# “China Shock” or China Dividend? - China GVC Participation’s Effects on Trading Partners’ Technological Progress

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**Abstract:** *This paper explores the effects of China’s global value chain (GVC) participation on technological progress in trading-partner countries based on estimated data on value-added trade between China and 52 trading partners. We find that, first, although China’s exports lowered the total factor productivity (TFP) of its trading partners (competitive effect), its imports greatly increased trading partners’ TFP (effect of scale). This implies that China’s GVC participation is beneficial to its trading partners’ technological progress in the form of a considerable technology dividend effect. Second, China’s export dividend effect compensates for the negative effect of Chinese competition on trading partners’ technological progress; the innovation effects attributable to China’s imports reinforce the positive effects of scale on technological progress. When innovation is factored in, the China dividend thus becomes further reinforced. Third, China’s merchandise imports have a diminishing positive effect on technological progress in trading partners as geographical distance increases, but trade in services transcends geographical boundaries, and the positive technological progress effect of China’s service imports do not diminish as distance increases. We find that the “China dividend” from China’s GVC participation is a significant contributor to technological progress in partner nations, and China’s imports are conducive to innovation and technological progress in developed countries in the long run.*

**Keywords:** *Global value chains, China dividend, trade in value-added, technology spillover, collaborative innovation*
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## 1. Introduction

Since the start of its reform and opening up in 1978, China has integrated itself into global production networks and emerged as “the world’s factory floor,” due to its advantages in production factor endowments. China’s participation in global value chains (GVCs) has provided developed countries with ample commodities and inputs to production and dramatically lowered production costs, contributing remarkably to the world economy’s vigorous growth for three decades. However, since China’s trade volume and foreign exchange surplus have expanded dramatically during this time, some scholars have blamed the “China shock” for economic imbalances and social problems in some

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developed countries following China's involvement in GVC. Autor et al. (2013a) were the first to investigate widening income disparities and job polarization in industrialized countries. They argued that China's participation in GVC significantly increased US import penetration, causing technology shocks and job polarization. Following that, Autor et al. (2013b) also examined the impact of import competition from China on the US labor market and found that a quarter of job losses in the US manufacturing sector were caused by import competition from China and that US government transfer payments for unemployment, disability, retirement, and healthcare also grew significantly. Other studies on the socioeconomic effects of the "China shock" on partner nations have followed (Autor et al., 2019; Asquith et al., 2019; Caliendo et al., 2019; Feenstra and Sasahara, 2018). These studies have blamed China for the United States' economic troubles over the past decade, putting Chinese-US trade in jeopardy. Based on their findings, the US government launched "301 investigators" and imposed repeated rounds of tariffs on imports from China, significantly weakening Chinese-US economic and trade ties and hampering global economic growth and integration.

According to the Heckscher-Ohlin theorem, the dividing labor based on comparative advantage increases welfare on both sides of trade. Indeed, wealthy countries may face job losses in labor-intensive industries. However, the problem can be alleviated if the government provides training to unemployed persons so that they can find work in areas with competitive advantages. In comparison to welfare losses for unskilled people, developed countries stand to benefit from imports of low-cost goods from China, allowing them to devote resources to R&D and innovation to promote technological progress. However, in reality this has not always occurred. Academics have even criticized China for triggering distributional disequilibrium in Western countries without considering the contribution of China's GVC participation to technological progress for its trading partners. According to the theory of international division of labor, China's GVC participation boosts developed countries' advantages in high-end GVC links that focus on R&D and innovation, which fuel technological progress. Existing research focuses mostly on "China shock" and job implications, which exaggerates the negative impact of China's GVC involvement. In order to clarify and establish theoretical arguments for GVC governance and global economic integration, this paper investigates the technological progress effects of China's GVC participation on its trading partners.

This study contributes to the existing literature in the following ways. First, it draws on the work of Yang and Fan (2015) and Feenstra and Weinstein (2017) to examine the technological progress effects of China's involvement in GVC. Based on import penetration, most current research has evaluated the effects of trade on the labor markets of importing nations. From the viewpoints of international trade, cross-border investment, and talent flow, however, many researchers have studied global technology diffusion since Coe and Helpman (1995) began to look at the import effect of home country's R&D (Fracasso and Marzetti, 2015; Madsen, 2007). Given China's major achievements in technological innovation over the last two decades, completely disregarding technology spillovers from Chinese products will result in biased results. China's proportion of global patent filings rose dramatically from 5.935% in 2000 to 16.347% in 2016, indicating a remarkable improvement in the country's capacity for R&D. The purpose of this paper is to measure the import penetration of China's exports within its trading partners by drawing on the work of Autor et al. (2013a) and Asquith et al. (2019). These results are then used to assess the effects of China's exports on technological progress in its trading partners through the CH framework.

Second, this paper offers an examination of how China's imports affect trading partners' technological progress, particularly of the collaborative innovation effect of imports. Previous research mainly focuses on how China's involvement in GVC affects its own R&D initiatives (Lyu et al., 2018). The world economy went through a period of adjustment following the global financial crisis that began in 2008, and as a GVC stakeholder, China began to transform from the world's factory floor to becoming an emerging global market by prioritizing both imports and exports instead of only exports. China's imports as a percentage of global imports rose from 2.36% in 2002 to 9.94% in 2017, according to World Bank data, making it a significant global market. Growing numbers of companies implementing new technology go hand in hand with expanding export opportunities (Bratt, 2017). China is a major importer of high-tech goods and production services, and it specializes in production and assembly-related GVC. Global high-tech sectors have benefitted from expanding demand, and companies have been encouraged to engage in R&D by growing returns to corporate R&D, which has generated endogenous momentum for technological advancement.

