in import prices will lead to a 0.3 to 0.4 percent increase in consumer

[12] The five major energy includes: electricity, natural gas, residual fuel oil, distillate fuel and coal.

prices.[13] The first stage results are reported in Appendix C.

Note that equation (8) predicts that the import price pass-through increases with the import share of that product category. To test this hypothesis, I interact the changes in import prices with the product-level import penetration, which is obtained from Schott (2006) at NAICS 4-digit level. Table 11 shows the results. As we see, consistent with our prediction, the interaction between import prices and import penetration is significant and positive, indicating that the pass-through is higher for industries with higher import penetration. As to magnitude, the import price pass-through is 0.261 for industries with average import penetration and a one standard deviation increase in penetration would result in a pass-through rate of 0.442.

Table 3: Import-Consumer Price Pass-through: Import Penetration

	(1) OLS	(2) IV	(3) IV
Changes in Import Prices	0.015***	0.362***	0.261***
	(0.004)	(0.096)	(0.071)
Imp $\times$ Penetration	0.012***	0.184*	0.181***
	(0.004)	(0.095)	(0.068)
Industrial PPI	0.183***	0.766***	0.625***
	(0.015)	(0.207)	(0.106)
Instrument		TPU$\times$*Crisis*	TPU$\times$*News*
Time FE	Yes	Yes	Yes
N	5819	5635	5635

Notes: ***p<0.01, **p<0.05, *p<0.1. The import penetration is normalized to have mean zero and standard deviation of one. In both IV regressions, I use changes in energy prices to instrument for industrial PPI.

4. Heterogeneity

Having estimated the import price pass-through into aggregate consumer prices, now I examine if there is heterogeneity in pass-through rates across consumers with different characteristics. To do so, I first define a consumer-specific price index by allowing for differences in expenditure share across varieties and variety-level prices, both of which could lead to differential pass-through. Specifically, the price index of product category

[13] As reviewed by Gopinath and Burnstein(2015), the exchange rate pass-through at least twice as high into border prices as it is into retail prices for the U.S..

g for consumer z is defined as

$$\Delta \ln P^z_{gt} = \sum_{v \in g} w^z_{vt} \Delta \ln p^{zr}_{vt} \tag{12}$$

where w^z_{vt} is the expenditure share on variety v for group z at time t and $\Delta \ln p^{zr}_{vt}$ denotes the changes in prices of variety v for consumer z. The differences in variety-level price changes could arise because consumers shop the same variety (UPC) in different retail outlets or have different search intensity.

The differential import price pass-through across consumers depend on both factors. To see this, note that as consumers pay different prices for the same variety, the same cost shock would have led to differential price adjustment at the variety-level. This is the first channel which I call differential variety pass-through. Second, as pass-through rates vary across varieties due to differences in distribution margin and markup elasticity, the differential expenditure shares could also cause differential pass-through.

To investigate each channel in detail, I decompose the changes in consumer-specific price index into the following:

$$\begin{aligned}\Delta \ln P^z_{gt} &= \sum_{v \in g} w^z_{vt} \Delta \ln p^{z,r}_{vt} = \sum_{v \in g} (w_{vt} + u^z_{vt}) \Delta \ln p^{z,r}_{vt} \\ &= \underbrace{\sum_{v \in g} w_{vt} \Delta \ln p^{z,r}_{vt}}_{\text{within}} + \underbrace{\sum_{v \in g} u^z_{vt} \Delta \ln p^{r}_{vt}}_{\text{across}} + \sum_{v \in g} u^z_{vt} v^z_{vt}\end{aligned} \tag{13}$$

where w_{vt} is the average expenditure share on variety v and u^z_{vt} is the deviation in expenditure share for consumer z from the average. Likewise, $\Delta \ln p^r_{vt}$ is the average change in (log) price for variety v and v^z_{vt} is the deviation in price changes for consumer z from the average.

The first term weights the changes in consumer-specific retail price by the average expenditure share, capturing the differential changes in retail prices for the same variety across consumers. The second term assumes the same change in variety-level price but allows for different expenditure patterns across varieties, thus measuring how differential expenditure shares contribute to the differential price index. Finally, the last term is the correlation between two deviations. For example, if high income consumers spend more on high quality goods, and the pass-through of high quality goods is disproportionately higher for high income consumers.

The decomposition highlights several channels that could cause differential price changes across consumers and therefore could be sources of heterogeneity in pass-through. In the following, I will link each component of consumer-specific price indices with changes in import prices and investigate how each channel contributes to the differential pass-through.

4.1. The Variety Pass-Through Channel

First, I examine how the price shocks in the border could cause differential changes in retail price for the same variety across consumers. Note that retail price of variety v for group z can be written as:

$$\ln p_{vt}^{z,r} = (1-\eta_v^z)\ln p_{vt}^T + \eta_v^z \ln p_t^N + \ln \gamma_{vt}^z(c_{vt}^z; \xi_{vt}^z) \tag{14}$$

Here I assume the price at the dock p_{vt}^T is the same for all consumers. However, the distribution margin, which captures the amount of domestic services being added to imported goods, and markup can vary across consumers. The variety pass-through for consumer z is defined as follows:

$$\rho_v^z = \frac{\partial \ln p_{vt}^{z,r}}{\partial \ln p_{vt}^T} = (1-\eta_v^z)(1+\frac{\partial \ln \gamma_{vt}^z}{\partial \ln c_{vt}^z}) = (1-\eta_v^z)(1-\theta_v^z) \tag{15}$$

As we can see in equation (15), variety pass-through varies across consumers because of the differences in distribution margin and markup elasticity. These differences are possibly due to the fact that consumers shop the same variety (UPC) in different retail outlets and these retailer outlets attach different domestic services and have different pricing decisions when facing the same cost shock. [14]

Note that distribution margin η_v represents the proportion of non-tradable services that are provided with imported goods to consumers. It naturally varies across locations because of different domestic transportation costs. In addition, it could also vary across locations due to the differences in rent, labor costs etc. In the case of income,

[14] Another possible explanation is that consumers have different search intensity.

as high income consumers tend to shop in stores with higher amenity, these stores usually attach more domestic services such as offering more customer services, nicer shopping environment, thus having higher distribution margin.

Markup elasticity captures the fact that when facing the same cost shocks, the markup adjustment could be different across consumers even for the same variety. In terms of income, it is possible that the high-amenity stores that cater to the rich have different markup elasticity due to the differences in demand elasticity between the rich and poor. For consumers at different locations, the differences in market structure and local competition in retail industry can affect the markup elasticity. For example, Smith (2018) documented an overall increase in concentration in retail industry in the U.S and considerable variations in concentration levels across locations.

Note that we can write the changes in variety retail price as a function of variety pass-through and changes in prices at the dock:

$$\Delta \ln p_{vt}^{z,r} = \rho_v^z \Delta \ln p_{vt}^T + \eta_v^z (1 + \theta_v^z) \Delta \ln p_t^N \tag{16}$$

Denote the first component of consumer price indices in equation (13) as $\Delta \ln P_{gt}^{z,1}$ and re-write it:

$$\begin{aligned} \Delta \ln P_{gt}^{z,1} &= \sum_{v \in g} w_{vt} \Delta \ln p_{vt}^{z,r} \\ &= s_{gt}^I \rho_g^z \Delta \ln P_{gt}^I + (1 - s_{gt}^I) \rho_g^z \Delta \ln P_{gt}^D + \tilde{\delta} \Delta \ln P_t^N \end{aligned} \tag{17}$$

When deriving the second equality, we distinguish between domestic and imported varieties and assume the variety pass-through is the same in product category g. As we can see in equation (17), the expenditure share across imported and domestic varieties is assumed to be the same across consumers. Therefore, if we find differential pass-through into the first component of price indices, it captures the differences in ρ_g^z: the variety-level pass-through. Note that

$$\rho_g^z = (1 - \eta_g^z)(1 - \theta_g^z) \tag{18}$$

The variety (product) pass-through is lower for consumers with higher distribution margin or higher markup elasticity. In other words, as consumers shop in different retail stores for the same variety, it captures the heterogeneity in distribution margin or markup elasticity across retailers.

4.2. The Expenditure Channel

The expenditure channel hinges on the fact that consumers consume different varieties within a narrow product category. To the extent that there is heterogeneity in pass-through across varieties in the same product category, the differential expenditure pattern could also result in different pass-through. One example is product quality. It is well know that high income consumers spend more on high quality varieties within a narrow product category. The high quality varieties might have a different pass-through rate than that of lower quality varieties due to differences in distribution margin or markup elasticity. Another example is the size of retailers. Some consumers tend to shop in large retail chains while others prefer small local stores. For example, Faber and Fally (2014) find that high income consumers tend to spend more on products from large firms. The spending pattern might also vary across different markets as some markets are dominated with a few large retailers while others have lots of local retailers to choose from. There is evidence that large firms tend to have a larger markup elasticity, i.e., they adjust their markup more intensively when facing cost shocks, than small firms (Amiti et al, 2019). Therefore, the differences in expenditure patterns across retailers of different size would result in differential pass-through rates as well.

