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International financial openness and industrial R&D

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Abstract

International financial integration may provide an important channel of financing for research and development (R&D) that ultimately enhances economic growth. Following the analysis of Maskus et al. (2012), we examine the impact of refined measures of international financial openness and capital controls on R&D intensities in 23 manufacturing industries in 22 OECD countries for the period 1995-2009. We interact these country-level financial measures with industry characteristics: external financial dependence and asset tangibility. Our results indicate that the significance of FDI as an international financial development measure is driven primarily by external FDI assets, perhaps indicating that multinational firms are able to access R&D funds from affiliate firms abroad. De jure measures provide corroborating evidence that financial openness may be particularly important for industries with fewer tangible assets. By contrast, the availability of international portfolio debt increases R&D intensities for those industries that rely more on external financing.

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1. Introduction

The importance of financing for research and development (R&D) as a channel by which finance affects economic growth has received recent attention in the literature. Hall and Lerner (2010) provide evidence that firms rely upon external financing from banks and equity markets to fund R&D expenditures once internal funds have been exhausted. In addition to domestic financial development, Maskus et al. (2012) highlight the importance of international capital markets as a source of external financing. Among several measures of international financial development, they find that only FDI is a significant factor in financing R&D at the industry-level. We further investigate this finding to provide a more comprehensive understanding of the effect of the availability of international financing on industrial R&D intensities.

Specifically, we examine the impact of refined measures of international financial development on R&D intensities in 23 manufacturing industries in 22 OECD countries for the period 1995-2009. Our contribution is to decompose the country-level measures of international financial openness into their constituent parts by examining separately the effects of external assets and liabilities using measures of FDI equity and portfolio debt. Our paper provides insight about whether industries may employ internal capital from foreign affiliates or access external funds via international borrowing to finance R&D. In addition, we further consider the effects of financial openness as measured by capital control indices. Kose et al. (2009) emphasize that equity market liberalization can boost growth. However, the distinction between *de facto* and *de jure* capital account openness measures can be very important because legal restrictions on capital movements may not always reflect the actual degree of openness *in practice*. Thus, we capture both the type and direction of international financial integration while examining both *de facto* and *de jure* measures of financial openness.

Our results suggest that the significance of FDI as an international financial development measure is driven primarily by external assets. This may indicate that multinational firms are able to access funds from affiliate firms abroad and use such funds as an important source of financing R&D expenditures. Portfolio debt liabilities also provide an important channel for increased R&D intensities for industries that depend on external finance or have fewer tangible assets. The *de jure* measures of financial openness indicate that industries with less tangible assets benefit from international financial openness.

The rest of this paper is organized as follows. Section 2 describes the methodology while section 3 describes the data used. We present our empirical results in section 4 and concluding remarks in section 5.

2. Methodology

We study the impact of international financial development on industrial R&D intensities, conditional on two industry characteristics identified by Maskus et al. (2012): dependence on external financing and asset tangibility. We consider whether external assets or liabilities drive the significant result in Maskus et al. (2012) within FDI equity and portfolio debt.

We expect external *liabilities*, which represent international borrowing or capital inflows, to drive these results for both the debt and equity components. The idea is that industries that are more dependent on external financing or have fewer tangible assets will innovate more in countries that are more financially open since they may access international financial markets in addition to domestic financial markets. Further, affiliate firms may be able to take advantage of funding from parent firms, such that the responses of R&D expenditures are expected to show similar behavior when international financial development is measured by FDI liabilities or by debt liabilities. However, given that multinationals may take advantage of host-country domestic financial markets via affiliates abroad or strategically allocate funds from affiliates abroad, external *assets* may also be an important factor.

When considering the *de jure* measures that reflect cross-border financial restrictions, we expect industries that are more dependent on external financing to innovate less in countries that have more cross-border financial restrictions. Similarly, we expect industries with more tangible assets to innovate relatively more in less financially open countries as they are less likely to need international funds due to higher levels of collateral, allowing them to access domestic debt markets.

We use the estimating equation from Maskus et al. (2012). This approach, developed by Rajan and Zingales (1998), includes interaction terms to allow for the utilization of cross-country variation to examine within-country differences across industries:

$$\begin{aligned}\text{R\&D intensity}_{j,k,t} =& \beta_0 + \beta_1(\text{external financial dependence}_k \text{ x financial openness}_{j,t}) \\ &+ \beta_2(\text{tangibility}_k \text{ x financial openness}_{j,t}) + \beta_3(\text{industry share}_{j,k,t}) \\ &+ \beta_4(\text{financial openness}_{j,t}) + \eta_j + \eta_k + \eta_t + \epsilon_{j,k,t}\end{aligned} \quad (1)$$

where j indicates countries, k denotes industries, and t represents time. The indicators η_k, η_j, and η_t control for unobserved industry, country, and time-specific effects. Industry share in GDP is included to control for different industry patterns across countries. The direct effect of financial openness is included in the regression as it varies across both countries and time. The direct effects of the industry characteristics are captured within η_k.

