A Note on Extensive Import Margins and Technology Adoption

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Abstract As suggested in recent growth models, a country's state of technology can be represented by the variety of capital goods available for production. Adopting new technology from abroad then involves increasing the variety of imported capital goods, i.e., increasing capital goods imports *along the extensive margin.* Fixed costs of technology adoption therefore imply a higher country size elasticity along the extensive margin of capital goods imports compared to consumer goods imports. To test this, I explore highly disaggregated import data within a gravity framework differentiating goods categories by use. find no evidence for the existence of substantial fixed costs of technology adoption.

Keywords: Gravity, product variety, technology adoption

JEL-Classification: F12, F14, O33

1. Adoption Costs and Trade in Capital Goods

Following the Smithian notion of the division of labour, Romer (1990) proposes the variety of capital goods used in production as a measure of technology. Analysing highly disaggregated trade data, Frensch and Gaucaite Wittich (2009) confirm that a trade-based count measure of the variety of capital goods indeed behaves 'as if' it represented technology when change of technology is understood as a learning process such as Jones' (2002, ch. 6). Adopting new technology from abroad then means increasing the set or variety of imported capital goods, i.e., increasing capital goods imports *along the extensive margin.*

Romer (1994) argues in favour of fixed costs of introducing new goods. The existence of fixed costs of market entry implies a positive relationship between destination country size and extensive import margins, i.e., an elasticity of a destination country's extensive import margin with respect to its size that increases with fixed costs within a gravity framework (cf. Hummels and Klenow, 2002). The fixed costs of market entry for capital goods exporters from the rest of the world (ROW) should arguably be higher than for ROW exporters of goods not involving transfer of technology: designs have to be adapted and licenses have to be traded such that a small market size may inhibit the adoption of new technology. *Ceteris paribus*, I should thus be able to find country size elasticities for the extensive margin of capital goods imports from ROW that are larger than those one can find for imports not involving transfer of technology, i.e., specifically for consumer goods. I test this hypothesis with highly disaggregated import data differentiating between goods categories by use.

2. Data Issues

2.1. Measuring the Extensive Import Margin

Import data are from 35 countries-reporters of very different size, ranging from the small island economies of Malta and Iceland to the U.S., for 1992–2004.[1] Not all countries report in each year (average: 34.1 countries per year), the cutoff-value of trade flows is 10,000$. Data are on the lowest aggregation level of the SITC, Rev. 3 in the UN COMTRADE database covering 3,114 items, while the UN Statistics Division's *Classification by Broad Economic Categories (BEC*) allows for SITC items to be grouped into primary, intermediate, and especially 471 capital, and 704 consumer good items (UN Statistics Division, no year, online).

My extensive margin measurement follows Feenstra and Kee's (2007) exact measure comparable over time and across countries when products enter consumption or production non-symmetrically. For this purpose, I define a benchmark that does not itself vary over time and encompasses as many of my sample countries as possible. Given data limitations (only OECD countries report in each year), this benchmark set is I_{OECD}, i.e., the total set of items imported by the *virtual country of all OECD economies* in my sample from ROW over all years. Then, $imports^{i}_{OECD}$ is the value of imports for SITC item i, summed over all OECD economies and averaged across the years 1992–2004. Accordingly, an exact measure of the extensive import margin of country c in period t for purposes of comparisons both over time and countries is given by an analogue to equation (4) in Feenstra and Kee (2007),

$$EM_{c,t} = \frac{\sum_{i \in I_{c,t}} imports^{i}_{OECD}}{\sum_{i \in I_{OECD}} imports^{i}_{OECD}}, \tag{1}$$

which depends on the set of items imported by country c at time t, $I_{c,t}$, but not on the value of its imports. $EM_{c,t}$ can be interpreted as that share of OECD-imported goods during 1992–2004 also imported by country c in t. As (1) immediately implies, for symmetric import flows, $EM_{c,t}$ simplifies to the number of goods imported by c in t relative to the number imported by the aggregate of all OECD countries during 1992–2004.

2.2. Trade Liberalisation

With a substantial proportion of (former) transition economies in the sample, liberalisation may have an independent impact on the extensive margin. To reflect this, I use the foreign trade and payments liberalisation index of the European Bank for Reconstruction and Development (EBRD), measured on a scale between 1 and 4.33. I assume this index to equal 4.33 for OECD economies, in line with its construction. The index being ordered qualitative rather than cardinal, I consider the impact of *full* liberalisation, i.e., I define $TradeLib_{c,t}$ to take the value of 1 if the index equals 4.33, and 0 otherwise. As liberalisation proceeded quickly across European emerging economies, half of all *TradeLib* observations for these countries take the value of one.

