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Uncertainty and International Trade Networks: An Empirical Analysis of Disaggregated Goods Trade*

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Abstract

Prior studies have shown that an increase in uncertainty tends to suppress international trade. This study examines this relationship using disaggregated trade data. To accommodate the high-dimensional dataset, we employ a factor-augmented vector autoregressive model to investigate the dynamic relationship between uncertainty and trade volumes. An empirical analysis based on sign restrictions within the proposed framework reveals that increasing uncertainty due to contractionary global demand generally reduces trade volumes. By contrast, uncertainty shocks associated with political developments, such as tariff conflicts, tend to increase trade volumes for certain categories of goods among specific substitutable countries. These findings suggest that the effects of uncertainty on international trade critically depend on the source of the shock.

JEL classifications: C22, F14.
Keywords: International trade network, factor-augmented VAR, uncertainty.

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1. Introduction

International trade networks act as arteries of the global economy. Through increasingly complex production fragmentation, global value chains, and cross-border exchange of intermediate and final goods, international trade networks play a central role in transmitting economic shocks across countries and regions. A growing body of literature examines the structure and evolution of these networks using econometric methods. In a comprehensive survey, de Benedictis and Tajoli (2011) illustrate that network analysis provides a powerful framework for understanding the structure and dynamics of international trade relationships and yields important insights into the resilience and vulnerability of the global trading system. At the same time, international trade networks are continuously influenced by changes in geopolitical conditions, trade policies, and developments in financial markets. Tariff conflicts, economic sanctions, and periods of financial instability alter the incentives and constraints faced by firms engaged in international trade, thereby reshaping trade relationships among countries. Therefore, understanding the dynamics of international trade networks and their determinants is essential for assessing future developments in the global economy and designing appropriate policy responses.

Among various factors that influence international trade, economic uncertainty has received considerable attention in recent decades. More broadly, uncertainty has emerged as a key determinant of economic fluctuations across a wide range of economic activities. Jurado et al. (2015) show, by developing a comprehensive measure of macroeconomic uncertainty, that uncertainty shocks greatly affect economic activity. Novy and Taylor (2020) provide evidence that increasing uncertainty significantly reduces international trade flows. They argue that uncertainty raises the option value of waiting, discourages firms from engaging in costly export activities, and ultimately suppresses trade volumes. Their findings highlight uncertainty as an important channel through which macroeconomic shocks affect international trade. Osnago et al. (2015) empirically show that trade policy uncertainty is a relevant barrier to export. Baum and Caglayan (2010) show that heightened uncertainty reduces bilateral trade flows by increasing the risk associated with international transactions and investment decisions. Anson et al. (2020) provide empirical evidence that the uncertainty associated with trade policy can cause severe disruptions in international trade.

Although the existing literature establishes a robust negative relationship between uncertainty and trade volumes, most empirical studies focus on aggregated trade measures such as bilateral total trade volumes of countries. Consequently, relatively little is known about how uncertainty affects trade volumes at the disaggregated level of goods. The impact of uncertainty may differ substantially across products, industries, and trading partners, implying that an aggregate analysis can overlook this relationship and heterogeneity.

This study addresses this gap by examining how uncertainty affects international trade volumes by analyzing goods at the disaggregated level. We construct a monthly bilateral trade dataset for eight major economies, consisting of a time series of trade volumes at the Harmonized System (HS) four-digit level. The resulting dataset contains more than a thousand product categories commonly available across bilateral trade relationships. Combining all bilateral trade flows and product categories generates a high-dimensional dataset containing more than 40,000 individual trade series for each month.

We employed a factor-augmented vector autoregressive (FAVAR) model to analyze the dynamics of such a large dataset effectively. Bernanke et al. (2005) introduce the FAVAR framework as a method for incorporating information from many economic variables into a tractable dynamic system. By summarizing high-dimensional information through a small number of latent factors, the FAVAR model is implemented to capture broad economic dynamics while avoiding the dimensionality problems associated with standard VAR models. This framework has been widely applied in macroeconomics and monetary economics, particularly in the analysis of policy transmission mechanisms. However, to the best of our knowledge, the FAVAR model has not been applied in previous studies to analyze international trade networks. This study contributes to the literature by introducing a novel methodological framework to investigate international trade dynamics in a high-dimensional data environment.

