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The Various Effects of Technology Trade on the Sustainable Market Value of Firms in OECD Countries

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Abstract: This study explores the various effects of technology trade on the sustainable market value of firms in 36 OECD member countries using panel data estimations. To proxy technology trade activities, our study uses the technology export and import growths of intellectual property rights (IPRs). We suggest that technology imports, proxied by IPR imports, increase the market value of firms in our sample countries. The net technology imports (exports) are also positively (negatively) associated with the sustainable value of the firms. We use panel data regression to analyze the specific effects of the trade (i.e., imports and exports) of technology assets, proxied by IPRs, on the market value of firms proxied by country benchmark composite stock returns in 36 OECD member countries. For robustness, our study uses an instrumental variable estimation to check for the possible effects of endogeneity biases for the baseline results. System dynamic panel regressions further examine the effect of the dependent variable's persistence. We find evidence of nonlinear effects for IPR exports and net IPR trade on the sustainable market value of firms. The positive effect of technology imports on the market value of firms is stronger at the lower and middle levels of the distribution of the firm value of stock returns, and this suggest heterogenous effects of technology trade across the quantiles. Overall, the empirical findings from our panel study suggest that the positive effects of technology trade for the market value of firms are due to the effect of its imports rather than exports.

Keywords: technology imports; technology exports; IPRs; firm value; panel data

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1. Introduction

In the knowledge based economy, the technological capability of a firm, such as its intellectual property rights (IPRs), should form a part of their sustainable development and market valuation in financial (stock) markets. The gap in the level of intellectual technology across countries significantly explains disparities in income and economic growth in those countries as well [1,2]. Developing countries lagging in the technological frontier mimic or follow technologies newly invented by other technologically advanced and innovative countries [3]. To catch up, mimicking or adapting new technologies is less expensive and risky than developing [4].

Technology may be diffused across borders through, for example, contracts for technology transfer, foreign direct investment, the migration of skilled labor, and imitation. Technology trade is an important channel for such diffusion across countries [2,5–7]. Therefore, firms behind in technological development can grow in a sustainable way via trading technology. In addition, cross border spillovers in technology allow firms to develop more environmentally friendly products, which can substantially contribute to an enhancement in their market value. In particular, competent IPRs allow firms to encourage greater technology trade [8,9].

According to the resource based theory of [10], a firm is perceived as a special unit of intrinsic resources and capabilities. Maximizing firm value using the optimal existing sources and capabilities is the principal task of managers. Firms limited by the availability

of technology may overcome these limits via the trade of technology imported from technologically advanced foreign firms, to sustainably enhance firm value. From the perspective of cash flow, firms holding competent technologies may sell them to foreign firms below a certain technological level via the trade of technology exports, and, thus, enjoy an increase in firm value.

The sustainable development and sound protection of technology (intangible) assets through IPRs are critical factors for firm valuation in knowledge based economies. Technology assets (i.e., computerized and innovative information and properties) are indeed considered more important for firms' sustainable success than tangible assets [11–14]. In reality, technologically advanced firms in several countries are more devoted to investing in the intangible assets of IPRs than tangible ones [15].

Accordingly, innovative firms consider the management of intellectual properties for the best sustainable survival and growth [16]. Even the stock markets show that market participants (i.e., investors and analysts) evaluate the intangible technology assets of IPRs from firms' technology innovation activity. That is, the technology assets (IPRs) of firms influence investors' and analysts' valuation of an asset's potential premiums on financial markets [17]. Indeed, firms' (tangible and intangible) assets are evaluated by their actual performances and by investors' expectations of their future performances. A better market valuation enables firms to finance larger funds with less expensive costs [18].

Despite the importance of both intangible technology assets and technology trade on firms' market valuation, studies on the effects of firms' IPRs on stock market valuation are sparse [14,17,19]. Moreover, very few studies explore the effects of firms' technology trade on their market valuation. To add to literature, our study aims to systematically and rigorously investigate the effects of firms' trade of technology imports and exports on their stock market valuation at a composite return level, for a sample of Organisation for Economic Co-operation and Development (OECD) countries. To the best of our knowledge, our study is the first to explore the effects of technology trade on market valuation. We analyze the specific effects of technology trade on stock market valuation depending on the trade balance (i.e., surplus and deficit) of the sample countries and its nonlinear and heterogenous effects on the valuations. These findings are also a novelty of our study. To this end, we use panel data analysis with quarterly data for each variable in the OECD countries from the first quarter (Q1) of 2005 to the fourth quarter (Q4) of 2019.

The principal findings of our study are summarized as follows: Technology imports proxied by IPR imports benefit the market value of firms in the sample countries. The net technology imports (exports) are also positively (negatively) associated with the firm value. There exist nonlinear effects of IPR exports and net IPR trade for the market value of firms. The positive effect of technology imports on the market value of firms is stronger at the lower and middle levels of the distribution of the firm value of stock returns. IPR trade (i.e., imports and exports) differently affects the firm value, depending on the balances (i.e., surplus or deficit) of technology trade in the sample countries.

The remainder of this paper is structured as follows. Section 2 reviews the literature. Section 3 presents the econometric strategy and data. Section 4 discusses empirical results. Section 5 concludes.

2. Literature Review

2.1. Theoretical Perspectives

According to the resource based theory [10], firms without any core resources for their sustainable growth and development may introduce other firms' resources, from domestic or foreign countries. Core resources embrace not only tangible resources, but also intangible resources, such as patents, trademark, and in house knowledge of technology. Previous studies also suggest that using core resources allows firms to obtain a competitive edge over rivals that is hard to duplicate and catch up with [20,21]. Similarly, Barney [22] claims that firms' (intangible) resources are crucial for having a sustainable current competitive advantage that even latent rivals cannot accomplish simultaneously. From this perspective,

firms may modify their managerial power with other organizations to acquire essential resources. This behavior is sufficient for growth and development, and, thus, to increase their market value.

The knowledge based theory by [23] contends that technology trade contributes to the greater efficiency of knowledge application across countries. Given a distinction between knowledge generation and application, technology trade may enhance knowledge application by improving the efficiency with which knowledge is integrated into the production of complex goods and services, and by increasing the efficiency with which knowledge is used across countries. Technology trade then enhances firms' operating performances (cash flows) through the efficient selling of goods and services via technology trade; this way, firm value increases [21].

2.2. Empirical Studies: Technology Assets and Market Value

The market value of firms associated with their technological capacities can be evaluated by the interactions among market participants (e.g., investors and analysts) whose actions in stock markets are based on future cash flows expected from the tangible and intangible assets of firms. Under the assumption of an efficient stock market, investments in intangible and tangible assets are expected to increase the market value of firms through the production of substantial revenues (i.e., cash flow) [24]. In particular, firms' intangible asset, such as IPRs, may be acquired by investing in R&D activities or importing advanced technologies from other (foreign) firms.

Along with technology imports and beyond technological cooperation with domestic firms, globalization has realized greater cooperation across foreign firms. The enlargement of technology trade enables firms to enhance their goods and services, and thus contribute to their sustainable development, as well as national economic growth [25–27]. For instance, Groizard [2] suggests that technology imports can reduce gaps in technological capabilities among countries.