3. A Gravity Framework

Recent research (see, e.g., Bernard et al., 2007; Felbermayr and Kohler, 2004 and 2007) has estimated gravity equations both for trade volumes and for volume components, i.e. along extensive (changes in the set of traded goods) *versus* intensive (changing volumes per traded good) margins of trade. As my interest is exclusively in extensive import margins, I estimate gravity equations for extensive import margins of 35 countries between 1992 and 2004 according to,

$$\log EM_{c,t} = \beta_0 + \beta_1 \log GDP\_Im_{c,t} + \beta_2\, TradeLib_{c,t} + \varepsilon_{c,t} \qquad (2)$$

Estimation is by OLS with country and period fixed effects, the latter to control for GDP data (sourced from the *World Development Indicators*) in current dollars, as recommended in Baldwin and Tagliani (2006).

The dependent variable is the log of $EM_{c,t}$, defined in equation (1). Since data are for a single exporter (ROW), exporter income is captured in the regression constant, leaving as explanatory variables the log of the importer's GDP, *GDP_Im*, and trade and payments liberalisation, *TradeLib*. Country heterogeneity, and specifically Anderson and van Wincoop's (2003) multilateral trade resistance effects should ideally, as in Baier and Bergstrand (2007), be taken care of by including time-varying country dummies. However, in my framework of trade with ROW, this requires NT dummies, where N is the number of countries and T is the number of years, i.e., more than the number of observation in my unbalanced panel. I therefore begin with correcting for multilateral trade resistance by estimating with country fixed effects and period fixed effects with the implication that no time-invariant parameters can be estimated.

Equation (2) is estimated separately for consumer goods and for capital goods. The seemingly unrelated regression (SUR) method can estimate (2) as a system across goods categories, accounting for heteroskedasticity and contemporaneous correlation in the errors for country c at time t between consumer goods and capital goods equations. While this should improve efficiency, I may use OLS by equation because the same regressors show up in each equation, in which case SUR estimates become equivalent to OLS. I perform SUR only in order to obtain covariances between estimates from different equations, necessary to properly perform Wald tests with the null that relevant coefficients be identical across equations (as in Kimura et al., 2007).

4. Results

4.1. First Results

According to Table 1, the point estimate of the destination market size elasticity of the extensive import margin of capital goods is indeed slightly higher than that for consumer goods (columns 1 and 4, respectively). This suggests that a 10 per cent rise in country size is accompanied by an increase of 0.34 per cent in the set or variety of imported capital goods. At the same time, a 10 per cent rise in country size is accompanied by an increase of only 0.30 per cent in the variety of imported consumer goods. While this suggests the existence of fixed costs of trade for both categories of goods, the difference between both point estimates is not significant at any conventional level on the basis of a Wald test. Results thus not provide significant evidence for the existence of substantial fixed costs of technology adoption over and above fixed costs of trade.

Results in columns (1) and (4) of Table 1 report destination market size elasticities of extensive import margins for the full sample of 35 reporter-countries, implicitly assuming that fixed costs of trade and adoption restrict import countries uniformly. Once there are additional potential restrictions on import margins, this need not be the case. Specifically, Frensch and Gaucaite Wittich (2009) rather underline labour force skills to constrain new technology adoption in the form of increasing capital goods imports along the extensive margin. Their measures of labour force skills are length of education data from the Barro and Lee dataset (Barro and Lee, 2000), available only at five-year intervals, which does not go well with my yearly panel data. As an alternative way of testing whether particularly small countries are actively constrained by market size – rather than by labour force skills or other potential constraints –, I add small market size dummies, interacted with market size, to my regression equation, thus explicitly allowing for different destination market size elasticities of extensive import margins for very small *versus* larger markets. The first small size dummy, *SmallGDP*1, equals one for the eight smallest markets in my sample (i.e., for Malta, Iceland, Albania, Macedonia, Estonia, Cyprus, Latvia, Lithuania), the second, *SmallGDP*2, is reserved to the four smallest markets (Malta, Iceland, Albania, Macedonia).

Estimation with these dummies, does not, however, change the first results. Destination market size elasticities of extensive import margins are higher for smaller countries than for the whole sample, but this difference holds equally for capital and for consumer goods (compare columns 2 *versus* 5, and columns 3 *versus* 6 in Table 1): as indicated by the appropriate Wald tests, in no case is the destination market size elasticity for the extensive margin of capital goods imports significantly higher than for consumer goods imports, and this holds equally for smaller countries and for the whole sample.

