Trading with China and the U.S. Labor Productivity Slowdown

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Abstract

Globalization is generally believed to benefit trading partners by stimulating competition, innovation, and productivity growth. However, this belief contrasts with the observed slowdown in U.S. productivity growth over recent decades. In this paper, we analyze industry-level data from 2002 to 2018 to investigate the relationship between Chinese import competition and productivity within the U.S. manufacturing sector. Employing a fixed-effects model, our analysis reveals three main findings: (1) Increased Chinese import competition is negatively correlated with labor productivity growth in U.S. manufacturing industries. (2) U.S. outward Foreign Direct Investment (FDI) into China is also negatively associated with labor productivity growth in four specific U.S. industries. (3) Both Chinese import competition and U.S. outward FDI into China have a negative relationship with Total Factor Productivity (TFP) growth in the U.S.

Keywords: Labor productivity, Import competition, innovation, Intellectual property, Forced technology transfer, Trading with China.

JEL classification: F16, O30, J24

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I. Introduction

It is well documented that U.S. productivity has been slowing down over the past several decades (e.g., Fernald 2014; Gordon 2016; Syverson 2017; Sprague 2021). Figure 1 shows the quarterly year-over-year growth rate of labor productivity (real output per hour of all persons) in the postwar U.S. The average growth rate of labor productivity is 3.1% during the period of 1948 to 1974, slowing to 2.2% in 1975 to 2004, slowing further to 1.4% in 2005 to 2019. The total factor productivity (TFP) growth rate also fell from 1.9% annually in 1948 to 1974, to 1.0% annually in 1975 to 2004, and to 0.5% annually in 2005 to 2018, as shown in Figure 2. In particular, Larry Summers (2014) has called the period after the Great Recession in 2008 a "secular stagnation" or a "new normal," in which lower growth rates of GDP and productivity are expected to continue. What causes the slowdown of the U.S. productivity?

Gordon (2012) suggests that innovation since 2000 has revolved around smaller and more intelligent entertainment and communication devices, which, however, do not fundamentally enhance labor productivity. "Low-hanging fruit" inventions such as steam engines, internal combustion engines, electricity, telegraphs, telephones, railroads, and indoor plumbing, etc., were remarkable productivity boosters but they were conceived long ago. Today, developing novel ideas for highly productive products has become increasingly challenging. In line with the theory of diminishing low-hanging fruits, Bloom et al. (2020) indicate a decline in research productivity, suggesting that finding new ideas is becoming more difficult. It is worth noting a surge in productivity growth from 1996 to 2004, as shown in Figures 1 and 2, driven by the accumulative digital and Internet revolution spanning from 1970 to 2000, with its combination of information with communications technology, e-commerce and search engines. Nevertheless, the surge was a temporary phenomenon (Byrne et al. 2013).

Additional explanations for weakened productivity growth include (1) slowing human capital growth (Gordon 2012), (2) reduced labor market fluidity and business dynamism (Davis and Haltiwanger 2014; Decker et al. 2014), (3) resource misallocation stemming from low real interest rates (Cette et al. 2016), (4) mismeasurement of value added and the producer price index (Fernald 2014; Byrne et al. 2018), and (5) slowdown in electronic miniaturization (Azar 2022). In this paper, we propose another complementary explanation for the slowing labor productivity in the 21st-century United States: trade with China. Our hypothesis posits that the U.S.'s increased imports and trade deficits from China are associated with a decline in productivity within the U.S. manufacturing sector.

Figure 3 displays three productivity growth rates: (1) labor productivity across all private businesses, (2) labor productivity within the manufacturing sector, and (3) total factor productivity (TFP) of the manufacturing sector. These three series share a consistent pattern: a decline in productivity growth rates from the early 2000s through 2016, with exceptions in 2009 and 2010 during the Great Recession. Figure 4 shows the cumulative contributions to the TFP (measured in percentage points) since 1988 by major sectors in the U.S. It presents a clear insight: the primary TFP contributions originate from the manufacturing sector, particularly the durable goods sector, and the trade sector, which comprises both retail trade and wholesale trade.

A significant body of literature explores the relationship between trade and productivity, with the prevailing consensus suggesting that trade liberalization generally bolsters overall industry productivity (e.g. Pavenik, 2002; Alcalá and Ciccone, 2004; Trefler, 2004; Ariel and Melitz, 2013). Shu and Steinwender (2019) review the studies focusing on the impact of trade liberalization on firms' innovation-related outcomes. They examine four types of trade shocks: import competition, export opportunities, access to imported intermediates, and foreign input competition. They summarize that in emerging countries, trade could increase productivity and innovation. In developed countries, export opportunities and access to imported intermediates tend to encourage innovation. However, the effect of import competition in the U.S. appears to yield mixed results.

On one hand, Bloom et al. (2016) find that Chinese import competition from 1996 to 2007 led to increased technical change across twelve European countries. Using firm-level data, they estimate that trading with China accounts for 14% of European technology upgrading over 2000-2007. On the other hand, Autor et al. (2020) find that there is a negative impact of rising Chinese import competition on firm-level and technology class-level patent production in the U.S from 1975 to 2013. Figure 5 depicts the percentage of total U.S. merchandise trade (imports plus exports) with the world over U.S. GDP and the percentage of total U.S. merchandise imports from the world over U.S. GDP since 1997. Figure 6 illustrates the percentages of merchandise imports with major U.S. trading partners over total U.S. imports. While the ratio of U.S. imports over GDP rose from 10% to 12.5% with fluctuations over the past two decades, the most prominent trend is that the ratio of U.S. imports from China over total U.S. imports shot up from 7% in 1997 to 21% in 2018. Combining Figures 1 to 6, it appears there is a simple and positive correlation between Chinese import competition and American productivity in the period of 1997 to 2004 while there is a negative correlation in the post 2004 period. The former is consistent with Bloom et al. (2016) but the latter is consistent with Autor et al. (2020).

In this paper, we utilize industry-level data from 2002 to 2018 to examine the correlation between Chinese import competition and productivity in the U.S. We employ a fixed effects model by three-digit manufacturing sectors in the U.S. Our analysis yields three key findings:

(1) We observe a negative association between the rising Chinese import competition and the growth rates of labor productivity in the U.S. manufacturing sector.

(2) U.S. outward Foreign Direct Investment (FDI) into China is negatively correlated with labor productivity growth in the U.S industry.

(3) Both Chinese import competition and U.S. outward FDI into China are negatively associated with TFP growth among U.S. manufacturers.

These findings challenge the conventional wisdom prevalent in the trade-productivity literature, which often suggests a virtuous cycle between globalization and technological progress. We propose two potential explanations: (1) The relationship between competition and innovation may be complex and nonlinear. (2) China may not conform to the assumptions of a typical trading country.

Industrial organization literature explores how competition influences firms' incentive to innovate, identifying two primary effects: (1) The Escape-Competition Effect: Arrow (1971) posits that innovation is greater in more competitive markets because competition would reduce a firm's profits in a competitive market, motivating it to innovate as a means to elude competitive pressures. (2) The Schumpeterian Effect: Joseph Schumpeter argues that firms holding market power due to innovation, e.g., through patents, have both the means and motivation to continue innovating. Conversely, firms with minimal market power and lower profits lack the necessary resources to innovate. In essence, high competition diminishes the profits a firm might gain from innovation, thus discouraging further innovative efforts.

Bridging these opposing perspectives, Aghion et al. (2005) present evidence of an inverted-U shaped relationship between competition and innovation, with innovation on the vertical axis and competition on the horizontal axis of a chart. On the left end of the chart , where few firms dominate the market, firms may have the revenue to invest in innovation but lack competitive pressures to do so. Therefore, innovation is hindered and favoring the Escape-Competition Effect. As competition increases, a positive correlation between competition and innovation emerges. On the right end of the chart in fragmented and highly competitive markets, firms may innovate less due to insufficient revenues from extensive profits to invest in costly R&D. Here, with high competition levels, the Schumpeterian effect is more prevalent.

We suggest that rising Chinese import competition after 2004 plays the role of Schumpeterian destruction on the innovation of U.S. firms whose declining profit margin mitigated their R&D activities. Atkinson (2021) presents case studies that show China's rampant "innovation mercantilist" policies harm global innovation by taking market share and revenues away from more-innovative foreign competitors, therefore diminishing their innovation capabilities, notably in three industries—telecommunications equipment, high-speed rail, and solar panels. Atkinson (2021) argues that Huawei and ZTE, under unfair Chinese policies (addressed below), artificially taking market share from more innovative companies, i.e. Ericsson, Nokia, and Samsung, and let these companies have less revenue to invest in cutting-edge R&D.