However, most studies prioritize the analysis of the relationship between a firm's technological IPR assets (e.g., patents, R&D investments, and trademark) and its value, measured by stock returns or Tobin's Q at the firm level. That is, empirical studies on the economic effects of the trade of intangible technology assets on market valuation are sparse. Few studies examine the effects of firms' technology imports exclusively on market valuation. For example, previous studies show that technology imports reinforce new innovation activity, which enhances firms' market value [19,28]. That is, technology imports allow firms to sustainably improve economic performances through better competitiveness in goods and services [22,27,29].

To examine the effects of the IPRs of technology assets on firms' market valuation, prior studies mostly use foreign direct investment, R&D expenditures, patents, patent citations, and technology transfer as proxies of technology imports [2,19,30]. In a study of listed U.S. firms, studies report that R&D ratio relative to total assets, patents, and their citation ratios relative to R&D, benefit the market value of firms. Especially, additional citations per patent further increase market value. It is well established that IPRs (i.e., patents, citations) increase firm value in stock markets by providing incentives for new inventions, and then stimulating technology innovations [19,31–33]. Bloom and Van Reenen [34] show that patents significantly enhance the productivity and market value of listed UK firms. Toivanen et al. [28], by measuring the Tobin's Q for UK firms' market valuation, also suggest a positive relation between the intangible assets of patents and firms' market value.

Regarding the time varying relationship between a firm's market value and IPRs of patent based indicators, Belenzon and Pataconi [35] analyze the data of 33,000 mergers and acquisitions in the U.S. and Europe spanning 1985 to 2007, to determine how the relationship between firm value and patent based indicators of inventive activity varies over time. They find that, over time, the European Patent Office patents had a dominant effect, but the U.S. Patent Office patents had no such effect on firm value. Their findings still remain valid even while controlling for citations.

More recently, Lee et al. [30] examine the Korean market. They use the event study method to show that disclosures of technology imports led to statistically significant positive abnormal stock returns around the disclosure date, which reflected an increase in the market value of Korean listed firms. Ocak and Findik [36] find that the aggregate value of intangible assets and its subcomponents has a positive effect on the sustainable development and market value of Turkish firms. They report that the aggregated value of intangible assets is positively associated with the sustainable growth and market value of the firms.

3. Econometric Strategy and Data Issue

3.1. Econometric Strategy

We use panel data regression to analyze the specific effects of the trade (i.e., imports and exports) of technology assets, proxied by IPRs, on the market value of firms, proxied by country benchmark stock returns, in 36 OECD member countries. The panel data regression method is useful for controlling for unobserved heterogeneity across cross sectional units. Equation (1) represents the main panel model specified in this study:

$$StoRet_{i,t} = \alpha + \delta_i + \beta_1 GroIPRIM_{i,t} + \beta_2 GroIPREX_{i,t} + \beta_3 NetGroIPRIM_{i,t} + \gamma C_{i,t} + \theta D + \epsilon_{i,t} \quad (1)$$

where the dependent variable $StoRet_{i,t}$ is the quarterly stock returns in the sample countries over time and α is a constant. δ_i represents (time invariant unobserved) cross-section effects, which can be fixed or random. $\beta_1, \beta_2, \beta_3, \gamma, \theta$ are the coefficients to denote the explanatory power of each regressor in the regression model on the dependent variable. $\epsilon_{i,t}$ is the error term over time. $GroIPRIM_{i,t}$, $GroIPREX_{i,t}$ and $NetGroIPRIM_{i,t}$ are the main explanatory variables of the proxies for technology trade, and denote the first log differences (growths) of the quarterly IPR imports, exports, and net imports series in the sample countries, respectively. C is a vector of control variables, including quarterly inflations, exchange rates, and short term interest rates in the sample countries. D is a vector of intercept dummies that includes D_{GIIPS} and $D_{Subprime}$ to account for the effects of the two worldwide financial crises in the full sample periods, respectively. $D_{Subprime}$ is an intercept dummy of the U.S. subprime crisis, with a value of 1 over 2008–2009 and 0 otherwise. D_{GIIPS} is an intercept dummy of the Greece, Ireland, Italy, Portugal and Spain (GIIPS) banking crisis, with a value of 1 over 2010–2011 and 0 otherwise.

In our panel data sets, the time series dimension T is 59 quarters, and the cross-section dimension N is 36 (OECD) countries. The quarterly frequency of stock returns in our sample decently reduces microstructure noise at a higher frequency of daily or weekly. For the panel regression estimations, we run the fixed and random effects models as well as the pooled ordinary least squares model. The fixed effects model is estimated by the ordinary least square method and the random effects model by the generalized least squares method. To statistically assess a more appropriate panel specification, we estimate the Hausman statistics. For diagnostic tests, we account for the problem of the cross-sectional dependence among error terms across cross-sectional units, correlations across variables, and unit roots in panel data sets. For robustness, our study uses an instrumental variable estimation to check for the possible effects of endogeneity biases for the baseline results. We also examine the effect of a persistence of the dependent variable by running system dynamic panel regressions.

3.2. Data Issue

3.2.1. Stock Return Data

We use the country-composite stock returns from 36 OECD member countries for 59 quarters of Q1 2005 to Q4 2019. Our sample countries are Australia, Austria, Belgium, Canada, Chile, Colombia, Czech, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, South Korea, Latvia, Lithuania, Mexico,

Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, the UK, and the U.S. Note that Luxembourg, an OECD member state, is excluded because of the unavailability of stock returns data and control variables for the entire period. All the quarterly country composite stock return indices herein are available from “investing.com” in the USD. The stock market returns are computed as the log differences in the closing index levels from one quarterly return to the next one, such that $r_{i,t} = \ln(p_{i,t}/p_{i,t-1}) \times 100$ for an individual country stock return i at quarter t for the entire period. $p_{i,t}$ and $p_{i,t-1}$ denote an individual country stock price at the quarter and the previous one, respectively.

3.2.2. Main Exogenous Explanatory Variables

Our study uses the IPR imports (*GroIPIM*) and exports (*GroIPEX*) variables as the two main proxies for technology trade. We use the growth variables of both the IPR imports and exports differenced by a natural logarithm in USD at the current price in millions. The raw data are collectable from “BPM6: Trade and growth” based on main service category in the United Nations Conference on Trade and Development database. To account for the net effects of the IPR trade, we add the net IPR import variable (*NetGroIPIM*), the difference of the IPR imports and exports, as another explanatory variable in our regression models. The frequency for the three variables should be quarterly, to match with that of the dependent variable.

3.2.3. Control Variables

We use several control variables to consider the effects of the macroeconomic performances of the sample countries on their stock returns, proxied for the market value of firms on a country level. Most studies in macrofinance offer evidence indicating that stock returns are significantly influenced by major macroeconomic performances in countries.

Among macroeconomic drivers, we include the quarterly changes of inflation, short term interest rate, and exchange rate in our sample countries, with a difference in their natural logarithm in the panel regression models. Specifically, the inflation (*Inflation*) variable is the log change of the consumer price index, based on 100 in 2015 to account for the stationarity over time. For the interest rate (*Interest rate*) variable, we use the level variable of the quarterly short term interest rate, calculated by the percentage per annum because the level is stationary over time. The two macroeconomic variables are collected from the OECD Main Economic Indicators. Note that an immediate interest rate is available only for Turkey due to unavailability of the short term rate. For the exchange rate (*FX*) variable, we use the log change of the quarterly real effective exchange rates, calculated on the basis of 100 in 2010. The raw data for the exchange rates are collected from the database of the Bank for International Settlement.

