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An Alloy of Steel and Information and Communication Technology (ICT): Does It Facilitate Trade?

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AN ALLOY OF STEEL AND INFORMATION AND COMMUNICATION TECHNOLOGY (ICT): DOES IT FACILITATE TRADE?

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The advances in Information and Communication Technology (ICT) over the last 20 years, particularly proliferation of the Internet, fixed-telephones, and mobile phones, have significantly reshaped the way modern firms do their business. The economic literature suggests that ICT could be a potential trade-enabler, given its ability to reduce costs of search and communication between trade partners. This research intends to examine whether ICT affects countries' capabilities to export steel and its articles. To estimate the impacts of the Internet, mobile phones, and fixed-telephones on bilateral trade flows in the steel industry, I apply various gravity model specifications, including those capturing multilateral resistance terms. Three different panels for total exports, exports of steel, and exports of articles of steel were analyzed over the period 2001-2012. The study reveals a positive influence of the Internet and mobile phones on exports of steel and its articles. Moreover, network effects of the Internet are observed in articles of steel. In addition, this study reviews the history and current state of the steel industry and reports a firm-level case study on how ICTs are being deployed at a global steel pipe manufacturer to boost its international sales.

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Finally, my warmest regards go to my parents and friends, who have unconditionally supported me throughout this two-year adventure.

List of Acronyms

APEC – Asia-Pacific Economic Cooperation

B2B – Business to Business

CES – Constant Elasticity of Substitution

CIS – Commonwealth of Independent States

EAF – Electric Arc Furnaces

ECA – Europe and Central Asia

EU – European Union

FDI – Foreign Direct Investments

FTA – Free Trade Agreement

GDP – Gross Domestic Product

HO – Heckscher-Ohlin model

HS – Harmonized Commodity Description and Coding Systems

ICT – Information and Communication Technology

IDI – ICT Development Index

ISO – International Organization for Standardization

ITU – International Telecommunication Union

LME – London Metal Exchange

NNTT – "New" New Trade Theory

NTM – Non-Tariff Measures

OECD – Organisation of Economic Cooperation and Development

OLS – Ordinary Least Squares

PML – Pseudo-maximum-likelihood

R&D – Research and Development

RTA – Regional Trade Agreement

SeBW – Sectoral e-Business Watch

TRAINS – Trade Analysis and Information System

UN – United Nations

UNCTAD – United Nations Conference on Trade and Investments

UNSD – United Nations Statistical Commission

WDI – World Development Indicators

WSA – World Steel Association

WTO – World Trade Organization

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Part I

Chapter 1 Introduction

In today's digitized world, information and communication technology (ICT) has become a vital necessity for doing business. Advancements in ICT have greatly reduced impediments of geographical distance by lowering costs of search and communication between trade partners (Chung et al., 2010). Use of ICT tools such as the Internet makes matching supply and demand much easier not only within a single country but also on the global market. The fact that more users are getting connected creates so called network effects[1] through a multitude of online activities (ITU, 2012). More and more firms are taking advantage of the growing use of ICT by customers as "*the world seems to be flatter online*" (Lendle et al., 2011, p.16).

Communication channels such as the Internet, fixed and mobile phones have significantly reshaped daily business operations. Firms use ICTs in various forms to track supply chains, sell products and services, issue digital invoices or make online money transfers. Corporate headquarters may interact with their subsidiaries and customers overseas by holding video conferences. Meanwhile, small and medium enterprises (SME) monitor demand on the market and sell their products on e-trade platforms such as e-Bay.[2] To illustrate how ICT affects trade performance on the industry-level, I use an example of trade in steel.

While the high-tech industry today draws a lot of attention from potential investors[3], the role of the steel industry in economic development remains solid. Indeed, steel has always been and still is an imperative element in infrastructure, transportation, energy, defense, and construction. As WSA (2012) suggests, steel may aid in solving the challenges of the global

[1] Network effects (network externality) appears in Katz and Shapiro (1985).
[2] Author's discussion with experts of the ICT Unit of The World Bank;
[3] Examples are recent IPOs of Twitter (2013) and Facebook (2012).

agenda, namely continuous urbanization, growing energy demand, and reduction of carbon emissions. The steel industry also plays an important role as a large employer and major supplier to national military-industrial complexes. The OECD forecasts a 1.5 increase in steel consumption from 1.5 billion tons in 2013 to 2.3 billion tons by 2025.[4] Given the role of ICT as a potential trade-enabler, I intend to research whether there is a positive effect of ICT proliferation on countries' capabilities to export steel and its articles.

The trade literature has already yielded various estimates on the relationship between ICT and trade. By and large, the majority of the findings observe positive impacts of ICT tools on bilateral trade flows. While Freund and Weinhold (2000, 2002, and 2004) pioneered the topic with an analysis of the role of the Internet with respect to trade in goods and services, Mattes et al. (2012) expanded an ICT variable by using the ICT Development Index that captures levels of national ICT infrastructures. Both Freund and Weinhold (2004) and Mattes et al. (2012) employ proxies for ICT that reflect the use of ICT by the general population. The most recent paper by Yushkova (2014) directly captures ICT capabilities of firms by employing a new variable – the extent of businesses Internet use – and differentiates trade flows by four technology groups; though without a breakdown by industries. Finally, there are several papers, namely Thiemann et al. (2012) and Chung et al. (2013), which estimate ICT impacts on trade in certain industries; yet, none of them looks at the steel industry.

My research topic complements the trade literature with an analysis of the impact that ICT has on the steel industry's trade flows. This paper provides additional arguments on whether ICT may serve as a trigger for boosting trade in less ICT-intensive manufacturing industries, such as steel. Additionally this research extends the set of empirical papers on the topic of ICT

[4] The European Commission MEMO/13/523; URL: http://europa.eu/rapid/press-release_MEMO-13-523_en.htm

and trade relations by applying state-of-the-art gravity model specifications for panel data that control for selection and omitted variables bias.

