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How Does Trade Openness Affect Output Growth? A Perspective from the Input Diversity

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Abstract: Globalization has led to a rapid increase in the international trade of intermediate goods, which plays a vital role in economic growth. This study investigates whether trade openness facilitates output growth by improving access to intermediate inputs. In particular, it has been examined whether industrial sectors with higher intermediate input diversity grow relatively faster in countries that are more open to trade. Through the adoption of the difference-in-differences approach, we find strong evidence that this is indeed the case based on a large cross-country sample. The empirical estimation indicates that industries more diversified in intermediate inputs will grow by 2.6 percentage points faster in more outward-oriented countries. Furthermore, our results are robust to various specification checks and are unlikely to be driven by omitted variables, outliers, or reverse causality. By identifying the mechanism through which trade openness facilitates output growth, our study highlights the additional gains from trade liberalization that may be undermined by increased protectionism, especially for industrial sectors that rely on diversified intermediate inputs.

Keywords: trade openness; intermediate inputs; output growth; Herfindahl index

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1. Introduction

The interplay between trade and growth has significant implications for economic advancement and sustainable development [1,2]. To date, examining the relationship between trade openness and output growth remains one of the major challenges in the field of international economics. Despite a major wave of trade liberalization undertaken during the last several decades, the debate on the causality between trade and growth is still open [3]. Ultimately, whether trade openness has a positive effect on growth is an empirical question, as the theoretical literature tends to provide mixed results based on diverse model assumptions [4,5]. This study, therefore, aims to shed light on this topic and examine the relationship from an empirical perspective.

There are two major issues related to the empirical analyses of trade-growth linkages: the way trade openness is measured on the one hand and the identification methodology on the other hand. To measure trade openness, the most straightforward approach is to adopt the ratio of total trade volume (i.e., the sum of exports and imports) relative to GDP. This simple measure, however, is subject to criticism given its endogeneity problem. For instance, better growth performance will lead to an increased exchange of goods and thus enhance the total trade volume, which could cause a bias in estimation resulting from simultaneity. An alternative indicator of openness has been proposed by Sachs and Warner [6] based on several specific trade policies, and afterward, it has been revisited by Wacziarg and Welch [7] with updated data. Since trade-related policies play a large and often decisive role in defining the status of trade liberalization, the openness indicator constructed using the Sachs–Warner criteria enables us to assess how trade policies influence the growth outcome. It is worth noting that the composite policy-based openness indicator alone is not necessarily a complete solution to the simultaneity problem. Therefore, a difference-in-differences estimation strategy has been employed to further mitigate concerns about endogeneity and to better establish a causal link between trade openness and output growth. To deepen our understanding of the causality between trade and growth, it is instructive to focus on a specific channel through which trade openness may affect output growth. In particular, global value chains have become a dominant feature in the era of globalization [8–10], and increased access to intermediate inputs could play an important role in promoting output growth when trade is liberalized [11–13].

The objective of this paper is to scrutinize whether trade openness facilitates output growth by improving access to intermediate inputs. The empirical method includes an interaction term in the estimation that captures the complementarity between country and industry characteristics. The identification strategy employed in this study has a distinct advantage in that it allows us to directly control for both country and industry fixed effects. Consequently, the resulting estimation equation is comparable to a standard difference-in-differences equation, and thus it provides a robust causal interpretation. The empirical results indicate that industries with higher diversity levels in intermediate inputs will grow by 2.6 percentage points faster in countries that are more open to trade. It is noteworthy that these findings are not only statistically significant but also economically significant.

The main contribution of this study is to provide concrete evidence that industries diversified in intermediate goods will indeed experience higher output growth rates in more outward-oriented countries. The empirical analysis is conducted based on 22 industries from 123 countries during the period 1963–2011. More importantly, our results are robust to a series of specification checks and unlikely to be driven by omitted variables, outliers, or reverse causality. First, a difference-in-differences estimation strategy is undertaken to examine the research hypothesis. We prudently incorporate an exhaustive set of pair-wise fixed effects and control for a number of determinants in the estimation. Second, our findings remain qualitatively identical and quantitatively similar after trimming the outliers. Third, the concern about reverse causality should be alleviated, as the main focus is on industry-level growth rather than country-level growth. Moreover, the properly constructed measures utilized in the estimation should ensure further shielding against endogeneity issues.

The remainder of this article is structured as follows: Section 2 reviews the related literature and elaborates on our research hypothesis. Section 3 elucidates the employed estimation strategy and describes the data sources and measures. Section 4 presents the empirical results and robustness checks. Finally, Section 5 provides the conclusion.

2. Literature Review and Hypothesis

2.1. Literature Review

Exploring the foundation of the relationship between trade and growth appears to be a promising area of research. There are a large number of studies that attempt to investigate the underlying mechanism through which trade liberalization fosters economic growth. In a remarkably influential paper, Frankel and Romer [14] exploit an instrumental variable (IV) approach to disentangle the causality in the estimation. Nonetheless, what they genuinely estimate is not the effect of trade on growth per se but the effect of trade on standards of living (i.e., income per capita). In addition, Rodríguez and Rodrik indicate that Frankel and Romer's geographically constructed trade share of GDP may not be a valid IV, considering that geography, in addition to trade, could potentially affect income per capita through other determinants, such as quality of institutions and factor endowments [3]. Moreover, Rodríguez and Rodrik [3] extensively re-examine a recent round of empirical research with regard to the growth effects of trade openness, including Dollar [15], Ben-David [16], Sachs and Warner [6], and Edwards [17]. One common finding of these studies concerns the positive impact of trade openness on economic growth [18]. In particular, Sachs and Warner [6] construct a neatly dichotomous policy indicator of trade openness and emphasize the assertion that outward-oriented economies will typically outperform inward-oriented economies in terms of growth outcomes. Wacziarg and Welch [7] update the Sachs–Warner policy-based openness indicator and extend their study with more recent data. It has been found that countries that liberalize their trade regimes experience average annual growth rates that are approximately 1.5 percentage points higher than rates prior to trade liberalization. Soo [19] develops a theoretical model and concludes that gains from trade in intermediate and final goods exceed those from trade only in final goods.

Output production is deeply integrated into global value chains, through which intermediate inputs are traded [8,9]. Previous studies have shown that increased access to intermediate inputs will enhance firm productivity in several countries, including China [11], Indonesia [20], Chile [21], India [22], and Hungary [23]. One common feature of this strand of literature is the identification of the productivity gains from trade through imported intermediate goods based on plant-level data [12,13]. It has been established that industries have further ability to achieve production improvement and increase the level of productivity by importing more varieties of intermediate inputs under liberalized regimes.

Apart from the empirical evidence, theoretical models provide enlightened insights into an understanding of the interrelationship between trade and growth through the impacts of intermediate inputs. The importance of intermediate inputs for productivity growth has been emphasized in numerous trade and growth models [24–28]. In these models, increased access to intermediate inputs will generate both static and dynamic gains from trade. On the one hand, when trade barriers are dismantled, the output will be promoted by improving access to intermediate inputs that were previously unavailable or were available but at a higher cost [4]. The improvement of productivity will bring about static gains. On the other hand, access to a wide variety of intermediate inputs after trade liberalization can create technological spillovers and lower the costs of innovations, which in turn will engender dynamic gains.

This paper examines whether trade openness facilitates output growth by improving access to intermediate inputs. The identification strategy undertaken by our study is to make predictions based on the interaction of industry characteristics with country characteristics. Fundamentally, the interaction term in the estimation specification arises due to the complementarity between industries' intrinsic features and countries' essential particularities. Since the reduced-form difference-in-differences rationale was introduced by Rajan and Zingales [29], research interest in focusing on this specific type of interaction has been revived. By exploiting an interaction between external finance dependence at the industry level and financial development at the country level, Rajan and Zingales [29] uncover that financially developed countries will grow disproportionately faster in industries relying more on external financing. Fisman and Love [30] revisit the results of Rajan and Zingales [29] and further corroborate the hypothesis that financial development benefits industries with global growth opportunities. As counterpart examples, Beck [31] and Manova [32,33] interact the country's measure of private credit availability with the industry measure of external finance dependence to demonstrate that countries with better financial development tend to export more in industries that are more dependent on external financing. By adopting an analogous approach, Romalis [34] provides the structural underpinnings of Heckscher–Ohlin forces, while Levchenko [35] and Nunn [36] separately examine the institutional impacts on comparative advantage. Putting all these elements together, Chor [37] extends the Eaton and Kortum [38] model to quantify different sources of comparative advantage, which are determined by the interactions between industry and country characteristics.