3.2.4. Dummy Variables

A. The U.S. Subprime Crisis

To capture an intercept shift to find the effect of the U.S. subprime crisis in 2008–2009 on the market value of firms in the sample countries, we include the intercept time dummy of the U.S. subprime crisis in the panel models. This takes the value of 1 for 2008–2009 and 0 otherwise.

B. The GIIPS Banking Crisis

To analyze the effect of the GIIPS banking crisis in 2010–2011 on the dependent variable, this paper includes the time dummy of capturing an intercept shift of the GIIPS banking crisis in the panel models. This dummy takes the value of 1 for the years 2010–2011 and 0 otherwise. Table 1 summarizes the descriptive statistics of the dependent variable and exogenous covariates with the panel data structure. The means of the dependent variable and all the independent variables, except for the *ln_FX* variable, are, somewhat, different from their respective medians. These figures may embrace some variation over

time. In particular, Table 1 also shows high kurtosis figures for all the variables in this study. This shows a tendency of the leptokurtic distribution toward the center.

Table 1. Descriptive statistics for dependent and independent variables.

Variables	Mean	Std. Dev.	Skewness	Kurtosis	Min.	Median	Max.	Obs.
<i>StoRet</i>	0.006	0.10	−2.65	35.95	−1.69	0.018	0.49	N = 1996 n = 36, T = 54.69
<i>GroIPRIM</i>	0.01	0.21	−0.53	8.83	−1.43	0.02	1.11	N = 1883 n = 36, T = 59
<i>GroIPREX</i>	0.02	0.46	0.90	59.03	−5.91	0.01	7.40	N = 1883 n = 36, T = 59
<i>NetGroIPRIM</i>	−0.01	0.47	−1.37	52.55	−7.54	0.00	4.95	N = 1883 n = 36, T = 59
<i>ln_Inflation</i>	2.13	2.29	2.38	15.65	−6.10	1.80	22.37	N = 1883 n = 36, T = 59
<i>ln_FX</i>	−0.05	3.01	−0.03	11.09	−19.17	0.00	24.07	N = 1883 n = 36, T = 59
<i>InterestRate</i>	2.13	2.69	1.95	10.56	−0.84	1.17	22.50	N = 1883 n = 36, T = 59

Notes: Results of Fisher type panel unit root tests on the independent variables. N: a total number of observations, n: a number of cross-sectional units (countries), T: a number of times (quarters).

The three explanatory variables associated with technology trade have no series skewness, while the dependent variable of *StoRet* and the two control variables of *ln_Inflation* and *InterestRate* have a negative skewness at −2.65, 2.38, and 1.95, respectively. These skewness and kurtosis present non-normal distributions overall. Prior to running our panel regression specifications, we diagnose stationarities of the exogenous variables over time using the Fisher type panel unit root tests developed by [37]

Table 2 shows the specific results for the unit root tests. In Panel A, the Fisher type statistic of *InterestRate* (158.301) at level rejects the null of the panel unit root at the 1% level. Therefore, we use the level for the exogenous covariate. For the exogenous covariates of the other explanatory and control variables, the Fisher type statistics on Panel B significantly reject the null of unit roots in log difference at the 1% level, and then suggest stationarities of the variables over time. We use their difference in our examination.

Table 2. Results of Fisher type panel unit root tests on the independent variables.

Panel A. Level		
Variables	H_0 : Unit Root	
	Test Statistics	Lags
<i>IPRIM</i>	26.945 (1.000)	0 to 10
<i>IPREX</i>	36.813 (0.999)	0 to 10
<i>NetIPRIM</i>	85.935 (0.125)	0 to 10
<i>Inflation</i>	2.713 (1.000)	0 to 10
<i>FX</i>	60.631 (0.828)	0 to 10
<i>InterestRate</i>	158.301 *** (0.000)	1 to 10

Table 2. Cont.

Panel B. Difference		
Variables	H_0 : Unit Root	
	Test Statistics	Lags
<i>GroIPRIM</i>	1930.79 *** (0.000)	0 to 10
<i>GroIPREX</i>	2149.72 *** (0.000)	0 to 10
<i>NetGroIPRIM</i>	2135.75 *** (0.000)	0 to 10
<i>ln_Inflation</i>	208.553 *** (0.000)	0 to 10
<i>ln_FX</i>	1841.08 *** (0.000)	0 to 8
<i>ln_InterestRate</i>	661.342 *** (0.000)	0 to 9

Notes: *** denote significance at 1% levels, respectively. Lags are the averaged lags chosen by the AIC criteria for the ADF regressions.

To diagnose the interactions across all the covariates, Table 3 shows the correlation values across them. The results show low estimates except for a high value (0.69) only for the *InterestRate* and *ln_Inflation* variables.

Table 3. Correlation matrix of the exogenous independent variables.

Variables	<i>GroIPRIM</i>	<i>GroIPREX</i>	<i>NetGroIPRIM</i>	<i>ln_Inflation</i>	<i>ln_FX</i>	<i>Interest Rate</i>
<i>GroIPRIM</i>	1					
<i>GroIPREX</i>	0.190	1				
<i>NetGroIPRIM</i>	0.254	−0.902	1			
<i>ln_Inflation</i>	0.018	0.006	0.002	1		
<i>ln_FX</i>	0.024	0.009	0.001	0.043	1	
<i>InterestRate</i>	0.008	−0.002	0.005	0.699	0.006	1

4. Empirical Findings

4.1. Baseline Results of Panel Regressions

In this subsection, we analyze the principal results obtainable from our panel data regressions. Table 4 presents the baseline results of the static panel regression results for the effects of the technology trade, proxied by the IPR imports and exports, on the market value of firms, proxied by the bench market stock returns in the 36 OECD countries for the entire period. To check which panel models are safer, between fixed and random effects panel specifications, all the Hausman statistics (100.93, 87.83, 87.85, and 87.63) in Table 4 reject the null at the 1% level. The statistics suggest a preference for the fixed effects panel model. Therefore, we focus on the estimation results from the panel regressions with fixed effects for all the specifications in Table 4.

For the specific effects of technology trade on the market value of firms in the OECD countries, the panel Regression 1 in Table 4 estimates a significant and positive coefficient (0.6263) at the 5% level for the *GroIPRIM* variable of technology imports proxied by IPR imports. Thus, technology imports significantly increase the market value of firms in OECD countries. This finding is in line with that of innovation studies [19,28] showing that technology imports reinforce firms' new innovation activity and improve their market value. Our results support the resource based theory in that knowledge or technology capability is a critical resource for raising firms' growth and value. In a similar vein, Lee et al. [30] also report evidence that disclosures of technology imports increase market value in the Korean stock market, supporting the resource based theory for firms' growth.

Table 4. Baseline results of the static panel regressions.