Third, this paper introduces the collaborative innovation effect of imports. Productivity and innovation are significantly affected by market scale, and firms that have access to international markets are more likely to export, which boosts productivity (Lileeva and Trefler, 2010). Over the past 20 years, product modularization and technology iteration have caused the global division of labor to shift from traditional manufacturing and trade sectors to innovation at a deeper level. In today's GVC, knowledge-based division of labor is emerging as a significant trend that gives rise to global innovation chain (GIC). China is ranked highly on the list of International Cooperation in Patenting, according to statistics from the European Patent Office (EPO). The foreign ownership of domestic inventions (FODI) and the domestic ownership of inventions made abroad (DOIA) are two categories of international cooperative patents registered at the EPO that represent China's involvement in worldwide collaborative R&D, and China saw notable gains in both the DOIA and FODI over the sample period, rising by 29.23% and 40.99%, respectively. This suggests that China has emerged as a key GVC innovation hub, and that export-driven demand growth spurs collaborative innovation that has a significant influence on technological progress in China's trading partners.

The remainder of this paper is structured as follows: Section 2 specifies the equations to be estimated, data sources, and calculation methods. Section 3 offers an empirical analysis of the relationship between China's GVC participation and technological progress in its trading partners, including heterogeneous effects for different sectors, patents, and trade modes. Section 4 performs a robustness test based on different methods. Section 5 presents concluding remarks and policy suggestions.

## 2. Research Design, Variable Specification and Data Sources

### 2.1 Empirical Specification

In this paper, we investigate the effects of China's GVC participation on technological progress in its trading partners from the dual perspectives of imports and exports based on the empirical equations of Autor et al. (2013a) and Asquith et al. (2019) and in light of data sample characteristics. The empirical equation is as follows:

$$\ln tfp_{it}=\alpha_0+\alpha_1\ln IP_{ict}+\alpha_2\ln export_{ict}+\alpha_3\overline{X}_{it}+\delta_t+\gamma_i+\varepsilon_{it} \quad (1)$$

where $tfp_{it}$ is the TFP of country $i$ in year $t$, $IP$ denotes import competition from China in the same year, *export* is country $i$'s exports to China, and $\overline{X}$ represents a series of control variables. Dual fixed effects are employed to control for the fixed effect of time $\gamma_i$ and the fixed effect of country $\delta_t$. Subscript $i$ denotes a partner country, $c$ denotes China, and $t$ is time.

We control for five determinants of technological progress, including R&D spending, factor endowment, marketization, government intervention, and monetary policy, and denote them as follows: *rd* is R&D spending, *Capital* is capital stock per capita, *market* is the degree of marketization, *gov* is the level of government intervention, and *money* is the robustness of the national currency. Given the autocorrelation in TFP, we have also introduced a lag term for TFP. Equation (1) can thus be rewritten as follows:

$$\ln tfp_{it}=\alpha_0+\alpha_1\ln IP_{ict}+\alpha_2\ln export_{ict}+\alpha_3\ln rd_{it}+\alpha_4\ln captial_{it}+\alpha_5\ln market_{it}$$

$$+\alpha_6 \ln gov_{it}+\alpha_7 \ln money_{it}+\alpha_8 \ln tfp_{it-1}+\delta_t+\gamma_i+\varepsilon_{it} \quad (2)$$

Existing research on the "China shock" is mostly concerned with the employment effects of trade (Autor et al., 2013b; Asquith et al., 2019; Feenstra and Sasahara, 2018), and there is little research on growth effects. However, China's GVC participation, may have an impact on economic development in partner nations from both the imports and exports. First, for imports Autor et al. (2013a) and Feenstra and Sasahara (2018) are only concerned with the direct employment market shocks caused by imports from China. By including the evolution of industrial structure into the analytical framework, Asquith et al. (2019) discovered that import shocks from China result in the evolution of industrial structure and the migration of jobs from tradable to nontradable sectors. However, all of these studies have overlooked the spillover effect of China's technological progress, which has been excluded from the analytical framework.[1] Imports, may help importing countries progress technologically through the technology diffusion effect. The purpose of this study is to look at the technology spillover impact of imports through the prism of how China's knowledge stock benefits its trading partners through imports, and we thus update Equation (2) as follows:

$$\ln tfp_{it}=\alpha_0+\alpha_1 \ln IP_{ict} * \ln R\&D_{ct}+\alpha_2 \ln IP_{ict}+\alpha_3 \ln R\&D_{ct}+\alpha_4 \ln export_{ict}+\alpha_5 \ln rd_{it}+ \alpha_6 \ln captial_{it}+\alpha_7 \ln market_{it}+\alpha_8 \ln gov_{it}+\alpha_9 \ln money_{it}+\alpha_{10} \ln tfp_{it-1}+\delta_t+\gamma_i+\varepsilon_{it} \quad (3)$$

where $R\&D_{ct}$ is China's knowledge stock. In addition, we also investigate the effects of exports on technological progress. Exports may promote technological cooperation between both sides of trade through demand expansion that in turn contributes to technological progress on both sides. Strengthening trade networks between countries are accompanied by increasing collaborative innovations along the value chain. In order to analyze the technological progress effects of collaborative innovation, we introduce an interaction term between collaborative R&D and export growth:

$$\ln tfp_{it}=\alpha_0+\alpha_1 \ln IP_{ict} * \ln R\&D_{ct}+\alpha_2 \ln IP_{ict}+\alpha_3 \ln R\&D_{ct}+\alpha_4 \ln export_{ict} * \ln innov_{ict}+ \alpha_5 \ln export_{ict}+\alpha_6 \ln innov_{ict}+\alpha_7 \ln rd_{it}+\alpha_8 \ln captial_{it}+\alpha_9 \ln market_{it}+\alpha_{10} \ln gov_{it}+ \alpha_{11} \ln money_{it}+\alpha_{12} \ln tfp_{it-1}+\delta_t+\gamma_i+\varepsilon_{it} \quad (4)$$

where $innov_{ict}$ represents the intensity of collaborative innovation between country $i$ and China, which is measured by the number of collaborative innovation patents between China and its trading partners.