2.2. Research Hypothesis

The aim of this paper is to explore the interplay between trade openness and output growth, with a particular focus on the channel of intermediate inputs.

First, if intermediate good use is dominated by a few inputs for some industries, these industries are more exposed to hold-up problems in the production process [35]. For example, the major intermediate input supplier may use this type of specific relationship as leverage to "hold up" the producer who is heavily relying on that particular intermediate input [10]. Moreover, it has been well established that the hold-up problem could lead to detrimental economic consequences such as inefficiency and underinvestment [36,39,40]. These resulting organizational frictions will bring about higher costs for producers, which in turn will negatively affect their output growth. Next, the market for intermediate inputs would be "thicker" for industries located in more liberalized countries. If the intermediate inputs are sold on a global market rather than a domestic market, the scope for the hold-up problem is limited as the market becomes more competitive. In other words, the hold-up problem is more severe in countries that are closed to international trade or less outward-oriented. From a macroeconomic perspective, industrial sectors in more liberalized countries are less vulnerable to aggregate shocks due to a richer array of practicable alternatives that are available to them. Finally, more accessible imports of intermediate goods could give a large boost to output growth. By adopting cutting-edge technologies embedded in imported intermediate inputs from more advanced countries, domestic industries will be capable of taking advantage of foreign-based research and development (R&D) and thereby improving the efficiency of production.

Based on the above analysis, it can be predicted that the growth outcome hinges on the interactions between industry characteristics (i.e., intermediate input diversity) and country characteristics (i.e., trade openness). Therefore, the research hypothesis of this paper is proposed as follows: *industrial sectors with higher intermediate input diversity will grow relatively faster in countries that are more open to trade.*

3. Methodology

3.1. Model Specification

This paper examines whether trade openness facilitates output growth by improving access to intermediate inputs. The identification strategy undertaken by our study is to make predictions based on the interaction of industry characteristics with country characteristics. Fundamentally, the interaction term in the estimation specification arises due to the complementarity between industries' intrinsic features and countries' essential particularities. We test the research hypothesis by estimating the following equation:

$$Growth_{ict} = \alpha + \beta HI_i \times Openness_{ct} + \boldsymbol{X}_{\boldsymbol{ict}}'\gamma + D_{ic} + D_{it} + D_{ct} + \epsilon_{ict} \quad (1)$$

where i indicates industry, c denotes countries, and t represents time. The dependent variable $Growth_{ict}$ is the output growth rate for industry i in country c at time t. The coefficient of interest β is on the interaction between the Herfindahl index of intermediate inputs HI_i and the trade liberalization dummy variable $Openness_{ct}$. We employ a variety of fixed effects in this panel specification. Specifically, industry-country, industry-time, and country-time fixed effects are indicated by D_{ic}, D_{it}, and D_{ct}, respectively. This set of fixed effects in the estimation equation is exhaustive in the sense that only those explanatory variables that vary by industry, country, and time can simultaneously be estimated. This should largely alleviate concerns regarding omitted variables and alternative explanations. In particular, the estimate of β essentially captures how within-country variations in trade openness affect output growth differentially across industries. Moreover, $\boldsymbol{X}_{\boldsymbol{ict}}$ is a vector of controls for robustness checks, and it will be discussed in detail later. Conventionally, α is the intercept, while ϵ_{ict} is the idiosyncratic disturbance.

In addition to employing a set of saturated pairwise fixed effects, we further control for other potential determinants of comparative advantage. To be more specific, the vector of controls $\boldsymbol{X}_{\boldsymbol{ict}}$ consists of various interactions between industry and country characteristics, incorporating overall development controls as well as factor endowment controls. First, it includes the interaction between the industry-level Herfindahl index and country-level real GDP per capita. This is meant to isolate the effect of trade openness from that of comprehensive economic development. Second, it incorporates the interaction between the industry-level Herfindahl index and the country-level Polity score. According to previous literature [41], the Polity score characterizes institutional constraints. This interaction control accounts for episodes of democracy that may not be captured by trade openness or real GDP per capita. Third, it embodies the interaction between industry indicators of financial vulnerability (e.g., external finance dependence, asset tangibility) and country measures of financial development. This is to control for the well-documented distinctive growth effects of financial development [29,42,43]. For instance, external capital will be more accessible to industries with a higher level of tangibility because tangible assets can serve as collateral for raising funds. This contributing factor could in practice influence the growth outcome of industrial sectors, especially those that have intensive upfront fixed costs (e.g., R&D expenditure). Finally, it comprises interactions between industries' physical capital, human capital, natural resource intensities, and countries' corresponding per capita factor endowments. It has been demonstrated that factor proportions are indeed important determinants of production structure and international trade [34], and these translate into sources of comparative advantage. Therefore, it is important to control for the Heckscher–Ohlin determinants in our estimation. In summary, exploiting a full set of controls in this manner allows us to further shield against omitted variable bias.

3.2. Data and Measures

This section describes the data in our study, explains the construction of corresponding measures, and provides some descriptive statistics. The data source contains data for the period from 1963 to 2011 for 123 countries.

3.2.1. Dependent Variable

The output data are obtained from the INDSTAT2 2014 ISIC Rev. 3 database published by the United Nations Industrial Development Organization (UNIDO). The data are arranged at the 2-digit level of the International Standard Industrial Classification (ISIC) Revision 3 pertaining to the manufacturing sector, which comprises 22 industries (see Appendix A Table A1). The INDSTAT2 2014 ISIC Rev. 3 database contains data for the period from 1963 to 2011 for 123 countries (see Appendix A Table A2). The availability of almost 50 years of data makes it possible to compare the growth performance of different industries across a large number of countries that are under liberalized and non-liberalized regimes. As expected, the three-dimensional panel data are unbalanced.

For the benchmark regression, the dependent variable is the 5-year average growth rate computed over nonoverlapping windows. In addition, the 3-year average and annual growth rates are used for comparison.

3.2.2. Key Independent Variables

Diversity of Intermediate Inputs

Our empirical strategy requires a variable that captures the diversity of intermediate inputs for different industries. Specifically, we adopt the Herfindahl index, which is computed from the U.S. Input—Output (IO) Use Table in 2002 [44], to characterize the degree of diversity for intermediate inputs. The calculation is as follows:

$$HI_i = \sum_j \theta_{ij}^2 \tag{2}$$

where θ_{ij} denotes the share of intermediate input j used in the industry i's final good production. The lower the HI_i, the more an industry diversifies its intermediate inputs.

We follow Cowan and Neut [45] and construct the Herfindahl index from the 2002 U.S. IO Use Table. The 6-digit IO categories are mapped into the 2-digit ISIC Rev. 3 using the concordance tables provided by the U.S. Bureau of Economic Analysis (BEA) and the U.S. Census Bureau (CB).

Computing the Herfindahl index from the U.S. data is motivated by the following considerations. First, the existing structure of intermediate good use is mainly driven by technological differences across industries, and these differences tend to persist across countries. Second, our identification strategy does not require that industries have exactly the same Herfindahl index of intermediate inputs in each country. It merely rests on the assumption that the ranking of industries' indices remains relatively stable for different countries. The measures constructed from the U.S. data indeed capture a considerable technological component that is inherent in the manufacturing sector and hence are reasonable proxies for ranking different industries across countries. Finally, using the U.S. as a reference country is convenient given that there are limited data for many other countries in our sample.