Variables	Reg. 1	Reg. 2	Reg. 3	Reg. 4
Constant	0.0427 *** (0.0040)	0.0411 *** (0.0039)	0.0408 *** (0.0039)	0.0411 *** (0.0039)
GroIPRIM	0.0263 ** (0.0116)		0.0273 ** (0.0118)	
GroIPREX		−0.0036 (0.0059)	−0.0062 (0.0060)	
NetGroIPRIM				0.0095 * (0.0057)
ln_Inflation	−0.0137 *** (0.0016)	−0.0125 *** (0.0016)	−0.0126 *** (0.0016)	−0.0125 *** (0.0016)
ln_FX	0.0037 *** (0.0007)	0.0029 *** (0.0007)	0.0029 *** (0.0007)	0.0029 *** (0.0007)
InterestRate	−0.0035 *** (0.0013)	−0.0050 *** (0.0014)	−0.0050 *** (0.0014)	−0.0049 *** (0.0014)
D _{Subprime}	Inclusive	Inclusive	Inclusive	Inclusive
D _{GIIIPS}	Inclusive	Inclusive	Inclusive	Inclusive
Number of observations	1796	1760	1760	1760
Number of groups	36	36	36	36
R ²	0.031	0.036	0.038	0.037
F – value (p-values)	28.24 *** (0.000)	26.25 *** (0.000)	23.33 *** (0.000)	26.69 *** (0.000)
Correlation (δ_i, x_i)	−0.6625	−0.6246	−0.6182	−0.6214
Hausman ($\chi^2_{(k)}$) statistics (p-value)	100.93 *** (0.000)	87.83 *** (0.000)	87.85 *** (0.000)	87.63 *** (0.000)

Notes: ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively. Figures in parentheses of each variable indicate standard errors.

As for the effect of technology exports, panel Regression 2 estimates an insignificant value for the *GroIPREX* variable of technology exports proxied by IPR exports, suggesting no relation with the market value of firms. A possible explanation for the unexpected result may be because market participants (e.g., investors and analysts) perceive technology exports as the long term release of the core technology of firms, more than an improvement in short term cash flows. Note that importing technology resources should be essential for growth and value to the importing firms, but exporting could release core competences to exporting firms. Given this fact, the above explanation is acceptable.

We find contrasting results on trade imports and exports in the estimates from panel Regression 3, including simultaneously the two technology trade variables of *GroIPRIM* and *GroIPREX*. That is, the former has a significant positive coefficient at 0.0273, but the latter has an insignificant value. We then test for the effect of the net technology trade on the market value of firms in our sample countries. The estimation result for this are indicated in Regression 4. Note, we separately run the panel regressions for the pairs of *GroIPIM* and *NetGroIPIM* (*GroIPEX* and *NetGroIPEX*) to consider high multicollinearities across them.

Regression 4 estimates a significantly positive coefficient, at 0.0095, for the *NetGroIPIM* variable of the net technology imports, and vice versa, at −0.0095 for the *NetGroIPEX* variable of net technology exports (untabulated). The results suggest a net positive effect of technology imports along with the effect of imports on Regression 1. However, the net negative effect of technology exports, even on the market value of firms, goes against the effect of the exports in Regression 1.

Regarding the effects of the control variables, we observe the common magnitudes of macroeconomic drivers on stock returns in the whole panel regression model. Specifically,

the *ln_Inflation* variable measured by the log difference of the consumer price indices and the *InterestRate* variable of the level of short-term interest rates in the sample countries are negatively associated with the stock returns. However, the *ln_FX* variable measured by the log difference of nominal exchange rates in the countries is positively associated with the returns. All the panel regressions are inclusive for the two types of dummies—*D_{Subprime}* of the U.S. subprime crisis in 2008–2009 and *D_{GIIPS}* of the GIIPS banking crisis in 2010–2011—to control for the effects of the recent globe crises on stock returns.

4.2. Diagnostic Test

Panel Estimation Accounting for the CSD across Panel Data Unit

The possibility of a cross-sectional dependence across error terms in the panel data units might bias the estimates. To overcome any possibility of biased estimates from the cross-sectional dependence problem, we run panel data regressions with the Driscoll and Kraay standard errors. (see [38] for its details). Table 5 reports the estimates from these panel specifications with fixed effects for the diagnostic test of the cross-sectional dependence. All the Hausman statistics highly reject the null at the 1% level, and then suggest the preference of panel models with fixed effects. All the estimates for the panel models in Table 5 are nearly identical to those from our benchmark panel models in Table 4. Therefore, the diagnostic panel tests using the fixed effects panel regression with Driscoll and Kraay standard errors still support our baseline results in Table 4.

Table 5. The FE panel regressions with DK errors for the CSD across cross sectional units.

Variables	Reg. 1	Reg. 2	Reg. 3	Reg. 4
Constant	0.0427 *** (0.0042)	0.0411 *** (0.0039)	0.0408 *** (0.0039)	0.0411 *** (0.0036)
GroIPRIM	0.0263 *** (0.0125)		0.0273 ** (0.0116)	
GroIPREX		−0.0036 (0.0056)	−0.0062 (0.0067)	
NetGroIPRIM				0.0095 * (0.0056)
ln_Inflation	−0.0137 *** (0.0028)	−0.0125 *** (0.0028)	−0.0126 *** (0.0028)	−0.0125 *** (0.0030)
ln_FX	0.0037 *** (0.0009)	0.0029 *** (0.0008)	0.0029 *** (0.0008)	0.0029 *** (0.0007)
InterestRate	−0.0035 * (0.0021)	−0.0050 ** (0.0025)	−0.0050 *** (0.0025)	−0.0049 * (0.0028)
<i>D_{Subprime}</i>	Inclusive	Inclusive	Inclusive	Inclusive
<i>D_{GIIPS}</i>	Inclusive	Inclusive	Inclusive	Inclusive
Number of observation	1796	1760	1760	1760
Number of groups	36	36	36	36
R ²	0.088	0.080	0.086	0.085
F – value (p-value)	15.35 *** (0.000)	22.89 *** (0.000)	19.66 *** (0.000)	30.00 *** (0.000)
Hausman ($\chi^2_{(k)}$) statistics (p-value)	69.46 *** (0.000)	22.89 *** (0.000)	15.55 ** (0.029)	48.78 *** (0.000)
Maximum lag	1	3	3	8

Notes: ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively. Figures in parentheses of each variable indicate Driscoll–Kraay standard errors. F – value is a joint test values for the panel models with p-values in the parentheses.

4.3. Robustness Tests

4.3.1. Endogeneity Bias test of Explanatory Variables

Given that an endogeneity of explanatory variables in panel regressions might be immanent, the estimates from the regressions might be biased. We thus check for endogeneity biases on the baseline estimates from our panel regressions on in Table 4 by using possible instrumental variable(s).

In this study, the proxies of the instruments are the first lag of the three technology trade variables (i.e., *GroIPRIM*, *GroIPREX*, and *NetGroIPRIM*). Wooldridge [39] suggests that lag variables are highly correlated with their original variables, and, thus, insulate explanatory variables from their error terms [40].

Table 6 presents the results for all the panel specifications with the instrumental variables. For the entire period, the estimation results are almost identical to the those from the baseline results in Table 4. These do not account for endogeneity biases. Therefore, our baseline results in Table 4 still remain firm, even though this study considers a possibility of endogeneity biases in the panel regressions. All the Hausman statistics support the panel model with fixed effects for all the panel regressions as the best fit to our panel data.

Table 6. Results of the endogeneity bias tests with instrumental variables.