Furthermore, U.S. trading with China deviates from conventional assumptions of normal trade in several ways. Aggregate trade benefits for both trading partners are based on the assumption of stability of trade balance. However, this is not the case with China. As shown in Figure 7, the percentage of the U.S. trade deficit with China over the total U.S. GDP has steadily risen from 0.6% in 1997 to 2% in 2018. The U.S. trade deficit from China accounted for 28% of total U.S. trade deficits in 1997. The ratio rose to 48% in 2018. Although the dynamics of trade deficits are directly related to U.S. domestic consumption and savings, we cannot rule out that Chinese mercantilism plays a significant role in these numbers. For example, as a non-market economy[4], China erected trade barriers, making it costly for U.S. manufacturers to export to China. Instead, they incentivized U.S. manufactures to invest in China and forced joint venture and technology transfers (Atkinson 2021). China's industrial policy with heavy subsidy on its manufacturing sector makes its firms artificially competitive. Additionally, intellectual property rights were not seriously enforced and often infringed upon in China[5]. All these distortions make China's manufacturing sector and products extremely competitive in the global market. As a result, China's trading partners and competitors lose their market share and profit margin and need to reduce their domestic capital expenditures and R&D, causing lower growth rates of labor productivity and TFP in the home country. Meanwhile, some international manufactures that had FDI in China enjoy substantial profits and has less incentive to invest and innovate in the home country.

The remainder of this paper is structured in the following way. Section II discusses data. Section III presents the results. Section IV concludes.

[4] On October 26, 2017, the United States Department of Commerce "concludes that China is a non-market economy (NME) country because it does not operate sufficiently on market principles to permit the use of Chinese prices and costs for purposes of the Department's antidumping analysis. The basis for the Department's conclusion is that the state's role in the economy and its relationship with markets and the private sector results in fundamental distortions in China's economy…. China's institutional structure and the control the Chinese government and the CCP exercise through that structure result in fundamental economic distortions, such that non-market conditions prevail in the operation of China's economy. These non-market conditions are built upon deeply entrenched institutional and governance features of China's Party-state, and on a legal mandate to "maintain a leading role for the state sector."

[5] "According to a 2017 report by the United States Trade Representative, Chinese theft of American IP currently costs between $225 billion and $600 billion annually." (Goldstein, 2018). The Hoover Institution's newly published report, *Chinese Influence & American Interests: Promoting Constructive Vigilance* (2018), provides an important perspective about China's theft of intellectual property (IP): "While not technology transfer per se, counterfeiting is so common in China that it has the same practical effect. Schemes range from the subtle to blatant: benchmarking against ISO standards;14 patent research where a design is modified slightly, if at all, re-patented in China and "legally" produced with government protection;15 reverse engineering; "imitative innovation" with or without the innovation (also called "imitative remanufacturing"); and marketing the pirated product without or with its original logo.19 Other reporting has detailed how the Chinese government exploits regulatory panels (often with members who have direct conflicts of interest by working for local competitors) and antitrust investigations to acquire trade secrets from foreign companies, aiding domestic industries.

II. Data

Our data is sourced from the U.S. Bureau of Economic Analysis (BEA), U.S. Bureau of Labor Statistics (BLS), USA Trade Online (compiled by the U.S. Census), and Statistics Canada. To sidestep the complexities introduced by the COVID-19 pandemic, which began in Wuhan, China, in December 2019, our focus is on data up to 2018. We've developed two industry-level panel datasets for our study, with Dataset I concentrating on international merchandise trade from 2002 to 2018, as provided by USA Trade Online.[6]

In 2018, U.S. imports from China's manufacturing sector were 98% of total imports from China, which accounted for 86% of all U.S. imports. This led us to focus our analysis on the manufacturing industry.[7] The North American Industry Classification System (NAICS) categorizes industries as "sectors" at the 2-digit level and "subsectors" at the 3-digit level. Dataset I includes data from 21 manufacturing subsectors as per the 3-digit NAICS codes. Our research also considers Foreign Direct Investment (FDI), but we are limited to FDI data at the NAICS 2-digit level from BEA, as more granular data are not available.

Despite this limitation, we aim to explore the relationship between FDI and labor productivity growth. We constructed Dataset II, defined by NAICS 2-digit codes, focusing on U.S. FDI to China from 1994–2018, covering mining, utilities, manufacturing, and wholesale trade. This dataset serves as a robustness check.

The dependent variables are the growth rates of labor productivity and TFP, as defined by the BLS. Labor productivity is a measure of economic performance that compares the amount of goods and services produced (output) with the number of hours worked. Figure 9 shows the labor productivity by subsector in Dataset 1. TFP, also known as multifactor productivity, is a measurement of economic performance that compares the amount of output with the amount of combined inputs like labor, capital, energy, and materials as shown in Figure 10. We've computed the mean years of education for each sector in Dataset II, using the Census Bureau's Quarterly Workforce Indicators, and incorporated it into our analysis. The average education level is about 13.2 years, but such data is not available for NAICS 3-digit subsectors in Dataset I.

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[6] "The General Imports value reflects the total arrival of merchandise from foreign countries that immediately enters consumption channels, warehouses, or Foreign Trade Zones. Imports for Consumption measure the total of merchandise that has physically cleared through Customs either entering consumption channels immediately or entering after withdrawal for consumption from bonded warehouses under Customs custody or from Foreign Trade Zones." (Source: Census Bureau, https://www.census.gov/foreign-trade/reference/guides/tradestatsinfo.html.)

[7] In addition to 21 subsectors in the manufacturing sector, there are agricultural products (111), livestock & livestock products (112), forestry and logging (113), fish and other marine products (114), oil & gas (211), and minerals & ores (212) in the international trade data from U.S. Census.

Key explanatory variables include the value of imports from China in Dataset I (from USA Trade Online) and U.S. FDI to China in Dataset II (from BEA). Figure 8 shows the aggregate amount of FDI over the sample period. Both datasets incorporate total and new capital expenditures, with additional variables such as trade data with various regions included only in Dataset I. R&D expenditure data, limited in availability, are not included in our datasets. Descriptive statistics for all variables are detailed in Table 1.

To address the issue of exogeneity, we apply the strict exogeneity test (Wooldridge 2010) and present the *p*-value and fixed-effects IV (instrument) estimation results. In Dataset I, we use imports and exports data in Canada as instruments for imports and exports data in the U.S. For U.S. imports from North American countries (Mexico and Canada) and U.S. exports to North American countries, the IVs are Canadian imports from Mexico and Canadian exports to Mexico. In Dataset II, data regarding Canada's FDI to China are unavailable. We use Canada's FDI to Asia as a proxy for American FDI to China, due to data unavailability. These instrumental variables are chosen for their relevance to U.S.-China trade but are unrelated to U.S. productivity growth.

III. Empirical Analysis

A. Fixed Effects (FE) Estimation Method

There are some time-invariant variables within an industry that make each industry distinct from the others. To control for time-invariant differences between industries (NAICS 2-digit sectors or 3-digit subsectors), we utilize the fixed effects (FE) estimation method to conduct our analysis. The econometric model is written as

$$y_{it} = x_{it}\beta + \alpha_i + u_{it}\,, \qquad t = 1,2,\dots,T \qquad (1)$$

where

i is an NAICS 3-digit *subsector* if we use data from Dataset I. It is an NAICS 2-digit *sector* when we use data from Dataset II;

t denotes year;

y_{it} is the growth rate of labor productivity;

x_{it} is the vector of explanatory variables;

β is the vector of coefficients;

α_i is the individual effect;

u_{it} is the error term.

The growth rate of labor productivity is negative over several years. Hence, we use the growth rate per se as the dependent variable instead of using the natural logarithm transformation of it.

The dependent variable in Table 2 is the annual growth rate of labor productivity in 21 NAICS 3-digit subsectors in the US manufacturing sector (Figure 9). The explanatory variables include the natural logarithm of lagged values of New Capital Expenditures (NKE), imports from China, and exports to China. To compare the impacts of international trade with other trading partners, we also perform regressions with other covariates, including lagged values of imports from and exports to other Asian countries, the EU, and North America (Canada and Mexico). A variable for the year of data is included in each regression. In specifications (5) and (6), we add a time dummy variable for the Great Recession (2009 and 2010) or its aftermath (2009 to 2018).

A Born and Breitung (2016) Heteroskedasticity-robust (HR) test for first-order serial correlation with specification (6) shows no evidence of first-order serial correlation.

The evidence based on six specifications in Table 2 shows that imports from China in the previous year and exports to China in the previous year are relevant explanatory variables with statistical significance. We reduce to a regression with these relevant explanatory variables, the natural logarithm of NKE, and an indicator for the aftermath of the Great Recession, in Table 3. To evaluate the contemporaneous effects of covariates, we also perform regressions with values of covariates in the current year. In addition, a heteroskedasticity-robust Born and Breitung (2016) test for the first and third specifications shows that there is no evidence of first-order serial correlation. The growth rate of labor productivity decreases significantly by 3.43 percentage points in the US as imports from China in the prior year increase by 1%.

It is worth noting that the growth rate of labor productivity decreases significantly by 1.57 percentage points in the U.S. as U.S. exports to China in the prior year increase by 1% according to the first regression in Table 3. This correlation may be partially explained by the incidents of intellectual property (IP) thefts and trade secret misappropriations in China, especially when sales of advanced products to China involve technology transfers.