There are a number of parties which may benefit from this research. First, the research community receives a ready-to-use approach to estimate ICT impacts on trade in industries other than steel. Second, steel manufacturers may use findings of this research to adjust their strategies for harnessing gains from growing demand in steel. Third, governments of the developing countries whose ICT infrastructures lag behind those countries in the developed world may use my findings for policymaking purposes. Some observers suggest that proliferation of ICT is likely to change trade patterns between developed and developing countries. Friedman (1999) claims that ICT may alter the composition of exports from developing countries towards more sophisticated products, changing the pattern of trade "raw materials in exchange of finished products." However, Melitz (2003) asserts that only efficient firms participate in the distribution of gains of trade, while less efficient ones do not. Extensive use of ICT can make firms engaged in international trade more productive due to optimization of their transaction costs associated with trade (Mattes et al., 2012).

The rest of the paper is organized in two parts. Part I includes an introduction, a literature review, background on the steel industry, and a case study. The aim of the literature review is three-fold. First, the review analyzes contemporary empirical studies describing the role of ICT penetration in measuring trade flows. This analysis identifies key ICT instruments that contribute to growth in trade. Second, the review puts together trade studies to understand what impact ICT has on trade with respect to the steel industry. Third, the review lays out theoretical foundations of the gravity model as gravity equations are commonly used for estimating bilateral trade.

To get a better picture of the modern steel industry, I briefly describe the major milestones in its evolution, outline the classification of steel manufacturers, list major steel producers and exporters, illustrate a typical supply chain, and sum up with the driving forces behind producers' competitive advantage over time. Then, I continue with a firm-level case study on how ICT are deployed at an Eastern European manufacturer of steel pipe for trade facilitation purposes. The case study elaborates on the company's ICT infrastructure and performs a comparative analysis with those of the leading companies in the industry.

Part II begins with theoretical models. I use ordinary least squares and fixed effects techniques for both standard gravity equation and one capturing multilateral resistance terms. Then I describe three samples and data sources. Lastly, I report the estimation results and summarize the main findings of the research.

Chapter 2 Literature Review

ICT and its Role in Trade

Prior to Freund and Weinhold (2000), who put the public discussion about the economic role of the Internet into econometric analysis, ICT tools such as landlines, cellular-phones, computers, and broadband used to be embedded into a broader term "technology." For example, Eaton and Kortum (2002) use exports in manufactures as a proxy for technology. Supposedly, ICT was not a separate research area due to the insignificant level of ICT penetration back then. According to the World Bank (WDI, 2012), the number of Internet users per 100 people grew from 6.7 in 2000 to 35.6 in 2012 and the number of mobile users per 100 population – from 12.1 in 2000 to about 90 in 2012. With a global rise of ICT over the past 20 years, economists have started to explore ICT as a potential enabler of economic growth, increased productivity, growth in trade, and even as a "*poverty killer*."[5]

The very first attempt of estimating the impact of the Internet on trade in goods was made in Freund and Weinhold (2000). The paper was later followed by Freund and Weinhold (2002) that was focusing on services trade. As Freund and Weinhold (2000 and 2004)[6] reveal, the increase in Internet use facilitates trade. In Freund and Weinhold (2004), the authors assume that ICT-skilled firms are incentivized to take market share from those less-ICT-equipped, and by doing so increase their volume of exports. This assumption is in agreement with the elements of theory on heterogeneous firms and inter-industry reallocations described in Meiltz (2003). Freund and Weinhold (2004) bring the evidence that the Internet has the ability to reduce market-specific costs of entry into foreign markets. Technology advantages of the Internet may

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[5] This term often appears in the discourse of the international development community. The World Bank President Jim Yong Kim and Chief Economist Kaushik Basu use the term with regard to India's digital unique identification program (May, 2013). URL: http://www.worldbank.org/en/news/feature/2013/05/02/India-8217-s-Massive-I-D-Program-Exemplifies-8216-Science-of-Delivery-8217?

[6] Freund and Weinhold (2000) is the preceding discussion paper of Freund and Weinhold (2004).

help exporters to reach new clients through the advertisement on the web and find relevant information on foreign markets. In addition, the authors assume that the Internet should reduce the importance of geographical distance as an obstacle for trade.

The authors use the number of Internet web-hosts[7], according to the International Organization for Standardization (ISO) country code, as a variable for the Internet. Freund and Weinhold (2004) do not include the web-sites under .com, .org, .net, .edu, or .int domains because it is hard to say which countries own those. In addition, the authors use "*an alternative measure of cybermass*", namely the number of Internet users, as a proxy for Internet usage (Freund and Weinhold, 2004, p.179). Their dataset contains data on 56 countries over the period 1995-1999. [8] The study conducts the empirical modelling using both panel and cross-section datasets. The empirical model includes export growth as a function of growth in the number of web hosts, economic growth in a foreign country, countries' proximity, growth in competition, and distance.

The panel regressions find that a "*10 percentage point increase in the growth of the Internet in the exporter country would lead to about a 0.2 percentage point increase in export growth*" (Freund and Weinhold, 2004, p.184). The authors suggest the Internet was the main driver of growth in exports over 1997-1999, taking into account that the Internet deployment doubled during that period. However, the results do not find robust evidence of either positive or negative effects of the Internet penetration on distance, which contradicts the findings in Lendle et al. (2011).

The cross-section analysis in Freund and Weinhold (2004) uses gravity equations and, thus, introduces dummy variables for common language, free trade agreements (FTA), and

[7] Data provided by the Internet Software Consortium;
[8] Data on 34 countries is taken from the World Development Indicators database (WDI).

contiguity to estimate the Internet effect on trade in 1995 and 1999 separately. One of the cross-section specifications for 1999 reflects the findings of panel estimation, that is, the web-host variable is both positive and significant with regard to the export growth. Even though Freund and Weinhold (2004) provide a theoretical base together with the evidence of a positive role of the Internet, one may question their findings, pointing at the sample selection and short period of estimation. Indeed, the majority of the countries included in their datasets represent the so called "developed world." Overall, this paper worked as a trigger for a number of subsequent empirical studies in the field.