As Table 1 results also reveal, the trade and payments liberalisation impact on the extensive import margin of (typically low substitutability) capital goods is an order of magnitude higher than that for (typically high substitutability) consumer goods. A country's trade and payments liberalisation, as measured by the EBRD, reflects lower fixed rather than lower variable costs for ROW exporters.[2] Accordingly, this result is perfectly in line with recent models of heterogeneous firms and trade, such as Chaney (2008), which predict that extensive import margin effects of lowering the fixed costs for ROW exporters increase with decreasing substitutability among products;

4.2. Product Differentiation by Country of Origin

While the import data distinguish between more than 3,000 items, fewer than 500 cover capital goods. Counting over this small product space may perhaps not produce suitable margin measures. Data detail can, however, be increased by expanding the product space by differentiating items by country of origin, as my data also cover each of the 35 reporter-countries' disaggregated imports from 54 selected partner countries, making up a set of 75 million data points.[3] The most preferable solution would be defining an exact margin measure over this expanded space. However, as any subset of countries, when chosen as benchmark, introduces a geographic specialisation bias, I follow Frensch and Gaucaite Wittich (2009) and use their simple count measure over the expanded product space as an alternative to $EM_{c,t}$, defined in (1): the number of imported items times the respective number of source countries corresponds to a simple count measure of the extensive import margin, $EM_{c,t}(PD)$, in the expanded product space. For this measure, I can identify a maximum of 168,156 since all 54 source countries can each potentially supply all 3,114 basic SITC items to a country-reporter.

Results of re-estimating (2) with these new extensive import margin measures are given in Table 2. The major change, compared to Table 1, is the now much larger effects along the extensive margin, due to the much higher data detail.

While the point estimate of the market size elasticity of the extensive import margin of capital goods now comes out slightly higher than for consumer goods only for small or very small countries (0.50 *versus* 0.47, in columns 8 *versus* 11; and 0.49 *versus* 0.48, in columns 9 *versus* 12, respectively), these difference are again never significant on the basis of the appropriate SUR-system based Wald tests.

4.3. Dummies in Gravity Estimations

While I cannot fully incorporate Baier and Bergstrand's (2007) time-variant country dummies, I can go some way in this direction by adding 'time-span-variant' country dummies to (all minus one) period fixed effects. I select three sub-periods, 1992–6, 1997–2000, and 2001–4.

As shown in Table 3, differences between market size elasticities of the extensive import margin of capital *versus* consumer goods are once again not significant on the basis of appropriate SUR-system based Wald tests.

Table 3 also reports much reduced effects of trade liberalisation: this is in line with the discussion in Baldwin and Taglioni (2006): the advantage of the time-span-variant country dummies' now taking better account of country heterogeneity and multilateral trade resistance comes at the cost of an increased collinearity between the liberalisation dummy and time-span-variant country dummies.

5. Conclusions

Within my sample of mostly European emerging and OECD economies, I find country size elasticities for the extensive margin of capital goods imports from ROW that are larger than those one can find for consumer goods imports. However, these differences are not statistically significant. Accordingly, the fixed costs of market entry for ROW capital goods exporters do not appear to be substantially higher than for ROW exporters of consumer goods. Against the background of recent growth models, in which the state of technology is represented by the variety of capital goods, I interpret this result as indicating that a small market size does not appear to significantly inhibit the adoption of new technology from abroad. I take this to support findings in Frensch and Gaucaite Wittich (2009) who rather underline labour force skills to constrain new technology adoption.

Endnotes

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1. Among them emerging European economies (Albania, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Macedonia, Malta, Poland, Romania,

Slovakia, Slovenia) and long standing OECD economies (Austria, Belgium and Luxembourg, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Netherlands, Norway, Portugal, Sweden, Spain, Switzerland, Turkey, United Kingdom, United States). The year 2004 was the latest year for the data to be available.

2. Progress on the EBRD scale reflects reducing administrative trade barriers, providing access to foreign exchange, and convertibility, i.e., results in lowering the fixed entry costs for ROW exporters rather than variable costs as if reducing tariff and non-tariff barriers. In fact, for the sample of countries used in the regressions, the simple correlation coefficient between the EBRD measure and the ten-scale IMF trade restrictiveness index, reflecting tariff and non-tariff restrictions between 1997 and 2003, is a mere –0.13. I am very grateful to the IMF for letting me use this data.