B. Endogeneity Check

Does the growth rate of the U.S. labor productivity affect the amounts of imports, exports, or FDI? To mitigate the concern of endogeneity, we used two methods. First, as discussed above, we begin with estimations with lagged explanatory variables in Table 2 (Dataset I) and Table 4 (dataset II) (Bellemare et al. 2017; Leszczensky and Wolbring 2019).

Second, we conduct a test of strict exogeneity (Wooldridge 2010) for the fixed effects (FE) estimation in Tables 3 and 5. We present the *p value* of the test along with the FE estimates.

In cases in which the *p value* is sufficiently small and consequently rejects the null hypothesis of strict exogeneity, we look for instrumental variables (IVs) to obtain consistent estimates for our NAICS industry-level data. The IVs of Autor, Dorn, and Hanson (2013) are well-documented in this line of research. They use Commuting-Zone (CZ) level data that contains aggregation of county-level data defined by the 1990 Census. However, we use NAICS industry-level data. Because the NAICS industry classification system is used by government and business in the U.S., Canada, and Mexico only, we do not have data from other countries.

With Dataset I, we use corresponding import and export data in Canada as instruments for imports and exports in the US. Canada also struggled with lagging productivity over the past two decades. According to the Business Council of British Columbia: "The main reason for Canada's inability to generate gains in per capita GDP is its persistent inability to achieve meaningful gains in labour productivity." [8]

In the following empirical analysis with IV estimation, Canada's imports from China serve as the instrument for imports from China in the US. Likewise, Canada's exports to China are the instrument for exports from the US to China. For US imports from North American countries and US exports to North American countries, the IVs are Canadian imports from Mexico and Canadian exports to Mexico, respectively. The rationale is that Canada is more similar to the U.S. than Mexico is in various aspects. Canada's international trade (imports and exports) could be related to the international trade (imports and exports) in the US due to geopolitical factors or peer effects. We assume that Canada's levels of international trade (imports and exports) are unrelated to the growth rate of labor productivity in the US.

With Dataset II, data regarding Canada's FDI to China at the NAICS 2-digit sector level are *unavailable*. Hence, we use Canada's FDI to Asia at the NAICS 2-digit sector level as an instrumental variable for the U.S. FDI to China.[9] This option is the second-best option. Similar to the rationale for the choice of the IVs for the U.S. imports and exports explained in the previous paragraph, we assume that Canada's FDI to Asia is related to US FDI to China due to geopolitical factors or peer effects. However, we assume that Canada's FDI to Asia is unrelated to the growth rate of labor productivity in the U.S.

We present the results from the fixed effects instrumental variable (IV) estimation/two-stage least squares (2SLS) estimation in Tables 3 and 5. Joshi and Wooldridge (2019)

[8] Williams, D (2022) Canada's productivity performance over the past 20 years. Business Council of British Columbia, Canada.
[9] Source: Statistics Canada. We thank Statistics Canada for providing data.

denoted the fixed effects IV/two stage least squares (2SLS) estimator as the FE2SLS estimator. The usual FE estimate of a coefficient is preferable to the FE2SLS estimate in cases that *do not reject* the null hypothesis of strict exogeneity. Tables 3 and 5 present regressions with contemporaneous explanatory variables as well.

The *p value* based on the test of strict exogeneity with the first regression in Table 3 is 0.0609. Hence, we do not reject the null hypothesis of strict exogeneity at the 5% level. The growth rate of LP decreases significantly by 3.43 percentage points in the US as imports from China in the previous year increase by 1%. To confirm the causal relationship, we conduct an FE2SLS estimation with the IVs mentioned earlier. Estimates from the first stage of FE2SLS regression show that Canada's imports from China are positively and significantly correlated with American imports from China. This evidence affirms instrument relevance. The second stage of FE2SLS regression shows that the growth rate of labor productivity decreases significantly by 4.99 percentage points in the US as imports from China in the prior year increase by 1%.

The effect of contemporary imports from China is also statistically significant in Table 3. The *p value* for the test of strict exogeneity with the FE regression (the 3rd regression in Table 3) is 0.3787. Hence, we do not reject the null hypothesis of strict exogeneity at the 5% level either. The growth rate of LP decreases significantly by 3.07 percentage points in the US as imports from China in the present year increase by 1%.

The significant negative effect of contemporaneous new capital expenditures (NKE) on the growth rate of labor productivity suggests that labor and capital goods in the current year are gross substitutes in 21 NAICS 3-digit manufacturing subsectors. To conduct a robustness check, we also replace NKE with total capital expenditures (TKE) in the regressions. The results with TKE are similar to those with NKE.

Note that data about mean years of education are *not* available for NAICS 3-digit subsectors. We look forward to opportunities to obtain access to these types of data in the future so that we can enrich the information in Dataset I.

The FDI (in both the goods and services sectors) from the US to China increases over time, except in a few years during the Great Recession and its aftermath (see Figure 8). The amount of US FDI to China was approximately $853 billion from 2000 to 2017, with $108 billion in 2017 (the U.S. BEA 2018). Firms that bring FDI to China bear high risks of losing advantages in technology when IP theft and forced technology transfer are common. To approximate the impacts of IP theft and forced technology transfer and provide more robustness checks for our empirical results with Dataset I, we construct another dataset with information about FDI. Although the FDI data at the NAICS 3-digit subsector level are not available on the BEA's website, the FDI data at the NAICS 2-digit sector level are available.

We compile an unbalanced panel dataset from 1994 to 2018 for four NAICS 2-digit sectors (mining, quarrying, and oil and gas extraction; utilities; manufacturing; and wholesale trade). Data on these four sectors are the *only* data we can access. We denote this dataset as Dataset II.

Tables 4 and 5 present estimates from regressions based on Dataset II. They serve as a robustness check for regressions with import and exports in Tables 2 and 3. The dependent variable in Table 4 is the growth rate of labor productivity. We focus on the lagged effects of the main explanatory variable, FDI from the US to China, controlling for NKE in the previous year, mean years of education in the current year, a variable for the year of data, a dummy variable for the Great Recession or a dummy variable for the aftermath of the Great Recession. Because the amount of FDI is negative in a few years, we use the level of FDI instead of the natural logarithm transformation of it in our analysis. Table 4 suggests that the FDI from the US to China significantly lowered the growth rate of labor productivity in the four sectors (mining, quarrying, and oil and gas extraction; utilities; manufacturing; and wholesale trade) in the US from 1994 through 2018.

The first regression of Table 5 reproduces the estimates of the last specification in Table 4. The usual FE estimation is preferable in the first and third specifications in Table 5 because the *p value* is large enough to accept the null hypothesis of strict exogeneity. The takeaway from Table 5 is that the amount of FDI from the US to China (considering the amount in either the previous year or the current year) has adverse and significant effects on the growth rate of labor productivity in the US. The evidence shows that when the FDI from the US to China in the prior year increases by $100 million, the growth rate of LP decreases significantly by 0.09 percentage points. Likewise, when FDI from the US to China in the current year increases by $100 million, the growth rate of LP decreases significantly by 0.12 percentage points.

To confirm a causal relationship, we conduct an FE2SLS estimation with the IVs mentioned earlier. Estimates from the first stage of FE2SLS regression show that Canada's FDI to Asia is negatively and significantly correlated with the U.S. FDI to China. This evidence affirms instrument relevance. The second stage of FE2SLS regression shows that the growth rate of labor productivity decreases significantly by 0.38 percentage points in the US as the current year's FDI from the US to China increases by $100 million.

Note that the sample size in Dataset II is relatively small due to data availability. We hope we will be able to obtain access to more data at the NAICS 2-digit sector level in the future. Tables 6-9 presents results with TFP as the dependent variable. The key takeaways from these regressions are in line with those in Tables 2-5.

IV. Conclusions

In this paper, we utilize industry-level data from 2002 to 2018 to examine the correlation between Chinese import competition and productivity in the U.S. We employ a fixed effects model by three-digit manufacturing sectors in the U.S. Our analysis yields three key findings: First, we observe a negative association between the rising Chinese import competition and the growth rates of labor productivity in the U.S. manufacturing sector. Second, U.S. outward Foreign Direct Investment (FDI) into China is negatively correlated with labor productivity growth in the U.S industry. Third, both Chinese import competition and U.S. outward FDI into China are negatively associated with TFP growth among U.S. manufacturers.

These findings suggest an abnormal outcome of trading with China overlooked by previous literature. Unlike trading with any other developed or developing country, trading with China not only reduces employment in the domestic manufacturing sector but also reduces innovation and labor productivity in the U.S. With the exceptional characteristics of China's mercantilist/non-market economy and with its substantial state subsidies on manufacturing and exports and violation of intellectual property rights, it creates a disruptive impact on its trading partners' innovation and productivity.

Why might it have this effect? Imagine if the copyright and patent laws were abolished in the United States. Wouldn't this negatively impact productivity and innovation? That seems very likely. With China's open disregard for intellectual property, its entry into the global trading system appears to have played a similarly disruptive role on our economy.