Some studies claim that development of ICT may help developing countries to overcome the technology gap and, thus, change the patterns of international trade. Clarke (2008) examines the role of the Internet in export growth in low and middle income countries of Eastern Europe and Central Asia (EECA). The author finds that firms with access to the Internet are more likely to increase their exports compared to those not connected to the worldwide web.

Continuing the discussion on trade margins, Clarke (2008) intends to answer the question: does the Internet affect "*how many firms export*" or "*how much firms that are already exporting export"?* (Clarke, 2008, p.17). The primary source of the firm-level disaggregated data used in the paper is a cross-country Business Environment and Enterprise Performance Surveys (BEEPS).[9] The survey contains data on 7,126 manufacturing and 12,547 service enterprises. The econometric analysis is performed using Logit and Probit models. To proxy for Internet use, this study constructs a dummy variable, which gets value 1 if an enterprise has access to the Internet. The base model also includes a number of independent variables such as firm size, industry size, legal form, owners' home country, the number of competitors on domestic market, and several

[9] Conducted jointly by the World Bank and the European Bank for Reconstruction and Development in 1999, 2002, and 2005.

other country characteristics to control for factors that may explain unequal levels of Internet use and propensity to export.

The results of the empirical analysis show that firms with Internet connectivity is "*25-26 percentage points more likely to export than a similar firm without access, while the average service enterprise is 15-16 percentage points more likely to export*" (Clarke, 2008, p.25). It appears that the Internet has a stronger impact on manufacturing firms rather than on service firms; though, 90% of the service firms in the sample required physical interaction with customers. The study reports that firms that had previously exported overseas do not tend to increase volumes of exports after getting connected to the Internet (Clarke, 2008). Though, the author also claims that having access to the Internet positively affects the decision to export. Overall, the study confirms the positive impacts of the Internet on enterprise's exports capabilities as the Internet enhances communications with foreign customers and allows participation in international biddings. The findings of this study somewhat complement those of Freund and Weinhold (2004), providing the evidence of positive impacts of the Internet on trade in the developing countries.

E-trade portals are another ICT tool, which is gaining popularity among firms and customers. Lendle et al. (2011) assert that e-trade platforms such as e-Bay minimize the effect of distance and help to incorporate developing countries into the global market. The authors match the data on cross-border trade flows from both e-Bay portal and UN Comtrade "offline" trade. The paper estimates the impact that e-Bay may have on geographical distance. Their dataset covers the period of 2004-2009 and includes data on 62 countries which represented over 90% of the world trade in 2008. The list of products traded "offline" appeared to be much more diverse as compared with that on e-Bay. In order to mirror the e-Bay trade categories and those offline, the authors create a sub-sample using the Harmonized Commodity Description and Coding Systems (HS), an internationally recognized trade classification maintained by the International Customs Union. As it turned out, the logs of all of the three trade flows, namely e-Bay, UN Comtrade "offline", and the matched one (Comtrade and E-Bay), are highly correlated with the coefficients ranging from 0.72 to 0.81.

Like many other studies analyzing bilateral trade, Lendle et al. (2011) start their empirical analysis with the gravity model. The log of bilateral imports is regressed on economic mass and other trade costs. The former is the product of countries' Gross Domestic Products (GDP) scaled by global GDP; the latter is a ratio of trade costs divided by the product of multilateral resistance for both countries, all raised to the power of trade cost elasticity (Lendle et al., 2011). The authors construct associated trade costs by including physical distance between two countries and shipping costs. They also introduce a set of dummy variables to control for other trade costs. Accordingly, the authors employ contiguity, colonial link, common language, common legal system, mutual membership in FTA, and level of institutional capacity. The paper also estimates whether the quality of institutions, which is a sum of corruption indices in both countries individually, has an impact on trade volumes. The estimation is done by applying a Taylor log-linearization of the multilateral resistance and dropping fixed effects (Lendle et al., 2011). At last, the study examines whether the E-bay powerseller status, which a reliable supplier can receive by earning a cumulative feedback from buyers, resolves the institutional problems in a seller's country. The seller's incentive towards getting a special status on e-Bay might be explained by the fact that buyers carefully review the feedback to avoid fraudulent schemes.

What the authors clearly observe is that search costs significantly affect the estimation coefficient on distance. The elasticity of distance is 3 times bigger when it comes to the offline trade (Lendle et al., 2011). This implies that online platforms like e-Bay may be a serious cost-cutter. These results somewhat challenge the findings of Freund and Weinhold (2004) and Mattes at al. (2012) who observe the rise in the magnitude of distance coefficients, when ICT variables are added. However, Lendle et al. (2011, p.17) note that one "*can't escape gravity*" and distance sill matters, although much less online.

Further, the results of the study show that contiguity, common legal institutions, and mutual membership in FTA have bigger influences in the offline trade sample. The model with multilateral resistance terms suggests that quality of institutions matter more online, while offline coefficients are almost equal for both buyer and seller countries. As expected, the E-bay powerseller status softens the influence of both poor institutions and high levels of corruption in a seller's country (Lendle et al., 2011). That is, buyers believe sellers can guarantee timely delivery and good quality products, regardless how inefficient or corrupted the institutions in the exporter's country. The effect of similar international platforms such as Chinese Alibaba.com (mostly for B2B), Latin MercadoLibre or PayPal could also be analyzed as costs of shipping vary in different parts of the world. However, the statistics for said portals are not publically available, which hampers further research in the field.