In addition, we calculate the Herfindahl index of intermediate inputs using the 1997 and 2007 U.S. IO Tables to show the stability of the index ranking over time. Appendix A Table A3 lists the three least diversified (denoted by the highest Herfindahl index) and the three most diversified (denoted by the lowest Herfindahl index) industries in terms of using intermediate inputs for 1997, 2002, and 2007. As shown in Table A3, the ranking of industries' indices is rather stable over time. For instance, industries such as refined petroleum products and chemical products have the highest Herfindahl index, which indicates that they are the least diversified in using intermediate inputs. In contrast, industries including furniture and nonmetallic mineral products have the lowest Herfindahl index, implying that they are the most diversified in using intermediate inputs. Moreover, Appendix A Table A4 shows that the coefficients of pairwise correlations are all above 0.9 for the Herfindahl index computed in different years. Hence, it is feasible to use 2002 as the benchmark year to calculate the Herfindahl index in our empirical analysis, as evidenced by the preceding findings from Tables A3 and A4.

Trade Openness

In addition to the Herfindahl index, the other key element from the interaction term that is of particular interest is the trade openness variable. The data on trade openness are collected from Wacziarg and Welch [7], who update the binary indicator originally coded by Sachs and Warner [6] after a painstaking check of the Sachs–Warner classification of openness. Sachs and Warner [6] construct a trade openness dummy variable based on five specific trade-related criteria. A country will be classified as closed to trade if it displays at least one of the following characteristics: average tariff rates are at least 40% (TAR); nontariff barriers cover at least 40% of trade (NTB); a black market exchange rate is at least 20% lower than the official exchange rate (BMP); a state monopoly on major exports (XMB); or a socialist economic system (SOC). Based on the updated dataset provided by Wacziarg and Welch [7], the trade openness indicator equals 1 if a country is open to trade and 0 otherwise. It should be emphasized that a country labeled "closed" under this classification may still engage in international trade but would in principle incur comparatively higher trade costs. Figure 1 depicts the number of countries that are open to trade throughout the entire period of 1963–2011. In 1963, out of a total of 123 countries, only 22 were open to trade based on the above criteria. A major wave of trade liberalization took place between 1980 and 2000, with 63 countries switching from "closed" to "open". However, 27 countries remained closed to trade after 2000. Figure 2 describes the percentage of the world population in countries that are open to trade. The share of the total population living in countries under liberalized regimes increased from roughly one-fifth to almost half during the entire sample period.

3.2.3. Control Variables

The control for two sets of factors that may affect output growth includes industry measures and country measures. The industry measures include external finance dependence, asset tangibility, physical capital intensity, human capital intensity, and natural resource intensity, and these measures are sourced from Braun [42]. These measures of industry characteristics are constructed using the data for all publicly listed U.S.-based companies from Compustat's annual industrial files for the 1986–1995 period, except natural resource intensity, which is a binary indicator. As in Rajan and Zingales [29], external finance dependence is calculated as the fraction of capital expenditures not financed by internal cash flows. Asset tangibility is similarly defined as the share of net property, plant, and equipment in total book-value assets. Both measures are averaged over the period 1986–1995 for the median U.S. firm in each industry. It is worthwhile to note that the measures of external finance dependence and asset tangibility appear quite stable over time when compared to values computed from 1966–1975 and 1976–1985. Physical capital intensity corresponds to the median ratio of gross fixed capital formation to value added in each industry in the U.S. for the 1986–1995 period. Human capital intensity records the median ratio of the average wage for each industry over that for the whole U.S. manufacturing sector for the 1986–1995 period. Natural resource intensity is a binary indicator that is equal to 1 for the following industries (and 0 otherwise): wood products (excluding furniture); paper and paper products; coke, refined petroleum products, nuclear fuel; and basic metals. Appendix A Table A5 shows the details of different industry characteristics, while Table A6 reports the pairwise correlations of industry characteristics.

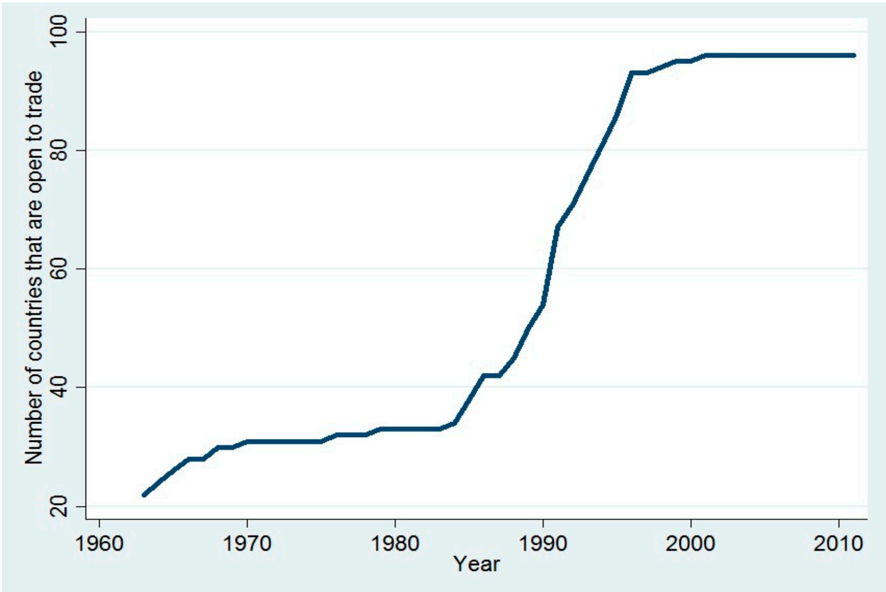

Figure 1. Number of countries that are open to trade.

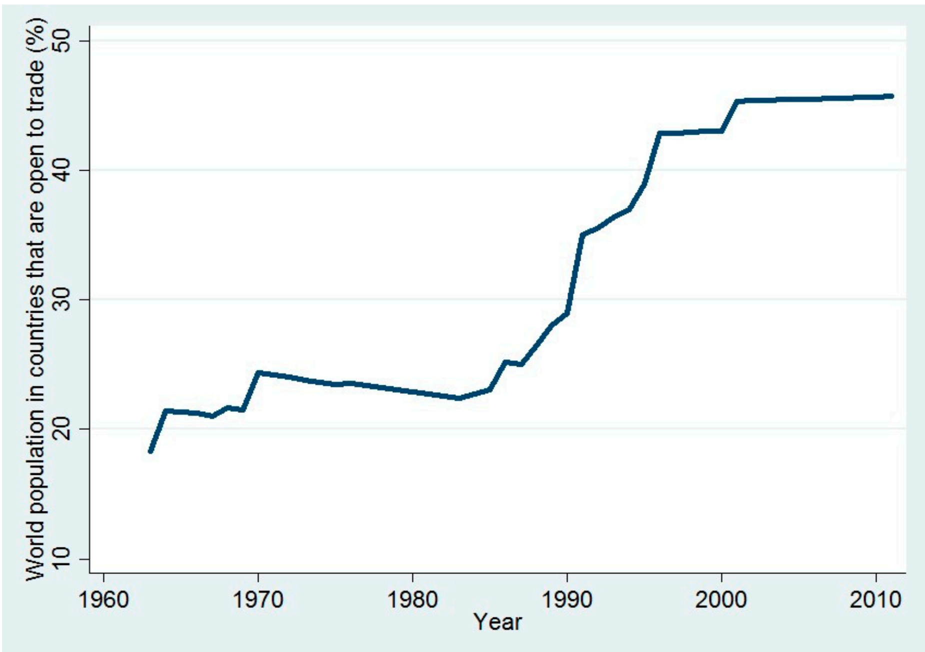

Figure 2. Percentage of world population in countries that are open to trade.

We also control for measures of country characteristics consisting of real GDP per capita, Polity score, financial development, and corresponding factor endowments (i.e., physical capital, human capital, and natural resources) per capita. Real GDP per capita, physical capital per capita, and human capital per capita are all taken from the Penn World Tables (PWT) Version 9.0. The country-level Polity score is sourced from the Polity IV database, and it captures the regime authority spectrum on a scale ranging from −10 (hereditary monarchy) to +10 (consolidated democracy). As in Beck et al. [46], financial development is defined as the ratio of private credit by deposit money banks and other financial intermediaries to GDP and is obtained from the Financial Development and Structure Dataset. It captures the amount of credit channeled through banks and other financial institutions to the private sector. Following previous literature [34], natural resources per capita are measured by total land area divided by total population, or equivalently, the inverse of population density. This estimate of the abundance of natural resources is obtained from the World Development Indicators (WDI). Appendix A Table A7 displays the descriptive statistics of country characteristics, and Table A8 shows the pairwise correlations of country characteristics.