The economic consequences of uncertainty depend critically on the source of the uncertainty shock. Existing studies suggest that uncertainty can arise from different underlying economic mechanisms and therefore generate heterogeneous effects. For example, Meinen and Roehe (2017) show that the uncertainty associated with deteriorating economic prospects tends to amplify business cycle fluctuations and depress economic activity. Shin and Zhong (2020) illustrate that uncertainty shocks vary substantially, depending on their origins and transmission channels. Drawing on these ideas, we distinguish between two broad sources of uncertainty in this study. The first originates from upheavals in global economic conditions and expected economic activities in the future. The second source reflects political uncertainty arising from events such as tariff conflicts and other policy-related tensions. To identify these uncertainty shocks, we integrate a sign-restriction approach into the FAVAR framework. This identification strategy allows us to separate uncertainty shocks associated with contractionary global demand from those primarily related to political development.

This study reveals that uncertainty has highly heterogeneous effects on international trade. From a policy perspective, the results suggest that policymakers and firms must distinguish between different forms of uncertainty when evaluating potential risks to international trade. Appropriate responses to uncertainty require an understanding of not only the magnitude of uncertainty but also its origins and transmission mechanisms.

The remainder of this paper is organized as follows: Section 2 describes the disaggregated trade volume data. Section 3 presents the model formulation and identification strategy. Section 4 provides the empirical results and discusses the findings. Section 5 concludes the study.

2. Data

Our empirical analysis employs monthly data covering the period 2016–2025. This section describes the construction of the dataset used for empirical analysis: a large monthly bilateral trade dataset covering major economies at the HS four-digit product level.

All trade data are obtained from the United Nations (UN) COMTRADE database. We focus on eight major economies: Canada, China, France, Germany, Japan, Mexico, the United Kingdom, and the United States. For each country pair, we collect the monthly bilateral trade volumes for all available HS four-digit product categories between January 2016 and December 2025. We restrict the analysis to product categories for which data are consistently available throughout the sample period and across all bilateral trade relationships included in the dataset. Specifically, we exclude series where nonzero figures are available for only six or fewer months (i.e., the value is zero for all other months). The resulting dataset contains 1,216 disaggregated goods. January 2016 is selected as the starting point because a large number of monthly trade series are unavailable for earlier periods.

The final dataset is constructed in stages. First, we examine each bilateral trade series for seasonal patterns. Whenever statistically significant seasonality is detected, seasonal adjustments are made using the X-13ARIMA-SEATS procedure developed by the U.S. Census Bureau. Removing seasonal variations allowed us to focus on economically meaningful cyclical movements in trade activities. Second, we extract the cyclical components from each trade series using a Hodrick-Prescott (HP) filter. Specifically, the observed trade volume series is decomposed into trend and cyclical components, and deviations from the trend are used as the observable variable in the FAVAR model.

The use of the HP filter has been debated in the literature. Hamilton (2018) recommends an alternative regression-based detrending procedure, arguing that the HP filter may generate spurious dynamic relationships. Nevertheless, the Hamilton filter removes several observations at the beginning of the sample period. Given the relatively short time periods in our dataset, the resulting reduction in sample size may substantially decrease the amount of available information. Therefore, we employ a traditional HP filter widely used in empirical macroeconomic analyses.

After applying seasonal adjustments, detrending, and screening procedures, the final dataset contains 46,018 individual time series from the disaggregated goods. The resulting panel data set represents a comprehensive collection of monthly bilateral trade information at the disaggregated level of goods. For shock identification, we collect, in addition to bilateral trade flow data, information on the following variables: the CBOE Volatility Index (VIX), the OECD Composite Leading Indicator (CLI), and the Economic Policy Uncertainty (EPU) index developed by Baker et al. (2016). The VIX is a measure of aggregate uncertainty in global financial markets. The CLI is employed to capture expected changes in global economic activity. The EPU index is used to measure uncertainty arising from policy-related and political developments.

The analysis was limited to selected economies because of practical constraints associated with obtaining and processing highly disaggregated monthly bilateral trade data for a large set of countries. Nevertheless, the selected economies account for approximately 40 percent of global merchandise trade during the sample period. Furthermore, these countries occupy central positions in the global trade network and play major roles in international production chains. This implies that the dataset contains sufficient information to capture the principal dynamics of international trade networks.