The trade literature also finds evidence of positive impacts of ICT on service trade. This finding correlates with the real world examples. Some big IT-companies outsource certain functions to small software firms located in developing countries, such Poland or India. Other examples of service trade are Apple iTunes and Google Play, on which developers sell their apps to millions of users from all over the world. The first paper that estimates the relationship of ICT and service trade asserts that the Internet should enhance services trade flows due to the ability of worldwide web to reduce "*physical contact between producers and consumers*" (Freund and Weinhold, 2002, p.236). Indeed, one may provide an electronic deliverable such as an accounting report, online training, or portfolio management by just one click of the mouse. Though, not all services can be delivered via the Internet. The authors claim trade in services, where face-to-face interaction and knowledge of cultural or language features directly affect the quality of service, may not grow in parallel with ICT proliferation.

The dataset in Freund and Weinhold (2002) includes bilateral flows in services in "other private services" disaggregated into 14 sectors. The set of countries includes the United States and its 31 trading partners over the period 1995-1999. Like in their succeeding paper (Freund and Weinhold, 2004), the authors use the number of web-hosts, attributed to a particular country, as a variable for Internet penetration. The empirical section contains two models. In the first one, the authors estimate the growth of U.S. trade in services as a function of variables including the number of web sites, GDP growth in a foreign country, the U.S. real exchange rate, sector fixed effects, and initial value of trade in 1995. The results of this model contend that "*10-percent increase in Internet penetration in a foreign country is associated with about a 1.7-percentage-point increase in export growth and a 1.1-percentage point increase in import growth*" (Freund and Weinhold, 2002, p.236). The second model is a modified gravity equation in which the log of trade is regressed on the Internet variable, log of home GDP, M2/GDP as a "financial depth", logs of population and distance, dummy variables for common language and adjacency, and time fixed effects. This model finds the positive evidence of the Internet's impact on imports, namely, "*a 10-percent increase in Internet penetration abroad leads to about a 1.2-percent increase of U.S. imports in business, professional, and technical services*" (Freund and Weinhold, 2002, p.240). Notably, these findings might have a bias due to endogeneity – both firms use the Internet to promote their services and greater Internet deployment makes firms use the Internet for services trade. In addition, the study depicts the ambiguous effect of the Internet variable on U.S. exports in the gravity model which has relatively high goodness-of-fit.

An attempt to study the relationship between ICT national infrastructure and trade was made by Mattes et al. (2012).[10] The paper examines the effect country's ICT infrastructure has on the European Union's (EU) trade over the period 1995-2007. Along with EU members (Malta, Luxemburg, and Cyprus excluded), the study also includes the five largest EU trade partners: the United States, Canada, Australia, South Korea, and Japan. Their dataset is perfectly balanced and contains no missing variables due to the interpolation technique applied. The paper's hypothesis is that higher levels of ICT development foster trade due to a reduction of fixed costs and network effects. The empirical analysis is performed using a set of gravity equations. The modeling starts with a basic gravity specification that also includes a set of dummy variables, namely common border, common language, and mutual EU membership. Further, the authors endow the model with ICT and transport infrastructure variables of both importer and exporter. The model also controls for multilateral resistance term by adding time and country fixed effects.

Mattes et al. (2012) uses the composite ICT Development Index (IDI) published by the International Telecommunication Union (ITU) as a proxy for national ICT infrastructure. This index includes 11 quantitative indicators representing the three-stage development of ICT: (i) technical capacity and access to network services; (ii) use of infrastructure by citizens; and (iii) human capabilities for effective use of ICT infrastructure (ITU, 2012). The authors drop some of

[10] This working paper to be published as a journal article with the extended dataset (as of December 2013);

the indicators due to either lack of data in the earlier periods or irrelevance to the EU countries.[11] The authors also include a transportation infrastructure variable retrieved from the IMD World Competitiveness Yearbook.

The empirical results of the study find evidence that level of national ICT infrastructure positively affects EU trade flows. The authors also observe network effects, particularly when two trade partners both have relatively developed ICT infrastructure. Interestingly, the study observes a diversion effect in bilateral trade, when ICT infrastructures are unequal. In other words, a highly ICT-endowed exporting country has fewer exports with less ICT-endowed countries and trades more with those who have relatively advanced ICT infrastructures. This paper captures diverse ICT dimensions such as access to infrastructure, intensity of use, and population's IT skills. However, one may argue that studying the aggregated index for the entire ICT infrastructure would not allow measuring impacts of particular ICT tools such as cellular phone, fixed line or the Internet. In addition, the sample contains only 29 highly developed economies and therefore excludes the rest of the developing world.

Yushkova (2014) is the most recent paper discovering the relationship between ICT and trade. The study aims to find out whether ICT positively affects bilateral trade; and whether that effect varies across four groups of products –high, medium-high, medium-low, and low technology groups. The author does not provide a breakdown by industries. Noteworthy, this paper employs an industry level ICT variable – the use of ICT by businesses[12]– rather than development of or use of ICT at the national level. The paper examines export flows in 2011 for forty countries (all of the OECD member countries and 6 others). OECD STAN Bilateral Trade Database serves as a source of trade data. The set of dummy variables is obtained from the CEPII

[11] The literacy level in the EU is likely to reach 100% of the population.
[12] The index is reported in The Global Information Technology Report of the World Economic Forum and INSEAD.

gravity set, publicly available on the web-site of the French Research Center in International Economics.

The empirical modelling in Yushkova (2014) includes two specifications of the gravity model. The first one, along with familiar variables such as economic mass (GDPs) and distance, extends the so called intuitive gravity model with individual ICT variables for both trade partners. The second specification accounts for multilateral resistance, as suggested by Anderson and van Wincoop (2003). To avoid a multicollinearity problem while using countries' fixed-effects, the author creates new variables, namely the product of GDPs and product of ICT variables of both trading partners.