4. Empirical Results

In this section, we start with the baseline results. Then, we turn to the empirical findings with overall development controls, factor abundance controls, and a full set of controls. Subsequently, we revisit the results using different periods and the Herfindahl index constructed based on tradeable goods and services. Finally, we outline relevant discussions.

4.1. Baseline Results

Preliminary estimates of Equation (1) with $\boldsymbol{X}_{ict}$ being a null vector are reported in Table 1. The dependent variables are the 5-year average growth rate, 3-year average growth rate, and annual growth rate in Columns (1), (2), and (3), respectively. The estimated coefficient of interest, β, is negative across all three columns, which corroborates our research hypothesis.

Table 1. Baseline results.

Dependent Variable	5-Year Average Growth	3-Year Average Growth	Annual Growth
	(1)	**(2)**	**(3)**
HI × Openness	−0.281	−0.200	−0.174
	[0.078] ***	[0.074] ***	[0.082] **
	(0.087) ***	(0.082) ***	(0.083) **
	{0.047} ***	{0.055} ***	{0.051} ***
Industry-Country FE	Yes	Yes	Yes
Industry-Time FE	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes
# Industries	22	22	22
# Countries	118	121	123
# Observations	8593	15,311	50,766
R-squared	0.69	0.55	0.43

Notes: The dependent variables are the 5-year average growth rate, 3-year average growth rate, and annual growth rate in Columns (1), (2), and (3), respectively. Constant terms are included in the regressions, but not displayed in the table. Three categories of standard errors are reported below the coefficients, with ***, **, and * denoting significance at the 1%, 5%, and 10% levels, respectively. The first, reported in square brackets, is a robust standard error. The second, reported in parentheses, is standard errors adjusted for clustering within countries. The third, reported in curly brackets, is standard errors adjusted for two-way clustering within industries and countries.

With the aim of coping with potential heteroskedasticity, three categories of standard errors are reported in Table 1: (i) robust standard errors; (ii) standard errors adjusted for clustering within countries, as in Bertrand et al. [47]; and (iii) standard errors adjusted for two-way clustering within industries and countries, following Cameron et al. [48]. In the first column, the coefficient on the interaction term of the Herfindahl index and the trade openness variable is negative and highly significant (at the 1% level) based on three different types of reported standard errors. Similarly, we obtain a statistically significant (at the 1% level) coefficient β with the expected negative sign in the second column. In the third column, we also find the negative and significant effect of the interaction term, as predicted by the hypothesis. When the annual growth rate enters the estimation equation as the dependent variable, β is significant at the 1% level when standard errors are adjusted for two-way clustering. In the meantime, it is significant at the 5% level based on robust standard errors as well as standard errors adjusted for clustering within countries. As seen from Table 1, standard errors adjusted for clustering within countries (shown in parentheses) are the highest, whereas the other two types of standard errors are relatively smaller. To be more conservative, we only report the standard errors clustered by the country for the remaining tables.

Despite being all negative and significant, the coefficient of interest apparently varies in magnitude across different columns in Table 1. The absolute magnitude increases as the length of the time frame for calculating output growth expands. The absolute magnitude estimated in Column (1) is almost twice as large as that reported in Column (3). Meanwhile, the absolute magnitude of β in Column (2) is approximately two-thirds of that in Column (1). It could be inferred from these numbers that the output-promoting effects arising from intermediate input diversity interacting with trade openness are more pronounced for long-term growth.

As the difference-in-differences approach is adopted as the identification strategy, one way to obtain a sense of the magnitude of the interaction term is as follows. The industry at the 25th percentile of the Herfindahl index (more diversified in intermediate inputs) is machinery, with an index of 0.097. Correspondingly, the industry at the 75th percentile of the Herfindahl index (less diversified in intermediate inputs) is textiles, with an index of 0.187. Thus, the difference between the 25th percentile and the 75th percentile of the Herfindahl index is -0.09 in the sample of 22 manufacturing industries. Similarly, the difference between the trade liberalization dummy variable denoting "open" and the one denoting "closed" is 1. Taking Column (1) in Table 1 as an example, the point estimate implies that industries that are more diversified in intermediate inputs (25th versus 75th percentile) will grow by 2.5 percentage points faster in countries that are more open to trade, ceteris paribus. (The number is calculated as $(-0.281) \times (-0.09) \times 1 = 0.025$). Likewise, the differences are 1.8 and 1.6 percentage points for the 3-year average growth rate and annual growth rate, respectively. (The numbers are calculated as $(-0.200) \times (-0.09) \times 1 = 0.018$ and $(-0.174) \times (-0.09) \times 1 = 0.016$).

In the next subsection, we will scrutinize whether the baseline results remain intact when other determinants are further incorporated into the estimation equation.

4.2. Robustness Checks

Table 2 reports the estimation results from a specification that embodies overall development controls. By conditioning on industry measures interacting with real GDP per capita, Polity score, and financial development, we could prevent the estimated coefficient of interest from picking up those effects stemming from overall development factors. Columns (1)–(4) of Table 2 separately take into account each type of interaction term, viz., (i) Herfindahl index with log real GDP per capita; (ii) Herfindahl index with Polity score; (iii) external finance dependence with financial development; and (iv) asset tangibility with financial development. Column (5) includes the former two interaction terms since they are directly linked to the Herfindahl index. Column (6) combines the latter two interaction terms, as both pertain to industry indicators of financial vulnerability interacting with country measures of financial development. Finally, all the controls are entirely incorporated in Column (7).

In the first instance, the top row of Table 2 indicates that the coefficient of interest continues to be significantly negative across all columns and remains approximately at the same magnitude as the baseline estimate from Table 1. The estimation of β in Table 2 suggests that our results are quite robust after conditioning on overall development controls, although the real GDP per capita and Polity score controls appear to be insignificant in the estimation. Next, we find a positive coefficient on the interaction between external financial dependence and financial development, which is statistically significant at the 5% level. It confirms that industries that are more intensive in obtaining external finance will grow disproportionately faster in countries with higher levels of financial development. This echoes the findings of Rajan and Zingales [29]. Finally, the estimated coefficient for the interaction of asset tangibility and financial development is negative but insignificant. This implies that sectors with less collateralizable assets tend to grow faster in countries that are more financially advanced, albeit not significantly. This is consistent with the results in previous literature [42].

Table 2. Regressions with overall development controls.

Dependent Variable	**5-Year Average Growth**						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
HI × Openness	−0.275 ***	−0.285 ***	−0.282 ***	−0.288 ***	−0.287 ***	−0.286 ***	−0.292 ***
	(0.085)	(0.089)	(0.098)	(0.099)	(0.086)	(0.099)	(0.105)
HI × ln(RGDPPC)	0.039				0.018		−0.002
	(0.100)				(0.101)		(0.104)
HI × Polity		0.008			0.007		0.005
		(0.005)			(0.006)		(0.006)
FinDep × FinDevt			0.038 **			0.037 **	0.039 **
			(0.018)			(0.018)	(0.018)
Tang × FinDevt				−0.031		−0.019	−0.018
				(0.041)		(0.041)	(0.043)
Industry-Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# Industries	22	22	22	22	22	22	22
# Countries	115	114	107	107	112	107	103
# Observations	8498	8282	7534	7534	8232	7534	7296
R-squared	0.70	0.71	0.63	0.63	0.71	0.63	0.64

Notes: The dependent variable is the 5-year average growth rate. Constant terms are included in the regressions, but not displayed in the table. Standard errors are clustered by country, with ***, **, and * denoting significance at the 1%, 5%, and 10% levels, respectively.