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Statements and Declarations

- The authors have no relevant financial or non-financial interests to disclose.
- The authors have no competing interests to declare that are relevant to the content of this article.
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Data availability

The data that support the findings of this study are available to the public.

Code availability

The code that supports the findings of this study is available to the public.

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Table 1. Descriptive Statistics

	Data Set #1		Data Set #2	
NAICS sectors or subsectors	21 NAICS 3-digit subsectors Manufacturing: 311–316, 321–327, 331–337, 339.		4 NAICS 2-digit sectors Mining, Quarrying, and Oil and Gas Extraction: 21 (1999–2017) Utilities: 22 (1999–2002) Manufacturing: 31,32,33 (1994–2018) Wholesale Trade: 42 (1994–2018)	
Time	2002-2018		1994-2018	
Nature of the Panel Data	Balanced		Unbalanced	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**
Labor Productivity Growth Rate (LPGR) (%)	0.8783	5.3446	2.2725	4.7848
Workers' Mean Years of Education	--	--	13.22	0.39
FDI to China (millions of dollars)	--	--	998.42	1,435.57
Total Capital Expenditures (TKE) (millions of dollars)	9,621.89	10,134.62	114,160.8	78,233.78
New Capital Expenditures (NKE) (millions of dollars)	9,304.49	9,965.99	109,723.0	76,193.40
Imports from China (millions of dollars)	17,300	28,900	--	--
Exports to China (millions of dollars)	3,040	5,100	--	--
Imports from Other Asian Countries (millions of dollars)	36,400	51,800	--	--
Exports to Other Asian Countries (millions of dollars)	15,100	21,800	--	--
Imports from the EU (millions of dollars)	15,900	22,600	--	--
Exports to the EU (millions of dollars)	10,300	14,900	--	--
Imports from North America (millions of dollars)	19,200	29,500	--	--
Exports to North America (millions of dollars)	18,600	21,900	--	
Number of Observations	357		69	

Note: 1. -- : Not Available. 2. Sources of data: BLS, BEA, and CB.
3. Data Set #1: based on observations in Tables 2. Data Set #2: based on observations in Tables 4.

Table 2. Fixed-Effects Estimation – Dataset I

A balanced panel with 21 NAICS 3-digit subsectors in manufacturing from 2002-2018
Dependent Variable: **Labor Productivity** Growth Rate (LPGR, %)
With Lagged Explanatory Variables

Explanatory Variables (Xs)	(1)	(2)	(3)	(4)	(5)	(6)
ln(Imports from China)$_{it-1}$	-4.11*** (1.24)	-3.73*** (1.16)	-3.11** (1.27)	-2.99** (1.32)	-2.98** (1.31)	-3.01** (1.32)
ln(New Capital Expenditures)$_{i(t-1)}$		-2.35* (1.36)	-0.19 (1.78)	-0.25 (1.85)	-0.25 (1.85)	-0.18 (1.81)
ln(Imports from other Asian Nations)$_{i(t-1)}$			0.50 (1.46)	0.16 (1.72)	0.15 (1.74)	0.22 (1.74)
ln(Imports from the EU)$_{i(t-1)}$			-1.10 (2.02)	-1.90 (1.86)	-1.91 (1.86)	-1.74 (1.99)
ln(Imports from Canada and Mexico)$_{i(t-1)}$			-3.33 (2.42)	-3.17 (2.76)	-3.17 (2.76)	-3.21 (2.79)
ln(Exports to China)$_{i(t-1)}$				-1.48** (0.60)	-1.48** (0.61)	-1.52** (0.64)
ln(Exports to other Asian Nations)$_{i(t-1)}$				1.24 (1.56)	1.24 (1.57)	1.12 (1.61)
ln(Exports to the EU)$_{i(t-1)}$				1.53 (1.97)	1.55 (1.98)	1.51 (1.96)
ln(Exports to Canada and Mexico)$_{i(t-1)}$				0.21 (2.58)	0.21 (2.60)	0.19 (2.57)
Year	0.05 (0.15)	0.06 (0.15)	0.04 (0.14)	0.11 (0.13)	0.11 (0.13)	0.09 (0.14)
Dummy_Great Recession (2009-2010)					-0.04 (0.59)	
Dummy_2009 to 2018						0.33 (1.17)
R^2	0.1126	0.1637	0.1714	0.1813	0.1809	0.1874
Observations	336	336	336	336	336	336

Notes:

1. A robust standard error is presented in each parenthesis.
2. ***: *p value* < 0.01. **: *p value* < 0.05. *: *p value* < 0.10.
3. Whole sample period: the first period is dropped because of the lagged explanatory variables.
4. R^2: from the corresponding least square dummy variable regression.
5. Results with TKE are similar.
6. A heteroskedasticity-robust Born and Breitung (2016) test for first-order serial correlation with regression (6) has a p value = 0.791. (H_0: No first-order serial correlation) Hence, there is no evidence of first-order serial correlation.

Table 3. **Fixed-Effects Estimation with Relevant Explanatory Variables – Dataset I**

A balanced panel with 21 NAICS 3-digit subsectors in manufacturing during 2002-2018
Dependent Variable: **Labor Productivity** Growth Rate (LPGR, %)

	With Lagged Xs	With Lagged Xs	With Contemporaneous Xs	With Contemporaneous Xs
Explanatory Variables (Xs)	FE	IV estimation, FE2SLS 2nd stage	FE	IV estimation, FE2SLS 2nd stage
ln(Imports from China)	-3.43***	-4.99***	-3.07***	-2.65
	(1.18)	(1.53)	(0.85)	(2.00)
ln(New Capital Expenditures)	-1.81	-1.86	-2.40*	-2.79*
	(1.34)	(1.32)	(1.42)	(1.63)
ln(Exports to China)	-1.57***	-0.47	-0.28	1.03
	(0.50)	(1.69)	(0.48)	(1.54)
Year	0.13	0.15	0.03	-0.11
	(0.16)	(0.23)	(0.13)	(0.15)
Dummy_ 2009 to 2018	1.07	0.77	-0.10	-0.51
	(1.07)	(1.18)	(1.17)	(1.39)
		FE2SLS 1st stage		FE2SLS 1st stage
ln(Canada's Imports from China)		0.44***		0.44***
		(0.14)		(0.14)
ln(Canada's Exports to China)		0.24***		0.26***
		(0.05)		(0.05)
R^2	0.2385		0.2447	
Observations	336	336	357	357
p value of the Wooldridge test for strict exogeneity (H_0: all imports and exports variables are exogenous)	0.0609		0.3787	
Reject H_0 at 5% significance level	No		No	

Notes: 1. ~ 5.: the same as those under Table 2.

6. A heteroskedasticity-robust Born and Breitung (2016) test for first-order serial correlation for the first and third regressions indicates that there is no evidence of first-order serial correlation at a 1% level in each regression.

Table 4. Fixed-Effects Estimation – Dataset II

An unbalanced panel of 4 NAICS 2-digit sectors during 1994-2018
Dependent Variable: Labor Productivity Growth Rate (LPGR, %)
With 2 Lagged Explanatory Variables

Variables	(1)	(2)	(3)	(4)
(FDI to China) $_{i(t-1)}$	-0.0012***	-0.0009***	-0.0009***	-0.0009***
	(0.0004)	(0.0001)	(0.0002)	(0.0002)
ln(New Capital Expenditures) $_{i(t-1)}$		5.70	5.45	5.30
		(3.92)	(4.12)	(3.52)
Edu $_{it}$	-3.61	11.56	9.26	10.30
	(8.24)	(8.61)	(11.15)	(6.99)
Year $_t$	0.06	-0.23*	-0.21*	-0.33**
	(0.16)	(0.12)	(0.13)	(0.15)
Dummy_Great_Recession			0.84	
			(1.10)	
Dummy_2009 to 2018				1.84
				(1.90)
R^2	0.1205	0.4511	0.4835	0.4546
Observations	73	69	69	69

Notes:

1. A robust standard error is presented in each parenthesis.
2. ***: *p value* < 0.01. **: *p value* < 0.05. *: *p value* < 0.10.
3. FDI is measured by millions of US dollars. Regressions with NKE have fewer years of data due to missing values.
4. The 4 sectors are mining [21], utilities [22], manufacturing [31, 32, 33], and wholesale trade [42]: NAICS 2-digit codes in brackets.
5. The results with TKE are similar.
6. Whole sample period: the first period is dropped because of the lagged explanatory variables.
7. A heteroskedasticity-robust Born and Breitung (2016) HR test for first-order serial correlation indicates no evidence of serial correlation of order one at a 1% level in regressions (3) and (4).