Overall, both models in find positive impacts of ICT on aggregated trade and the reduction in the importance of distance, language barrier, and colonial ties in the past. The results of the model with fixed-effects show that if the Internet use index rises "*by 1 unit, total exports increases by approximately 27%*" (Yushkova, 2014, p.175). With regard to the technological groups, this model reports statistical significance of the Internet interaction variable only for medium-high-tech and medium-low-tech products. The standard gravity model yields results that allow them to differentiate the estimates of both exporting and importing countries. Yushkova finds that the use of ICT by businesses in exporting countries has significant positive coefficients only for high-tech and medium-high-tech industries. To explain insignificant results on ICT in medium-low and low technology groups, the author proposes a guess that "*countries that export low-tech products are less developed in terms of ICT*" (Yushkova, 2014, p.175). Though, she finds that the Internet use positively affects importers of medium-low and low-tech goods, assuming that ICT-advanced countries tend to purchase those from abroad and export more sophisticated ones.

In Search of ICT Impact on Trade in Steel

This section reviews factors that determine the importance of the steel industry and also seeks evidence whether ICT affects trade in steel. I begin with the discussion on why trade in steel should be considered an important topic and then elaborate on the current situation in global steel trade. The remainder of this section touches upon the literature on the extensive and intensive margins and puts together available studies that help connect ICT and trade in steel.

The economic literature such as Ark et al. (2003) suggests advances in ICT have greatly contributed to the growth in firm productivity since the middle of the 1990s. In particular, growth in productivity was strongly observed in the ICT-producing sectors and service industries that intensively use ICT in their operations – banking, retail, and telecom (Ark et al., 2003). For the non-ICT intensive industries, such as steel manufacturing or mining, one should expect lower productivity gains from adoption of ICT (SeBW, 2008). However, the results of the e-Business Survey[13] of 2007 depict the opposite. The survey reveals deep penetration of ICT such as the Internet, mobile phones, and e-business applications into operations of the majority of steel manufacturers surveyed. Therefore, continuous deployment of cloud-based ICT solutions encourages further empirical research of the impacts ICT has on the steel industry in general, and on trade in steel products in particular.

Today the steel industry is a large employer with some 155,000 workers in the United States[14] and over 360,000 in the European Union[15] respectively. Not only is steel critical to economic development and jobs, it has always been vital for the national security agenda.[16] The military-industrial complexes in most countries rely on steel in production of defensive and

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[13] E-Business Survey; URL: http://ec.europa.eu/enterprise/archives/e-business-watch/statistics/table_chart_reports.htm
[14] Steel Industry Profile, American Iron and Steel Institute; URL: http://www.steel.org/About%20AISI/Industry%20Profile.aspx
[15] European Commission – MEMO/13/523; URL: http://europa.eu/rapid/press-release_MEMO-13-523_en.htm
[16] Steel Industry Profile, U.S. Department of Energy; URL: http://energy.gov/eere/amo/advanced-manufacturing-office

offensive arms. Notably, some countries differentiate steel products by origin. For instance, the U.S. Congress recently renewed the norm for procurement of only domestically produced steel for production of military equipment and construction of public buildings.[17]

The unique feature of steel is that it has become the most recyclable material discovered on the planet – up to 70% of steel products can be recovered (WSA, 2012). This fact makes steel a reliable "partner" while designing solutions for global challenges in the long-run. WSA (2012) identifies three main factors that will boost the demand in steel – continuous urbanization, growing energy demand, and reducing carbon emissions. As the world population and urbanization grow steadily, cities begin facing infrastructure constraints. It is expected that by 2050 about 70% of the population will live in urban areas – 20% more than in 2010 (WSA, 2012). Cities will have to envisage construction of public and private buildings as well as expand their transportation systems and utility networks. Most of these tasks require steel as a main engineering material. The other global challenge is an increasing demand in hydrocarbons. The invention of hydraulic fracturing for oil and gas extraction as well as building transcontinental pipelines requires quality steel tubular products to ensure both technical safety and no harm to the environment (WSA, 2012). The steel industry may help to decrease CO2 emissions and thus contribute to global warming preventing initiatives (WSA, 2013b). Research and development partnerships of steel makers and the automotive industry are seeking new grades of steel which would make electric vehicles lighter without serious loss in steel hardness (WSA, 2012). Finally, WSA (2012) suggests the renewable energy sector would also require steel to build new plants and grids.

Having applied the Heckscher-Ohlin (HO) model to the global trade in steel, one would observe that countries relatively abundant in iron ore[18] or steel production facilities are more

[17] H.R.1817 – American Steel First Act of 2013; URL: http://beta.congress.gov/bill/113th/house-bill/1817/text

likely to export both steel and its articles (O'Rourke et al., 2000). Recent statistics reveal that the European Union, China, Japan, Korea, Russia, and the United States are the six largest exporters of iron and steel; and together account for 73% of world exports.[19] Interestingly, at the same time all of the above, excluding Japan and Russia, are also among the largest importers of iron and steel products. This may possibly be explained by heterogeneity of both steel products and firms within the industry; and by sizes of their economies.

Table 2-1 shows that trade in iron and steel accounts for 2.7% of the global trade. Noteworthy, steelmakers from the Commonwealth of Independent States (CIS)[20] average 6.6% in total exports. Among other manufacturing industries[21], iron and steel constitute almost 4% in manufacture trade. Again, CIS countries outrank the rest of the world with 28.6%.

Table 2-1 Share of Iron and Steel in Total Trade and in Manufactures by Region, 2012

Region	Iron and steel in total trade		Iron and steel in manufactures	
	Exports, %	Imports, %	Export, %	Imports, %
World	***2.7***	***2.7***	***4.2***	***4.2***
North America	1.4	2.2	2.1	3.1
South and Central America	2.6	2.7	9.7	4.1
Europe	3.1	2.8	4.2	4.3
Commonwealth of Independent States (CIS)	6.6	4.3	28.6	5.7
Africa	1.4	3.6	8.3	5.9
Middle East	0.5	5.0	2.7	7.0
Asia	3.0	2.5	3.8	4.2

Source: WTO International trade statistics 2013

These significant figures along with the job protection issues make trade in steel a very sensitive topic for both producers and governments. Governments of developing countries such as from CIS are interested in receiving foreign currency to maintain their current accounts and