We further explore whether the role of the Herfindahl index interacting with trade openness differs across subsamples of countries. Hence, the whole sample is split into two groups, namely, OECD countries and non-OECD countries, according to the level of overall development. Table 3 shows that our findings are most robust to the sample division, with the only exception being Column (5). In terms of the coefficient magnitudes, it could be inferred that the effects of trade liberalization are more pronounced in economies with relatively lower levels of development (i.e., non-OECD countries), which tend to be less outward-oriented at the very beginning of the study period.

The standard Heckscher–Ohlin model predicts that countries rich in physical capital, human capital, or natural resources are more likely to possess a comparative advantage in products that are intensive in those that have abundant input factors. Table 4 demonstrates the impacts of Heckscher–Ohlin forces on the pattern of output growth. In particular, we control for countries' logs of per capita physical capital, human capital, and natural resources interacting with industries' corresponding factor intensities. The coefficient of interest, which also carries the expected negative sign, is significant at the 1% level for Columns (1)–(2), at the 5% level for Columns (3)–(4), and at the 10% level for Columns (5)–(6). One noteworthy fact is that only the physical capital interaction term and the natural resources interaction term occasionally enter the estimation significantly. Moreover, Table 4 shows that industries more intensive on physical capital (or natural resources) tend to grow faster in countries endowed with abundant physical capital (or natural resources). This is in line with the canonical prediction delivered by the Heckscher–Ohlin model, which states that factor endowment abundances will translate into sources of comparative advantage for industries that are intensive in those factors. Controlling for the Heckscher–Ohlin factors in the estimation does not alter the key finding.

Table 3. Regressions with overall development controls for different country groups.

Dependent Variable	5-Year Average Growth			3-Year Average Growth			Annual Growth		
Country Group	All	OECD	Non-OECD	All	OECD	Non-OECD	All	OECD	Non-OECD
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
HI × Openness	−0.292 ***	−0.242 ***	−0.350 ***	−0.270 **	−0.126	−0.379 ***	−0.209 *	−0.211 ***	−0.281 *
	(0.105)	(0.077)	(0.123)	(0.111)	(0.077)	(0.144)	(0.107)	(0.075)	(0.153)
HI × ln(RGDPPC)	−0.002	0.131	−0.007	0.116	0.228 **	0.122	0.010	0.140	−0.029
	(0.104)	(0.135)	(0.145)	(0.094)	(0.109)	(0.145)	(0.079)	(0.127)	(0.107)
HI × Polity	0.005	0.009	0.003	0.004	0.003	0.004	0.001	0.004	−0.004
	(0.006)	(0.006)	(0.010)	(0.006)	(0.003)	(0.010)	(0.006)	(0.005)	(0.009)
FinDep × FinDevt	0.039 **	−0.009	0.052 **	−0.007	0.002	−0.006	0.032 **	0.012	0.041 **
	(0.018)	(0.017)	(0.021)	(0.021)	(0.020)	(0.028)	(0.016)	(0.021)	(0.019)
Tang × FinDevt	−0.018	0.010	−0.036	0.037	0.044	0.017	0.011	0.044	−0.004
	(0.043)	(0.036)	(0.059)	(0.047)	(0.037)	(0.069)	(0.038)	(0.045)	(0.052)
Industry-Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# Industries	22	22	22	22	22	22	22	22	22
# Countries	103	32	71	108	32	76	109	32	77
# Observations	7296	3227	4069	12,891	5645	7246	42,583	18,460	24,123
R-squared	0.64	0.72	0.63	0.54	0.64	0.52	0.36	0.50	0.34

Notes: The dependent variables are the 5-year average growth rate for Columns (1)–(3), 3-year average growth rate for Columns (4)–(6), and annual growth rate for Columns (7)–(9). Constant terms are included in the regressions, but not displayed in the table. Standard errors are clustered by country, with ***, **, and * denoting significance at the 1%, 5%, and 10% levels, respectively.

Table 4. Regressions with factor endowment controls.

Dependent Variable	5-Year Average Growth		3-Year Average Growth		Annual Growth	
	(1)	(2)	(3)	(4)	(5)	(6)
HI × Openness	−0.225 ***	−0.219 ***	−0.192 **	−0.184 **	−0.153 *	−0.144 *
	(0.076)	(0.076)	(0.085)	(0.086)	(0.081)	(0.082)
Kint × ln(KPC)	0.165	0.162	0.371 **	0.326 **	0.409 **	0.379 *
	(0.150)	(0.151)	(0.167)	(0.161)	(0.189)	(0.199)
Hint × ln(HPC)	0.003	0.003	0.002	0.011	−0.053	−0.046
	(0.048)	(0.048)	(0.049)	(0.048)	(0.065)	(0.067)
Nint × ln(NPC)		0.008		0.037 *		0.024
		(0.017)		(0.021)		(0.028)
Industry-Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes	Yes	Yes
# Industries	22	22	22	22	22	22
# Countries	112	112	115	115	117	117
# Observations	8335	8208	14,825	14,603	49,048	48,378
R-squared	0.67	0.67	0.55	0.55	0.39	0.39

Notes: The dependent variables are the 5-year average growth rate for Columns (1)–(2), 3-year average growth rate for Columns (3)–(4), and annual growth rate for Columns (5)–(6). Constant terms are included in the regressions, but not displayed in the table. Standard errors are clustered by country, with ***, **, and * denoting significance at the 1%, 5%, and 10% levels, respectively.

Now, we turn to the results with a full set of controls and examine whether previous results remain the same. Table 5 encompasses all the controls that we have hitherto examined, including overall development controls and factor abundance controls. Column (1a) is the benchmark regression, with the 5-year average growth rate being the dependent variable.

It is worth noting that the estimated coefficient on the interaction term of our particular interest, β, stays negative and statistically significant at the 1% level. The magnitude remains virtually identical to the baseline estimate in Table 1, suggesting that industries with higher diversity levels in intermediate inputs (1st versus 3rd quartile of the Herfindahl index) will grow by 2.6 percentage points faster in countries that are more liberalized in international trade. To gauge the relative importance of all the explanatory variables in the regression, Column (1b) reports the standardized beta coefficients based on the specification in Column (1a). The standardized beta coefficient is meant to capture the change in standard deviation units of the dependent variable induced by one standard deviation change in the independent variable. In other words, a one standard deviation change in HI $\times$ Openness will lead to a -0.231 standard deviation change in the 5-year average output growth rate. To further quantify the impacts of all the explanatory variables, Column (1c) reports the factor changes of growth in the 75th percentile compared to the 25th percentile industry and country. The interaction of HI $\times$ Openness will generate a change of 2.6 percentage points in growth. Compared with other interactions, it appears to have the greatest impact on the growth outcome. In Column (2), the dependent variable is the 3-year average growth rate. The coefficient on HI $\times$ Openness is still negative and statistically significant (at the 5% level). The economic importance of the interaction term remains sizable, as can be deduced from the point estimate. When the annual growth rate is taken as the dependent variable, Column (3) shows that β remains negative but only tends to approach statistical significance. Nevertheless, the estimated coefficient implies a differential of 1.5 percentage points, which is still substantial in the context of output growth.

Table 5. Regressions with a full set of controls.