3. The econometric model

3-1. The FAVAR model

The main objective of this study is to investigate the effects of uncertainty shocks on a high-dimensional time series of disaggregated international trade. A standard VAR model, which is an econometric tool to investigate the dynamics among variables, cannot handle such high-dimensional datasets because the number of parameters increases rapidly with the number of variables, resulting in a severe dimensionality problem. To address this issue, we employ a FAVAR model.

The key idea of the FAVAR approach, first illustrated by Bernanke et al. (2005), is that the dynamics can be studied well among a relatively small number of latent common factors, summarizing co-movements among a large number of observable variables. These latent factors capture the systematic variation shared across the entire dataset while filtering out idiosyncratic fluctuations specific to individual series. Therefore, the FAVAR framework can utilize information contained in a large dataset by avoiding the substantial increase in dimensionality. This feature is particularly advantageous in the current context of international trade networks, in which individual trade flows are interconnected through common macroeconomic, financial, and political factors.

Let X_t denote an $(N \times 1)$ vector containing all the disaggregated trade volumes at time t. We assume that the observed variables can be represented as follows:

$$X_t = \Lambda F_t + e_t,$$

where F_t is a $(K \times 1)$ vector of latent common factors, Λ is an $(N \times K)$ matrix of factor loadings, and e_t denotes idiosyncratic disturbances that follow normal distributions. The number of factors (K) is assumed to be substantially lower than (N).

The dynamics of the latent factors are modeled in a standard VAR formulation,

$$F_t = A_1 F_{t-1} + \cdots + A_p F_{t-p} + u_t,$$

where A_i denotes the coefficient matrices for the lagged variables, and u_t represents innovations that follow a multivariate normal distribution. The VAR component captures the dynamic interactions among latent factors.

An important advantage of the FAVAR model is its ability to incorporate information from a large number of variables while maintaining its computational feasibility. Because latent factors summarize common movements across many observations of trade volume, the model captures broad changes in international trade networks that are difficult to observe using conventional aggregate trade measures. Furthermore, the factor structure mitigates measurement errors that could exist in highly disaggregated trade time series.

Two main estimation approaches have been proposed for FAVAR models. One approach involves jointly estimating the factor model and the VAR system using Bayesian methods. In the second approach, which is more common in empirical applications, the factors are first estimated and the VAR system is subsequently modeled using the extracted factors. Bernanke et al. (2005) show that the resulting estimates are generally similar when the cross-sectional dimensions are sufficiently large. As our empirical analysis relies on a sign-restriction identification procedure implemented within the VAR component, we adopt a two-step estimation approach.

First, we extract latent factors from the high-dimensional observations of trade volume using principal component analysis (PCA). We then estimate the VAR model using these extracted factors, together with selected macroeconomic variables associated with uncertainty and global economic conditions. This procedure substantially reduces the dimensionality of the system, while preserving the informational content of observations.

3-2. Sign restriction approach

A key challenge in analyzing uncertainty shocks is that their sources may differ. Increasing uncertainty may reflect deteriorating global economic conditions and a weaker outlook for future demand. Another source could be political developments such as tariff disputes, trade conflicts, and policy-related tensions, which elevate uncertainty. Although both situations increase uncertainty, their implications for international trade may differ significantly.

To distinguish between these shocks, we employ a sign restriction approach within the FAVAR framework. Our identification strategy involves the use of the CBOE VIX, the OECD CLI, and the EPU index. VIX is widely regarded as a forward-looking indicator of uncertainty and financial market volatility. The CLI summarizes information regarding expected economic activity and future business cycle development. The EPU index quantifies policy-related uncertainty by analyzing newspaper coverage of economic policy issues.

Structural shocks are identified through sign restrictions imposed on the impulse responses during the impact period. The first shock is referred to as a contractionary global demand uncertainty shock. This shock simultaneously increases uncertainty and signals a deterioration in economic prospects. Accordingly, we impose the following restrictions:

$$VIX > 0,\ CLI < 0, \text{ and } EPU = 0.$$

An increase in the VIX combined with a decline in the OECD CLI reflects uncertainty originating from weaker global demand expectations rather than political developments. The EPU index response is left unrestricted at approximately zero to ensure that the identified shock primarily captures macroeconomic uncertainty.