Table 5. Fixed-Effects Estimation with Relevant Explanatory Variables – Dataset II

An unbalanced panel of 4 NAICS 2-digit sectors during 1994-2018
Dependent Variable: Labor Productivity Growth Rate (LPGR, %)
X1: FDI to China (millions of dollars); X2: New Capital Expenditures (millions of dollars)

	With Lagged X1 & X2	With Lagged X1 & X2	With Contemporaneous X1 & X2	With Contemporaneous X1 & X2
Explanatory Variables (Xs)	FE	IV estimation, FE2SLS 2^{nd} stage	FE	IV estimation, FE2SLS 2^{nd} stage
(FDI to China)	-0.0009***	-0.0017	-0.0012***	-0.0038***
	(0.0002)	(0.0015)	(0.0003)	(0.0013)
ln(New Capital Expenditures)	5.30	5.65	0.85	-1.44
	(3.52)	(4.39)	(3.18)	(3.90)
Edu	10.30	12.61	3.98	-1.23
	(6.99)	(10.09)	(14.82)	(18.77)
Year	-0.33**	-0.24	-0.15	0.19
	(0.15)	(0.39)	(0.18)	(0.16)
Dummy_2009 to 2018	1.84	1.43	2.23	1.70
	(1.90)	(2.48)	(2.81)	(2.65)
		FE2SLS 1^{st} stage		FE2SLS 1^{st} stage
(Canada's FDI to Asia)		-0.16***		-0.16***
		(0.05)		(0.05)
R^2	0.4546		0.5251	
Observations	69	56	73	60
p value of the Wooldridge test for strict exogeneity (H_0: the (FDI to China) variable is exogenous)	0.5572		0.1144	
Reject H_0 at 5% significance level	No		No	

Notes: 1. ~ 6.: the same as those under Table 4.

7. The instrumental variable for (FDI to China) is (Canadian FDI to Asia)$_{it}$: 1999 to 2019, with missing data in some sectors for a few years.

8. The sample size in the IV estimation is smaller due to missing values for Canada's FDI to Asia.

9. A heteroskedasticity-robust Born and Breitung (2016) test for first-order serial correlation indicates no serial correlation of order one at a 1% level in the first and third regressions.

Table 6. Fixed-Effects Estimation – Dataset I

A balanced panel with 21 NAICS 3-digit subsectors in manufacturing from 2002-2018
Dependent Variable: **Total Factor Productivity** Growth Rate (MFPGR, %)
With Lagged Explanatory Variables

Explanatory Variables (Xs)	(1)	(2)	(3)	(4)	(5)	(6)
ln(Imports from China)$_{it-1}$	-2.28***	-1.96***	-1.74***	-1.83**	-1.66**	-1.76**
	(0.72)	(0.67)	(0.67)	(0.74)	(0.74)	(0.73)
ln(New Capital Expenditures)$_{i(t-1)}$		-1.95***	-0.72	-0.77	-0.82	-0.99
		(0.59)	(0.77)	(0.79)	(0.81)	(0.91)
ln(Imports from other Asian Nations)$_{i(t-1)}$			2.46**	2.86***	2.66***	2.65***
			(1.01)	(0.93)	(0.99)	(0.97)
ln(Imports from the EU)$_{i(t-1)}$			-2.45	-2.43	-2.49	-2.94*
			(1.54)	(1.57)	(1.58)	(1.61)
ln(Imports from Canada and Mexico)$_{i(t-1)}$			-1.78	-1.83	-1.90	-1.69
			(1.50)	(1.45)	(1.41)	(1.44)
ln(Exports to China)$_{i(t-1)}$				0.14	0.18	0.25
				(0.43)	(0.44)	(0.45)
ln(Exports to other Asian Nations)$_{i(t-1)}$				1.45*	1.37	1.84**
				(0.84)	(0.84)	(0.94)
ln(Exports to the EU)$_{i(t-1)}$				-0.65	-0.33	-0.58
				(0.61)	(0.62)	(0.64)
ln(Exports to Canada and Mexico)$_{i(t-1)}$				-1.13	-1.26	-1.05
				(1.30)	(1.41)	(1.39)
Year	0.03	0.05	-0.02	-0.03	-0.04	0.04
	(0.06)	(0.06)	(0.07)	(0.10)	(0.10)	(0.12)
Dummy_Great Recession (2009-2010)					-0.71	
					(0.50)	
Dummy_2009 to 2018						-1.03
						(0.71)
R^2	0.1343	0.2069	0.0782	0.0686	0.0604	0.0493
Observations	336	336	336	336	336	336

Notes:

1. A robust standard error is presented in each parenthesis.
2. ***: *p value* < 0.01. **: *p value* < 0.05. *: *p value* < 0.10.
3. Whole sample period: the first period is dropped because of the lagged explanatory variables.
4. R^2: from the corresponding least square dummy variable regression.
5. Results with TKE are similar.
6. A heteroskedasticity-robust Born and Breitung (2016) test for first-order serial correlation with regression (6) has a p value = 0.791. (H_0: No first-order serial correlation)
   Hence, there is no evidence of first-order serial correlation.

Table 7. Fixed-Effects Estimation with Relevant Explanatory Variables – Dataset I

A balanced panel with 21 NAICS 3-digit subsectors in manufacturing during 2002-2018
Dependent Variable: **Total Factor Productivity** Growth Rate (MFPGR, %)

	With Lagged Xs	With Lagged Xs	With Contemporaneous Xs	With Contemporaneous Xs
Explanatory Variables (Xs)	FE	IV estimation, FE2SLS 2nd stage	FE	IV estimation, FE2SLS 2nd stage
ln(Imports from China)	-1.90***	-3.54**	-0.29	-0.50
	(0.66)	(1.40)	(0.78)	(1.22)
ln(New Capital Expenditures)	-2.12***	-2.07***	-0.57	1.29
	(0.77)	(0.65)	(0.81)	(0.82)
ln(Exports to China)	-1.11	0.67	0.10	-0.86
	(0.27)	(1.30)	(0.27)	(0.89)
Year	0.11	0.16	- 0.08	-0.16*
	(0.11)	(0.24)	(0.07)	(0.09)
Dummy_ 2009 to 2018	-0.61	-0.80	-0.39	-0.84
	(0.75)	(0.71)	(0.59)	(0.66)
		FE2SLS 1st stage		FE2SLS 1st stage
ln(Canada's Imports from China)		0.44***		0.44***
		(0.14)		(0.14)
ln(Canada's Exports to China)		0.24***		0.26***
		(0.05)		(0.05)
R^2	0.2025		0.2290	
Observations	336	336	357	357
p value of the Wooldridge test for strict exogeneity (H_0: all imports and exports variables are exogenous)	0.2253		0.7004	
Reject H_0 at 5% significance level	No		No	

Notes:

1.~5.: the same as those under Table 2.

7. A heteroskedasticity-robust Born and Breitung (2016) test for first-order serial correlation for the first and third regressions indicates that there is no evidence of first-order serial correlation at a 1% level in each regression.

Table 8. Fixed-Effects Estimation – Dataset II

An unbalanced panel of 4 NAICS 2-digit sectors during 1994-2018
Dependent Variable: **Total Factor Productivity** Growth Rate (MFPGR, %)
With 2 Lagged Explanatory Variables

Variables	(1)	(2)	(3)	(4)
(FDI to China) $_{i(t-1)}$	-0.0008***	-0.0005	-0.0005	-0.0005
	(0.0002)	(0.0003)	(0.0003)	(0.0004)
ln(New Capital Expenditures) $_{i(t-1)}$		4.68*	4.86*	4.93*
		(2.67)	(2.88)	(2.79)
Edu $_{it}$	-13.34	-2.05	-0.40	-1.27
	(8.74)	(8.89)	(10.79)	(8.96)
Year $_t$	0.08	-0.16	-0.17	-0.10
	(0.10)	(0.14)	(0.15)	(0.15)
Dummy_Great_Recession			-0.60	
			(0.83)	
Dummy_2009 to 2018				-1.13
				(1.28)
R^2	0.9712	0.2123	0.0256	0.1081
Observations	73	69	69	69

Notes:

1. A robust standard error is presented in each parenthesis.
2. ***: *p value* < 0.01. **: *p value* < 0.05. *: *p value* < 0.10.
3. FDI is measured by millions of US dollars. Regressions with NKE have fewer years of data due to missing values.
4. The 4 sectors are mining [21], utilities [22], manufacturing [31, 32, 33], and wholesale trade [42]: NAICS 2-digit codes are in brackets.
5. The results with TKE are similar.
6. Whole sample period: the first period is dropped because of the lagged explanatory variables.
7. A heteroskedasticity-robust Born and Breitung (2016) HR test for first-order serial correlation indicates no evidence of serial correlation of order one at a 1% level in regressions (3) and (4).