Note that in addition to the above mentioned reasons, the differences in expenditure share across imported versus domestic varieties are also captured in this channel. To see this, denote the second term of equation (13) as $\Delta \ln P_{gt}^{z,2}$ and re-write it as:

$$\begin{aligned}\Delta \ln P_{gt}^{z,2} &= \sum_{v \in g} u_{vt}^{z} \Delta \ln p_{vt}^{r} \\ &= s_{gt}^{z,I} \sum_{v \in g,I} w_{vt}^{z,I} \rho_v \Delta \ln p_{vt}^{T,I} + (1 - s_{gt}^{z,I}) \sum_{v \in g,D} w_{vt}^{z,D} \rho_v \Delta \ln p_{vt}^{T,D} - \Delta \ln P_{gt}\end{aligned} \tag{19}$$

where $s_{gt}^{z,I}$ and $w_{vt}^{z,I}$ are the expenditure share on imported goods of consumer z and the expenditure share on imported variety v within imported varieties respectively. If we regress this component of price indices on a uniform import price index, the coefficient would increase in consumers z's expenditure share on imported varieties.

In other words, the import price has a larger impact on consumers that spend more on imported goods.

Within imported varieties, the differential pass-through is determined by the interaction between variety expenditure share $w_{vt}^{z,I}$ and variety pass-through ρ_v. All the previously mentioned product characteristics including product quality, firm size are captured in this interaction. For example, if consumers spend more on high quality imported goods (higher $w_{vt}^{z,I}$ with v denotes the high quality varieties), and if the pass-through of high quality variety ρ_v is lower, it would lead to overall lower pass-through for this group of consumers.

In any case, if we find the differential effect is significantly positive (negative) through this channel, it suggests this group of consumers spend more on varieties that have higher (lower) pass-through. However, we are unable to identify which product characteristics play a more important role unless we dig deeper into each possibility. Note that the differential pass-through of import prices could also be a result of differential changes in import prices across varieties following the shock, i.e., the interaction of $w_{vt}^{z,I}$ and $\Delta \ln p_{vt}^{T,I}$.

5. Heterogeneity: Evidence

5.1. Consumers with Different Income

To investigate whether the pass-through varies across consumers at different income levels, in the first step, I calculate income-specific consumer price index as in equation (12). I use fixed weights to avoid some endogeneity issue. Note that both the expenditure share on each variety (UPC) and variety-level unit value vary across income groups. I divide households into ten income bins according to their income level. As to household income, I use two measures. The first one is self-reported annual income. The second one is total spending by aggregating transaction-level expenditures in Nielsen data. Both measures are adjusted for household size.[15] I calculate income-specific price index for each product category and ten income groups.[16] Note

[15] The correlation between the two measures is about 0.3.

[16] One can calculate household-level price index. However, as each household consumes a limited number of varieties each period, we lose substantial price information when calculating price changes. For this reason, we calculate group-specific price index.

that households with different income might consumer different bundles of varieties within the same product category. Using the price changes of varieties consumed is equivalent to applying zero weights to unconsumed varieties.

I estimate a reduced form equation on the income-specific price indices to determine the direction of the differential effect, for example, if there is larger impact on low-income vs higher income consumers. Because there are different forces affecting the pass-through and the direction of each force can be contradicting, the overall impact on different consumers is ambiguous in a theoretical perspective. Specifically, I estimate the following equation:

$$\Delta \ln P_{igt} = \alpha + \beta \Delta \ln P_{gt}^{I} + \gamma \Delta \ln P_{gt}^{I} \times D_z + \Delta \ln P_{gt}^{D} + \delta_{zt} + \epsilon_{igt} \tag{20}$$

where $\Delta \ln P_{igt}$ is the log changes in price index of income group i for product g. $\Delta \ln P_{gt}^{I}$ represents import price index of product g. D_z are income dummies. In the baseline, I divide the ten income groups into two categories: high and low income.[17] I add income-time fixed effects to control for other shocks experienced by each income group.

Table 4 reports the regression results based on IV estimation. I use reported income in column 1-2 and total spending in column 3-4. As we can see in column 1-2, the pass-through into consumer prices of lower income is significant higher compared with that of higher income. The magnitude of the difference varies slightly across specifications. Overall, the pass-through into lower income is about 35% to 45% higher than that into higher income. The results are robust to using total spending as income measure.

To dig deeper into the heterogeneity across income groups, I divide the sample into three categories: lower, middle and upper income.[18] Table 5 reports the results for three income categories. As we see, the pass-through into lowest income is significantly higher than that of highest income group. However, according to column 1-2, the pass-through into middle income group is not significantly different from that of highest income. It suggests the differences in pass-through across high and low income groups in previous table are mostly driven by the top and bottom income groups. Using total

[17] I take the top 5 income groups as high income and the remaining 5 as low income

[18] As we cannot split ten income groups into 3 categories of equal size, I assign top 3 income groups as upper income, bottom 3 groups as lower income and the middle 4 groups as middle income.

Table 4: Import Price Pass-Through: Income

	Reported Income		Total Spending	
	(1)	(2)	(3)	(4)
Changes in Import Prices	0.268***	0.289***	0.261***	0.274***
	(0.029)	(0.032)	(0.028)	(0.031)
Imp $\times$ Lower Income	0.115***	0.099***	0.102***	0.095***
	(0.021)	(0.021)	(0.021)	(0.020)
Industrial PPI	0.401***	0.419***	0.441***	0.455***
	(0.035)	(0.030)	(0.036)	(0.030)
Instrument	TPU$\times$*Crisis*	TPU$\times$*News*	TPU$\times$*Crisis*	TPU$\times$*News*
Income*Time FE	Yes	Yes	Yes	Yes
N	61215	61215	61093	61093

Notes: ***p<0.001, **p<0.005, *p<0.01. In all regressions, I use changes in energy prices to instrument for industrial PPI.

spending as income measure in column 3-4, the results are slightly different. Both the pass-through into lower income and middle income is significantly higher than that into higher income. A test of equality shows that there is no significant difference in pass-through between lower and middle income.

The results are robust to using other income measures including the total household income (total spending) without adjusting for household size, household income (total spending) adjusting for size and other demographics. These results are reported in Appendix C.

Table 5: Import Price Pass-Through: 3 Income Categories

	Reported Income		Total Spending	
	(1)	(2)	(3)	(4)
Changes in Import Prices	0.271***	0.289***	0.234***	0.250***
	(0.031)	(0.033)	(0.031)	(0.033)
Imp $\times$ Lower Income	0.131***	0.111***	0.143***	0.127***
	(0.028)	(0.027)	(0.028)	(0.027)
Imp $\times$ Middle Income	0.037	0.039	0.088***	0.083***
	(0.024)	(0.024)	(0.024)	(0.023)
Industrial PPI	0.401***	0.419***	0.442***	0.455***
	(0.035)	(0.030)	(0.036)	(0.030)
Instrument	TPU$\times$*Crisis*	TPU$\times$*News*	TPU$\times$*Crisis*	TPU$\times$*News*
Income*Time FE	Yes	Yes	Yes	Yes
N	61215	61215	61093	61093

Notes: ***p<0.001, **p<0.005, *p<0.01. In all regressions, I use changes in energy prices to instrument for industrial PPI.

To investigate the channels driving the differential pass-through across consumers at different income levels, I decompose the income-specific price index into three components as in equation (13) and run the regressions on different components. Table 6 show the decomposition results using total reported income. As we see in column 1, the variety pass-through is higher for low income consumers but barely significant. The result in column 2 suggests the differential expenditures across varieties with heterogeneous pass-through account for most of the effect. To be more specific, the positive and significant sign before the interaction implies that low income consumers spend more on varieties with higher pass-through compared with high income consumers. One possible explanation is that low income consumers spend more on imported varieties. It is also possible that the relatively low quality varieties low income consumers consume more have higher pass-through rates. Lastly, the positive significant sign on the interaction term (column 3) indicates that the low income consumers spend more on varieties that have disproportionately higher pass-through for low income consumers.

Table 6: Price Decomposition: Income

	(1) Variety Pass-through	(2) Expenditure Patterns	(3) Interaction
Changes in Import Prices	0.268***	0.245***	-0.024***
	(0.022)	(0.021)	(0.005)
Imp $\times$ Lower Income	0.029	0.064***	0.012**
	(0.019)	(0.018)	(0.005)
Industrial PPI	0.604***	0.383***	0.011
	(0.026)	(0.024)	(0.006)
Income*Time FE	Yes	Yes	Yes
N	63050	63050	63050

Notes: ***p<0.001, **p<0.005, *p<0.01. In all regressions, I use TPU*Crisis as instrument for import prices and changes in energy prices to instrument for industrial PPI.