## 2.2 Variable Specification

*2.2.1 Explained variable: TFP*

We use TFP as a proxy variable for technological progress to perform nonparametric estimation using the Data Envelope Analysis (DEA) based Malmquist index method. This method is not dependent on any specific form of production function and thus avoids 7estimation bias and leads to more generally robust results[2]. We estimate TFP for 52 countries and regions for the period between 2000 and 2013, where nominal GDP is adjusted using the GDP deflators from the World Bank. Inputs include capital stock and labor force, with labor data coming from the International Labor Organization (ILO)[3].

*2.2.2 Two-way value-added trade volumes*

[1] Coe and Helpman (1995) analyzed the technology spillover effect of imports using cross-national panel data, and identified the technology spillover of imports as the primary source of technological progress. Subsequently, many researchers have employed data for various countries and regions to carry out in-depth research of the technology spillover effects of imports to reach similar conclusions (Fracasso and Marzetti, 2015; Zaclicever and Pellandra, 2018).

[2] The global collaborative R&D database published by the EPO encompasses data for collaborative R&D between China and its trade partners. We employ WIOD data to calculate two-way trade in value-added goods and services between 2000 and 2014. Hence, our final sample includes 52 countries and regions over the 14-year period from 2000 to 2013.

[3] In their statistics, total labor force includes the economically active population aged 15 years or above, as well as persons who provide labor for goods and services during specific stages. They include both the employed and the unemployed.

Earlier research on China's GVC participation was focused on aggregate trade, which cannot clearly reflect the value-adding process of intermediate inputs along GVC. Furthermore, earlier research also has the problem of repetitive calculations. These problems are properly addressed by the multilateral framework model for the measurement of trade in value-added goods and services developed by Koopman et al. (2014). Referencing Feenstra and Sasahara's (2018) framework, our model combines the WIOD database with the OECD Inter-Country Input-Output Tables (ICIO) to obtain data for two-way trade in value-added goods and services between China and 52 trading partners between 2000 and 2014.

*2.2.3 Import competition and technology spillover*

In this paper, we created indicators for the import competition effect and technology spillover effect in our investigation of imports versus technological progress. In measuring the import competition effect, we reference the method of Asquith et al. (2019), who define import competition as the share of imports in actual domestic consumption. Here, import competition is defined as follows:

$$IP_{ict}=\frac{IM_{ict}}{Y_{it}+IM_{it}-EX_{it}} \tag{5}$$

where $IM_{ict}$ is country $i$'s imports of value-added goods and services from China in year $t$, and $Y_{it}+IM_{it}-EX_{it}$ is the actual domestic receipt of value-added goods and services (total value-added goods and services plus imported value-added goods and services minus exported value-added goods and services). Autor et al. (2013b) considered that $IP_{ict}$ to be able to reflect the import pressures that China's exports place on its trading partners. In order to reflect the dynamic effect of China's export shock, however, Asquith et al. (2019) further modified the research of Autor et al. (2013b) with the following equation:

$$\Delta IP_{ict}=\frac{\Delta IM_{ict}}{Y_{it}+IM_{it}-EX_{it}} \tag{6}$$

where $\Delta IM_{ict}=IM_{ict}-IM_{ic,1999}$. The year 1999 is the previous year of our sample period, and the change in China's export shock is measured by the difference between value-added imports in each year and the value-added imports of 1999.

Both Autor et al. (2013b) and Asquith (2019) have used IP in their analyses while overlooking the technology spillover effect of imports. In this paper, we remedy this by referencing Coe and Helpman (1995):

$$S_{i,t}^{c}=\Delta IP_{ict} * S_{ct}^{d} \tag{7}$$

To solve equation (4), we also need to know China's knowledge stock. Given the significant differences in R&D efficiency across countries, which are not necessarily reflected in R&D spending, we follow Madsen (2007) and denote a country's knowledge accumulation by the number of patent filings by nonresidents[4]. A country's knowledge stock is thus calculated using the perpetual inventory method:

$$S_{ct}^{d}=I_{ct-1}+(1-\delta)S_{ct-1}^{d} \tag{8}$$

where $S_{ct-1}^{d}$ is China's knowledge stock in the $t$-$1$ year, and $I_{it-1}$ is incremental knowledge, i.e., annual patent filings by non-residents in China; $\delta$ is the depreciation rate (specified to be 5% in this paper). We use the following equation to compute the initial knowledge stock:

$$S_{c,1999}^{d}=\frac{S_{c,1999}}{(\overline{g_c}+\delta)} \tag{9}$$

where $S_{c,1999}$ is China's incremental knowledge flow in 1999, $\overline{g_i}$ is the annual average growth rate of

[4] Patent filings refer to those submitted worldwide in accordance with the Patent Cooperation Treaty or to national patent authorities. Such data are from the World Intellectual Property Organization (WIPO).

China's knowledge flow during the 14 years from 2000 to 2013, and $\delta$ is the depreciation rate. Equation (9) can be used to compute China's initial knowledge stock, which is then substituted into equation (8) to obtain China's knowledge stock in each year. Then, China's knowledge stock is multiplied by $\Delta IP_{ict}$ to include the competition effect and spillover effects.