Dependent Variable	5-Year Average Growth			3-Year Average Growth	Annual Growth
	(1a)	(1b)	(1c)	(2)	(3)
HI × Openness	−0.288 ***	−0.231 ***	−0.026	−0.265 **	−0.171
	(0.106)			(0.112)	(0.105)
HI × ln(RGDPPC)	−0.048	−0.317	−0.007	0.092	−0.005
	(0.112)			(0.102)	(0.090)
HI × Polity	0.005	0.053	0.007	0.005	0.001
	(0.006)			(0.006)	(0.006)
FinDep × FinDevt	0.026 *	0.225 *	0.012	−0.017	0.020
	(0.015)			(0.022)	(0.015)
Tang × FinDevt	−0.039	−0.143	−0.008	0.027	−0.001
	(0.046)			(0.049)	(0.040)
Kint × ln(KPC)	0.223	0.562	0.011	0.082	0.148
	(0.168)			(0.154)	(0.184)
Hint × ln(HPC)	0.034	0.243	0.014	0.009	−0.011
	(0.055)			(0.064)	(0.061)
Nint × ln(NPC)	−0.004	−0.135	0.000	0.013	−0.000
	(0.021)			(0.022)	(0.036)
Industry-Country FE	Yes	Yes	Yes	Yes	Yes
Industry-Time FE	Yes	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes	Yes
# Industries	22	22	22	22	22
# Countries	100	100	100	105	105
# Observations	7033	7033	7033	12,473	41,123
R-squared	0.64	0.64	0.64	0.54	0.36

Notes: The dependent variables are the 5-year average growth rate for Columns (1a)–(1c), the 3-year average growth rate for Column (2), and the annual growth rate for Column (3). Column (1b) reports standardized beta coefficients from Column (1a), while Column (1c) reports the factor changes of growth in the 75th percentile industry and country compared to the 25th percentile industry and country. Constant terms are included in the regressions, but not displayed in the table. Standard errors are clustered by country, with ***, **, and * denoting significance at the 1%, 5%, and 10% levels, respectively.

As has been demonstrated earlier, it is the within-country variations in trade openness that we are exploiting to estimate β. Since the overall status of trade liberalization varies substantially across time, it is of interest to split the entire sample period into two and re-estimate the specification with a full set of controls. This exercise helps identify which episode of liberalization is more important in terms of output growth. As shown in Figure 1, a major wave of trade liberalization took place between 1980 and 2000. We divided the time period into two, using 1980, 1990, and 2000 as the cutoff points. The results are presented in Table 6. Three major findings stand out. First, we observe a negative and significant β for the earlier time episodes (i.e., before 1980, before 1990, and before 2000). This suggests that, in contrast to the latter periods, the earlier periods seem to be relatively more important for industrial output growth. Second, the estimated effect stemming from trade openness interacting with intermediate input diversity is remarkably pronounced for the period before 1990, with a magnitude approximately twice that of the benchmark regression for the entire period. Third, the coefficient of interest, β, is omitted in Column (7) for the period after 2000. To be more precise, it has been absorbed by the industry-country fixed effects D_{ic} in Equation (1), as there is no variation across time in the trade liberalization dummy variable $Openness_{ct}$, which essentially degenerates to $Openness_c$ after 2000 (As seen from Figure 1, the overall status of trade liberalization is very stable after 2000. However, it is the within-country variations in openness that yield the estimate of β. An issue related to this is to control for the interaction between the Herfindahl index and the institutional quality as in Levchenko [35]. Due to data limitations, the institutional quality variable is not available for the entire period of 1963–2011. There are two major data sources: "law and order" from the International Country Risk Guide (ICRG) back to the mid-1980s, along with "rule of law" from Worldwide Governance Indicators (WGI) mainly after 2000. Since variations across time in the $Openness_{ct}$ variable are needed in order to estimate β, we thus use the "law and order" data that are available for a relatively long time span. The results with additional law and order controls are reported in Table A9. The estimate of β remains virtually unchanged when we further control for the interaction between the Herfindahl index and the institutional quality. Note that the insignificance of β is largely due to the sample period, which is similar to Column (3) and Column (5) in Table 6).

It is worth noting that the Herfindahl index is constructed using all intermediate inputs, including tradeable goods (e.g., agriculture, fishing, mining, manufacturing, etc.) as well as services (e.g., utility, transportation, communication, financial intermediaries, etc.). To better establish that the growth-promoting effect of trade liberalization is indeed operating through the diversity of intermediate inputs that are by nature tradeable, we perform a placebo test by calculating the Herfindahl index based on tradeable goods and services. One would expect to find a significant coefficient for the Herfindahl index using tradeable goods but probably not so for the one using service inputs, as the openness variable is measuring, by and large, to what extent the goods could be freely traded. Table 7 confirms that this is exactly the case. We find a negative and significant β in Column (2), in which the Herfindahl index is constructed using tradeable intermediate inputs. In contrast, an insignificant and even positive β appears in Column (3), in which the Herfindahl index is based on service inputs. The results are not surprising given that trade liberalization usually pertains to tradable goods and should have less of a direct impact on services. Furthermore, Table A10 shows that the Herfindahl index constructed using all inputs is highly and significantly correlated with the one based on tradeable goods, with a coefficient of correlation close to 0.9. This implies that the diversity of all intermediate inputs is mainly driven by the diversity of tradeable intermediate goods, which corroborates our research hypothesis.

Table 6. Regressions with a full set of controls for different time periods.

Dependent Variable	5-Year Average Growth						
Time Period	All Time	T <= 1980	T > 1980	T<= 1990	T > 1990	T <= 2000	T > 2000
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
HI × Openness	−0.288 ***	−0.235 *	−0.208	−0.661 ***	−0.003	−0.277 **	—
	(0.106)	(0.126)	(0.137)	(0.108)	(0.099)	(0.130)	—
HI × ln(RGDPPC)	−0.048	0.133	0.128	0.297	0.222	−0.046	−0.488
	(0.112)	(0.383)	(0.211)	(0.212)	(0.349)	(0.139)	(1.198)
HI × Polity	0.005	0.003	0.006	0.003	0.010	0.006	−0.027
	(0.006)	(0.010)	(0.007)	(0.008)	(0.012)	(0.008)	(0.048)
FinDep × FinDevt	0.026 *	0.028	0.022	0.063 ***	0.020	0.032	−0.079
	(0.015)	(0.037)	(0.020)	(0.023)	(0.023)	(0.021)	(0.060)
Tang × FinDevt	−0.039	−0.040	−0.025	−0.093	−0.028	−0.035	−0.023
	(0.046)	(0.179)	(0.056)	(0.085)	(0.074)	(0.060)	(0.138)
Kint × ln(KPC)	0.223	0.105	0.280	−0.062	0.067	0.342 *	−2.101
	(0.168)	(1.034)	(0.313)	(0.440)	(0.552)	(0.204)	(2.212)
Hint × ln(HPC)	0.034	0.238	0.066	−0.065	0.168	−0.068	0.912
	(0.055)	(0.296)	(0.100)	(0.167)	(0.183)	(0.076)	(0.658)
Nint × ln(NPC)	−0.004	0.008	0.020	−0.023	0.028	−0.022	0.657 *
	(0.021)	(0.120)	(0.043)	(0.048)	(0.083)	(0.034)	(0.330)
Industry-Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# Industries	22	22	22	22	22	22	22
# Countries	100	58	95	70	88	96	71
# Observations	7033	1784	5249	3071	3962	5082	1951
R-squared	0.64	0.70	0.63	0.70	0.65	0.66	0.69

Notes: The dependent variable is the 5-year average growth rate. The time periods are all time, the periods before 1980, after 1980, before 1990, after 1990, before 2000, and after 2000, for Columns (1), (2), (3), (4), (5), (6), and (7), respectively. Constant terms are included in the regressions, but not displayed in the table. Standard errors are clustered by country, with ***, **, and * denoting significance at the 1%, 5%, and 10% levels, respectively.

Table 7. Regressions with the Herfindahl index for different input categories.

Dependent Variable	5-Year Average Growth		
HI Constructed Using	All Inputs	Tradeable Goods	Services
	(1)	(2)	(3)
HI × Openness	−0.288 ***	−0.168 **	0.012
	(0.106)	(0.067)	(0.187)
HI × ln(RGDPPC)	−0.048	0.007	0.111
	(0.112)	(0.073)	(0.235)
HI × Polity	0.005	0.001	−0.005
	(0.006)	(0.004)	(0.010)
FinDep × FinDevt	0.026 *	0.026 *	0.027 *
	(0.015)	(0.015)	(0.015)
Tang × FinDevt	−0.039	−0.041	−0.026
	(0.046)	(0.045)	(0.046)
Kint × ln(KPC)	0.223	0.164	0.290
	(0.168)	(0.178)	(0.177)
Hint × ln(HPC)	0.034	0.032	0.030
	(0.055)	(0.054)	(0.063)
Nint × ln(NPC)	−0.004	−0.004	0.002
	(0.021)	(0.021)	(0.021)
Industry-Country FE	Yes	Yes	Yes
Industry-Time FE	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes
# Industries	22	22	22
# Countries	100	100	100

Table 7. *Cont.*

Dependent Variable	5-Year Average Growth		
HI Constructed Using	**All Inputs**	**Tradeable Goods**	**Services**
	(1)	**(2)**	**(3)**
# Observations	7033	7033	7033
R-squared	0.64	0.64	0.64

Notes: The dependent variable is the 5-year average growth rate. The Herfindahl index is constructed using all inputs, tradeable goods, and services for Columns (1), (2), and (3), respectively. Constant terms are included in the regressions, but not displayed in the table. Standard errors are clustered by country, with ***, **, and * denoting significance at the 1%, 5%, and 10% levels, respectively.