5.2. Consumers at Different Locations

In this section, I investigate whether the import price pass-through into consumer prices varies across locations. A recent literature shows that the differences in prices across locations within countries are driven by both trade costs and markups (Atkin and Donaldson 2015, Hottman 2017). The two factors play an important role in determining the pass-through in our theoretical framework. The consumer prices at different locations could therefore respond differently to price shocks at the dock.

To proceed, I calculate the consumer price index for 50 markets in the US using Nielsen consumer panel, with the price index defined as in equation (12).[19] As in calculating income-specific price indices, we allow for market-specific expenditure shares and unit prices. I focus on two dimensions of locations. The first one is remoteness, which is a proxy for domestic distribution/trade cost. The second is local market competition, which could play an important role in determining markup and markup elasticity. In the following, I discuss how I construct these measures and how each of them could affect pass-through into consumer prices across markets.

First, to capture the remoteness of each location, I construct minimum distance measure using information on each market's distance to ports and port-level imports. To be more specific, I use the weighted average of (log) distance to 3 closest ports:

$$Dist^{w}_{gz} = \sum_{p} \ln d_{zp} \times s_{pg} \tag{21}$$

where d_{zp} is the distance of market z to port p, which is calculated as the fastest route using Google Maps and s_{pg} is the import share of port p of product g. I include 372 sea and land ports in the US and the port-level imports are available through US Census Bureau.[20]

Consumers at relatively remote locations might have different consumption basket from these by the coastline. In particular, they may consume less imported goods as there is higher distribution cost. Moreover, consumer prices of imported goods at remote locations contain larger proportion of non-tradable domestic transportation costs, thus having a higher distribution margin. Both channels could result in a smaller pass-through rate to remote locations.

Second, to measure the competition in local market, I construct Herfindahl-Hirschman Index (HHI) in retail industry for each market using the information on market share of each retailer in Nielsen data. Each transaction in Nielsen data includes

[19]Nielsen defined 52 major scantrack markets with each market contains urban and suburban areas. I combine Suburban New York, Exurban New York and urban New York into one area as New York. Note that according to Nielsen, the sample of households in each market is representative of the whole population in that market.

[20]I dropped ports outside US mainland including those in Hawaii, Virgin Island, Puerto Rico and Alaska.

information on the retail stores and retail chains. I use the latter one to define a retailer as ... There are 849 different retailers in total and the median number of retailers operate in each market-product cell is 46. To test the robustness, I also construct alternative concentration measures using market shares of top 4, 8, 20 retailers following Autor et al (2014). To avoid endogeneity, all concentration measures are constructed using aggregate sales across products.

Models with oligopolistic competition would predict that firm's markup elasticity depends its market share (Atkenson and Burnstein(2008)). Furthermore, using firm-level data, Amiti et al (2018) show that larger firms respond to its own cost shock with elasticity of 0.5, while small firms exhibit complete pass-through. As the import price pass-through varies across firms of different size, it could therefore vary across locations with different size distribution of firms, which is captured by market concentration measures.

Moreover, the remoteness and competition conditions in one market could be correlated. The more remote market might exhibit less competition. Thus, we estimate the following equation:

$$\begin{aligned} \Delta \ln P_{zgt} =& \alpha + \beta \Delta \ln P_{gt}^{I} + \gamma_1 \Delta \ln P_{gt}^{I} \times Dist_{zg} + \gamma_2 \Delta \ln P_{gt}^{I} \times Concentr_{z} \\ &+ \rho \Delta \ln P_{gt}^{D} + \delta_g + \delta_{zt} + \epsilon_{zgt} \end{aligned} \tag{22}$$

where on the left hand side is the changes in market-specific price index of product g for market z. On the right hand side, I add the interactions of changes in import prices with both remoteness and concentration measures. As before, I control for domestic prices through PPI and add product and market-time fixed effects.

Table 7 represents the regression results based IV estimation. For concentration measures, I use Herfindahl index, market shares of top four, eight and twenty retailers respectively in column 1-4. As we see across columns, the remoteness have no impact on the pass-through. One possible explanation is that distribution margin includes not only transportation costs, but also various other costs such as marketing, labor, rent. Some of the costs might work in the opposite direction of transportation costs,thus causing the coefficient to be insignificant.[21]

The concentration in retail industry has a negative and significant effect on the

[21] For example, rent and labor costs might be less expensive in more remote places.

Table 7: Import Price Pass-through across Markets

	(1)	(2)	(3)	(4)
Changes in Import Prices	0.161**	0.160**	0.170**	0.194***
	(0.053)	(0.052)	(0.052)	(0.052)
Imp × $Dist^w$	0.003	0.004	0.003	0.001
	(0.004)	(0.004)	(0.004)	(0.004)
Imp × HHI	-0.020**			
	(0.010)			
Imp × Top 4		-0.014		
		(0.010)		
Imp × Top 8			-0.024**	
			(0.010)	
Imp × Top 20				-0.042***
				(0.010)
Industrial PPI	0.256***	0.256***	0.258***	0.263***
	(0.045)	(0.045)	(0.045)	(0.045)
Market*Time FE	Yes	Yes	Yes	Yes
N	298639	298639	298639	298639

Notes: ***p<0.01, **p<0.05, *p<0.1. In all regressions, I use TPU*Crisis as an instrument for import prices and changes in energy prices to instrument for industrial PPI.

pass-through rate, suggesting that the pass-through to more concentrated market is lower. To explain it, consider the previously mentioned findings that cost pass-through is lower for larger firms. The more concentrated market is dominated with a few large retailers which generally have lower pass-through, thus making the average pass-through lower for that market.

I repeat the price decomposition exercise for markets. Table 8 shows the decomposition results. As we see, the variety pass-through is not significantly different across market with different concentration levels, while the differential expenditure patterns across markets explains all of the differential effect. The negative and significant sign before the interaction term in column 2 suggests that consumers in more concentrated markets tend to spend more on varieties that have lower pass-through. It is consistent with the fact that large retailers have lower pass-through and consumers in more concentrated markets tend to spend more on varieties from large retailers.

Table 8: Price Decomposition: Markets

	(1) Variety Pass-through	(2) Expenditure Patterns	(3) Interaction
Changes in Import Prices	0.172***	0.033	-0.052
	(0.042)	(0.034)	(0.028)
Imp $\times$ Dist^w	0.002	0.005*	0.002
	(0.003)	(0.003)	(0.002)
Imp $\times$ HHI	0.003	-0.022***	0.000
	(0.006)	(0.005)	(0.004)
Industrial PPI	0.927***	0.065**	-0.003
	(0.027)	(0.022)	(0.018)
Market*Time FE	Yes	Yes	Yes
N	347400	347400	347400

Notes: ***p<0.001, **p<0.005, *p<0.01. In all regressions, I use TPU*Crisis as an instrument for import prices and changes in energy prices to instrument for industrial PPI.

6. Consumer Welfare: the Impact of Imported Varieties

New trade models predict that an important source of welfare gains from trade is the access to more imported varieties. For example, using disaggregated import data, Broda and Weinstein (2006) show that the imported varieties increased by threefold and lowered the exact price index by 28 percent during 1972-2001. On the flip side, the increase in trade barriers could possibly decrease the availability of varieties to consumers, thus causing welfare loss. Indeed, Amiti et al (2019) find that the US import tariffs in recent trade war have led to a sharp decline in number of imported varieties. Then how would the changes in imported varieties affect the number of varieties in consumption basket and what is the implication for consumer welfare?

To account for the changes in varieties on consumer welfare, Feenstra (1994) developed a exact price index which is composed of two components. The first one is the price changes of continuing varieties, which has been used to estimate the import price pass-through. The second one is the "variety" component, which captures the entry and exit of varieties. The impact of of trade policy shocks on consumers therefore depends not only on the pass-through of import prices to the consumer prices of continuing varieties, but also on the effect of changes in imported varieties on the availability of consumption varieties.

Specifically, the exact price index for product g can be written as follows:

$$\Delta \ln P^E_{gt} = \underbrace{\sum_{v \in \bar{\Omega}_g} w_{vt} \Delta \ln p^r_{vt}}_{\Delta \ln P^R_{gt}} + \underbrace{\frac{1}{\sigma - 1} \Delta \ln \lambda_{gt}}_{VA_{gt}} \tag{23}$$

where the first term is a weighted average of changes in retail prices, while the second term contains the (log) changes in expenditure share λ_{gt}. To be more specific, λ_{gt} is the expenditure share on continuing varieties of product category g at time t. An increase in λ_{gt} indicates less expenditures on new varieties (or less entry) at time t, thus lowering consumer welfare by pushing up the consumer price index. Similarly, an decrease λ_{gt-1} indicates more expenditures on exiting varieties (or more exit) at time $t-1$, which also increases the price index. Elasticity of substitution σ captures how the changes in expenditures would affect consumers in a CES setting.