### 2.4 The Quantitative Expansion and Collaborative R&D Effect of Exports

Exports drive manufacturing expansion and stimulate R&D, thereby raising TFP. Our measurement of trade in value-added exports and the collaborative R&D effect is based on the following equation:

$$export_{ic,t}=\frac{exp_{ic,t}-exp_{ic,1999}}{t-1999},\ t=2000,\ ...,\ 2013 \tag{10}$$

where $export_{ic,t}$ is the growth rate of country $i$'s value-added exports to China in year $t$, and $exp_{ic,t}$ is country $i$'s value-added exports to China in year $t$.

### 2.5 Control Variables

We use R&D spending as a control variable given its important role in a country's long-term technological progress. Additionally, according to endogenous growth theory, growth in capital stock is vital for a country to maintain technological progress in the long run, and we therefore control for a country's factor endowments by using capital stock per capita as a control variable. In addition, more control variables are introduced from the three dimensions of marketization, government size, and monetary policy, as measured by market rules, government size, and monetary policy robustness, respectively. Data for these indicators come from the economic freedom index of the Fraser Institute.

## 3. Empirical Analysis

### 3.1 Full Sample

Considering the dynamic panel characteristics of the data, as previously mentioned we introduced a one-phase lag for TFP into the explanatory variable, which we estimated using the generalized method of moments (GMM) after testing all six equations for validity and relevance for instrumental variables.

**Table 1: Full Sample Analysis of the Technological Progress Effect of China's GVC Participation on Its Trading partners**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| *L.* ln*tfp* | -0.016***<br>(0.000) | -0.012***<br>(0.000) | -0.012***<br>(0.001) | -0.018***<br>(0.000) | -0.027***<br>(0.000) | -0.027***<br>(0.001) | -0.034***<br>(0.000) |
| *IP* | -0.014***<br>(0.001) | | -0.021***<br>(0.001) | 11.470***<br>(0.258) | | 12.100***<br>(0.416) | 11.670***<br>(0.459) |
| *export* | | 3.552***<br>(0.040) | 3.534***<br>(0.081) | | 2.788***<br>(0.063) | 2.071***<br>(0.178) | 1.870***<br>(0.246) |
| *IP** ln*R&D* | | | | -0.858***<br>(0.019) | | -0.907***<br>(0.031) | -0.872***<br>(0.036) |
| ln*R&D* | | | | 6.513***<br>(0.226) | | 2.715***<br>(0.837) | 2.456*<br>(1.275) |
| *Export** ln*innov* | | | | | 2.257***<br>(0.021) | 2.394***<br>(0.057) | 10.61***<br>(0.324) |
| ln*innov* | | | | | 1.685***<br>(0.050) | 1.836***<br>(0.122) | 0.809***<br>(0.220) |
| *IP** ln*R&D**ln*dist* | | | | | | | -0.001<br>(0.001) |
| *Export** ln*innov**ln*dist* | | | | | | | -0.961***<br>(0.029) |

Table 1 Continued

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| ln*rd* | -0.489***<br>(0.039) | -1.150***<br>(0.044) | -0.978***<br>(0.074) | 0.117*<br>(0.070) | -3.215***<br>(0.067) | -2.768***<br>(0.153) | -4.170***<br>(0.241) |
| ln*captial* | 6.040***<br>(0.194) | -0.613***<br>(0.229) | -0.216<br>(0.262) | -0.312*<br>(0.183) | -2.146***<br>(0.332) | -3.027***<br>(0.431) | -3.531***<br>(0.497) |
| ln*market* | 10.340***<br>(0.687) | -10.680***<br>(0.180) | -9.259***<br>(0.898) | -12.660***<br>(0.518) | -22.930***<br>(0.760) | -20.920***<br>(0.993) | -24.060***<br>(2.164) |
| ln*gov* | -15.020***<br>(0.292) | -24.880***<br>(0.308) | -24.270***<br>(0.587) | -21.970***<br>(0.752) | -39.660***<br>(0.537) | -38.540***<br>(1.499) | -37.080***<br>(1.403) |
| ln*money* | 6.680***<br>(0.654) | 16.170***<br>(0.850) | 15.450***<br>(2.552) | 23.360***<br>(1.007) | 12.620***<br>(1.409) | 18.350***<br>(4.538) | 15.650***<br>(4.278) |
| *AR(1)* | 0.041 | 0.0389 | 0.039 | 0.043 | 0.040 | 0.040 | 0.041 |
| *AR(2)* | 0.570 | 0.514 | 0.513 | 0.653 | 0.624 | 0.712 | 0.789 |
| *Sargan* | 0.9997 | 0.9997 | 0.9998 | 1.00 | 0.9999 | 0.9999 | 1.00 |
| Country FE | Y | Y | Y | Y | Y | Y | Y |
| Year FE | Y | Y | Y | Y | Y | Y | Y |
| Observations | 676 | 674 | 674 | 676 | 674 | 674 | 674 |

Note: ***, **, and * denote significance levels at 1%, 5% and 10%, respectively; numbers in parentheses are robust standard deviations (the same below).

Columns (1) and (2) of Table 1 present the effects of China's GVC participation on its trading partners from the two perspectives of import competition and export expansion separately, and column (3) shows the results when both factors are included. Column (3) suggests that China's involvement in the global trade network influences technological progress in its trading partners in two ways. First, import competition from China impedes TFP improvement in its trading partners. The negative shock was concentrated in standardized industrial sectors, causing labor to migrate to service sectors. Service sector expansion then triggered the "Baumol-Fuchs" effect, dragging down TFP in partner countries (Holmes and Stevens, 2014). Second, developed countries have taken a firm hold on R&D activities on the front end of GVC, forcing China to import high-quality intermediate inputs. This "importation for the sake of exports" triggered a significant increase in global demand for high-tech products, and this expansion promoted the specialization of developed countries in high-tech industries, contributing to TFP growth.