<i>Variables</i>	Reg. 1	Reg. 2	Reg. 3	Reg. 4
<i>Constant</i>	0.0435 *** (0.0042)	0.0442 *** (0.0042)	0.0440 *** (0.0042)	0.0442 *** (0.0042)
<i>GroIPRIM</i>	0.0294 *** (0.0122)		0.0305 *** (0.0124)	
<i>GroIPREX</i>		−0.0037 (0.0063)	−0.0064 (0.0064)	
<i>NetGroIPRIM</i>				0.0104 * (0.0061)
<i>ln_Inflation</i>	−0.0145 *** (0.0017)	−0.0141 *** (0.0017)	0.0142 *** (0.0017)	−0.0141 *** (0.0017)
<i>ln_FX</i>	0.0038 *** (0.0007)	0.0033 *** (0.0008)	0.0032 *** (0.0008)	0.0032 *** (0.0008)
<i>InterestRate</i>	−0.0027 ** (0.0013)	−0.0054 *** (0.0015)	−0.0054 *** (0.0015)	−0.0054 *** (0.0015)
<i>D_{Subprime}</i>	Inclusive	Inclusive	Inclusive	Inclusive
<i>D_{GIIPS}</i>	Inclusive	Inclusive	Inclusive	Inclusive
Number of observations	1666	1607	1607	1607
Number of groups	36	36	36	36
Correlation (δ_i, x_i)	−0.6475	−0.5333	−0.5286	−0.5299
R^2	0.037	0.052	0.055	0.087
Wald $-\chi^2_{(k)}$ (<i>p</i> -value)	177.31 *** (0.000)	176.24 *** (0.000)	182.80 *** (0.000)	179.12 *** (0.000)
Instrumented variable(s)	1st lag of <i>GroIPIM</i>	1st lag of <i>GroIPEX</i>	1st lag of <i>GroIPIM</i> & <i>GroIPEX</i>	1st lag of <i>NetGroIP</i>
Hausman ($\chi^2_{(k)}$) statistics (<i>p</i> -value)	91.43 *** (0.000)	72.63 *** (0.000)	73.26 *** (0.000)	72.76 *** (0.000)

Notes: ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively. Figures in parentheses indicate standard errors. Wald $-\chi^2_{(k)}$ is a joint test values for the panel models with *p*-values in the parentheses. R^2 is a statistic of a goodness of fit test. This coefficients in the FE model are estimated by the fixed effect (within) IV methods.

4.3.2. Dynamic Panel Estimations

A persistence of the dependent variable might distort the estimates on the exogenous variables in the panel regression models. For an additional robustness, we run the system dynamic panel models with AR (1) and (2) of the dependent variable (*StoRet*) in our panel models. The dynamic panel estimations are implemented by the Arellano-Bover/Blundell bond estimator. The system dynamic panel model estimated is as follows:

$$\begin{aligned} StoRet_{i,t} = & \alpha + \delta_i + \beta_1 StoRet_{i,t-1} + \beta_2 StoRet_{i,t-2} + \beta_3 GroIPRIM_{i,t} + \beta_4 GroIPREX_{i,t} + \beta_5 NetGroIPRIM_{i,t} \\ & + \gamma C_{i,t} + \theta D + \vartheta_{i,t} + \epsilon_{i,t} \end{aligned} \quad (2)$$

Note that, unlike the static panel model in Equation (1) above, the dynamic panel model includes a time-varying panel effect term denoted by $\vartheta_{i,t}$. Table 7 presents the results estimated from the system dynamic panel models. Overall, the dynamic panel estimation results are qualitatively identical to our baseline results for the explanatory variables and most exogenous control and dummies in Table 4 previously. Exceptionally, the *NetGroIPRIM* variable in Regression 4 only shows insignificant efficiency, unlike the significant positive value in Table 4. Therefore, our main results obtained in Table 4 are still valid, although one accounts for the dynamics of the dependent variable in our panel analysis.

Table 7. Results of the system dynamic panel regressions.

Variables	Reg. 1	Reg. 2	Reg. 3	Reg. 4
Constant	0.0372 *** (0.0046)	0.0390 *** (0.0046)	0.0387 *** (0.0045)	0.0392 *** (0.0046)
<i>StoRet</i> _{t−1}	0.0036 (0.0211)	−0.0029 (0.0213)	−0.0016 (0.0212)	−0.0013 (0.0213)
<i>StoRet</i> _{t−2}	−0.0122 (0.0190)	−0.0218 (0.0192)	−0.0209 (0.0192)	−0.0199 (0.0192)
<i>GroIPRIM</i>	0.0317 *** (0.0129)		0.0334 *** (0.0132)	
<i>GroIPREX</i>		0.0030 (0.0064)	0.0004 (0.0065)	
<i>NetGroIPRIM</i>				0.0046 (0.0061)
<i>ln_Inflation</i>	−0.0115 *** (0.0018)	−0.0110 *** (0.0019)	−0.0110 *** (0.0019)	−0.0110 *** (0.0019)
<i>ln_FX</i>	0.0035 *** (0.0008)	0.0029 *** (0.0008)	0.0028 *** (0.0008)	0.0029 *** (0.0008)
<i>InterestRate</i>	−0.0030 ** (0.0014)	−0.0053 *** (0.0016)	−0.0054 *** (0.0016)	−0.0053 *** (0.0016)
<i>D_{Subprime}</i>	Inclusive	Inclusive	Inclusive	Inclusive
<i>D_{GIIIPS}</i>	Inclusive	Inclusive	Inclusive	Inclusive
Number of observations	1597	1564	1564	1564
Number of groups	36	36	36	36
Wald − $\chi^2_{(k)}$ (p-value)	115.20 *** (0.000)	112.57 *** (0.000)	119.32 *** (0.000)	112.80 *** (0.000)

Table 7. Cont.

Variables	Reg. 1	Reg. 2	Reg. 3	Reg. 4
Instrument for difference & level equations	GMM type-difference & lag of <i>StoRet</i>	GMM type-difference & lag of <i>StoRet</i>	GMM type-difference & lag of <i>StoRet</i>	GMM type-difference & lag of <i>StoRet</i> , <i>NetGroIP</i>

Notes: *** and ** denote significance at 1% and 5% levels, respectively. Coefficients of all the panel regression models are estimated by the GMM method. Figures in parentheses indicate robust standard errors. The dynamic panel data models are fitted by the Arellano-Bover/Blundell bond estimation. All the dynamic panel data models include lags (2) of dependent variable as covariate and have unobserved panel effects.

4.4. Additional Analyses

4.4.1. Nonlinearities of Technology Trade

It would be interesting to explore the nonlinear effects of technology trade on market value of firms proxied by stock returns in the sample OECD countries, given the significant effects of technology imports. We thus examine the nonlinear effects of the *GroIPRIM*, *GroIPREX*, and *NetGroIPRIM* (*NetGroIPREX*) variables, proxied for technology trade, on the firm value, using a variety of panel models employed previously. To this end, we use the squared values of the four proxy variables for technology trade as explanatory variables in the panel models. The benchmark panel model for nonlinearities of technology trade are specified as below:

$$\begin{aligned}
 StoRet_{i,t} = & \alpha + \delta_i + \beta_1 GroIPRIM_{i,t} + \beta_2 GroIPRIM_{i,t}^2 + \beta_3 GroIPREX_{i,t} \\
 & + \beta_4 GroIPREX_{i,t}^2 + \beta_5 NetIPRIM_{i,t} + \beta_6 NetGroIPRIM_{i,t}^2 \\
 & + \gamma C_{i,t} + \theta D + \epsilon_{i,t}
 \end{aligned} \quad (3)$$

The specific results for the tests are shown in Table 8. First, regarding the nonlinear effect of technology imports, all the panel models with fixed effects (i.e., Regressions 1, 2, 3, and 4) on Panel A estimate insignificant coefficients on the squared *GroIPRIM* variable, *GroIPRIM*². The results suggest no relation between the squared technology imports and market value of firms, reflecting only the linear effects for the market value of firms in the sample countries, without any nonlinear effect of technology imports.