Now let's focus on the second term, specially the expenditure share on common varieties, and explore how it can be affected by the entry and exit of imported varieties. Note that the expenditure share on continuing varieties at time $t-1$ can be written as:

$$\lambda_{gt-1} = \frac{\sum_{v \in \bar{\Omega}_{gt-1}} p^r_{vt-1} q_{vt-1}}{\sum_{v \in \bar{\Omega}_{gt-1}} p^r_{vt-1} q_{vt-1} + \sum_{v \in \Omega^{exit}_{gt-1}} p^r_{vt-1} q_{vt-1}} \tag{24}$$

where p^r_{vt-1} is the retail price of variety v at time $t-1$ and q_{vt-1} is the corresponding quantity. The numerator are the expenditures on varieties that exist in both t and $t-1$, while the denominator are all expenditures on product group g at time $t-1$, which equals to the sum of expenditures on continuing and exiting varieties.

Assuming consumers have CES preference across varieties and write the retail price as a function of import prices, I have the following equation:

$$\chi^{exit}_{gt-1} = s^{I,\Omega}_{gt-1} \times \chi^{exit,imp}_{gt-1} + (1 - s^{I,\Omega}_{gt-1}) \times \chi^{exit,d}_{gt-1} \tag{25}$$

where χ^{exit}_{gt-1} on the LHS represents the consumer expenditure share on exiting varieties relative to common varieties at $t-1$:

$$\chi^{exit}_{gt-1} = \frac{\sum_{v\in\Omega^{exit}_{gt-1}} {p^{r}_{vt-1}}^{1-\sigma}}{\sum_{v\in\bar{\Omega}_{gt-1}} {p^{r}_{vt-1}}^{1-\sigma}} \tag{26}$$

It is a weighted sum of expenditure share on exiting imported varieties and exiting domestic varieties and the weight $s^{I,\Omega}_{gt}$ is the expenditure share on imported continuing varieties relative to all continuing varieties. Note that $\chi^{exit,imp}_{gt-1}$ is the consumers' expenditure share on exiting imported varieties and can be written as:

$$\chi^{exit,imp}_{gt-1} = \frac{\sum_{v\in\Omega^{exit,imp}_{gt-1}} {p^{T}_{vt-1}}^{(1-\sigma)(1-\eta)}}{\sum_{v\in\bar{\Omega}^{imp}_{gt-1}} {p^{T}_{vt-1}}^{(1-\sigma)(1-\eta)}} \tag{27}$$

When $\eta = 0$ (no distribution margin), it equals to the import expenditure share on exiting varieties. The distribution margin parameter η adds curvature in that equation and governs how much the changes in imported varieties affected consumer welfare.[22]

As equation (25) makes clear, the import expenditure on exiting varieties has a positive impact on consumption expenditure share on exiting varieties at time $t-1$. The magnitude of impact depends on the import share in this product category and the cost share of distributional services. Similarly, we have a relationship between import expenditure on new varieties and the consumption expenditure share on new varieties at time t:

$$\chi^{new}_{gt} = s^{I,\Omega}_{gt} \times \chi^{new,imp}_{gt} + (1 - s^{I,\Omega}_{gt}) \times \chi^{new,d}_{gt} \tag{28}$$

To estimate the impact of changes in imported varieties on consumer welfare, I take equation (25) and (28) into data. On the left hand side, we have the consumption expenditure share on new and exiting varieties, which can be obtained from Nielsen data. Here I define a variety as a brand-module combination to capture the entry or exit of firm-products, which is more consistent with the definition of imported

[22] Note that when $\eta = 1$, $\chi^{new,imp}_{gt} = 1$, which means the changes in imported varieties have no impact on consumer welfare.

varieties (HS10-Country).[23] A variety is "new" if it does not exist in base period and exists in period t, where the base period is the corresponding quarter of 2004. On the right hand side, we have the import expenditure share on new (exiting) varieties. I proxy this term by the number of new and existing HS10-country. To address the endogeneity of changes in imported varieties, I again instrument it with changes in TPU. Here I focus on estimating the effect of variety exit on consumer welfare as it is possibly the main channel the increasing trade barriers affected number of varieties. The estimation results on effect of new varieties is reported in Appendix B.

Table 9: The Impact of Exiting Imported Varieties

	num^R_{exit}		$\ln \chi^{exit}_{gt-1}$	
	OLS	IV	OLS	IV
num^I_{exit}	0.461***	2.570***	0.004**	0.056***
	(0.066)	(0.393)	(0.002)	(0.011)
First-stage F		94.21		82.79
Product FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
N	7602	7350	7292	7040

Notes: ***p<0.001, **p<0.005, *p<0.01. In IV regressions, I use TPU*Crisis as an instrument for the number of exited varieties.

Table 9 shows the impact of exiting imported varieties. I use the number of exiting varieties in consumption basket as dependent variable in the first two columns. As expected, the number of exiting imported varieties has a positive and significant effect on the number of varieties exiting the consumption basket in both OLS and IV estimation. Note that the high first-stage F indicates that changes in TPU has a significant impact on the exit of imported varieties during the GTC. In addition, consistent with our prediction in equation (25), the number of exiting imported varieties also has a significantly positive impact on the consumption expenditures on exiting varieties (column 3 and 4). It suggests the exiting of imported varieties leads an increase in the exact consumer price index, thus causing additional welfare loss. As to the magnitude, if the number of exiting varieties increases from 25th to 75th percentile, the expenditure on exiting varieties at $t-1$ would increase 1.06 (0.056*19) according to our IV estimate. If we hold the entry margin fixed and assume $\sigma = 7.5$, which is the

[23] Moreover, if we define a variety at the UPC-level, it would capture the introduction of new products of multi-product firms.

estimated elasticity of substitution across brand-modules within a product group by Broda and Weinstein (2010), the consumer price index for a given product would be 2.1 percent larger.

The impact of imported varieties can also vary across consumers. To see this, note that in equation (25) and (28), not only the expenditure share on imported varieties $s_{gt}^{I,\Omega}$ is consumer-specific, the expenditure on new (exiting) varieties within imported varieties $\chi_{gt}^{new,imp}$ ($\chi_{gt}^{exit,imp}$) could be heterogeneous as well. If one group of consumers consumes more of imported varieties and/or the new or exited imported varieties are more skewed to one group of consumers, the impact of imported varieties would be larger. Table 10 reports the impact of the exit and entry of imported varieties across income and all results are based on IV estimation with TPU-crisis as instrumental variable. The first two columns focus on the exit margin. As we see, the number of exiting imported varieties has a larger impact on the lower income (column 1), and a slightly larger impact on expenditures and consumer welfare (column 2). Table A8 reports the result using log number of varieties.

Across markets, the number of exiting of imported varieties has a smaller impact on the number of consumption varieties in more remote markets and have a larger impact on the more concentrated markets. However, the impact of the exiting imported varieties on expenditure share and consumer welfare is not significantly different across markets. The results are reported in Appendix B.

7. Quantification Exercises

The goal of the exercise to assess the effect of trade war on consumer prices and its heterogeneous impact across income levels and regions. Suppose US imposes a 25% tariff on all consumer goods from China, which is highly likely as the Trump Administration already imposes 15% tariffs on 125 billion imports from China that includes considerable amount of consumer goods starting Sep 4, 2019 and threatens to increase these tariffs further.

Based on recent findings of complete tariff pass-through into import prices during the trade war (Amiti et al (2019); Fajgelbaum et al (2019)), I take the tariff changes as the changes in import prices. Therefore, the log changes in import prices of product g

Table 10: The Impact of Imported Varieties across Income

	Exit		Entry	
	num^R_{exit}	$\ln \chi^{exit}_{gt-1}$	num^R_{new}	$\ln \chi^{new}_{gt}$
num^I_{exit}	0.896***	0.040***		
	(0.061)	(0.005)		
$num^I_{exit} \times$ Lower Income	0.075***	0.003***		
	(0.010)	(0.000)		
num^I_{new}			-7.218**	-0.272*
			(2.521)	(0.138)
$num^I_{new} \times$ Lower Income			-0.109**	-0.001
			(0.035)	(0.001)
Product FE	Yes	Yes	Yes	Yes
Income*Time FE	Yes	Yes	Yes	Yes
N	72712	69295	72712	69290

Notes: ***p<0.001, **p<0.005, *p<0.01. In all regressions, I use TPU*Crisis as an instrument for number of exited or new varieties.

at period t are:

$$\Delta \ln P^T_{gt} = \sum_i w_{ig} \Delta \ln P^T_{igt} \tag{29}$$

Assuming the import prices from the unaffected countries constant, the increase in import prices of product g equals to the share of imports from China times the increase in prices of Chinese imports.[24] For the expenditure share on Chinese imports of all imports, I use the average expenditure share on Chinese imports among Nielsen goods, which is 0.185. Thus, the import prices of affected products increase 4% on average.