The second shock is referred to as a political uncertainty shock. This shock reflects the uncertainty associated with trade conflicts, tariff disputes, and policy changes. We impose the following restrictions:

$$VIX > 0,\ EPU > 0, \text{ and } CLI = 0.$$

Under this identification scheme, political developments cause uncertainty, whereas the outlook for aggregate economic activity remains unchanged.

After identifying these structural shocks, we compute the impulse responses of the latent factors. Because each factor summarizes the common movements among thousands of bilateral trade series, the estimated responses provide information on how uncertainty propagates throughout the international trade network. By combining the factor loadings with the estimated factor responses, we obtain the implied responses of the individual bilateral trade flows of disaggregated goods.

4. Empirical results and discussion

This section presents the empirical findings of the FAVAR model with sign-restricted identification. We computed a principal component analysis to obtain five common factors, which accounted for approximately 50 percent of the total variation in high-dimensional observations. Although additional factors marginally increased the cumulative explanatory power, the incremental gains were small beyond the fifth factor. For the VAR equation, the Bayesian Information Criterion (BIC) selects a lag of three months.

We examined the effects of contractionary global demand uncertainty shocks. By construction, these shocks are characterized by an increase in the VIX, a deterioration in the OECD CLI, and no systematic response in the EPU Index. Such shocks capture episodes in which uncertainty increases because market participants become pessimistic about future economic conditions. The impulse response analysis reveals that contractionary uncertainty shocks generate a broad decline in international trade activities.

As Figure 1 shows, most extracted factors exhibit significantly negative responses following the shock, indicating that the effects are pervasive across product categories and bilateral trade relationships. Translating the factor responses into individual trade series further confirms that trade volumes decline for a large proportion of goods and country pairs. By contrast, uncertainty shocks associated with political developments, such as tariff conflicts, tend to increase trade volumes for certain categories of goods among specific groups of substitutable countries. These findings indicate that the effects of uncertainty on international trade depend significantly on the source of the uncertainty shock.

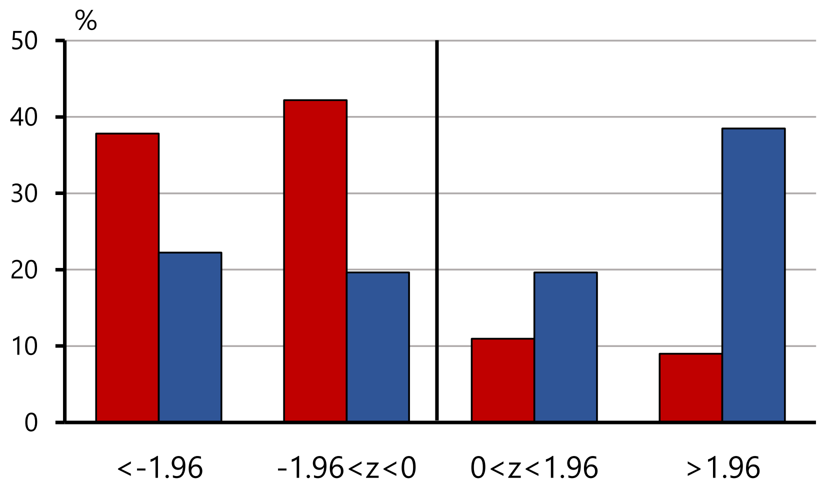

Figure 1. The histogram of z-score of the impulse responses (at the largest response in its absolute value) across bilateral trade volumes of disaggregated goods: the red and blue bars indicate responses to the contractionary and political shocks, respectively.

Several economic mechanisms are consistent with our findings. First, deteriorating expectations regarding future economic activity reduce expected demand for both intermediate and final goods. Therefore, firms postpone production, investment, and inventory accumulation, leading to a lower import demand. Second, heightened uncertainty increases the option value of waiting, which encourages firms to delay export-related decisions and cross-border investment projects. Third, financial market uncertainty tends to tighten financing conditions, thereby increasing the costs associated with international transactions. These channels jointly contribute to contractions in global trade.