The existing literature is primarily concerned with the direct effects of China's GVC participation and overlooks its technology spillover and collaborative R&D effects. On the basis of Coe and Helpman's (1995) research, we now examine the vertical division of labor and technology spillover effects of China's GVC participation. Column (4) reveals how the import competition and technology diffusion effects influenced technological progress in China's trading partners, and column (5) provides an analysis of the innovation effect stemming from export growth and vertical specialization. Column (6) incorporates the effects of both factors. As shown in column 6, even after including technology spillover, imports from China continued to impede technological progress in trading partners. After China's technology spillover effect is taken into account, an increase in the penetration of imports from China by 1% drove down technological progress in its trading partners by 0.947%.

Moreover, exports to China intensely promoted technological progress. After the innovation effect is taken into account, an increase in value-added exports to China by 1% was associated with a TFP increase of 2.394%. With increasing global innovation activities, GVC has evolved into GIC. Since value-added exports account for a growing share of trade, international businesses often choose to increase R&D spending and take an active part in GIC under the strategy of collaborative innovation for technological progress in both importing and exporting countries. This implies that vertical specialization stemming from China's GVC participation promotes R&D activities in its trading partners, contributing to their technological progress under the innovation effect.

Last, we also examined the technology spillover and the innovation effects that change with geography. According to the empirical results in column (7), the partial regression coefficient of the cubic term *Export** ln*innov**ln*dist* is negative and statistically significant. This implies that value-added exports had a diminishing positive effect on trading partners with increasing geographical distance. The partial regression coefficient of *IP** ln*R&D***lndist* is also negative but not statistically significant.

### 3.2 Consideration of Distance

Existing research has shown that two-way trade is influenced by geographical distance (Anderson, 1979; Egger et al., 2015; Rose and Van Wincoop, 2001), and the intensity of technology spillover also diminishes with geographical distance (Bisztray et al., 2018)[5]. Hence, we specified the following equation:

$$\begin{aligned} \ln tfp_{it} = & \alpha_0 + \alpha_1 \ln IP\_C_{ict} * \ln R\&D_{ct} * \ln dis_{ic} + \alpha_2 \ln IP\_S_{ict} * \ln R\&D_{ct} * \ln dis_{ic} + \alpha_3 \ln IP\_C_{ict} + \alpha_4 \ln IP\_S_{ict} \\ & + \alpha_5 \ln R\&D_{ct} + \alpha_6 \ln dis_{ic} + \alpha_7 \ln export\_C_{ict} * \ln innov_{ict} * \ln dis_{ic} + \alpha_8 \ln export\_S_{ict} * \ln innov_{ict} * \ln dis_{ic} \\ & + \alpha_9 \ln export\_C_{ict} + \alpha_{10} \ln export\_S_{ict} + \alpha_{11} \ln innov_{ict} + \alpha_{12} \ln rd_{it} + \alpha_{13} \ln captial_{it} + \alpha_{14} \ln market_{it} + \alpha_{15} \ln gov_{it} \\ & + \alpha_{16} \ln money_{it} + \alpha_{17} \ln tfp_{it-1} + \delta_t + \gamma_i + \varepsilon_{it} \end{aligned} \tag{11}$$

where, *IP_C* is the import penetration of merchandise trade, *IP_S* is the import penetration of service trade, *Export_C* is the growth rate of merchandise exports, and *Export_S* is the growth rate of service exports. *lndis* is the distance between China and its trading partners based on data from the CEPII database. Cross-border manufacturing collaboration is subject to severe problems of reverse choice and fleecing, undermining the efficiency of international cooperation. In the process of GVC governance, disparate governance structures can also affect management cost and manufacturing efficiency, and disparate modes of value chain participation are what ultimately determine a country's economic growth rate (Humphry and Schmitz, 2002). The empirical results are listed in the following table.

**Table 2: Inclusion of the Distance Factor**

| | Domestic ownership of inventions made abroad | | | Foreign ownership of domestic inventions | | |
|---|---|---|---|---|---|---|
| | Merchandise trade | Service trade | Dual trade | Merchandise trade | Service trade | Dual trade |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | ln*tfp* | | | | | |
| *L.tfp* | -0.019***<br>(0.000) | -0.023***<br>(0.000) | -0.022***<br>(0.000) | -0.019***<br>(0.000) | -0.021***<br>(0.000) | -0.020***<br>(0.001) |
| *IP_C** ln*R&D* *ln*dis* | -0.035***<br>(0.001) | | -0.057***<br>(0.007) | -0.037***<br>(0.001) | | -0.113***<br>(0.010) |
| *Export_C**ln*innov1**ln*dis* | 0.135***<br>(0.001) | | -0.024***<br>(0.000) | | | |
| *IP_S** ln*R&D* *ln*dis* | | -0.138***<br>(0.001) | -0.009<br>(0.023) | | -0.113***<br>(0.004) | 0.178***<br>(0.037) |
| *Export_S**ln*innov1**ln*dis* | | 0.365***<br>(0.003) | 0.407***<br>(0.005) | | | |
| *Export_C**ln*innov2**ln*dis* | | | | 0.140***<br>(0.002) | | -0.097***<br>(0.011) |
| *Export_S**ln*innov2**ln*dis* | | | | | 0.312***<br>(0.005) | 0.430***<br>(0.021) |
| *AR(1)* | 0.04 | 0.041 | 0.040 | 0.039 | 0.040 | 0.040 |
| *AR(2)* | 0.618 | 0.690 | 0.688 | 0.551 | 0.583 | 0.575 |
| *Sargan* | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Control variables | Y | Y | Y | Y | Y | Y |