However, regarding the *GroIPREX* variable, a proxy for technology exports, we find meaningful evidence of its nonlinear effect for market value in Panel B. Specifically, Regression 1 and 2 estimate marginally significant negative coefficients, at -0.0070 and -0.0074 for the squared *GroIPREX* variable (*GroIPRIM*²), unlike the insignificant values for *GroIPREX*. Regression 3 and 4 estimate significant negative values at -0.0070 and -0.0089 for the *GroIPRIM*², unlike the insignificant values for the *GroIPREX* variable. Unlike the positive effects of the technology exports at a normal level on firms' market value, the results suggesting negative (reverse) effects of the squared *GroIPREX* on firms' market value, reflecting a nonlinearity of the excessive technology exports for firms' value. As for the *netGroIPRIM* and *netGroIPREX* variables, proxied for the net technology trade, we observe clearer nonlinearities for the market value of firms.

In Panel C, Regression 1 of the benchmark fixed effect panel model and Regression 2 of the fixed effect panel model considering endogeneity biases estimate significant negative and positive coefficients at -0.0066 and -0.0071 as well as 0.0066 and 0.0071 for *NetGroIPRIM*² and *NetGroIPREX*², the squared *NetGroIPRIM* and *NetGroIPREX* variables, respectively, unlike the significant positive (0.0096 and 0.0111) and negative (-0.0096 and -0.0111) coefficients for the linear variables of both. In a similar vein, Regression 3 of the DK-fixed effect panel model and Regression 4 of the dynamic system panel model also estimate marginally significant negative (-0.0066 and -0.0071) and positive (0.0066 and 0.0071) effects for the two squared variables, respectively. Thus, in terms of net technology (imports and exports) trade, excessive technology imports and exports switch the intrinsic effects (+, −) of technology trade on the firm value into reverse ones (−, +). Showing a

reverse U (for net technology imports) and U (for net technology exports) shaped curves, the findings reflect interesting evidence on nonlinear effects on the market value of firms in our sample countries.

Table 8. The panel regressions for nonlinear effects of technology trade.

Panel A. Regressions on Technology Imports				
<i>Variables</i>	Reg. 1 Benchmark-FE Model	Reg. 2 Endogeneity-FE Model	Reg. 3 DK-FE Model	Reg. 4 Dynamic panel Model
<i>Constant</i>	0.0413 *** (0.0041)	0.0420 *** (0.0043)	0.0413 *** (0.0047)	0.0365 *** (0.0047)
<i>StoRet_{t-1}</i>				−0.0034 (0.0211)
<i>StoRet_{t-2}</i>				−0.0113 (0.0190)
<i>GroIPRIM</i>	0.0277** (0.0116)	0.0309 *** (0.0122)	0.0277** (0.0122)	0.0330 *** (0.0130)
<i>GroIPRIM</i> ²	0.0356 (0.0235)	0.0356 (0.0240)	0.0356 (0.0292)	0.0165 (0.0267)
<i>ln_Inflation</i>	−0.0136 *** (0.0016)	−0.0145 *** (0.0017)	−0.0136 *** (0.0029)	−0.0114 *** (0.0018)
<i>ln_FX</i>	0.0037 *** (0.0007)	0.0039 *** (0.0007)	0.0037 *** (0.0009)	0.0035 *** (0.0008)
<i>InterestRate</i>	−0.0035 *** (0.0013)	−0.0027** (0.0013)	−0.0035 (0.0024)	−0.0030** (0.0008)
<i>D_{Subprime}</i>	Inclusive	Inclusive	Inclusive	Inclusive
<i>D_{GIIPS}</i>	Inclusive	Inclusive	Inclusive	Inclusive
Number of observations	1796	1666	1796	1597
Number of groups	36	36	36	36
R ²	0.089	0.094	0.089	
F – value	24.55 *** (0.000)	173.63 *** (0.000)	16.30 *** (0.000)	115.47 *** (0.000)
Hausman ($\chi^2_{(k)}$) statistics(<i>p</i> -value)	105.10 *** (0.000)	100.52 *** (0.000)	14.82 ** (0.038)	
Instrumented variable(s)		1st lag of <i>GroIPIM</i> & <i>GroIPIM</i> ²		GMM type-lag of <i>StoRet</i>
Maximum lag			3	2
Panel B. Regressions on technology exports				
<i>Variables</i>	Reg. 1 Benchmark-FE Model	Reg. 2 Endogeneity-FE Model	Reg. 3 DK-FE Model	Reg. 4 Dynamic panel Model
<i>Constant</i>	0.0420 *** (0.0040)	0.0451 *** (0.0042)	0.0420 *** (0.0040)	0.0401 *** (0.0046)
<i>StoRet_{t-1}</i>				−0.0041 (0.0213)
<i>StoRet_{t-2}</i>				−0.0249 (0.0193)
<i>GroIPREX</i>	0.0032 (0.0059)	−0.0039 (0.0063)	−0.0032 (0.0066)	0.0036 (0.0064)

Table 8. Cont.

Panel B. Regressions on technology exports				
Variables	Reg. 1 Benchmark-FE Model	Reg. 2 Endogeneity-FE Model	Reg. 3 DK-FE Model	Reg. 4 Dynamic panel Model
<i>GroIPREX</i> ²	−0.0070 (0.0046)	−0.0074 (0.0050)	−0.0070 *** (0.0038)	−0.0089 * (0.0048)
<i>ln_Inflation</i>	−0.0125 *** (0.0016)	−0.0141 *** (0.0017)	−0.0125 *** (0.0028)	−0.0109 *** (0.0019)
<i>ln_FX</i>	0.0029 *** (0.0007)	0.0033 *** (0.0008)	0.0029 *** (0.0008)	0.0029 *** (0.0008)
<i>InterestRate</i>	−0.0049 *** (0.0014)	−0.0053 *** (0.0015)	−0.0049 ** (0.0025)	−0.0053 (0.0016)
<i>D_{Subprime}</i>	Inclusive	Inclusive	Inclusive	Inclusive
<i>D_{GIIPS}</i>	Inclusive	Inclusive	Inclusive	Inclusive
Number of Obs.	1796	1607	1760	1564
Number of groups	36	36	36	36
R ²	0.085	0.098	0.085	
F – value	22.85 *** (0.000)	178.61 *** (0.000)	20.90 *** (0.000)	116.13 *** (0.000)
Hausman ($\chi^2_{(k)}$) statistics (p-value)	89.370 *** (0.000)	75.91 *** (0.000)	15.14 ** (0.034)	-
Instrumented variable(s)		1st lag of <i>GroIPEX</i> & <i>GroIPEX</i> ²		GMM type-difference & lag of <i>StoRet</i>
Maximum lag			3	2
Panel C. Regressions on net technology trade				
Variables	Reg. 1 Benchmark-FE Model	Reg. 2 Endogeneity-FE Model	Reg. 3 DK-FE Model	Reg. 4 Dynamic panel Model
<i>Constant</i>	0.0421 *** (0.0040)	0.0452 *** (0.0042)	0.0421 *** (0.0040)	0.0402 *** (0.0046)
<i>StoRet_{t-1}</i>				−0.0023 (0.0213)
<i>StoRet_{t-2}</i>				−0.0220 (0.0192)
<i>NetGroIPRIM/</i> <i>NetGroIPREX</i>	0.0096 */ −0.0096 * (0.0057)	0.0111 */ −0.0111 * (0.0061)	0.0096 / −0.0096 (0.0068)	0.0047 / −0.0047 (0.0061)
<i>NetGroIPRIM</i> ² / <i>NetGroIPREX</i> ²	−0.0066 */ 0.0066 * (0.0042)	−0.0071 */ 0.0071 * (0.0045)	−0.0066 / 0.0066 (0.0042)	−0.0071 */ 0.0071 * (0.0044)
<i>ln_Inflation</i>	−0.0125 *** (0.0016)	−0.0141 *** (0.0017)	−0.0125 *** (0.0026)	−0.0110 *** (0.0019)
<i>ln_FX</i>	0.0029 *** (0.0007)	0.0033 *** (0.0008)	0.0029 *** (0.0009)	0.0029 *** (0.0008)
<i>InterestRate</i>	−0.0049 *** (0.0014)	−0.0053 *** (0.0015)	−0.0049 ** (0.0022)	−0.0053 (0.0016)
<i>D_{Subprime}</i>	Inclusive	Inclusive	Inclusive	Inclusive
<i>D_{GIIPS}</i>	Inclusive	Inclusive	Inclusive	Inclusive