An important feature of the estimated responses is their broad nature. The decline in trade volume is not confined to a specific sector or trading relationship. Negative effects appear across a wide range of categories and countries. This finding suggests that the uncertainty associated with deteriorating global economic prospects operates primarily through aggregate demand channels rather than sector-specific mechanisms. In this respect, our results are broadly consistent with existing literature documenting a negative relationship between uncertainty and aggregate trade flows.

The results differ substantially when the uncertainty originates from political development. Political uncertainty shocks are innovations that simultaneously increase the VIX and the EPU Index while leaving the OECD CLI unchanged on impact. Such shocks correspond to events such as tariff disputes, trade negotiations, regulatory uncertainty, and geopolitical tensions that affect international trade relationships without necessarily immediately altering aggregate economic prospects.

Unlike contractionary uncertainty shocks, political uncertainty shocks do not produce a uniform decline in trade activity. Instead, the estimated responses reveal substantial heterogeneity across goods and bilateral trade relationships. While some trade flows decline, others significantly increase after the shock. This disaggregated analysis reveals pronounced reallocations in trade activity across countries and products.

A particularly notable finding is that political uncertainty tends to increase trade volumes for certain categories of goods in substitutable countries. This pattern is realistic and consistent with trade-diversion mechanisms. When tariff conflicts or policy-related tensions emerge between trading partners, firms seek alternative suppliers and export destinations to mitigate the risks associated with disrupted trade relationships. Trade volumes can expand among countries capable of providing similar products and production capacities.

The heterogeneous responses in our analysis highlight the importance of examining disaggregated trade data. Aggregate trade statistics tend to conceal offsetting movements across products and countries. A decline in some bilateral trade relationships may occur simultaneously with an expansion in others, leaving the aggregate measures relatively unchanged. The high-dimensional framework employed in this study allows these reallocation dynamics to be directly observed.

The network interpretation of the results further reinforced this conclusion. However, international trade networks are not static. Instead, they continuously adapt to the changing economic and political conditions. Contractionary uncertainty shocks primarily reduce the overall intensity of network connections by lowering trade activity throughout the system. By contrast, political uncertainty shocks alter the configuration of the network by changing the allocation of trade flows across countries. In this sense, political uncertainty generates structural reorganization rather than simple contraction.

From a policy perspective, these findings imply that policymakers should avoid treating uncertainty shocks as equivalent. Policies designed to stabilize aggregate demand may be effective in mitigating the effects of contractionary uncertainty shocks but may have limited influence on uncertainty arising from political conflicts. Trade diversification and supply chain resilience may play important roles in the latter case. Firms engaged in international trade may benefit from maintaining diversified supplier networks and flexible sourcing strategies that enable rapid adaptation to changing political conditions.

One notable limitation of the dataset is that the analysis focuses exclusively on trade relationships among the selected major economies. Trade flows involving countries outside this group are not explicitly incorporated into the estimation. This setting implies that some potentially important trade linkage channels are omitted from the analysis.

5. Concluding remarks

This study investigates the relationship between uncertainty and international trade by using a disaggregated dataset of bilateral trade flows among major economies. Our analysis exploits the information contained in more than 40,000 monthly trade series at the HS four-digit level. To analyze this high-dimensional dataset, we employed the FAVAR framework combined with a sign-restriction identification strategy that distinguishes between different sources of uncertainty. The empirical results reveal that the uncertainty associated with deteriorating global economic conditions has generated a broad decline in trade activity across countries and products. By contrast, uncertainty arising from political developments does not necessarily reduce trade volumes uniformly; instead, it often triggers substantial reallocations of trade flows across countries and sectors. Specifically, certain groups of substitutable countries experience an increase in trade volume as firms adjust their sourcing and export decisions in response to changing political conditions. These results suggest that uncertainty influences not only the volume of international trade but also the structure of international trade networks.

The framework developed in this study offers several promising directions for future research. First, it would be valuable to develop an econometric model that explicitly incorporates the substitution effects among trading partners. Although this study indirectly identifies trade reallocation through the responses of disaggregated trade flows, a framework that formally models substitution behavior provides a deeper understanding of the mechanisms through which uncertainty reshapes international trade networks. Such an extension would also facilitate a more detailed analysis of how network structures evolve after uncertainty shocks. The FAVAR-based methodology proposed in this study offers a useful foundation for pursuing this line of research because it can accommodate large and highly interconnected trade datasets.

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