Table 11: Increases in Consumer Prices in response to Tariffs

	(1)	(2)	(3)
	Aggregate Prices	Lower Income	Higher Income
Changes in Consumer Prices	1.2%	1.53%	1.07%
Adjusted for Domestic Prices	2.65%	2.69%	2.23%
Estimated Pass-Through Rate	0.3	0.38	0.27

Notes: The estimated pass-through rates are based on regressions using TPU*Crisis as instruments. The increases in domestic prices are calculated using a pass-through rate of 0.5.

[24]Note that the tariff-inclusive import price of product g from country i is $P^T_{igt} = (1 + \tau_{igt})P^*_{igt}$, where P^*_{igt} is the price exporters charge. Thus $\Delta \ln P^T_{igt} = \ln(1 + \tau_{igt})$, if we assume complete pass-through and zero tariffs at base period.

From our estimates, the pass-through from an increase in import price to aggregate consumer prices is about 0.3-0.4. If we further assume the prices of domestic goods g and prices of non-tradables are constant, the log changes in consumer prices of product g are given by $\Delta \ln P_{gt} = \theta \Delta \ln P^T_{gt}$, which are a product of pass-through and changes in import prices. For an average product with a 4% increase in import prices, the increase in consumer prices ranges from roughly 1.2% to 1.6%.

Note that we are underestimating the impact as we assume the prices of imports from other countries and domestic prices constant. Domestic prices and import prices from other countries of the affected products could increase as consumers switch away from Chinese imports. Further, domestic price could also increase because of Input-Output linkages. That is, production of domestic goods uses intermediate inputs that are subject to import tariffs. In fact, Fajgelbaum et al (2019) find a positive relationship between domestic PPI and import tariffs, indicating the higher tariffs induced an increase in domestic prices.[25] If we take the elasticity they estimate (0.13), a 25% increase in tariffs would lead to a 2.9% increase in domestic prices. Multiplying it with the estimated domestic price pass-through (about 0.5), it would result in an additional 1.45% increase in consumer price index. Adding it together, the consumer prices of affected goods would increase by 2.65% to 3.05% on average.

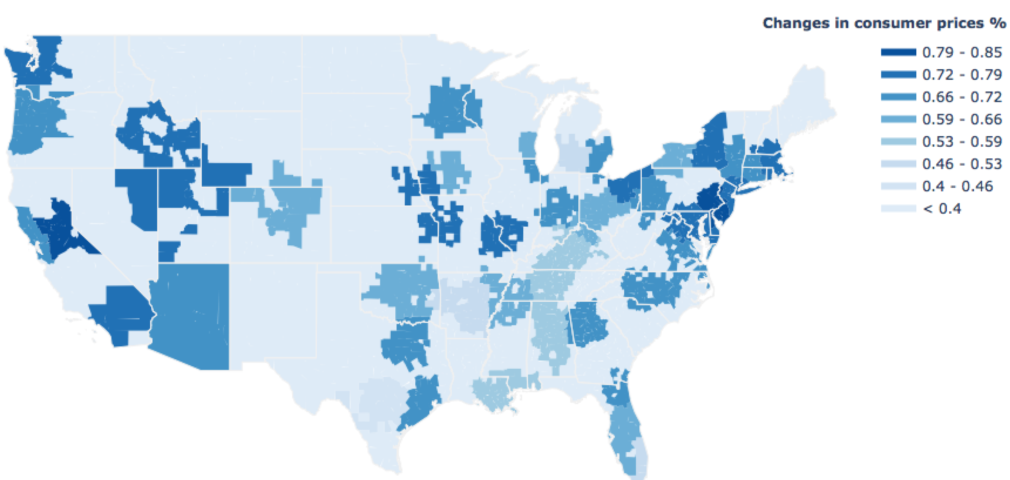

Figure 2: Changes in Consumer Prices across US markets

[25] Amiti et al (2019) has similar findings by distinguishing between input tariffs and output tariffs.

To see how the increases in import prices translate to differential changes in consumer prices, I apply the estimates of consumer-specific pass-through rates. I find that a 25% tariff leads to a 1.53% increase in consumer prices for lower income households and a 1.07% increase for higher income households. If we take into account the increase in domestic prices, the numbers become to 2.69% for low income and 2.23% for high income.

Figure 2 shows the impact of trade war on consumer prices across markets, where the darker color represents a larger increase in consumer prices.[26] As we see, consumers in large cities of the Northeast region and Western Coast experienced larger increases in consumer prices, while consumers in the South received the least impact. Meanwhile, the Mountain West and Midwest experienced modest increases in consumer prices. The differential effects are mostly driven by the differences in retail industry concentration across markets. That is, the large cities usually have more competitive retail market while small cities have less competition in retail industries.

Using a general equilibrium quantitative model, Fajgelbaum et al (2019) estimate that prices of tradable goods increased 1.5% on average during the trade war, which is consistent with our estimates before taking into account of domestic prices. Across different regions, they find that counties in Rust Belt and Southeast experienced relatively large increase in nominal wages in tradable sector. However, according to my estimates, some of the Rust Belt cities such as Pittsburgh, Detroit and Baltimore have relatively high pass-through rates and therefore experience larger increases in cost of living during the trade war. The real wages in this region might be lower if taking into account the heterogeneous price effects across locations.

8. Conclusion

This paper examines how did the changes in import prices caused by trade policy shock transmit to consumers during the GTC. By exploiting the exogeneous variations in trade policy uncertainty across industries, I estimate that the import price pass-through ranges from 0.3-0.4 after using TPU as an instrument for import prices. Furthermore, I find the pass-through is heterogeneous across consumers. The pass-

[26] The increases in consumer prices for each market is reported in Appendix.

through is higher for consumers with lower income and at less concentrated markets. The results are robust to using alternative income and concentration measures.

To explain the incomplete pass-through and its heterogeneity, I develop a theoretical framework linking import prices and consumer prices following Burstein and Gopinath (2014) and extend it to allow heterogeneity in consumers. The incomplete pass-through could arise both from the non-tradable distribution margin and variable markups in distribution sector. I construct a consumer-specific price index by allowing for the differences in both expenditure shares and variety-level retail prices. I distinguish two channels that could cause differential pass-through. The first one captures that fact that consumers shop in different retail outlets for the same variety (UPC) and thus face differential retail price adjustment following an import price shock. The second channel focuses on the different expenditure shares across varieties and heterogeneous pass-through across varieties within a narrow product category.

I then explore the underlying mechanisms that drive the differential pass-through across consumers. A price decomposition shows that for consumers with different income, both variety pass-through and differential expenditure shares contribute to the higher pass-through into consumer prices of lower income, with the latter plays a more important role. For consumer prices across markets with different concentration, the variety pass-through is not significantly different across markets. However, consumers in more concentrated markets spend more on varieties with lower pass-through.

The impact of trade policy shocks on consumers not only depends on the price changes of continuing varieties, but also the availability of imported goods. To account for the changes in imported varieties on consumer welfare, I derive a relationship between the variety component of exact price index and the entry and exit of imported varieties. Empirically, I show that the number of exiting imported varieties has a significantly negative impact on the expenditures on common varieties at $t-1$, thus leading to an increase in the exact price index. If the number of exiting varieties increases from 25 percentile to 75 percentile, the consumer price index for a given product would be 2.1 percent larger. The impact of imported varieties, especially the exit of imported varieties, is slight larger for low income consumers and does not vary across markets.

In the last part, I provide a quantification on the effect of trade war on consumer prices based on my estimates. I find that the consumer prices are estimated to increase

1.2% to 1.6% in response to 25% tariffs on Chinese imports of consumer goods. In addition, I find that a 25% tariffs lead to 1.53% increase in consumer prices for lower income households and 1.07% increase for higher income households. Across locations, consumers in big cities of the Northeast and Western Coast experienced larger increase in consumer prices, while consumers in the South received the least impact.

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A. TPU and Import Prices

In this section, I examine the effect of trade policy uncertainty (TPU) shock on import prices during the GTC. Recent literature documents that TPU affected imports and import prices. In particular, Handley and Limão (2017) show that the import prices from China decreased more in industries with higher initial TPU during China's accession to WTO.