Table 9. Fixed-Effects Estimation with Relevant Explanatory Variables – Dataset II

An unbalanced panel of 4 NAICS 2-digit sectors during 1994-2018
Dependent Variable: **Total Factor Productivity** Growth Rate (MFPGR, %)
X1: FDI to China (millions of dollars); X2: New Capital Expenditures (millions of dollars)

	With Lagged X1 & X2	With Lagged X1 & X2	With Contemporaneous X1 & X2	With Contemporaneous X1 & X2
Explanatory Variables (Xs)	FE	IV estimation, FE2SLS 2^{nd} stage	FE	IV estimation, FE2SLS 2^{nd} stage
(FDI to China)	-0.0005 (0.0004)	-0.0002 (0.0013)	-0.0007 (0.0005)	-0.0011*** (0.0003)
ln(New Capital Expenditures)	4.93* (2.79)	2.85 (1.88)	0.72 (2.43)	0.84 (2.01)
Edu	-1.27 (8.96)	-10.40 (7.24)	-10.65 (12.44)	-10.39 (14.68)
Year	-0.10 (0.15)	-0.12 (0.24)	0.08 (0.22)	0.10 (0.07)
Dummy_2009 to 2018	-1.13 (1.28)	-0.03 (0.92)	-0.67 (0.64)	-0.47 (1.31)
		FE2SLS 1^{st} stage		FE2SLS 1^{st} stage
(Canada's FDI to Asia)		-0.16*** (0.05)		-0.16*** (0.05)
R^2	0.1081		0.9500	
Observations	69	56	73	60
p value of the Wooldridge test for strict exogeneity (H_0: the (FDI to China) variable is exogenous)	0.5977		0.5136	
Reject H_0 at 5% significance level	No		No	

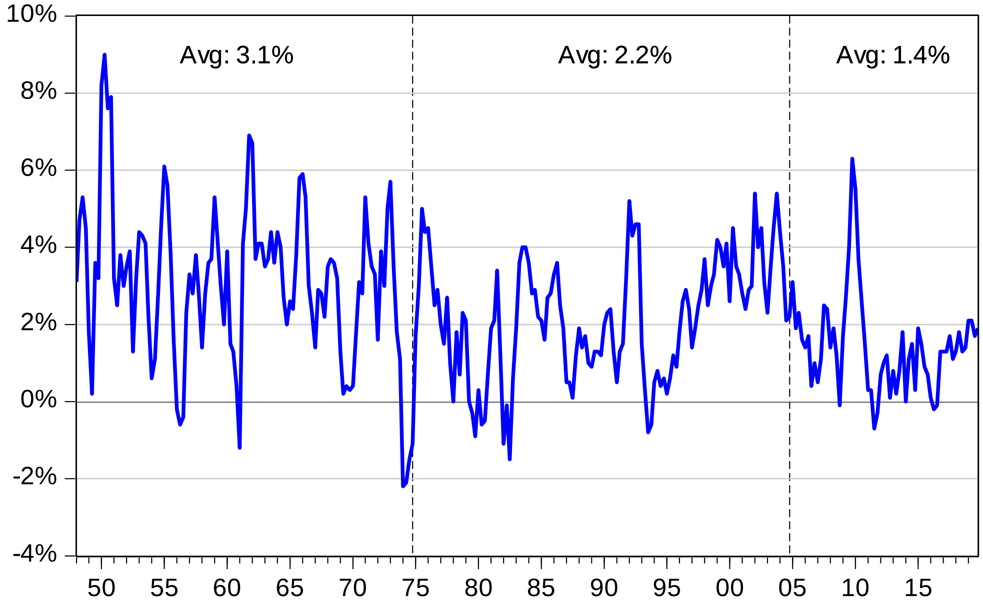
Notes: 1. ~ 6.: the same as those under Table 4.

7. The instrumental variable for (FDI to China) is (Canadian FDI to Asia)$_{it}$: 1999 to 2019, with missing data in some sectors for a few years.

8. The sample size in the IV estimation is smaller due to missing values for Canada's FDI to Asia.

9. A heteroskedasticity-robust Born and Breitung (2016) test for first-order serial correlation indicates no serial correlation of order one at a 1% level in the first and third regressions.

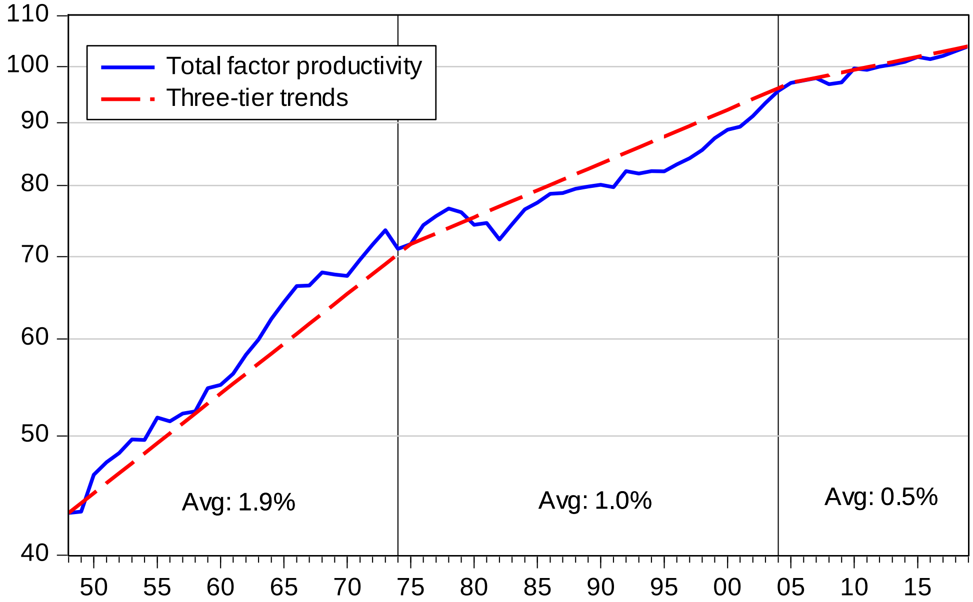
Figure 1. Year-over-year Quarterly Labor Productivity Growth Rate in the U.S., Seasonally Adjusted



Source: Bureau of Labor Statistics

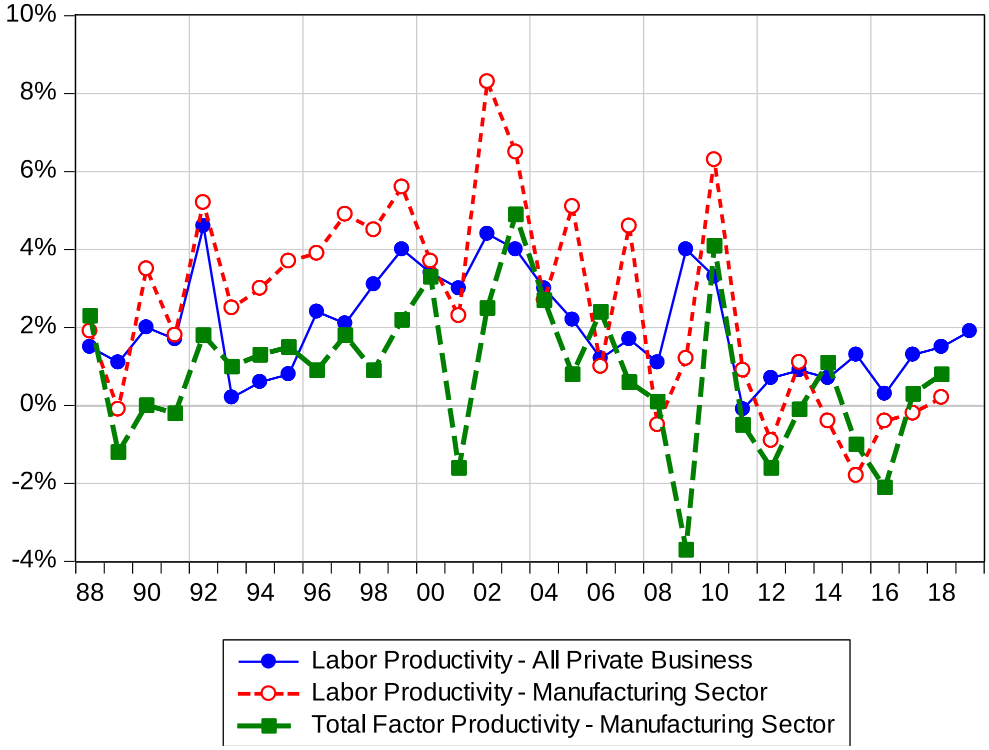
Note: Real output per hour of all persons in business sector

Figure 2. Total Factor Productivity in the U.S., Private Business Sector



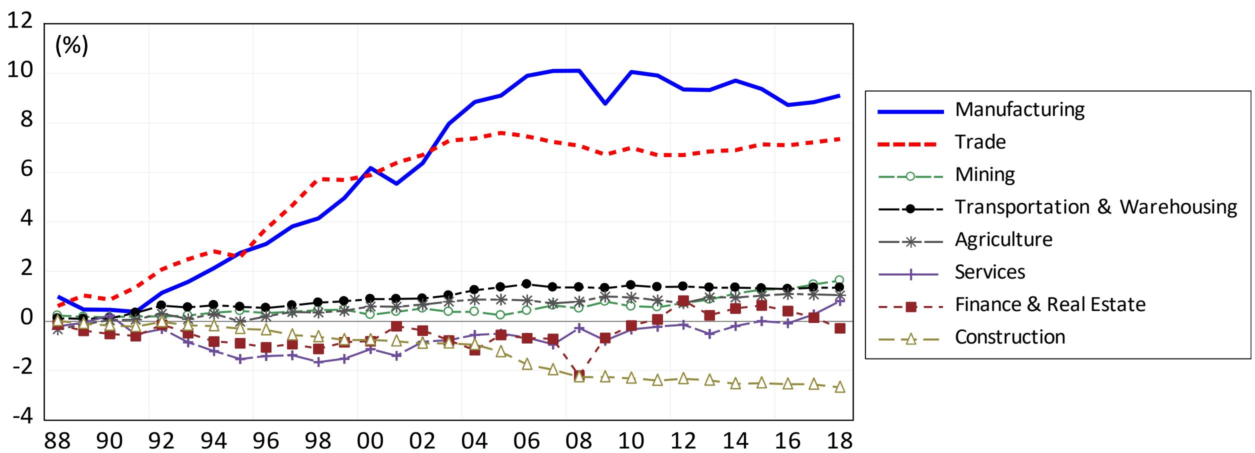
Source: Bureau of Labor Statistics
Note: Multifactor Productivity, Index 2012 = 100