[18] Iron ore is a primary material for steel production (excluding production from scrap).
[19] WTO International trade statistics; URL: http://wto.org/english/res_e/statis_e/its2013_e/its13_merch_trade_product_e.pdf
[20] CIS is a regional grouping that includes Republic of Belarus, the Russian Federation, Ukraine, Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Turkmenistan, Tajikistan, and Uzbekistan.
[21] WTO classifies manufacture as production of chemicals, iron and steel, office and telecom equipment, automotive products, textiles, and clothing.

collect budget revenues. Therefore, they are willing to support national steel exporters by creating favorable conditions for both production and exports in the form of credit, subsidies, or tax reductions.[22] Meanwhile, governments of high-income countries intend to protect their domestic markets from foreign competitors, especially from countries with cheaper labor. Among trade protection measures are tariffs, antidumping duties, quotas, and compliance with environmental standards (Blonigen et al., 2013). Such policies may entail gains for domestic producers as some foreign importers would need to exit the market. Though, multinational steel firms often overcome these challenges, as they own production facilities located in several countries or even in the country that imposed trade protection measures.

By and large, the global steel industry can be characterized as a monopolistically competitive market with a large number of firms producing differentiated products. Thus, in order to stay competitive, steel producers must constantly minimize their cost and increase international sales at both extensive and intensive margins (Ottaviano, 2011). As preceding section concludes, recent ICT advances have reduced market entry costs. Lowering entry costs should supposedly foster creation of new trade relations. The recent trade literature raises a very important question: what actually makes firms export and which firms become exporters?

As suggested by Felbermayr and Kohler (2006), the growth in global trade is attributed to two margins – intensive and extensive. The trade literature is divided over the definitions of both margins. Besedeš and Prusa (2011) point out that both margins can be interpreted at the country level, country-product level, or a firm level. According to Felbermayr and Kohler (2006), the intensive margin occurs when existing bilateral relation expands or deepens over time, while the extensive margin occurs as a result of establishing new trade relations between countries that have not previously traded with each other. Looking at the product level, Amiti and Freund

[22] Author's discussion with experts of Ukraine's economic Reforms Coordination Center.

(2010) define the extensive margin as an increase in new product varieties, while the intensive margin is an expansion of existing varieties.

Besedeš and Prusa (2011, p.372) define the extensive margin "*as the number of relationships in a year*", implying the country-product level. The paper looks at the intensive margin through the lens of survival and deepening. The authors observe the high failure rate of newly established relationships. They suggest an ability to maintain the relationship after 1-2 years is critical for the future increase in trade volumes. Finally, Lawless (2008, p.1) defines the extensive margin as the number of firms exporting, while the intensive margin implies "*average export sales per firm*."

There is no consensus on which of the margins contributed most to the growth in exports over past 50 years. Besedeš and Prusa (2011) point out on primacy of the intensive margin in the growth of trade, while Evenett and Venables (2002) find the importance of the extensive margin in export growth for developing countries.

Having examined the duration of U.S. import relationships at the product level between 1972 and 2001, Besedeš and Prusa (2006) conclude that homogeneous goods tend to be traded in shorter relationships than differentiated goods. One would argue that steel products are homogenous, though the examples from the real world would challenge this argument. What makes steel products extremely diverse is that there are many different steel grades, international standards, and production methods. The product mix varies from basic steel billets and slabs to more sophisticated drilling pipes and railway wheels.

The discussion on the extensive and the intensive margins unveils potential research topics regarding trade in steel and ICT impact on trade. As suggested by Besedeš and Prusa (2006), further research in analyzing duration of trade relationships should be focused on product-firm data. The idea is to track the duration of trade in particular goods being traded by particular firms rather than aggregated industries or countries. Therefore, firm-level data on trade in steel, if available, can be used to test the findings in Besedeš and Prusa (2006) regarding the difference in duration of trade relation between homogeneous and differentiated products.

While the review of papers measuring the impact of ICT on aggregated trade flows appeared in the previous section, this section intends to shed the light on studies connecting trade, steel and ICT. However, a few empirical papers estimate the effect of ICT on trade in particular industries. Thiemann et al. (2012) examine the influence of the Internet, mobile phones, and landlines on trade in fruits and vegetables over the period 1995-2009. Using the gravity model, the study finds a positive impact of the Internet on imports, though only in tomatoes. Mobile phone penetration, however, positively influences the exports of both fruits and vegetables. Another study by Chung et al. (2013) addresses the same research question, but limits its set of countries to the members of Asia-Pacific Economic Cooperation (APEC) with observations over the period 1997-2006. To solve the problem of zero-value observations, the authors apply a Poisson Pseudo-Maximum Likelihood (PPML) model. Chung et al. (2013) find smaller positive impacts of both the Internet and cellular phones on trade in fruits and vegetables as compared to more traditional fixed telephones which get higher coefficients.

To my knowledge, neither paper assesses the effect of ICT on global trade in steel and its articles. An attempt to discover the role of e-business in the European steel industry was made by the European Union's Sectoral e-Business Watch (SeBW, 2008). The report states that the steel industry does not lag behind other manufacturing industries in terms of deployment of ICT. Moreover, it reveals great dependency of the steel business on the Internet. The empirical part analyzes the results of the survey on adoption of ICT by European steel firms. The econometric part tests several hypotheses of ICT impacts on productivity, innovation dynamics, market structure, and value chains. The data come from e-Business Survey 2007 and EU KLEMS, a European database of major economic performance indicators.[23] Overall, the empirical study confirms the importance of ICT and e-business for the steel industry, however those impacts cannot be considered crucial. Notably, the report says nothing about ICT effects on firms' trade performance.

The empirical paper by Folfas et al. (2011) focuses on trade flows in the steel and cement industries by employing the gravity model. The data are retrieved for the the period 1995-2009. The theoretical model includes two proxy variables for carbon leakages, namely CO2 emission per capita and environmental taxes. The authors use a Hausman-Taylor estimator due to the presence of time-invariant variables. The results of the study suggest that trade in cement and steel tends to be 2 and 1.5 times higher respectively for the neighboring countries than for those that do not have a common border. Also, the paper observes 1.14 times higher trade flows in cement and steel from the countries with higher CO2 emissions than from those with lower one. The empirical analysis, however, does not consider any ICT factors.