4.3. Discussions

To address the validity of our empirical findings, we provide several related discussions.

First, our results are less likely to be subject to criticism with regard to omitted variable bias. First, this paper adopts a difference-in-differences approach to examine the research hypotheses. The nice feature of this methodology is that we make predictions about growth differences based on the interaction between industry characteristics and country characteristics. Consequently, it enables us to overcome concerns about omitted variables. Second, one of the major strengths of our empirical strategy is the ability to employ an extensive set of fixed effects. Conditioning on a variety of pairwise fixed effects in the estimation makes it possible to control for various unobservables and guard against omitted variable bias. Finally, we take into account the determinants of overall development (e.g., real GDP per capita, Polity score, financial development, institutional quality), along with the factor endowments. These elements are generally believed to have potential impacts on the growth outcome. Notably, our results remain qualitatively identical and quantitatively similar after incorporating all these controls. Altogether, our empirical findings are robust against the omitted variable bias problem.

Second, we trim the tails of the growth rate distribution to inspect whether these results are robust to outliers. We re-estimate the same specification after truncating the extreme values and obtain the same findings as before (Winsorizing the tails produces a similar outcome as truncating the extreme values in our study; these results are available upon request). Reducing the effect of possibly spurious outliers through truncation leaves our results essentially unchanged. Moreover, we further exclude countries with less than ten years of data from the sample. By doing so, very few countries are affected in our sample (Seven countries with less than 10 years of observations are Benin (BEN), Belarus (BLR), Croatia (HRV), Liberia (LBR), Lesotho (LSO), Tajikistan (TJK), and Uganda (UGA)). We reached virtually identical results.

Finally, the reverse causality issue is limited in this study for the following reasons. First, reverse causality appears to be a major cause of concern in the trade openness and growth literature. However, the main focus of our investigation is industry-level growth rather than country-level growth. It is unlikely that the growth performance of the manufacturing industry could have a huge impact on the timing of trade liberalization. This helps to alleviate the concern about reverse causality. Second, the openness variable is constructed based on relevant trade policies, as opposed to the trade volume as a share of GDP, which is usually found to be positively correlated with growth. The exact timing of trade liberalization is arguably exogenous from the manufacturing industry's perspective. Finally, the Herfindahl index of intermediate inputs is calculated using U.S. data instead of being constructed individually for each country. This feasible method helps shield against the endogeneity problem. The variation in intermediate input diversity across sectors allows us to establish that the direction of causality is indeed running from trade openness to growth. Although issues of trade and growth are still debatable in the literature [3,6,7], the results of this paper provide country- and industry-specific insights into the causal relationship between trade openness and output growth.

Taken together, we provide well-grounded evidence that our empirical findings are unlikely to be driven by omitted variables, outliers, or reverse causality.

5. Conclusions

This paper seeks to shed light on the underlying relationship between trade openness and output growth, with a specific focus on the diversity of intermediate inputs. We provide concrete evidence that industrial sectors with higher intermediate input diversity will grow relatively faster in countries that are more open to trade. The estimation indicates that industries more diversified in intermediate inputs (25th versus 75th percentile) will grow by 2.6 percentage points faster in more outward-oriented countries. These results are not only statistically significant but also economically significant.

In the context of the trade literature, our study suggests substantial effects of trade openness on output growth, which has important policy implications. In particular, identifying the mechanism through which trade openness facilitates output growth helps evaluate different trade policies [49]. Our findings point to additional gains from trade liberalization that could be whittled down by increased protectionism [50], and more so for industrial sectors that are diversified in intermediate inputs. And most importantly, the ambiguity of whether trade openness promotes output growth has been clarified from the perspective of input diversity in this empirical study. Therefore, policymakers should simultaneously consider industry characteristics, country characteristics, and their interactions, which are all vital for economic development and sustainable growth.

Because of data limitations, this paper mainly focuses on the output growth of industrial sectors, leaving firm dynamics out of consideration. These limitations may open up interesting directions for further studies. Future research could seek to explore the micro-level factors accounting for heterogeneity in the growth effects of trade openness. Finally, examining the micro foundations of the link between trade openness and output growth remains an important topic for future research.

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Appendix A

Table A1. List of 2-digit ISIC Rev. 3 industries (22).

ISIC Code	Industry
15	Food and beverages
16	Tobacco products
17	Textiles
18	Wearing apparel, fur
19	Leather, leather products and footwear
20	Wood products (excluding furniture)
21	Paper and paper products
22	Printing and publishing
23	Coke, refined petroleum products, nuclear fuel
24	Chemicals and chemical products
25	Rubber and plastics products
26	Nonmetallic mineral products

Table A1. *Cont.*

ISIC Code	Industry
27	Basic metals
28	Fabricated metal products
29	Machinery and equipment n.e.c.
30	Office, accounting and computing machinery
31	Electrical machinery and apparatus
32	Radio, television and communication equipment
33	Medical, precision and optical instruments
34	Motor vehicles, trailers, semitrailers
35	Other transport equipment
36	Furniture; manufacturing n.e.c.

Table A2. List of countries in the sample (123).

Code	Country Name	Code	Country Name	Code	Country Name
ALB	Albania	GBR	United Kingdom	MYS	Malaysia
ARG	Argentina	GEO	Georgia	NER	Niger
ARM	Armenia	GHA	Ghana	NGA	Nigeria
AUS	Australia	GMB	Gambia	NIC	Nicaragua
AUT	Austria	GRC	Greece	NLD	Netherlands
AZE	Azerbaijan	GTM	Guatemala	NOR	Norway
BDI	Burundi	HND	Honduras	NPL	Nepal
BEL	Belgium	HRV	Croatia	NZL	New Zealand
BEN	Benin	HTI	Haiti	PAK	Pakistan
BFA	Burkina Faso	HUN	Hungary	PAN	Panama
BGD	Bangladesh	IDN	Indonesia	PER	Peru
BGR	Bulgaria	IND	India	PHL	Philippines
BLR	Belarus	IRL	Ireland	PNG	Papua New Guinea
BOL	Bolivia	IRN	Iran	POL	Poland
BRA	Brazil	IRQ	Iraq	PRT	Portugal
BRB	Barbados	ISL	Iceland	PRY	Paraguay
BWA	Botswana	ISR	Israel	ROU	Romania
CAF	Central African Republic	ITA	Italy	RUS	Russia
CAN	Canada	JAM	Jamaica	SEN	Senegal
CHE	Switzerland	JOR	Jordan	SGP	Singapore
CHL	Chile	JPN	Japan	SLV	El Salvador
CHN	China	KAZ	Kazakhstan	SOM	Somalia
CIV	Côte d’Ivoire	KEN	Kenya	SVK	Slovakia
CMR	Cameroon	KGZ	Kyrgyzstan	SVN	Slovenia
COG	Congo	KOR	South Korea	SWE	Sweden
COL	Colombia	LBR	Liberia	SWZ	Swaziland
CRI	Costa Rica	LKA	Sri Lanka	SYR	Syria
CYP	Cyprus	LSO	Lesotho	THA	Thailand
CZE	Czech Republic	LTU	Lithuania	TJK	Tajikistan
DEU	Germany	LUX	Luxembourg	TTO	Trinidad and Tobago
DNK	Denmark	LVA	Latvia	TUN	Tunisia
DOM	Dominican Republic	MAR	Morocco	TUR	Turkey
DZA	Algeria	MDA	Moldova	TZA	Tanzania
ECU	Ecuador	MDG	Madagascar	UGA	Uganda
EGY	Egypt	MEX	Mexico	UKR	Ukraine
ESP	Spain	MKD	Macedonia	URY	Uruguay
EST	Estonia	MLT	Malta	USA	United States
ETH	Ethiopia	MMR	Myanmar	VEN	Venezuela
FIN	Finland	MOZ	Mozambique	YEM	Yemen
FRA	France	MUS	Mauritius	ZAF	South Africa
GAB	Gabon	MWI	Malawi	ZMB	Zambia

Table A3. Industries with the highest and lowest Herfindahl index.