Figure 3. Labor Productivity Growth Rates in All Private Sector and the Manufacturing Sector and Total Factor Productivity in the Manufacturing Sector



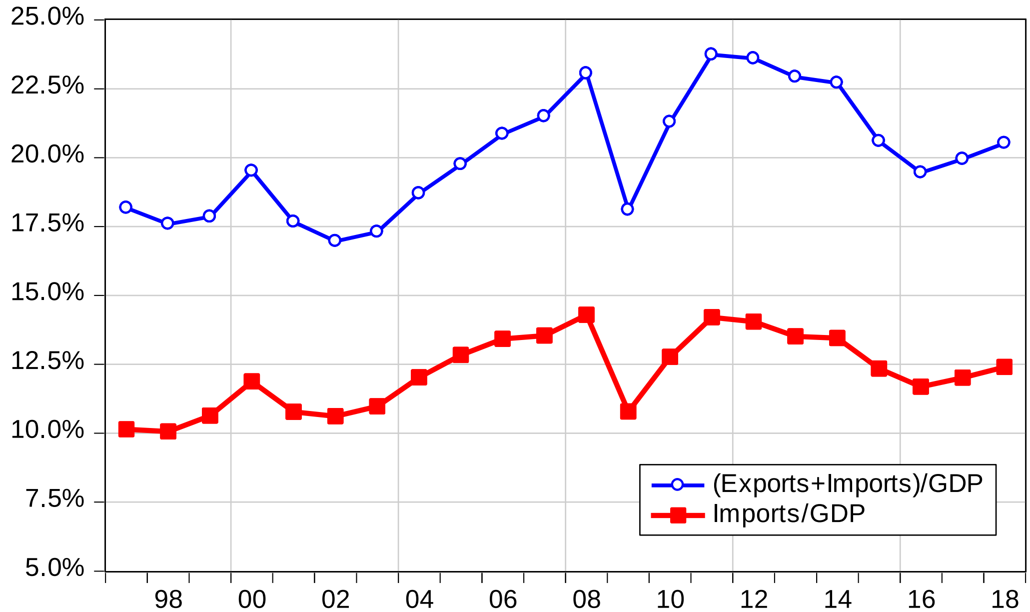
Source: Bureau of Labor Statistics

Figure 4. Accumulated Contributions to the Total Factor Productivity Growth (Percentage Point) by Major Sector



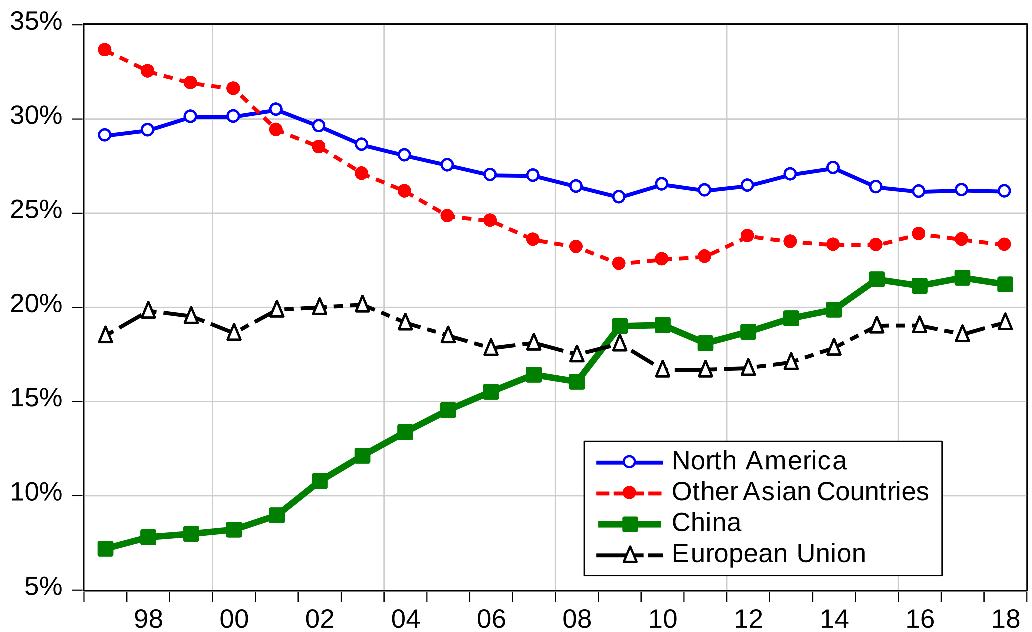
Source: Bureau of Labor Statistics

Figure 5. Percentages of U.S. Exports and Imports over GDP and Imports over GDP



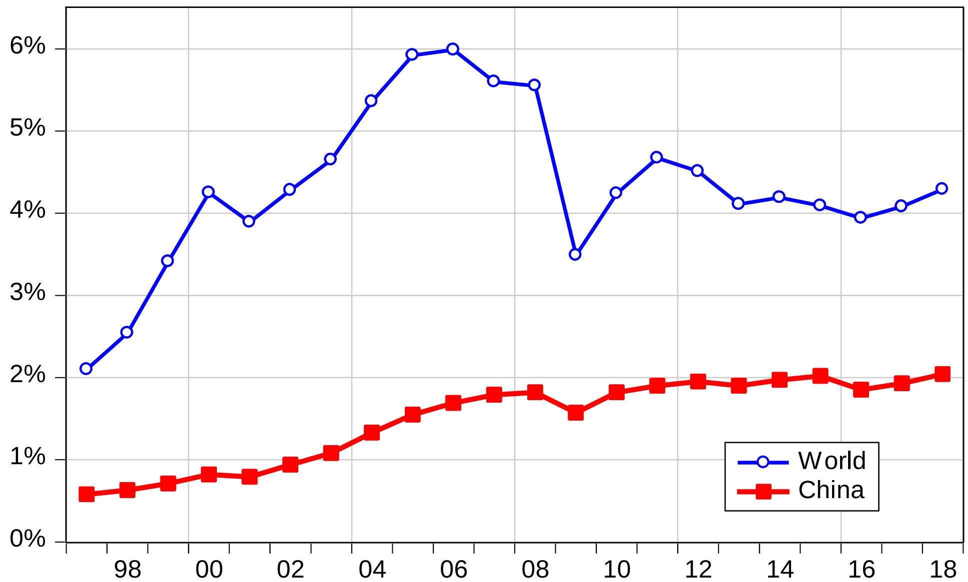
Source: U.S. Census

Figure 6. Percentages of Imports From U.S. Major Trading Partners Over U.S. Total Imports



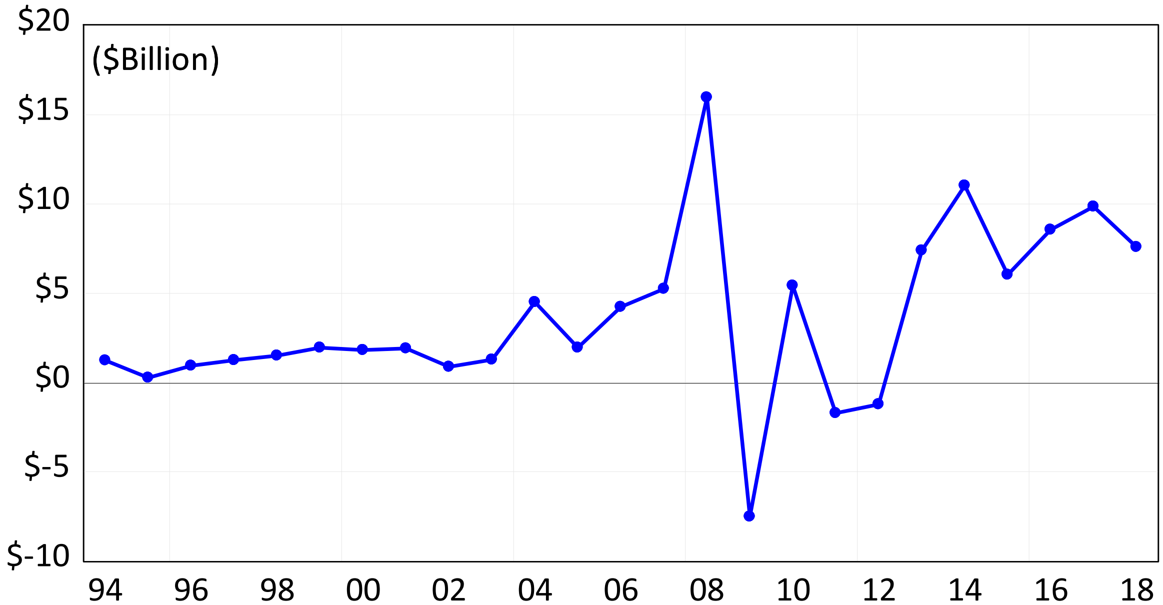
Source: U.S. Census

Figure 7. Percentages of U.S. Merchandise Trade Deficits with the World and China over U.S. GDP