3. Partner countries comprise the 35 reporter-countries plus: Bosnia and Herzegovina, Serbia and Montenegro, twelve CIS economies (Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Turkmenistan, Ukraine, Tajikistan, Uzbekistan) and six Asian economies (China, Hong Kong, Japan, South Korea, Taiwan, and Thailand). Partner countries generally account for 80–95 per cent of total imports.

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Tables and Figures

Table 1. Extensive Import Margin Gravity Regressions: OLS with Country and Period Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)
	Capital Goods			Consumer Goods		
log *GDP_Im*	0.034*** (3.74)	0.026*** (2.72)	0.028*** (3.08)	0.030*** (7.14)	0.019*** (4.56)	0.024*** (6.25)
Wald test 1 [p-value]	[0.5926]	[0.3611]	[0.6164]			
log *GDP_Im* × *SmallGDP*1		0.024*** (2.63)			0.035*** (8.86)	
Wald test 2 [p-value]		[0.7949]				
log *GDP_Im* × *SmallGDP*2			0.053*** (4.17)			0.051*** (9.57)
Wald test 2 [p-value]			[0.6493]			
TradeLib	0.025*** (5.65)	0.023*** (5.23)	0.024*** (5.65)	0.0056*** (2.79)	0.0031* (1.69)	0.0051*** (2.83)
Observations (cross sections; time)	434 (35; 1992–2004)	434 (35; 1992–2004)	434 (35; 1992–2004)	434 (35; 1992–2004)	434 (35; 1992–2004)	434 (35; 1992–2004)
Adj. R-squared	0.77	0.77	0.77	0.89	0.91	0.91

General notes to Tables 1–3: Fixed effects not reported, t-statistics in parentheses. * (**, ***) indicate significance at 10 (5, 1) per cent.

The null hypothesis in the SUR-based Wald test 1 is that coefficients for log *GDP_Im* are identical for capital goods and consumer goods.

The null hypothesis in the SUR-based Wald tests 2 is that the sum of the coefficients for log *GDP_Im* and log *GDP_Im* × *SmallGDP*1 or for log *GDP_Im* and log *GDP_Im* × *SmallGDP*2 are identical for capital goods and consumer goods.

Table 2. Extensive Import Margin Gravity Regressions with National Product Differentiation: OLS with Country and Period Fixed Effects

	(7)	(8)	(9)	(10)	(11)	(12)
	Capital Goods			Consumer Goods		
log *GDP_Im*	0.39*** (10.42)	0.34*** (8.71)	0.38*** (9.79)	0.39*** (10.89)	0.35*** (9.38)	0.38*** (10.46)
Wald test 1 [p-value]	[0.8458]	[0.5078]	[0.7897]			
log *GDP_Im* × *SmallGDP*1		0.16*** (4.21)			0.12*** (3.30)	
Wald test 2 [p-value]		[0.5045]				
log *GDP_Im* × *SmallGDP*2			0.11** (2.12)			0.095*** (10.46)
Wald test 2 [p-value]			[0.8162]			
TradeLib	0.12*** (6.90)	0.11*** (6.33)	0.12*** (6.87)	0.058*** (3.37)	0.049*** (2.88)	0.057*** (3.33)
Observations (cross sections; time)	434 (35; 1992–2004)	434 (35; 1992–2004)	434 (35; 1992–2004)	434 (35; 1992–2004)	434 (35; 1992–2004)	434 (35; 1992–2004)
Adj. R-squared	0.98	0.98	0.98	0.98	0.98	0.98

Table 3. Extensive Import Margin Gravity Regressions with National Product Differentiation: OLS with Time-varying Country and Period Effects

	(13)	(14)	(15)	(16)	(17)	(18)
	Capital Goods			Consumer Goods		
log *GDP_Im*	0.37***	0.32***	0.34***	0.37***	0.32***	0.33***
	(7.51)	(6.55)	(6.95)	(6.93)	(6.06)	(6.40)
Wald test 1 [p-value]	[0.9082]	[0.9891]	[0.9587]			
log *GDP_Im* × *SmallGDP*1		0.20***			0.19***	
		(4.15)			(3.53)	
Wald test 2 [p-value]		[0.6642]				
log *GDP_Im* × *SmallGDP*2			0.29***			0.27***
			(4.43)			(3.87)
Wald test 2 [p-value]			[0.7004]			
TradeLib	0.045**	0.038**	0.031*	0.019	0.012	0.0060
	(2.43)	(2.07)	(1.71)	(0.96)	(0.62)	(0.31)
Observations (cross sections; time)	434 (35; 1992–2004)	434 (35; 1992–2004)	434 (35; 1992–2004)	434 (35; 1992–2004)	434 (35; 1992–2004)	434 (35; 1992–2004)
Adj. R-squared	0.99	0.99	0.99	0.99	0.99	0.99

Note: time-varying country effects are defined for three sub-periods, 1992–6, 1997–2000, and 2001–4.