3. Data

Table I summarizes our data sources.[1] *De facto* measures of international financial development include FDI equity assets, FDI equity liabilities, portfolio debt assets, and portfolio debt liabilities.[2] Accumulated capital inflows are captured by external liabilities and accumulated capital outflows are captured by external assets.

We also include indices that measure *de jure* restrictions on cross-border financial transactions. KAOPEN measures a country's degree of financial account openness in an aggregate sense, with a higher index value indicating greater openness. Capital control indices from

[1] Our data appendix includes summary statistics, a list of industries, and a list countries in Tables A.I, A.II, and A.III respectively.

[2] Other refined measures from Lane and Milesi-Ferretti (2007) do not yield significant results.

Fernández et al. (2016) can be decomposed into inflow and outflow restrictions, allowing for a comparison of *de jure* and *de facto* measures with a directional component.

Our industry characteristics, external dependence and tangibility, do not vary across countries or time. As Maskus et al. (2012) indicate, these characteristics represent inherent technological differences across industries that can be used to create a ranking. U.S. data provide a sufficient proxy as differences in these characteristics are likely to be small across OECD countries. It also mitigates endogeneity and causality concerns as industry-level R&D intensities that vary across time and countries are not likely to be causal for characteristics computed for U.S. industries (Maskus et al., 2012).[3]

4. Results

4.1 De facto measures

Table II presents results for FDI equity and portfolio debt, decomposed into assets and liabilities. We include country, industry, and time fixed effects in all specifications. We report results with both robust and clustered standard errors at the country-level, to provide both a standard and more conservative benchmark. We follow Cameron and Miller (2015) and cluster the standard errors at the highest level to control for within-cluster correlations in the error term.[4]

We focus first on the portfolio debt measures of financial openness. We find a positive and significant β_1 coefficient on portfolio debt liabilities interacted with external financing. The coefficient on portfolio debt liabilities interacted with tangibility (β_2) is negative and statistically significant. These results hold for both standard error types. Together, these highlight the importance of foreign borrowing (capital inflows), as compared to portfolio debt assets. The ability to borrow abroad may loosen credit constraints for firms in these industries. We examine the sensitivity of these results to specific industries by dropping one industry at a time. In a number of cases, the interaction between external dependence and debt liabilities becomes significant at $p < 0.05$ instead of $p < 0.10$ when using clustered standard errors (and remains highly significant with robust standard errors). The interaction between tangibility and debt liabilities, however, may be sensitive to specific industries, losing significance in particular when industry number 37 (Recycling) is dropped. This finding is consistent with debt liabilities (either domestic or international) requiring collateral for financing, such that financing via debt may rely more on the availability of tangible assets. Overall, the availability of international portfolio debt impacts innovation most for those industries that rely more on external financing.

The FDI equity measures of financial openness provide somewhat different results, with

[3]We omit the U.S. from the regression analysis to avoid feedback effects that may result from including U.S. R&D intensities.

[4]Studies that apply this method differ with respect to their choice of standard errors. Maskus et al. (2012) report their results with robust standard errors while Seitz and Watzinger (2017) utilize clustered errors.

Table I: Data sources

Variable	Construction	Source
R&D intensity	Total industry R&D expenditures relative to industry output	OECD ANBERD Database
Industry share in GDP	Industry production divided by GDP	OECD/World Bank World Development Indicators 2013
FDI equity	FDI equity relative to GDP	Lane and Milesi-Ferretti (2007)
Portfolio debt	Portfolio debt relative to GDP	
KAOPEN	Principle component analysis of binary variables that indicate the presence of multiple exchange rates, capital and current account restrictions, and regulatory requirements of the surrender of export proceeds.	Chinn and Ito (2008), IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER).
Overall restriction index	Unweighted average of binary variables where 0 indicates unrestricted and 1 indicates restricted capital flows for a series of disaggregated asset categories.	Fernández et al. (2016), IMF's AREAER
External dependence	Industry-level median across firms of the ratio of capital expenditures less cash flow from operations divided by capital expenditures (Klapper et al., 2006)	Standard and Poor's Compustat Database for U.S. companies 1990-1999
Tangibility	Industry's share of physical assets in total capital stock (Braun, 2005)	