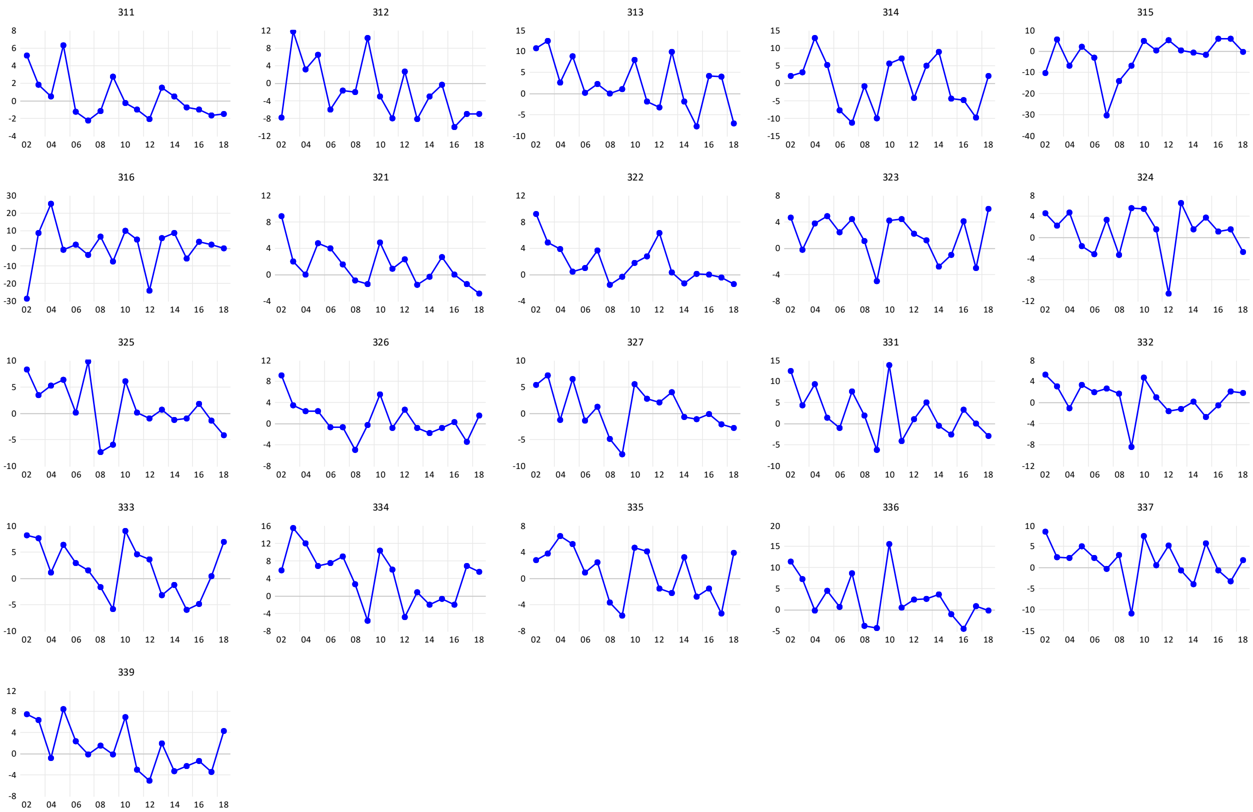
Source: U.S. Census and Bureau of Economic Analysis

Figure 8. FDI from the U.S. to China, Goods and Services



Source: BEA, U.S. Direct Investment Abroad: Financial Transactions Without Current-Cost Adjustment, outflows (+), inflows (-)

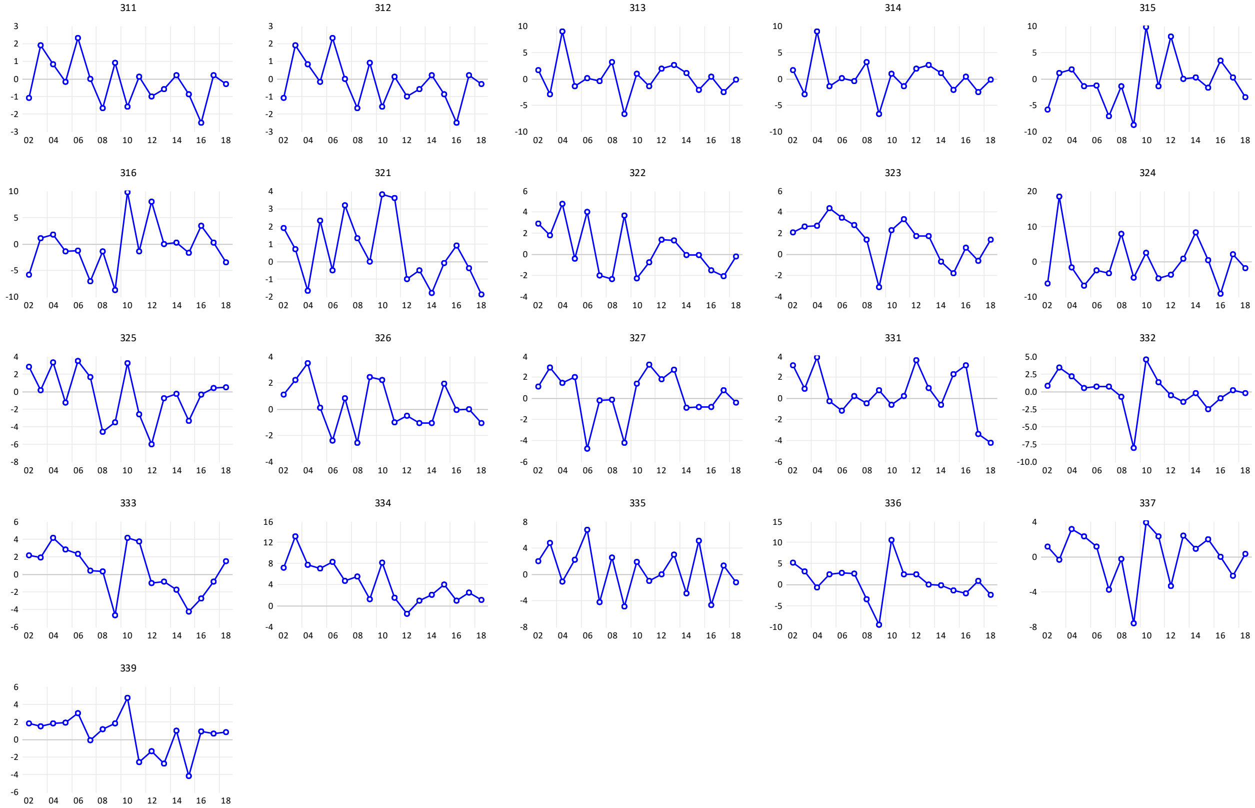
Figure 9. Growth Rate of Labor Productivity by Manufacturing Subsector in the U.S.



Source: BLS

Note: 311- Food manufacturing, 312-Beverages and tobacco products, 313-Textile mills, 314-Textile product mills; 315-Apparel, 316-Leather and allied products, 321-Wood products, 322-Paper and paper products, 323-Printing and related support activities, 324-Petroleum and coal products, 325-Chemicals, 326-Plastics and rubber products, 327-Nonmetallic mineral products, 331-Primary metals, 332-Fabricated metal products, 333-Machinery, 334-Computer and electronic products, 335-Electrical equipment and appliances, 336-Transportation, 337-Furniture and related products, 339-Miscellaneous manufacturing

Figure 10. Growth Rate of Total Factor Productivity by Manufacturing Subsector in the U.S.



Source: BLS

Note: 311- Food manufacturing, 312-Beverages and tobacco products, 313-Textile mills, 314-Textile product mills; 315-Apparel, 316-Leather and allied products, 321-Wood products, 322-Paper and paper products, 323-Printing and related support activities, 324-Petroleum and coal products, 325-Chemicals, 326-Plastics and rubber products, 327-Nonmetallic mineral products, 331-Primary metals, 332-Fabricated metal products, 333-Machinery, 334-Computer and electronic products, 335-Electrical equipment and appliances, 336-Transportation, 337-Furniture and related products, 339-Miscellaneous manufacturing