Year	Highest Herfindahl Index			Lowest Herfindahl Index		
	Ranking	ISIC Code	Industry	Ranking	ISIC Code	Industry
1997	1	23	Refined petroleum products	1	36	Furniture; manufacturing n.e.c.
	2	18	Wearing apparel, fur	2	26	Nonmetallic mineral products
	3	24	Chemicals and chemical products	3	31	Electrical machinery
2002	1	23	Refined petroleum products	1	36	Furniture; manufacturing n.e.c.
	2	18	Wearing apparel, fur	2	26	Nonmetallic mineral products
	3	24	Chemicals and chemical products	3	33	Medical and precision instruments
2007	1	23	Refined petroleum products	1	36	Furniture; manufacturing n.e.c.
	2	24	Chemicals and chemical products	2	26	Nonmetallic mineral products
	3	25	Rubber and plastics products	3	33	Medical and precision instruments

Table A4. Pairwise correlations of the Herfindahl index for different years.

	HI for 1997	HI for 2002	HI for 2007
HI for 1997	1		
HI for 2002	0.97 ***	1	
HI for 2007	0.90 ***	0.95 ***	1

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table A5. Summary of industry characteristics.

ISIC Code	Industry	Herfindahl Index	External Finance Dependence	Asset Tangibility	Physical Capital Intensity	Human Capital Intensity	Natural Resources Intensity
15	Food and beverages	0.163	0.107	0.329	0.062	0.973	0
16	Tobacco products	0.117	−0.451	0.221	0.018	1.354	0
17	Textiles	0.187	0.401	0.373	0.073	0.688	0
18	Wearing apparel, fur	0.239	0.029	0.132	0.019	0.502	0
19	Leather, leather products and footwear	0.139	−0.109	0.104	0.025	0.610	0
20	Wood products (excluding furniture)	0.171	0.284	0.380	0.065	0.741	1
21	Paper and paper products	0.153	0.176	0.558	0.132	1.139	1
22	Printing and publishing	0.111	0.204	0.301	0.052	0.934	0
23	Coke, refined petroleum products, nuclear fuel	0.507	0.188	0.487	0.135	1.404	1
24	Chemicals and chemical products	0.199	0.212	0.304	0.092	1.308	0
25	Rubber and plastics products	0.157	0.683	0.362	0.077	0.906	0
26	Nonmetallic mineral products	0.090	0.062	0.331	0.068	0.952	0
27	Basic metals	0.159	0.046	0.421	0.101	1.175	1
28	Fabricated metal products	0.143	0.237	0.281	0.053	0.914	0
29	Machinery and equipment n.e.c.	0.097	0.445	0.183	0.058	1.119	0
30	Office, accounting and computing machinery	0.153	0.445	0.183	0.058	1.119	0
31	Electrical machinery and apparatus	0.095	0.768	0.213	0.077	1.064	0
32	Radio, television and communication equipment	0.175	0.768	0.213	0.077	1.064	0

Table A5. *Cont.*

ISIC Code	Industry	Herfindahl Index	External Finance Dependence	Asset Tangibility	Physical Capital Intensity	Human Capital Intensity	Natural Resources Intensity
33	Medical, precision and optical instruments	0.090	0.961	0.151	0.053	1.234	0
34	Motor vehicles, trailers, semitrailers	0.191	0.307	0.255	0.071	1.322	0
35	Other transport equipment	0.134	0.307	0.255	0.071	1.322	0
36	Furniture; manufacturing n.e.c.	0.068	0.353	0.226	0.039	0.727	0
	Mean	0.161	0.292	0.285	0.067	1.026	0.182
	Std. Dev.	0.086	0.308	0.112	0.029	0.251	0.386

Table A6. Pairwise correlations of industry characteristics.

	HI	FinDep	Tang	Kint	Hint	Nint
HI	1					
FinDep	−0.14	1				
Tang	0.42 *	−0.13	1			
Kint	0.50 **	0.22	0.82 ***	1		
Hint	0.21	0.06	0.23	0.49 **	1	
Nint	0.48 **	-0.18	0.74 ***	0.66 ***	0.17	1

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table A7. Summary of country characteristics.

	Mean	Std. Dev.	Min.	25th	Median	75th	Max.
Openness	0.59	0.49	0	0	1	1	1
ln(RGDPPC)	9.03	1.08	5.75	8.29	9.15	9.89	11.34
Polity	3.43	7.17	−10	−5	7	10	10
FinDevt	3.44	0.94	−0.77	2.85	3.42	4.18	5.65
ln(KPC)	10.13	1.30	5.94	9.15	10.25	11.23	12.64
ln(HPC)	2.23	0.73	1.01	1.58	2.24	2.84	3.71
ln(NPC)	9.80	1.41	4.91	9.01	9.69	10.73	13.46

Table A8. Pairwise correlations of country characteristics.

	Openness	ln(RGDPPC)	Polity	FinDevt	ln(KPC)	ln(HPC)	ln(NPC)
Openness	1						
ln(RGDPPC)	0.53 ***	1					
Polity	0.50 ***	0.56 ***	1				
FinDevt	0.44 ***	0.69 ***	0.39 ***	1			
ln(KPC)	0.54 ***	0.94 ***	0.58 ***	0.67 ***	1		
ln(HPC)	0.55 ***	0.80 ***	0.65 ***	0.53 ***	0.78 ***	1	
ln(NPC)	−0.14 ***	−0.04 **	−0.09 ***	−0.20 ***	−0.09 ***	−0.04 **	1

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table A9. Regressions with additional law and order controls after 1985.

Dependent Variable	5-Year Average Growth			
Time Period	T > 1985			
	(1)	(2)	(3)	(4)
HI × Openness	−0.127	−0.126	−0.095	−0.096
	(0.119)	(0.119)	(0.155)	(0.155)
HI × Law and Order		0.043		0.008
		(0.039)		(0.043)

Table A9. *Cont.*

Dependent Variable	5-Year Average Growth			
Time Period	T > 1985			
	(1)	(2)	(3)	(4)
HI × ln(RGDPPC)			0.155	0.147
			(0.310)	(0.306)
HI × Polity			0.015	0.015
			(0.010)	(0.010)
FinDep × FinDevt			0.027	0.027
			(0.020)	(0.020)
Tang × FinDevt			−0.042	−0.043
			(0.066)	(0.067)
Kint × ln(KPC)			−0.005	−0.004
			(0.418)	(0.418)
Hint × ln(HPC)			0.120	0.117
			(0.121)	(0.124)
Nint × ln(NPC)			0.038	0.039
			(0.055)	(0.054)
Industry-Country FE	Yes	Yes	Yes	Yes
Industry-Time FE	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes
# Industries	22	22	22	22
# Countries	97	97	88	88
# Observations	5041	5041	4448	4448
R-squared	0.64	0.64	0.64	0.64

Notes: The dependent variable is the 5-year average growth rate. The time period corresponds to the period after 1985, for which the law and order data are available from the International Country Risk Guide (ICRG). Constant terms are included in the regressions but are not displayed in the table. Standard errors are clustered by country, with ***, **, and * denoting significance at the 1%, 5%, and 10% levels, respectively.

Table A10. Pairwise correlations of the Herfindahl index for different input categories.

	HI for All Inputs	HI for Tradeable Goods	HI for Services
HI for All Inputs	1		
HI for Tradeable Goods	0.89 ***	1	
HI for Services	−0.06	0.08	1

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

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