the important component for innovation being FDI equity assets rather than FDI equity liabilities. The coefficient on the interaction between international financial development and external dependence, (β_1), is positive and significant for FDI equity assets with robust standard errors. The coefficient on the interaction between tangibility and international financial development (β_2) is negative and significant for FDI equity assets with robust standard errors and with clustered errors. Industries with less tangible assets benefit in terms of innovation from being in a country with greater FDI abroad. By contrast, β_1 and β_2 are insignificant for FDI equity liabilities. These results suggest that the FDI estimation from Maskus et al. (2012) may be driven by assets, rather than liabilities. This may be due to the fact that multinational firms are already significantly innovative. Prior research also indicates that multinational corporations strategically employ internal capital from foreign affiliates or access host-country domestic financial markets via foreign affiliates (Desai et al., 2004). Alfaro (2017) summarizes previous literature that shows that rather than transferring capital, multinationals instead finance investments in the local market. Generally, the accumulation of FDI assets means that more multinational companies are operating in the economy. Such firms are able to access global financial markets, taking advantage of better opportunities for financing both internally and externally, and that they can use these financing opportunities for innovation. While we expect that the accumulation of FDI liabilities should allow local firms to access internal capital from multinational parents, we show that the availability of these types of financing does not result in higher industry innovation. Instead, affiliate firms may borrow from parent firms to finance physical capital or as a cushion during difficult periods (e.g., Alfaro and Chen (2012) show that foreign ownership promotes affiliate resilience during crisis periods). Further, host-country characteristics (such as local financial markets) may be important for countries to take advantage of FDI inflows (Alfaro et al., 2004; Alfaro, 2017). Such domestic market conditions may be even more important for innovation, perhaps explaining why the interaction terms for FDI liabilities are insignificant.

4.2 De jure measures

Table III shows the results for the international financial restriction indices. We report results using clustered standard errors as they do not differ from those using robust errors. Using KAOPEN, which takes on higher values the more open the country is, we observe a negative and significant coefficient on the tangibility interaction term. Thus, industries that have fewer tangible assets innovate more in countries that are more financially open since they can potentially access funds from abroad.

The Fernández et al. (2016) indices provide the same result for the tangibility interaction. Ranging from 0 to 1, with 1 indicating restricted capital flows, the Fernández et al. (2016) indices give a positive and statistically significant β_2 coefficient, indicating that industries that have fewer tangible assets innovate more in countries that have less capital restrictions. There is not a significant difference between inflow and outflow restrictions, with similar coefficients and significance levels. Overall, our findings suggest that more open countries tend to have higher R&D because tapping into international financial markets may provide additional financing options that industries with fewer tangible assets cannot access

Table II: Impact of *de facto* measures of financial openness on R&D intensities

Type of International	FDI Equity		Portfolio Debt	
Financial Integration (IFI)	Assets	Liabilities	Assets	Liabilities
Industry share in GDP	-0.090	-0.092	-0.092	-0.102
	[0.021]***	[0.021]***	[0.021]***	[0.022]***
	(0.057)	(0.056)	(0.051)*	(0.067)
External dependence*IFI	0.021	0.004	-0.002	0.031
	[0.006]***	[0.004]	[0.002]	[0.010]***
	(0.014)	(0.007)	(0.005)	(0.015)*
Tangibility*IFI	-0.061	-0.001	-0.011	-0.043
	[0.017]***	[0.012]	[0.005]**	[0.012]***
	(0.032)*	(0.031)	(0.021)	(0.024)*
IFI	0.018	0.002	0.002	0.009
	[0.007]	[0.005]	[0.002]	[0.004]**
	(0.011)	(0.010)	(0.005)	(0.007)
Constant	0.014	0.014	0.017	0.019
	[0.003]***	[0.003]***	[0.003]***	[0.003]***
	(0.007)*	(0.007)*	(0.005)***	(0.007)**
Observations	5,310	5,310	5,310	5,310
Adjusted R-squared	0.215	0.209	0.209	0.224

Robust standard errors in brackets;
Standard errors clustered at the country-level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

domestically.

Surprisingly, the β_1 coefficients are not statistically significant for any of these *de jure* measures of restrictions. This may reflect the disadvantages of *de jure* measures in general. *De jure* measures do not capture variation in enforcement across countries, may not include other regulations that effectively act as capital controls, or may include exchange rate restrictions that do not actually impact capital flows.[5] We examine both *de facto* and *de jure* measures here to examine whether the different measures of financial openness provide systematically different results. Quinn et al. (2011) find that there are weaker growth impacts of financial openness in more recent periods (after 2000) using *de jure* measures. To see if this impacts our results using *de jure* measures, we drop all observations after the year 2000. While the results using the Fernandez et. al (2016) indices do not change, the β_1 coefficient becomes statistically significant and positive using KAOPEN[6], thus indicating that the largest R&D benefits from loosening capital restrictions for industries that are more dependent on external financing occurred during the early stages of *de jure* liberalization. Importantly, however, the *de facto* measures show that there are continued R&D benefits from greater access to international financial markets for industries that rely on external financing, highlighting the importance of considering both types of international financial openness measures.