Lastly, the fact that Yushkova (2014) measures the impact of the Internet use by businesses across different technological groups makes it possible to extrapolate her findings on the steel industry. According to the OECD classification of manufacturing industries based on R&D intensities, production of basic metals and fabricated metal products is defined as a medium-low technology industry. Yushkova's results suggest that the product of Internet use of both trading partners positively affects trade flows in medium-low technology group. Separation of ICT use variable between exporting and importing countries yields an interesting pattern.

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[23] EU KLEMS Project. A database on economic growth, productivity, employment creation, capital formation and technological change at the industry level; URL: http://www.euklems.net/project_site.html

Exporters with more extensive use of the Internet tend to ship high-tech and medium-high products, while more ICT-advanced importers tend to buy medium-low-tech and low-tech products. To get more precise results for the steel industry, one needs to test the aforementioned results using trade flows of steel and its articles.

Theoretical Underpinnings of the Gravity Model

Most of the papers estimating the relationship between ICT and trade employ gravity equations. The gravity model of trade received its name "*by analogy with the Newtonian theory of gravitation*" (UNCTAD, 2012, p.103). The model suggests that the volume of bilateral flows between exporter and importer is proportional to their economic mass, often represented by GDP, and inversely proportional to the distance between two partners (Lendle et al., 2011). This section reviews the most notable economic studies on the theoretical foundations of the gravity theory's and describes major milestones in its evolution.

Pioneered by Tinbergen (1962), the gravity model has been applied over the last 50 years as "*a workhorse for analyzing the determinants of bilateral trade flows*" (Head and Mayer, 2013, p.2). The trade literature has successfully used gravity equations for estimating the effect of trade agreements or certain trade policies (Anderson and van Wincoop, 2003). Additionally, gravity equations may be used to estimate bilateral flows of FDI, migration, and equity. However, this empirical tool was not been considered a reliable instrument for trade analysis until 1995. Before then, the research community had used the gravity model cautiously due to the lack of theoretical underpinnings (Head and Mayer, 2013).

Head and Mayer indicate that the gravity model has had three main milestones in its evolution towards recognition and wide usage in empirical studies. The first – so called "admission stage" – is referred to 1995 when the research community realized the empirical importance of distance in trade and the fact that gravity models can be used to explain "missing trade" observed by Trefler (1995). This finding was at odds with the media who had reported "the death of distance" and "a flat globe." The second milestone (2002-2004) is attributed to controlling for multilateral resistance; for which Anderson and van Wincoop (2003) developed a theoretical foundation. The most recent stage had its beginning with the convergence of gravity theory and recent literature on heterogeneous firms such as Melitz (2003) and Chaney (2008). This merge makes the gravity theory applicable for measuring "*the new distinction between intensive and extensive margins of adjustment to trade shocks*" (Head and Mayer, 2013, p.6). I apply the order suggested by Head and Mayer (2013) to discuss major findings discovered in the trade literature over the past 50 years.

One of the founding papers on the gravity model by Anderson (1979, p.106) raised a concern that the model was "*hampered by its unidentified properties*", thus it had no justification to be used in policy analysis. The paper intended to derive a theoretical base for the demand-side gravity model. Anderson showed that a simple form of a gravity equation can easily be derived by rearranging a Cobb-Douglas expenditure system. Anderson's basic specification of the gravity equation is presented below:

$$M_{ijk} = \alpha_k Y_i^{\beta_k} Y_j^{\gamma_k} N_i^{\xi_k} N_j^{\epsilon_k} d_{ij}^{\mu_k} U_{ijk} \qquad \text{(Eq.1)}$$

The theory is based on the assumptions of (i) commodities differentiated by country of origin and (ii) homothetic preferences across regions and countries. The model estimates a flow of trade in goods M_{ijk} from origin i to destination j as a function of income Y, population N, and the distance d between trade partners. The equation also includes a "*lognormally distributed error term*" U_{ijk} which is equal to 0 (Anderson, 1979, p.106).

Even though the paper fails to provide a theoretical explanation of integrating income and population into the model, it served as a foundation for further research in the field. In this paper, Anderson for the first time derived the gravity model based on "*constant elasticity of substitution (CES) preference structure*" (Anderson and van Wincoop, 2003, p.174). Subsequent studies by Bergstrand (1989, 1990) and Deardoff (1998) also used the CES preference approach, but extended previous work by introducing Heckshner-Ohlin structure and monopolistic competition. Later, Anderson and VanWincoop (2003) used the conditional general equilibrium model formed in Anderson (1979) to enable comparative statics of multilateral resistance. Though, some economists such as Leamer and Lewinson (1995, fn.13) called Anderson's theory generally solid, but "*too complex to be part of our everyday toolkit*."

Anderson and van Wincoop (2003) continued the development of the gravity's theoretical foundation due to the problem of omitted variables bias and model's inability to conduct comparative statics. The authors offered a method that would effectively address both impediments as it "*estimates a theoretical gravity equation*" and "*correctly calculates statics of trade frictions*" (Anderson and van Wincoop, 2003, p.170). The papers introduced a multilateral resistance term into cross-section models. This term is often referred to as an average trade barrier. The authors underlined that multilateral resistance term would capture more trade barriers than just a remoteness variable, which used to be embedded in gravity equations to control for an average distance of reported region from all of its trade partners. The paper argued that distance is the only bilateral trade barrier experienced by countries and classified barriers into 3 components, namely bilateral barrier between two partners *i* and *j*, exporter's resistance to trade with the rest of the world (ROW), and importer's resistance to trade with ROW (Anderson and VanWincoop, 2003).