Following their work, I exploit the variations in changes in TPU across industries. As shown in Figure 1, trade policy uncertainty in general increased during the crisis. More importantly, there is heterogeneity in TPU across industries because the potential threat tariffs are product-specific. Handley and Limão (2017) model trade policy uncertainty by allowing for three policy states: high, low and intermediate. The intermediate state is characterized by tariffs between high and low protection and that could change to either states with some probability. In our empirical setting, the trade policy was in intermediate state, specifically, low protection state (MFN tariff), before the crisis. The arrival of the crisis indicates an increase in probability of changing into high protection state, i.e, non-cooperative import tariffs.[27] We can therefore measure the increase in TPU each industry experienced during the crisis using the differences in MFN tariffs and non-cooperative tariffs (Column 2). Specifically, we define TPU for industry i as the following:

$$TPU_i = 1 - (\frac{\tau_2^i}{\tau_m^i})^{-\sigma} \tag{30}$$

where τ_2^i and τ_m^i are Column 2 and MFN tariff for industry i respectively. In the baseline, I define an industry at the HS6-digit level and the industrial tariffs are the average of tariffs across HS8s within that industry. According to Handley and Limão(2017), in a standard trade model with TPU, it represents the potential profit loss if high protection state realizes.[28]

The definition of the import price index follows Feenstra(1994) and Broda and

[27] In Handley and Limão(2017), when at the intermediate state, tariffs could change with probability γ, with λ to high protection and $1-\lambda$ to low protection state. In our empirical application, the intermediate state has tariff levels that are equal to low protection state. Thus, the probabilities of changing tariffs (γ) and changing to high protection (λ) are equivalent.

[28] In the empirical analysis, I use σ=3 following Handley and Limão(2017).

Weinstein(2006) and is specified as follows:

$$\Delta \ln P_{ict} = \sum_{\omega \in \bar{\Omega}_{ic}} w_t(\omega) \Delta \ln p_t(\omega) + \frac{1}{\sigma - 1} \ln \frac{\lambda_{ict}}{\lambda_{ict-1}} \tag{31}$$

where $\ln P_{ict}$ is the log import price index of product i from country c at time t. The first component on the RHS is a weighted average of price changes of continuing varieties in that product-country cell, with sato-vatia weight w_t which takes into account of the substitution across periods. $\Delta \ln p_t(\omega)$ is the log changes in variety-level prices and a variety is defined as a HS10-country combination. The second component accounts for the entry and exit of varieties, where λ_{ict} is the expenditure share of continuing varieties in all varieties at period t. Thus, the variety component increases as more varieties exit (lower λ_{ict-1}) or less varieties enter (higher λ_t).

To calculate the import price index, I use US quarterly import data from 68 countries during 2004Q1-2011Q4.[29] The sample includes all US major trading partners and imports from these countries account for more than 85% of all imports in 2004. The list of countries is in Appendix.

I estimate the effect of TPU on import prices by the following equation:

$$\begin{aligned} \Delta \ln P_{ict} = & \beta_1 Crisis_t \times TPU_i + \beta_2 Crisis_t \times TPU_i \times PTA_{ct} + \\ & \beta_3 TPU_i \times PTA_{ct} + \beta_4 TPU_i + \delta_{ct} + \varepsilon_{ict} \end{aligned} \tag{32}$$

where $\Delta \ln P_{ict}$ is the changes in import prices relative to the corresponding quarter in 2004. $Crisis_t$ is a dummy variable that equals to one for periods during 2008Q4-2011Q4, and equals to zero otherwise. I control for country-specific supply shocks using country by time fixed effects (δ_{ct}). I also divide exporting countries into PTA and non-PTA countries based on whether or not it has a Preferential Trade Agreement (PTA) with the United States. As shown by Carballo et al (2018), credible trade agreement could potentially reduce TPU as it provides extra commitment to trade policy relative to WTO.

Table A1 represents the baseline results, where I use import price index defined at HS6-country level.[30] The first two columns use the price changes of continuing vari-

[29] The data is publicly available through US Census Bureau.

[30] Due to the measurement error in unit values, I trim observations with values that fall outside of median+/-3IQR range. These outliers account for about 3% of all observations.

Table A1: TPU and Import Prices

	Continuing		Varieties		Aggregate	
	(1)	(2)	(3)	(4)	(5)	(6)
TPU×Crisis	-0.072***	-0.068***	0.019***	0.015***	-0.053***	-0.052***
	(0.010)	(0.010)	(0.004)	(0.004)	(0.011)	(0.011)
TPU	-0.014*		0.005**		-0.009	
	(0.006)		(0.002)		(0.007)	
TPU×Crisis×PTA	-0.033	-0.027	-0.001	0.001	-0.034	-0.026
	(0.021)	(0.020)	(0.008)	(0.007)	(0.022)	(0.021)
TPU×PTA	0.015	0.011	-0.004	-0.004	0.010	0.007
	(0.013)	(0.013)	(0.004)	(0.005)	(0.013)	(0.014)
Country*Time FE	Yes	Yes	Yes	Yes	Yes	Yes
HS6 FE	No	Yes	No	Yes	No	Yes
N	795590	795573	795590	795573	795590	795573
R-Squared	0.018	0.048	0.005	0.050	0.017	0.049

Table A2: TPU and Import Prices: Matched Sample with Nielsen

	Continuing		Varieties		Aggregate	
	(1)	(2)	(3)	(4)	(5)	(6)
TPU×Crisis	-0.050**	-0.057***	0.015*	0.013*	-0.035*	-0.045**
	(0.016)	(0.016)	(0.006)	(0.006)	(0.017)	(0.017)
TPU	0.031**		0.004		0.035***	
	(0.010)		(0.003)		(0.010)	
TPU×Crisis×PTA	-0.017	-0.012	-0.022	-0.019	-0.040	-0.031
	(0.033)	(0.032)	(0.014)	(0.013)	(0.035)	(0.035)
TPU×PTA	0.061**	0.057**	-0.004	-0.009	0.057**	0.048*
	(0.020)	(0.021)	(0.008)	(0.008)	(0.021)	(0.022)
Country*Time FE	Yes	Yes	Yes	Yes	Yes	Yes
HS6 FE	No	Yes	No	Yes	No	Yes
N	255750	255749	255750	255749	255750	255749
R-Squared	0.027	0.050	0.011	0.064	0.026	0.054

eties as dependent variable. From the first column, we see that TPU has a significantly negative effect on import prices of continuing varieties during the crisis. The significant negative sign before TPU_i indicates that TPU had a negative effect even before the crisis. In addition, there is no significant difference between PTA and non-PTA countries in terms of the impact of TPU. In Column 2, I control for product-specific trend using fixed effect, and the results are similar.

To explain the negative effects, note that a variety is defined as a HS10-country combination. If the increased TPU induced less productive (potentially higher priced) firms to exit within the product-country category, the (average) unit value for the variety could be lower as the remaining firms are more productive and charging lower prices. In addition to the exit effect, it is possible that firms temporarily lowered their prices when facing higher TPU during the crisis with the expectation that TPU would decrease after the crisis.

Column 3-4 use the variety component as dependent variable. As we see in column 3, β_1 is positive and significant, implying that in industries with higher TPU, there were more varieties exit and/or less varieties entry during the crisis. This is consistent with the theory that higher TPU would deter export entry if there is sunk entry cost. When adding the two component of price indices, the overall effect of TPU is negative as the price effect of continuing varieties outweigh the variety exit effect (column 5 and 6).

The results are robust when we use a matched sample of HS6s with Nielsen (Table A2). Products in Nielsen are mostly consumer packaged goods and constitute about one fifth of all import value. As we can see in Table A2, the magnitude of negative effect is slightly smaller and the signs and significance are the same with that in Table 1 except that the effect of TPU is positive before the crisis. I also do robustness checks using HS4 by country import price index. The results are reported in Appendix.

Because Crisis dummy hardly capture the variations in TPU over time, I replace it with the News-based TPU index as depicted in Figure 1. The regression results are reported in Table A3. For news index, I normalize it to have mean zero and standard deviation of one. As we see, the results are similar to the specifications that use Crisis dummy. Table A4 provide robustness checks at the HS-4 industrial level.