Table 8. Cont.

Panel C. Regressions on net technology trade				
Variables	Reg. 1 Benchmark-FE Model	Reg. 2 Endogeneity-FE Model	Reg. 3 DK-FE Model	Reg. 4 Dynamic panel Model
Number of observations	1760	1607	1760	1564
Number of groups	36	36	36	36
R ²	0.086	0.100	0.086	
F – value	23.26 *** (0.000)	181.82 *** (0.000)	14.40 *** (0.000)	115.71 *** (0.000)
Hausman ($\chi^2_{(k)}$) statistics (p-value)	89.02 *** (0.000)	75.67 *** (0.000)	48.11 *** (0.000)	
Instrumented variable(s)		1st lag of <i>NetGroIPIM</i> & <i>NetGroIPIM</i> ²		GMM type-difference & lag of <i>StoRet</i>
Maximum lag			1	2

Notes: ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively. Figures in parentheses of each variable in benchmark, endogeneity FE, and dynamic panel models indicate standard errors but the case in the DK-FE model indicates Driscoll–Kraay standard errors. F – value is a joint test values for the panel models with *p*-values in the parentheses.

4.4.2. Heterogeneity across Levels of Stock Returns of the Dependent Variable

In Table 1, we note the differences between the mean and median for the dependent variable of *StoRet* and the explanatory variables of *GroIPIM*, *GroIPEX*, and *NetGroIPIM* proxied for technology trade. This suggests that the dependent and explanatory variables embrace substantial non-normality in their distributions. In this case, using the classical ordinary or generalized least squares method based on the mean estimation might make the estimates inefficient and biased, since the targeted estimators are not robust for the normality in their error distributions. As an alternative, using the conditional quantile regressions based on a conditional median approach should be robust for the normality and skewed tails of error terms [41–44]. In particular, [42,43,45] effectively used this estimation technique to examine the heterogeneity of explanatory variable(s) across the several quantiles of a dependent variable for each study.

By using the quantile regression method, we examine the heterogenic effects of the three explanatory variables for technology trade on the market value of firms in our sample countries across the level of the dependent variable. To apply the quantile regressions for our panel data, we use the conditional panel quantile regressions with fixed effects devised by [44] for the full model with all the covariates. For comparison, focusing on the central tendency of the distribution of dependent variable, we estimate the simple panel regression with fixed effects for the full model with all the covariates. The panel quantile regression with fixed effects in this study is as follows:

$$\begin{aligned} \text{Quant}(\text{StoRet}_{i,t} | X_{i,t}) &= \alpha + \delta_i + \beta_{\tau 1} \text{GroIPRIM}_{i,t} + \beta_{\tau 2} \text{GroIPEX}_{i,t} \\ &+ \beta_{\tau 3} \text{NetGroIPRIM}_{i,t} + \gamma_{\tau} C_{i,t} + \theta_{\tau} D + \epsilon_{i,t} \end{aligned} \quad (4)$$

where $\text{Quant}(\text{StoRet}_{i,t} | X_{i,t})$ denotes the τ^{th} conditional quantile of *StoRet*_{*i,t*} of the dependent variable, that is, the stock returns in the sample countries at quarter (*t*). Note that, unlike other panel analyses in this study, our panel quantile regressions including all the covariates omit the *NetGroIPRIM* variable due to the strong multicollinearity with the *GroIPRIM* and *GroIPEX* variables.

Table 9 shows the results of estimating Equation (4) using panel quantile regressions at the seven conditional quantiles (τ) of the distributions of the stock returns in the 36 OECD countries for the entire period. Focusing on the central tendency of the distribution of dependent variable, the estimates from the simple panel regression with fixed effects are

reported in order to compare with those from the panel quantile regressions on the first column of Table 9.

Table 9. Panel quantile regressions with fixed effects for heterogeneity across the levels of the dependent variable.

Variables	FE-Panel Regression	FE-Panel Quantile Regressions (Method of Moment-Q Regressions)						
		τ_5	τ_{10}	τ_{25}	τ_{50}	τ_{75}	τ_{90}	τ_{95}
Constant	0.0408 *** (0.0039)	Na	Na	Na	Na	Na	Na	Na
GroIPRIM	0.0273 ** (0.0118)	0.0751 ** (0.0353)	0.0642 ** (0.0290)	0.0442 *** (0.0186)	0.0252 ** (0.0132)	0.0090 (0.0160)	−0.0048 (0.0223)	−0.0129 (0.0266)
GroIPREX	−0.0062 (0.0060)	0.0036 (0.0174)	0.0013 (0.0143)	−0.0066 (0.065)	−0.0066 (0.0065)	−0.0100 (0.0078)	−0.0128 (0.0110)	−0.0145 (0.0131)
ln_Inflation	−0.0126 *** (0.0016)	−0.01025 ** (0.0060)	−0.0125 *** (0.0049)	−0.0126 *** (0.0022)	−0.0126 *** (0.0022)	−0.0126 *** (0.0027)	−0.0126 *** (0.0038)	−0.0126 *** (0.0045)
ln_FX	0.0029 *** (0.0007)	0.0057 ** (0.0024)	0.0051 *** (0.0020)	0.0027 *** (0.0009)	0.0027 *** (0.0009)	0.0018 *** (0.0011)	0.0009 (0.0015)	0.0005 (0.0018)
InterestRate	−0.0050 *** (0.0014)	−0.0251 *** (0.0060)	−0.0206 *** (−0.0049)	−0.0041 * (0.0022)	−0.0041 * (0.0022)	0.0026 (0.0027)	0.0086 ** (0.0038)	0.0120 *** (0.0045)
D _{Subprime}	Inclusive	Inclusive	Inclusive	Inclusive	Inclusive	Inclusive	Inclusive	Inclusive
D _{GIIPS}	Inclusive	Inclusive	Inclusive	Inclusive	Inclusive	Inclusive	Inclusive	Inclusive
Num. of Obs.	1760	1760	1760	1760	1760	1760	1760	1760
Num. of groups	36	36	36	36	36	36	36	36
R ²	0.038	Na	Na	Na	Na	Na	Na	Na

Notes: The figures in parentheses are standard errors. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Na denotes 'not available'.