[5] Bisztray et al. (2018) employed Hungary's micro-level data to analyze the spatial and managerial network effects of import spillovers. In order to investigate the role of the headquarters' economy, they limited importing destinations to the Czech Republic, Slovenia, Romania and Russia with the business headquarters located in Budapest. In total, they identified 210,000 businesses with 1.18 million observations. Empirical research revealed that first, technology spillover has significant spatial and managerial spillover effects, and the intensity of spillovers decreases with the geographical distance. Second, the spillover effect is subject to significant heterogeneity, and larger and more productive sectors benefit more greatly from the spillover effect.

| | | | | | | |
|---|---|---|---|---|---|---|
| Country FE | Y | Y | Y | Y | Y | Y |
| Year FE | Y | Y | Y | Y | Y | Y |
| Observations | 676 | 676 | 676 | 676 | 676 | 676 |

Notes: *IP_C* is the import penetration of merchandise trade, *IP_S* is the import penetration of service trade, *Export_C* is the growth rate of merchandise trade, and *Export_S* is the growth rate of service trade. Columns (1) and (2) have controlled for the technological progress effects of merchandise trade and service trade for trading partners, respectively, and column (3) investigates the technological progress effects of the four conduits of both types of trade (merchandise import, merchandise export, service import, and service export) for trading partners. Column (4) through (6) adopt the same empirical strategy. In columns (1) through (3), ln*innov1* is the number of overseas patents owned by China and filed at the EPO, and in columns (4) through (6), ln*innov2* is the number of patents and joint patents owned by other countries and filed at the EPO.

Columns (1) and (2) examine the effects of value-added merchandise trade and value-added service trade, respectively, and column (3) incorporates both types of trade into the analytical framework. Column (3) demonstrates that after the geographical distance factor is taken into account, China's merchandise imports did not drive technological progress in its trading partners, but service imports may have significantly contributed to it. The former's partial regression coefficient is -0.057, and the latter's partial regression coefficient is 0.407, which means that China's service imports were a major driving force of technological progress in its trading partners during the sample period. Increasing geographical distance led to a higher cost of trade, smaller intensive and extensive margins, and a smaller intensity of technology spillover. This in turn caused the technological progress effect of China's merchandise imports on its trading partners to diminish with increasing geographical distance, but trade in intangible services was not affected by geographical distance. Service trade is driven by information technology (Choi, 2010; Kneller and Timmis, 2016; Mainardes et al., 2017), and its spillover effects are therefore hardly susceptible to geographical distance. Hence, China's service imports promoted technological progress in its trading partners.

**3.3 Re-Examination based on GVC Position**

In the previous section, we investigated the technological progress effect of China's GVC participation on its trading partners in the two dimensions of the quantitative expansion effect and the import competition effect. Given China's rise in position on many GVC, its spillover effect to trading partners must naturally have changed. A higher GVC position signifies a country's greater capability for value-added production, and businesses may change their cooperation strategies with rising value chain status, resulting in different growth efficiencies (Antràs and Gortari, 2020). Hence, this section examines the impact of GVC position on the spillover effect. Antràs et al. (2012) developed the concept of upstreamness, and considered it a good indicator for measuring a country's value chain position. The specific equation is as follows:

$$U_i^r = 1\times\frac{F_i^r}{Y_i^r} + 2\times\frac{\sum_{s=1}^{S}\sum_{j=1}^{J} a_{ij}^{rs} F_j^s}{Y_i^r} + 3\times\frac{\sum_{s=1}^{S}\sum_{j=1}^{J}\sum_{t=1}^{S}\sum_{k=1}^{J} a_{ij}^{rs} a_{jk}^{st} F_k^t}{Y_i^r} + \cdots \quad (12)$$

where, country $i$'s sector $r$ employs intermediate input $Z_{ij}^{rs}$ from country $j$'s sector $s$, final consumption is $F_{ij}^r$, and aggregate output is $Y_i^r$. $a_{ij}^{rs} = \frac{Z_{ij}^{rs}}{Y_j^s}$ is the intermediate input consumption coefficient of country $i$'s sector $r$ with respect to country $j$'s sector $s$. Upstreamness measures the distance of a given sector to the final consumer, which is the distance downstream, but cannot reflect the distance upstream. Antràs and Chor (2017) thus developed the concept of "downstreamness", i.e., distance to raw materials:

$$D_j^s = 1\times\frac{VA_j^s}{Y_j^s} + 2\times\frac{\sum_{r=1}^{S}\sum_{i=1}^{J} b_{ij}^{rs} VA_i^r}{Y_j^s} + 3\times\frac{\sum_{s=1}^{S}\sum_{j=1}^{J}\sum_{t=1}^{S}\sum_{k=1}^{J} b_{ki}^{tr} b_{ij}^{rs} VA_k^t}{Y_j^s} + \cdots \quad (13)$$

where, $b_{ij}^{rs} = \frac{Z_{ij}^{rs}}{Y_i^r}$ is the consumption coefficient of products from country $i$'s sector $r$ by country $j$'s sector

[6] Refer to Antràs (2012) and Wang et al. (2015) for the specific method of calculation.

*s*. Similar to upstreamness, the absolute value of downstreamness is also greater than 1, and higher value implies a greater degree of downstreamness. However, downstreamness takes sectoral output value, import and export volume, and cross-national input-output tables (Leontief Inverse Matrix) to compute[6].