In sum, I find that TPU has a negative impact on import prices during the GTC. In particular, industries that experienced larger increase in TPU have lower import prices

Table A3: TPU and Import Prices: News-Based TPU Index

	Continuing		Varieties		Aggregate	
	(1)	(2)	(3)	(4)	(5)	(6)
TPU×News	-0.026***	-0.025***	0.005*	0.004	-0.022***	-0.022***
	(0.005)	(0.005)	(0.002)	(0.002)	(0.006)	(0.006)
TPU	-0.046***		0.013***		-0.032***	
	(0.005)		(0.002)		(0.005)	
TPU×News×PTA	0.000	0.001	-0.001	0.000	-0.001	0.001
	(0.011)	(0.011)	(0.004)	(0.004)	(0.012)	(0.011)
TPU×PTA	-0.001	-0.002	-0.005	-0.004	-0.005	-0.005
	(0.010)	(0.011)	(0.004)	(0.004)	(0.011)	(0.012)
Country*Time FE	Yes	Yes	Yes	Yes	Yes	Yes
HS6 FE	No	Yes	No	Yes	No	Yes
N	795590	795573	795590	795573	795590	795573
R-Squared	0.018	0.048	0.005	0.050	0.017	0.049

Table A4: TPU and Import Prices: HS4 by Country

	Continuing		Varieties		Aggregate	
	(1)	(2)	(3)	(4)	(5)	(6)
TPU×Crisis	-0.086***	-0.082***	0.014	0.009	-0.072***	-0.073***
	(0.012)	(0.012)	(0.008)	(0.008)	(0.015)	(0.014)
TPU	-0.025**		-0.007		-0.031***	
	(0.007)		(0.004)		(0.009)	
TPU×Crisis×PTA	0.019	0.024	0.011	0.016	0.030	0.039
	(0.027)	(0.026)	(0.017)	(0.016)	(0.032)	(0.030)
TPU×PTA	-0.020	-0.025	-0.009	-0.008	-0.028	-0.033
	(0.017)	(0.017)	(0.009)	(0.009)	(0.019)	(0.019)
Country*Time FE	Yes	Yes	Yes	Yes	Yes	Yes
HS4 FE	No	Yes	No	Yes	No	Yes
N	400226	400223	400226	400223	400226	400223
R-squared	0.028	0.054	0.009	0.055	0.024	0.054

for continuing varieties and less variety entry.

B. Consumer Welfare: the Impact of Imported Varieties

In the section, I show the detailed derivation of estimation equation (25) and (28) and other regression results in consumer welfare part.

B.1. Theoretical Derivation

Note that the expenditure share on continuing varieties at time t can be written as:

$$\lambda_{gt} = \frac{\sum_{v \in \bar{\Omega}_{gt}} p^r_{vt} q_{vt}}{\sum_{v \in \bar{\Omega}_{gt}} p^r_{vt} q_{vt} + \sum_{v \in \Omega^{new}_{gt}} p^r_{vt} q_{vt}} \tag{33}$$

where p^r_{vt} is the retail price of variety v and q_{vt} is the corresponding quantity. The numerator are the expenditures on varieties that exist in both t and $t-1$, while the denominator are all expenditures on product group g at time t, which equals to the sum of expenditures on continuing and new varieties. Assume consumers have CES preference on varieties within product group g, the above equation can be rewritten as:

$$\ln \lambda_{gt} = -\ln\left(1 + \chi^{new}_{gt}\right) \tag{34}$$

where χ^{new}_{gt} represents the consumer expenditure share on new varieties relative to common varieties:

$$\chi^{new}_{gt} = \frac{\sum_{v \in \Omega^{new}_{gt}} {p^r_{vt}}^{1-\sigma}}{\sum_{v \in \bar{\Omega}_{gt}} {p^r_{vt}}^{1-\sigma}} \tag{35}$$

Note that the expenditure share on new varieties is a weighted sum of expenditure share on new domestic and imported varieties:

$$\chi^{new}_{gt} = s^{I,\Omega}_{gt} \times \chi^{new,imp}_{gt} + (1 - s^{I,\Omega}_{gt}) \times \chi^{new,d}_{gt} \tag{36}$$

where $s_{gt}^{I,\Omega}$ is the expenditure share on imported continuing varieties relative to all continuing varieties and $\chi_{gt}^{new,imp}$ is the consumers' expenditure share on new imported varieties relative to continuing imported varieties.

Remember that the retail price of variety v can be written as a function of import price of variety v:

$$p_{vt}^{r} = p_{vt}^{T\,(1-\eta_v)} p_t^{N\,\eta_v} \gamma_{vt} \tag{37}$$

Plug in, the consumers' expenditure share on new imported varieties can be written as:

$$\chi_{gt}^{new,imp} = \frac{\sum_{v\in\Omega_{gt}^{new,imp}} p_{vt}^{T\,(1-\sigma)(1-\eta)}}{\sum_{v\in\bar{\Omega}_{gt}^{imp}} p_{vt}^{T\,(1-\sigma)(1-\eta)}} \tag{38}$$

Here I assume the distribution margin η and markup γ doesn't vary across varieties in one product group. When $\eta = 0$ (no distribution margin), it equals to the import expenditure share on new varieties:

$$\chi_{gt}^{new,imp} = \frac{\sum_{v\in\Omega_{gt}^{new,imp}} p_{vt}^{T\,(1-\sigma)}}{\sum_{v\in\bar{\Omega}_{gt}^{imp}} p_{vt}^{T\,(1-\sigma)}} \tag{39}$$

The distribution margin parameter η adds curvature in that equation and governs how much the changes in varieties in import data affected consumer welfare.[31]

As equation (36) makes clear, the import expenditure on new varieties has a positive impact on consumption expenditure share on new varieties at time t. The magnitude of impact depends on the import share in this product category and the cost share of distributional services. Similarly, we have a relationship between import expenditure on exiting varieties and the consumption expenditure share on exiting varieties at time $t-1$:

$$\chi_{gt}^{exit} = s_{gt}^{I,\Omega} \times \chi_{gt}^{exit,imp} + (1 - s_{gt}^{I,\Omega}) \times \chi_{gt}^{exit,d} \tag{40}$$

[31]Note that when $\eta = 1$, $\chi_{gt}^{new,imp} = 1$, which means the changes in imported varieties have no impact on consumer welfare.

B.2. Empirical Results

Table A5: The Impact of New Imported Varieties

	num_{new}^{R}		$\ln \chi_{gt}^{new}$	
	OLS	IV	OLS	IV
num_{new}^{I}	0.976***	-25.363	0.006***	-0.100
	(0.177)	(21.098)	(0.002)	(0.169)
First-stage F		1.65		0.87
Product FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
N	7602	7350	7288	7036

Table A5 shows the impact of new imported varieties. In the first two columns, I use the number of new varieties in consumption basket as dependent variable. As we see in column 1, the number of new imported varieties has a positive and significant impact on number of new consumption varieties. However, we have the weak instrument issue with IV estimation (low first-stage F statistics) possibly because the changes in TPU had little impact on the number of new imported varieties during the GTC. In column (3) and (4), I use (log) consumption expenditure share on new varieties as dependent variable. Consistent with our prediction, the OLS estimation gives positive and significant sign. But the IV estimation has the same problem as before.

Table A6: The Impact of New Imported Varieties: $\ln(num)$

	$\ln num_{new}^{R}$		$\ln \chi_{gt}^{new}$	
	OLS	IV	OLS	IV
$\ln num_{new}^{I}$	0.007	0.985***	0.014	2.656***
	(0.009)	(0.171)	(0.036)	(0.307)
First-stage F		64.94		94.32
Product FE	Yes	No	Yes	No
Time FE	Yes	Yes	Yes	Yes
N	7602	7350	7288	7038

Table A9 reports the differential impact across markets. As we see in column 1, the exits of imported varieties have a smaller impact on the number of consumption varieties for more remote places and have a larger impact on the more concentrated markets. It is possibly due to the fact that the more remote places consume less

Table A7: The Impact of Exiting Imported Varieties: $\ln(num)$

	$\ln num^R_{exit}$		$\ln \chi^{exit}_{gt-1}$	
	OLS	IV	OLS	IV
$\ln num^I_{exit}$	0.032***	0.329**	-0.002	1.853***
	(0.009)	(0.119)	(0.040)	(0.210)
First-stage F		116.17		97.52
Product FE	Yes	No	Yes	No
Time FE	Yes	Yes	Yes	Yes
N	7602	7350	7292	7040

Table A8: The Impact of Imported Varieties across Income: $\ln(num)$

	Exit		Entry	
	$\ln num^R_{exit}$	$\ln \chi^{exit}_{gt-1}$	num^R_{new}	$\ln \chi^{new}_{gt}$
$\ln num^I_{exit}$	0.480***	2.471***		
	(0.035)	(0.097)		
$\ln num^I_{exit} \times$ Lower Income	0.023**	0.043*		
	(0.009)	(0.019)		
$\ln num^I_{new}$			0.876***	2.698***
			(0.049)	(0.109)
$\ln num^I_{new} \times$ Lower Income			0.012	0.001
			(0.010)	(0.021)
Income*Time FE	Yes	Yes	Yes	Yes
N	72712	69295	72712	69290

Table A9: The Impact of Imported Varieties across Markets

	Exit		Entry	
	num^R_{exit}	$\ln \chi^{exit}_{gt-1}$	num^R_{new}	$\ln \chi^{new}_{gt}$
num^I_{exit}	0.359***	-0.007		
	(0.024)	(0.005)		
$\text{num}^I_{exit} \times$ Dist	-0.018***	0.000		
	(0.002)	(0.000)		
$\text{num}^I_{exit} \times$ HHI	0.016***	-0.001		
	(0.004)	(0.001)		
num^I_{new}			0.705***	0.323***
			(0.044)	(0.013)
$\text{num}^I_{new} \times$ Dist			0.094***	0.123***
			(0.018)	(0.006)
$\text{num}^I_{new} \times$ HHI			-0.045*	-0.028***
			(0.022)	(0.005)
Product FE	Yes	Yes	Yes	Yes
Market*Time FE	Yes	Yes	Yes	Yes
N	350825	319793	350825	319830

of imported goods initially and the concentrated markets are dominated with larger retailers which are more likely to source internationally. However, the exits of imported varieties have no significant impact on expenditure shares (column 2).The IV estimates on entry margin still have the weak instrument issue and are inaccurate.