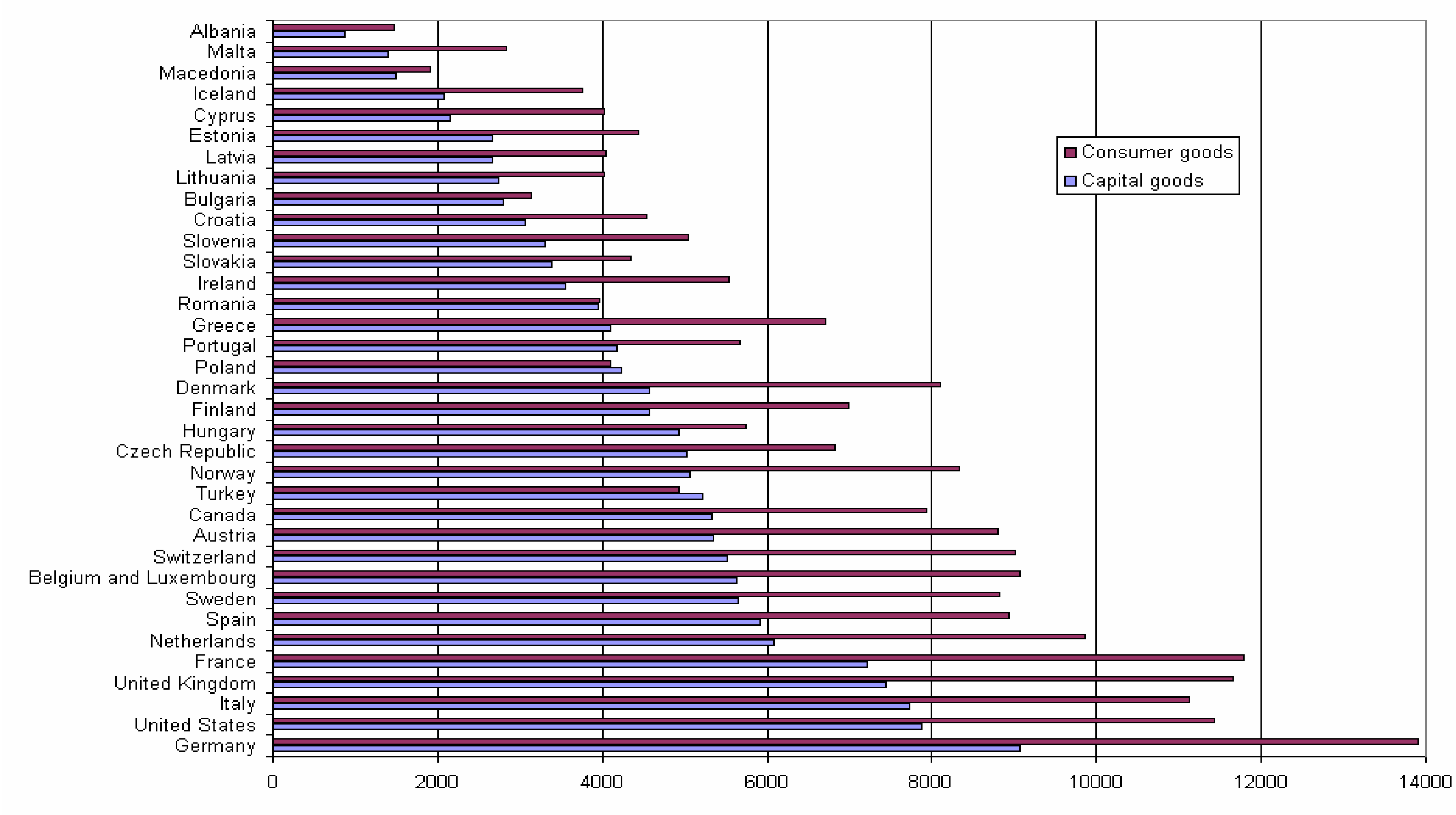

Figure 1. Simple Extensive Import Margin Count Measures with Product Differentiation by Country of Origin, 2000.

Notes: Maximum counts are 38,016 for consumer goods; and 25,434 for capital goods.
Source: United Nations COMTRADE database and own calculations.