Upstreamness and downstreamness investigate distance to the upstream and downstream of a value chain, respectively but cannot reflect GVC position itself. Based on the research of Wang et al. (2017), we therefore introduce the following equation for GVC position:

$$\ln GVC_{it} = \ln[(1+\frac{export_{it}}{VA_{it}})U_{it} - (1+\frac{import_{it}}{VA_{it}})D_{it}] \qquad (14)$$

where, $GVC_{it}$ is the relative GVC position of sector $i$ in year $t$, *export* is export value added, *import* is import value added, and *VA* is sectoral value added. *U* is sectoral upstreamness, and *D* is sectoral downstreamness. The approach to equation (14) is as follows: A country's relative GVC position is subject to industrial capabilities for value addition (local value-added ratio is measured by the difference between export value added and import value added). Upstreamness and downstreamness are calibrated as the accounting weights of the forward linkage effect and backward linkage effect, respectively. After calculating the GVC position, the result was substituted into Equation (11) to analyze the technological progress effect of China's rising GVC position on its trading partners, and the empirical results are listed in the following table.

**Table 3: Re-Examination Based on the GVC Position**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | ln*tfp* | | | | | |
| *L.* ln*tfp* | -0.018***<br>(0.000) | -0.018***<br>(0.000) | -0.018***<br>(0.000) | -0.014***<br>(0.000) | -0.010***<br>(0.000) | -0.021***<br>(0.000) |
| *gvc* | 2.345***<br>(0.017) | 2.387***<br>(0.033) | 2.888***<br>(0.034) | 3.362***<br>(0.055) | 3.587***<br>(0.078) | |
| *gvc**ln*innov* | | | | | | 0.025***<br>(0.000) |
| *AR(1)* | 0.039 | 0.039 | 0.039 | 0.039 | 0.038 | 0.040 |
| *AR(2)* | 0.553 | 0.555 | 0.559 | 0.529 | 0.509 | 0.597 |
| *Sargan* | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Control variable | Y | Y | Y | Y | Y | Y |
| Country FE | Y | Y | Y | Y | Y | Y |
| Year FE | Y | Y | Y | Y | Y | Y |
| Observations | 674 | 674 | 674 | 674 | 674 | 674 |

Column (1) of Table 3 investigates the technological progress effect of China's GVC position on its trading partners. These empirical results suggest that China's rising GVC position had a positive effect on the technological progress of its trading partners. In columns (2) through (5), we introduce capital stock per capita, marketization, government size, and monetary policy, respectively, and the partial regression coefficient of *gvc* remains positive and statistically significant. This implies that the relationship between GVC position and technological progress is robust to these various model specifications. An increase in China's GVC position by 1% drove up technological progress in its trading partners by 3.587% during the sample period.

China's per capita income has been increasing steadily with its rising GVC status as well, and corresponding growth in consumer demand has increased the effect of market scale. In addition, China's rising GVC position and national R&D capabilities are conducive to the collaborative innovation effect. In column (6), we introduce an interaction term between *gvc* and ln*innov* to examine how rising GVC position contributes to the collaborative R&D effect, and these results indicate that rising GVC position significantly enhanced collaborative R&D. This implies that China's ascent to high-end GVC links enhanced the two-way collaborative R&D effect, thereby contributing to technological progress in its trading partners.

## 4. Robustness Tests

### 4.1 Depreciation Parameter Values

Different technology depreciation rates result in different levels of the knowledge stock, thereby affecting the measurement results of the technological progress effects of import penetration and technology spillover for trading partners. Referencing Madsen (2007), we estimated knowledge stock at 5%, 15%, and 20% depreciation rates. Based on the resulting knowledge stocks, we also remeasured the intensity of technology spillover arising from import penetration.

**Table 4: Empirical Results at Different Knowledge Depreciation Rates**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | 5% | | 15% | | 20% | |
| L.tfp | -0.023*** (0.000) | -0.022*** (0.000) | -0.023*** (0.000) | -0.022*** (0.000) | -0.023*** (0.000) | -0.022*** (0.000) |
| *IP** ln*R&D* | -0.313*** (0.007) | -0.359*** (0.006) | | | | |
| *IP** ln*R&D* | | | -0.324*** (0.007) | -0.370*** (0.007) | | |
| *IP** ln*R&D* | | | | | -0.328*** (0.007) | -0.375*** (0.007) |
| *Export**ln*innov1* | 2.191*** (0.012) | | 2.190*** (0.012) | | 2.190*** (0.012) | |
| *Export**ln*innov2* | | 2.254*** (0.026) | | 2.254*** (0.026) | | 2.254*** (0.026) |
| *AR(1)* | 0.040 | 0.040 | 0.040 | 0.039 | 0.040 | 0.039 |
| *AR(2)* | 0.684 | 0.591 | 0.684 | 0.591 | 0.684 | 0.591 |
| *Sargan* | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Control variable | Y | Y | Y | Y | Y | Y |
| Country FE | Y | Y | Y | Y | Y | Y |
| Year FE | Y | Y | Y | Y | Y | Y |
| Observations | 676 | 676 | 676 | 676 | 676 | 676 |

Note: Columns (1) and (2) set the knowledge depreciation rate at 5%, columns (3) and (4) set the knowledge depreciation rate at 15%, and columns (5) and (6) set the knowledge depreciation rate at 20%..

No matter how the depreciation rate of knowledge stock varies, our conclusion remains the same: Import penetration and technology spillover restrained technological progress in China's trading partners, and export growth and collaborative innovation promoted technological progress. The positive effect outweighed restrictive effect, i.e. China's GVC involvement was conducive to technological progress in its trading partners. This conclusion is consistent with the findings in the preceding section.