C. Import Price Pass-Through: Robustness Checks

C.1. Import Price Pass-through: First Stage Results

C.2. Heterogeneous Pass-Through Across Income: Other Income Measures

Table A10: Import Price Pass-through: First Stage

	Changes in Import Prices		PPI	
	(1)	(2)	(3)	(4)
TPU×*Crisis*	-0.167**		-0.214***	
	(0.059)		(0.022)	
TPU×*News*		-3.508**		-5.558***
		(1.075)		(0.409)
Energe Prices(log)	0.100***	0.096**	0.020***	0.013**
	(0.029)	(0.029)	(0.004)	(0.004)
F-Statistics	11.70	13.63	55.27	92.78
N	5834	5834	5992	5992
R-Squared	0.033	0.033	0.187	0.202

Table A11: Import-Consumer Price Pass-through: BLS PPI

	(1)	(2)	(3)
	OLS	IV	IV
Changes in Import Prices	0.007**	0.563***	0.584***
	(0.002)	(0.168)	(0.155)
Industrial PPI	0.076***	0.300**	0.311***
	(0.011)	(0.096)	(0.086)
Instrument		TPU×*Crisis*	TPU×*News*
Time FE	Yes	Yes	Yes
N	5841	5629	5629

Table A12: Pass-Through Across Income: unadjusted

	Reported Income			Total Spending		
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	IV	IV	OLS	IV	IV
Changes in Import Prices	0.016***	0.083*	0.006	0.004***	0.323***	0.218***
	(0.002)	(0.040)	(0.038)	(0.001)	(0.039)	(0.036)
Imp × Lower Income	0.028***	0.324***	0.311***	0.001	0.052**	0.058***
	(0.002)	(0.015)	(0.014)	(0.002)	(0.016)	(0.014)
Industrial PPI	0.253***	0.096***	0.142***	0.316***	0.109***	0.166***
	(0.013)	(0.027)	(0.025)	(0.013)	(0.026)	(0.024)
Instrument		TPU×*Crisis*	TPU×*News*		TPU×*Crisis*	TPU×*News*
Product FE	Yes	Yes	Yes	Yes	Yes	Yes
Income*Time FE	Yes	Yes	Yes	Yes	Yes	Yes
N	68537	66233	66233	75201	72681	72681

Table A13: Income Adjusted for Household Size and other demographics

	Reported Income			Total Spending		
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	IV	IV	OLS	IV	IV
Changes in Import Prices	0.007***	0.291***	0.194***	0.007***	0.335***	0.240***
	(0.002)	(0.039)	(0.037)	(0.001)	(0.040)	(0.036)
Imp × Lower Income	0.007***	0.102***	0.093***	0.001	0.056***	0.061***
	(0.002)	(0.016)	(0.014)	(0.002)	(0.016)	(0.014)
Industrial PPI	0.307***	0.104***	0.160***	0.321***	0.108***	0.159***
	(0.013)	(0.027)	(0.025)	(0.013)	(0.027)	(0.025)
Instrument		TPU×*Crisis*	TPU×*News*		TPU×*Crisis*	TPU×*News*
Product FE	Yes	Yes	Yes	Yes	Yes	Yes
Income*Time FE	Yes	Yes	Yes	Yes	Yes	Yes
N	75220	72700	72700	75213	72693	72693

Table A14: Total Spending: Decomposition

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Variety Pass-through			Expenditure Patterns			Interaction	
	OLS	IV	IV	OLS	IV	IV	OLS	IV	IV
Changes in Import Prices	0.010***	0.469***	0.322***	-0.003**	-0.122***	-0.076***	0.001	-0.018	-0.016
	(0.001)	(0.046)	(0.035)	(0.001)	(0.021)	(0.022)	(0.001)	(0.010)	(0.011)
Imp × Lower Income	0.001	0.018	0.013	0.002	0.042***	0.050***	0.002*	-0.000	-0.001
	(0.001)	(0.018)	(0.014)	(0.002)	(0.012)	(0.011)	(0.001)	(0.005)	(0.005)
Industrial PPI	0.370***	0.109***	0.189***	-0.058***	-0.010	-0.037**	0.001	0.011*	0.010
	(0.013)	(0.032)	(0.025)	(0.010)	(0.013)	(0.014)	(0.003)	(0.005)	(0.006)
Instrument		TPU×*Crisis*	TPU×*News*		TPU×*Crisis*	TPU×*News*		TPU×*Crisis*	TPU×*News*
Product FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Income*Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	72560	70040	70040	72560	70040	70040	72560	70040	70040

Table A15: Changes in Consumer Prices across Markets

Market	Pass-Through	Increase in Consumer Prices	Domestic Adjusted
Philadelphia	0.194	0.80%	1.52%
Sacramento	0.190	0.79%	1.51%
Washington DC	0.189	0.78%	1.50%
Suburban NY	0.187	0.77%	1.49%
Baltimore	0.185	0.77%	1.48%
Syracuse	0.185	0.76%	1.48%
Cleveland	0.183	0.76%	1.48%
Los Angeles	0.179	0.74%	1.46%
San Diego	0.178	0.73%	1.45%
Omaha	0.178	0.73%	1.45%
Boston	0.176	0.73%	1.45%
Salt Lake City	0.175	0.72%	1.44%
Kansas City	0.175	0.72%	1.44%
St. Louis	0.175	0.72%	1.44%
Seattle	0.174	0.72%	1.44%
Portland OR	0.172	0.71%	1.43%
Indianapolis	0.169	0.70%	1.42%
Phoenix	0.169	0.70%	1.42%
Richmond	0.169	0.70%	1.42%
Raleigh - Durham	0.169	0.70%	1.42%
Chicago	0.167	0.69%	1.41%
Hartford - New Haven	0.167	0.69%	1.41%
Pittsburgh	0.166	0.68%	1.40%
Charlotte	0.165	0.68%	1.40%
Detroit	0.165	0.68%	1.40%
Atlanta	0.165	0.68%	1.40%
Albany	0.165	0.68%	1.40%
San Francisco	0.165	0.68%	1.40%
Minneapolis	0.163	0.67%	1.39%
Jacksonville	0.163	0.67%	1.39%
Dallas	0.163	0.67%	1.39%
Houston	0.161	0.66%	1.38%
Denver	0.158	0.65%	1.37%
Oklahoma City - Tulsa	0.154	0.64%	1.36%
Orlando	0.152	0.63%	1.34%
Columbus	0.151	0.62%	1.34%
Memphis	0.149	0.62%	1.34%
Milwaukee	0.148	0.61%	1.33%
Buffalo - Rochester	0.148	0.61%	1.33%
Tampa	0.145	0.60%	1.32%
Cincinnati	0.143	0.59%	1.31%
Des Moines	0.143	0.59%	1.31%
Nashville	0.140	0.58%	1.30%
Birmingham	0.139	0.58%	1.29%
New Orleans - Mobile	0.132	0.55%	1.27%
Louisville	0.130	0.54%	1.26%
Grand Rapids	0.124	0.51%	1.23%
Miami	0.123	0.51%	1.23%
Little Rock	0.122	0.50%	1.22%
San Antonio	0.103	0.42%	1.14%

Notes: The third column is the increase in consumer prices after adjusting for the increase in domestic manufacturing prices.

Table A16: Country List in Trade Data

non-PTA countries		PTA countries
Argentina	Kazakhstan	Australia
Armenia, Republic of	Korea, Republic of	Canada
Austria	Kyrgyz Republic	Chile
Azerbaijan, Republic of	Latvia	Guatemala
Belarus	Lithuania	Israel
Belgium	Luxembourg	Mexico
Bolivia	Macao	Morocco
Botswana	Malaysia	
Brazil	Malta	
Bulgaria	Mauritius	
China	Moldova	
Colombia	Netherlands	
Croatia	New Zealand	
Cyprus	Norway	
Czech Republic	Philippines	
Denmark	Poland	
Ecuador	Portugal	
Estonia	Romania	
Finland	Russia	
France	Serbia, Republic of	
Georgia	Slovak Republic	
Germany	Slovenia	
Greece	South Africa	
Hong Kong	Spain	
Hungary	Sweden	
Iceland	Switzerland	
Indonesia	Thailand	
Ireland	Turkey	
Italy	Ukraine	
Jamaica	United Kingdom	
Japan		