In Table 9, the five panel quantile regressions at the lower and middle quantiles of τ_5 , τ_{10} , τ_{25} , τ_{50} , and τ_{75} estimate significant and positive coefficients, at 0.0751, 0.0062, 0.0442, and 0.0252, for the *GroIPRIM* variable, as in the panel estimate (0.0273) with fixed effects. However, the two panel quantile regressions at the high levels of τ_5 and τ_{10} of the stock returns estimate insignificant values for the *GroIPRIM* variable, suggesting no effect on technology imports at the high level of stock returns in the sample countries. Instead, the panel quantile regressions estimate significantly positive coefficients for *ln_Inflation* and *InterestRate* at the high levels of the distribution of the dependent variables even.

The results suggest that high level firm values proxied by stock returns are more influenced by macroeconomic drivers, such as the growth of inflation and short term interest rates. These findings suggest evidence of a heterogeneity across the levels of the distribution of the dependent variable (*StoRet*), whereby technology imports differently affect firm value depending on its level. Regarding the *GroIPREX* variable, as in the simple panel regression, the panel quantile regressions estimate insignificant values for it at the whole level of distribution of the dependent variable and this suggests no effect for the market value of firms in our sample countries.

4.4.3. Effects of Technology Trade Depending Technology Trade Balance

The balance from firms' technology trade directly affects cash flows of firms, and this balance would, thus, crucially affect market value. For the final analysis, we examine the specific effects of technology trade on stock returns, depending the technology trade balance of surplus and deficit in our sample countries.

The results obtained from the fixed effects panel regressions for this analysis are reported in Panel A for surplus countries and Panel B for deficit countries in Table 10. First, for the effects of technology imports, Panel A and B present the significant positive coefficients at 0.0352 and 0.0245 for the *GroIPRIM* variable, respectively, as in most of the previous panel regressions on this variable. Interestingly, surplus countries enjoy a stronger positive effect from technology imports on firm value than do deficit countries. Second, regarding the effects of technology exports (*GroIPREX*), Panel A and B show contrasting results. That is, Regression 1 in Panel A estimates a significant positive coefficient for *GroIPREX*, while Regression 1 in Panel B estimates an insignificant one for this variable. Thus, technology exports harm market value in surplus countries and have no effect in deficit countries. This finding implies that market participants perceive the technology exports of surplus countries as bad information for their wealth because it releases the core capacity of firms' technology. This interpretation of the results is explainable when considering that firms with core technologies are mostly from highly advanced countries with surplus from technology trade.

Table 10. Panel regressions depending on technology trade balance.

Variables	Panel A. Surplus Countries		Panel B. Deficit Countries	
	Reg. 1	Reg. 2	Reg. 1	Reg. 2
<i>Constant</i>	0.0581 *** (0.0075)	0.0583 ** (0.0075)	0.0340 *** (0.0045)	0.0343 *** (0.0045)
<i>GroIPRIM</i>	0.0352 * (0.0208)		0.0245 * (0.0141)	
<i>GroIPREX</i>	−0.0251 ** (0.0129)		−0.0002 (0.0065)	
<i>NetGroIPRIM/NetGroIPREX</i>		0.0272 **/−0.0272 ** (0.0122)		0.0032/−0.0032 (0.0062)
<i>ln_Inflation</i>	−0.0176 *** (0.0033)	−0.0176 *** (0.0033)	−0.0102 *** (0.0019)	−0.0102 *** (0.0019)
<i>ln_FX</i>	0.0059 *** (0.0014)	0.0060 *** (0.0014)	0.0015 * (0.0008)	0.0015 ** (0.0008)
<i>InterestRate</i>	−0.0088 *** (0.0030)	0.0088 *** (0.0030)	−0.0038 ** (0.0016)	−0.0038 ** (0.0016)
<i>DSubprime</i>	Inclusive	Inclusive	Inclusive	Inclusive
<i>DGIIPS</i>	Inclusive	Inclusive	Inclusive	Inclusive
Number of observations	658	658	1102	1102
Number of groups	13	13	23	23
R ²	0.085	0.085	0.027	0.025
F – value (p-value)	14.45 *** (0.000)	16.84 *** (0.000)	11.69 *** (0.000)	13.15 *** (0.000)
Correlation (δ_i, x_i)	−0.4091	−0.4912	−0.6462	−0.6509
Hausman ($\chi^2_{(k)}$) statistics (p-value)	29.50** (0.000)	30.90 *** (0.000)	51.16 *** (0.000)	50.90 *** (0.000)

Notes: The figures in parentheses are standard errors. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

As for the net effect of technology imports, Regression 1 in Panel A estimates a significant positive coefficient at 0.0272 for *netGroIPRIM*, suggesting a positive effect of technology trade on market value in surplus countries. Meanwhile, Regression 1 in Panel B estimates an insignificant value for the same variable, suggesting no effect in deficit

countries. The unexpected results for *netGroIPRIM* in deficit countries can be attributed to market inefficiency in these countries. This interpretation is explainable given that countries with a deficit in technology trade balance are often economically developing with emerging securities markets. All the estimates for the control variables are qualitatively identical to the ones estimated in the previous analyses.

5. Conclusions

We systematically investigated a variety of effects of technology trade of imports and exports on the market value of firms using composite stock returns in the 36 OECD member countries over the Q2 2005 to Q4 2018 period. To proxy technology trade activities in the sample countries, we used the growth of IPR imports and exports for imports and exports, respectively.

Our findings suggest that technology imports, proxied by IPR imports, increase market value. The results support the (knowledge) resource based view for firms' growth, in that technology (IPRs) imports from foreign countries could effectively help firms obtain core technological capabilities that are needed for sustainable growth and value of firms. Our study suggests that net technology imports are also positively associated with firm value. Along with the nonlinearity of technology trade, we find no nonlinearity for the effect of IPR imports on market value, but significant nonlinearity for IPR exports and net IPR trade when using the respective squares of the proxies for technology imports and exports and its net trade in our panel specifications. The positive effect of technology imports on market value is stronger at the lower and middle levels of the distribution of the firm value of stock returns in the sample countries. However, we find no evidence of the effect of technology exports proxied by IPR exports on firm value in our panel regressions even. For countries with a technology trade surplus, technology exports harm market value.

Overall, the empirical findings suggest that the positive effect of technology trade for market value is owing to the effects of imports rather than exports. These findings provide researchers, firm managers and policymakers with valuable insights on effective (financial) management and policy making to craft the technology trade strategies for firms' sustainable development, growth and market value. In particular, the U or reversed U-shaped-nonlinearities of net technology trade on firms' market value, observable in our panel study, suggest a valuable guideline for the minimum or maximum level of technology trade for increasing firms' market value. The heterogeneous effects of technology trade on the market value evidence the differentiated effects of firms' technology trade, according to the levels of their market value. In addition, our finding, depending on technology trade balance, also provides one with a meaningful implication for a relationship between technol trade balance and firms' market value.

Lastly, the current study is based on a country level analysis. We used country benchmark stock indices as a proxy of firms' market value and country level data for its drivers. For a richer analysis, future studies should consider the data for each variable (especially, technology trade) at the firm level, given its availability.

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