### 4.2 Instrumental Variables

The problem of endogeneity cannot be avoided in our analysis of the technological progress effect of China's GVC participation since technological progress in trading partners may have been the cause rather than result of additional imports and exports with China. To solve this problem, we created a shift-share instrumental variable (IV) with the following specifications:

$$\begin{aligned} IPiv_{it} &= IP_{i,2000} * (1+G_{1t}) \\ exportiv_{it} &= export_{i,2000} * (1+G_{2t}) \end{aligned} \tag{15}$$

where, $IP_{i,2000}$ and $export_{i,2000}$ denote import competition from China and country *i*'s exports to China during the initial sample period, and $G_{1t}$ and $G_{2t}$ represent the growth rates of the global average import competition and export volume for country *i* in year *t* relative to the industrial chain length in the initial year. A Bartik IVs is then computed by multiplying the import and export volumes of two-way trade in value-added goods and services in the initial state with exogenous growth rates, and after controlling for the fixed effects of country and time, this variable is not correlated with any residual term that affects technological progress. Moreover, this variable is highly correlated with initial status. Hence, the Bartik IV offers a good solution to the problem of endogeneity that arises from such causes as omitted variables and reverse causality, making it an appropriate instrumental variable for a robustness test (Autor et al., 2013a). The empirical results are shown in the following table.

**Table 5: Empirical Results Based on Bartik IVs**

| | (1) | (2) |
|---|---|---|
| | ln*tfp* | ln*tfp* |
| *IP** ln*R&D* | -0.948*<br>(0.535) | -0.948*<br>(0.535) |
| *Export** ln*innov* | 1.090**<br>(0.475) | 1.090**<br>(0.475) |
| Anderson canon. corr. LM statistic | 723.000<br>[0.000] | 723.000<br>[0.000] |
| Cragg-Donald Wald F statistic | 1.4e+11 | 1.4e+11 |
| Stock-Yogo critical values: | 16.380 | 16.380 |
| Control variable | Y | Y |
| Country FE | Y | Y |
| Year FE | Y | Y |
| Observations | 723 | 723 |

Note: Numbers in brackets are P values corresponding to LM test values.

Column (1) of Table 5 is the regression results of Bartik IV estimated based on the initial values of import competition, and the P value of Anderson test and the Cragg-Donald test value suggest that the Bartik IV is free from weak instrumental variable and under-identification problems. Regression results with the instrumental variable are significant in both statistical and economic senses and are consistent with the baseline regression: although import competition restrained technological progress in trading partners with technology spillover taken into account, the innovation effect driven by export growth promoted technological progress. Column (2) provides regression results for Bartik IV, and the P value of Anderson test and the Cragg-Donald statistic value demonstrate that the Bartik IV is free from weak instrumental variable and under-identification problems here as well. These regression results are again significant in both statistical and economic senses and consistent with the baseline regression: Although import competition restrained technological progress in trading partners with technology spillover controlled for, innovation spurred by export growth was conducive to technological progress.

## 5. Concluding Remarks and Policy Suggestions

The "China shock" has become a focal point of concern for in academia. Existing research on this question has focused on the shock of China's merchandise imports to the job markets of its trading partners, overlooking the "China dividend", i.e., the contribution of China's GVC participation to technological progress in its trading partners. To fill this research gap, we systematically investigated the technological progress effects of China's GVC participation on its trading partners from dual perspectives of imports and exports based on sectoral data of two-way trade in value-added goods and services between China and 52 trading partners. The empirical results lead us to the following conclusions: (i) although China's exports created employment shocks and restrained technological progress in its trading partners, China's imports expanded product demand in its trading partners, and the quantitative expansion effect was conducive to technological progress. As China's opening up strategy shifted priority from exports to an equal focus on both imports and exports, China has begun to transform from the world's factory floor to a global market, offering trading partners broader access to its products. (ii) After the innovation effect is incorporated into the analytical framework, China's imports induced manufacturing expansion and stimulated collaborative R&D innovation in its trading partners, generating a growth effect that compensated for the negative shock of China's exports. Although the "China shock" exists only in the job market, the "China dividend" strongly promoted technological progress in its trading partners. Economists so far have been largely concerned only with the employment shock and have overlooked the growth effect of the "China dividend." (iii) Our sectoral analysis suggests that the quantitative expansion effect and collaborative R&D effect triggered by China's value-added imports have significantly contributed to global technological progress. Due to China's massive imports of intermediate goods and services, the quantitative expansion effect and the R&D innovation effect of imports significantly boosted the development of high-end services and advanced manufacturing globally. They also helped developed nations avoid "cost disease" crises and their continued growth in the service-based economy.

We now present the following policy implications based on the above conclusions. First, China's policymakers should strive to coordinate the interests of multilateral trading partners. While continuing its opening up policy, it is important for China to balance the interests of various stakeholders and shift its "export-oriented" strategy to an equal focus on both imports and exports. We therefore suggest that China expand imports, especially those for less advantageous domestic sectors, and increase the volume and categories of merchandise imports for mutual benefit. We expect imports of upstream high-tech goods and services to compensate for China's shortfall in high-tech products while increasing the technological sophistication of downstream sectors. Second, as knowledge has become increasingly fluid across internationally borders, it has become common for countries and businesses to pursue collaborative innovation, thereby deriving GIC from GVC. China should seize this opportunity for bilateral and multilateral cooperation for innovation, unlock its broad market and innovation potential to attract talent and business interest worldwide, develop a so-called headquarters economy, and build global innovation chain to improve relations with countries involved in its GVC. Deepening division of labor may increase specialization and enhance the multilateral innovation system, contributing to technological progress in China's trading partners that spurs mutual development. Third, China's ascent towards higher GVC links serves the interests of all stakeholders. We expect that China's industrial upgrade to deepen the global division of labor and promote economic growth in its trading partners. Chinese policymakers should be more vocal at the WTO, IMF, and the World Bank and make use of multilateral trade agreements to foster a trade environment that is conducive to global economic integration. CE

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