5. Conclusion

In this paper we examine the impact of financial openness on industrial R&D intensities. For industries that rely more on external finance or have fewer tangible assets, access to capital inflows via portfolio debt liabilities is associated with higher industry R&D. This association also holds for FDI assets but not FDI liabilities, perhaps indicating the importance of multinational corporations and their ability to access global financial markets. *De jure* measures of capital restrictions also highlight the importance of access to international capital for those industries lacking tangible assets (rather than those industries relying more on external capital). Notably, the differential impact from the direction of capital flows is captured by *de facto* but not *de jure measures*, highlighting the importance of considering different measures of international financial openness. Overall, international financial openness can be a key factor in innovation investment particularly for those industries with fewer tangible assets or for those who rely on more external financing.

[5]One shortcoming of *de jure* indices is less variability in general. This may be a concern for KAOPEN. However, we find that most of the loss of variability occurs in the time dimension. The variation across countries from KAOPEN, interacted with tangibility, which varies across industries, provides enough variation for our analysis.

[6]These additional results are not shown here but are available from the authors.

Table III: Impact of *de jure* measures of financial openness on R&D intensities

	Chinn and Ito (2008)	Fernández et al. (2016)		
Type of International Openness Index (IOI)	KAOPEN	Overall Restrictions Index	Inflow Restrictions Index	Outflow Restrictions Index
Industry share in GDP	-0.093	-0.093	-0.092	-0.093
	(0.055)	(0.055)	(0.055)	(0.056)
External dependence*IOI	-0.000	-0.007	-0.004	-0.009
	(0.005)	(0.013)	(0.016)	(0.010)
Tangibility*IOI	-0.017	0.097	0.100	0.083
	(0.007)**	(0.027)***	(0.029)***	(0.024)***
IOI	0.004	-0.019	-0.018	-0.018
	(0.002)	(0.008)**	(0.007)	(0.007)**
Constant	0.021	0.014	0.014	0.014
	(0.007)***	(0.006)**	(0.006)**	(0.006)**
Observations	5,310	5,310	5,310	5,310
Adjusted R-squared	0.211	0.214	0.213	0.213

Higher values of KAOPEN indicate greater openness;
Fernández et al. (2016) indices range from 0 to 1, with 1 indicating restricted capital flows;
Standard errors clustered at the country-level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

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A. Data appendix

Table A1: Summary statistics

Variable	Mean	Std. Dev	Min.	Max.	N
R&D intensity	0.016	0.045	0	1.669	5310
Industry share in GDP	0.026	0.028	0	0.232	5310
FDI equity assets	0.298	0.32	0.004	1.982	5310
FDI equity liabilities	0.364	0.343	0.006	2.095	5310
Portfolio debt assets	0.351	0.594	0	5.108	5310
Portfolio deb liabilities	0.431	0.471	0.022	3.275	5310
KAOPEN	1.762	1.017	-1.189	2.389	5310
Overall restrictions index	0.160	0.235	0	1	5310
Overall inflow restrictions index	0.148	0.225	0	1	5310
Overall outflow restrictions index	0.173	0.262	0	1	5310
Financial dependence	0.300	0.303	-0.121	1.058	23
Tangibility	0.279	0.134	0.113	0.611	23

Table A2: List of industries

Food products and beverages	15
Tobacco products	16
Textiles	17
Wearing apparel, dressing and dying of fur	18
Leather, leather products and footwear	19
Wood and products of wood and cork	20
Pulp, paper and paper products	21
Printing and publishing	22
Coke, refined petroleum products and nuclear fuel	23
Chemicals and chemical products	24
Rubber and plastics products	25
Other nonmetallic mineral products	26
Basic metals	27
Fabricated metal products, except machinery and equipment	28
Machinery and equipment, n.e.c.	29
Office, accounting and computing machinery	30
Electrical machinery and apparatus, n.e.c.	31
Radio, television and communication equipment	32
Medical, precision and optical instruments	33
Motor vehicles, trailers and semitrailers	34
Other transport equipment	35
Furniture; manufacturing n.e.c.	36
Recycling	37

Table A3: List of countries

Belgium, Canada, Czech Republic, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Mexico, Netherlands, Norway, Poland, Portugal, Slovenia, Spain, United Kingdom