Their basic model specification is as follows:

$$x_{ij} = \frac{y_i y_j}{y^W} \left(\frac{t_{ij}}{P_i P_j} \right)^{1-\sigma} \quad \text{(Eq.2)}$$

Here, x_{ij} is a consumption for region *i* of region *j* goods, *y* is income, *P* is a consumer price index, σ is the elasticity of substitution, and t_{ij} is a trade cost factor. This specification treats the price index *P* as "multilateral resistance." As is shown, bilateral trade flows depend on the economic mass of trade partners, trade barriers, and the product of their multilateral resistance factors.

The empirical analysis in Anderson and van Wincoop (2003) was done in two samples: for a two-country (US-Canada) model and a multi-county model with some twenty two industrialized countries. The paper provided a solution to the so-called McCallum border puzzle. McCallum (1995) underlined a decisive effect that border had on the US-Canada bilateral trade. One of his model specifications explicitly showed that cross-border trade in 1988 was 22 times (2,200 percent) smaller than trade between Canadian provinces. By adding multilateral resistance Anderson and VanWincoop (2003) demonstrated that national borders led to 20-50 percent reduction in bilateral trade among industrialized countries. Additionally, the authors showed that the border effect was substantially higher for small countries or regions. Even though Anderson and VanWincoop (2003) complemented the theory with multilateral resistance and explained the McCallum border puzzle, it still needed further extensions because of the set of assumptions, such as identical firms and homogeneous goods, ignored some important real world features.

Eaton and Kortum (2002) introduced heterogeneous industries in the supply-side gravity models. The paper combined the assumptions of both differences in technologies among countries' industries and diminishing effects of geographical distance on trade. In Eaton and Kortum (2002), the Ricardian model of international trade received its extension by introducing geographic barriers – both natural and artificial. Among others, the study aimed to understand how technology and geographical barriers affect countries' specialization. Eaton and Kortum used the following equation to define a share of country *n*'s consumption from country *i:*

$$\frac{X_{ni}}{X_n} = \frac{T_i(c_i d_{ni})^{-\theta}}{\Phi_n} = \frac{T_i(c_i d_{ni})^{-\theta}}{\sum_{k=1}^{N} T_k(c_k d_{nk})^{-\theta}}, \qquad \text{Eq. (3)}$$

Here, the left-hand side represents a fraction of country *n*'s expenditure on goods from country *i*. The authors set out c_i as input costs – manufacturing wages, *d* as a geographic barrier – distance, *N* as a number of countries, and Φ_n as a price parameter. While *T* accounts for a country's state of technology (absolute advantage), θ "*regulates heterogeneity across goods in country's efficiency*", implying a comparative advantage (Eaton and Kortum, 2002, p.1747).

Their theoretical model used Dornbusch, Fischer, and Samuelson (1977) with a continuum of homogenous goods. The model assumed perfectly competitive industries. Like in the Ricardian model, countries had different levels of technology as a proxy for their efficiency. The cross-section model estimated bilateral import flows in manufactures among 19 OECD countries in 1990. Eaton and Kortum (2002, p.1748) revealed that countries with *"a higher state of technology relative to its wage"* tend to specialize more in technology-intensive industries such as manufacturing. The results of Eaton and Kortum (2002, p.1771) suggested one interesting takeaway for the large countries – with a fall of geographic barriers, the manufacturing sector would at first grow but then would contract leading to *"specialization more along Ricardian lines.*"

The methodological paper by Santos Silva and Tenreyro (2006) continued the improvement of gravity techniques by addressing an issue of heteroskedasticity in log-linearized models. The authors referred to the impediments of Jensen's inequality, that is, "*the expected value of the logarithm of a random variable is different from the logarithm of its expected value*" (Santos Silva and Tenreyro, 2006, p.641). Among other problems of log-linearization, they displayed its inability to cope with zero-value observation which would lead to a sample truncation. To handle said problems the authors proposed a solution for the gravity and other CES models, namely a simple Poisson pseudo-maximum-likelihood (PML) estimation technique. Santos Silva and Tenreyro (2006) found that OLS results of both standard gravity equation and that with multilateral resistance produced significant bias in estimates, as compared with those using PML; in particular, they exaggerated the role of distance and colonial ties. The authors found that heteroskedasticity rather than the sample truncation problem was in charge of the discrepancies in estimates.

Arrival of the “New” new trade theory (NNTT), which focuses more on firms rather than industries, has triggered further advancement in gravity theory (Ottaviano, 2011). Ottaviano states that increasing trade liberalization makes exporters with different levels of productivity decide either to compete with foreign firms or exit the market. Firm productivity is what really fosters intra-industry reallocations and adjustments. According to Ottaviano (2011), a number of studies which use firm-level data clearly reveal that exporting firms are not identical, in terms of size and productivity, among others. Melitz (2003) contributes to NNTT with a concept of firm heterogeneity meaning differences in firm productivity. He states that firms are more advanced and productive prior to making the decision to export, and not vice versa. In addition, countries’ exposure to trade entails inter-firm reallocations which would lead to welfare gains in the long-run. However, greater exposure to trade “*forces least efficient firms out of the industry*” (Melitz, 2003, p.1719). Melitz’s work induced a series of studies addressing unobserved heterogeneity such as Baier and Bergstrand (2007) and Helpman et al. (2008).

The inclusion of firm heterogeneity in a simple trade model was done in the recent study by Helpman et al. (2008). Their generalized model allows both positive and zero trade values.

The authors propose a two-stage estimation approach. In the first stage a Probit-model yields a probability of a country's firms to export and then obtained results are used in a gravity equation of trade. Noteworthy, the proposed method allows decomposing trade flows on the extensive and intensive margins (Helpman et al., 2008). While Helpman et al. (2008) perform the empirical modeling using a cross-section data, the empirical work Baier and Bergstrand (2007) demostrates the estimation procedure for both cross-section and pooled data.

Conclusion

This literature review has analyzed different linkages between ICT and international trade. Most of the reviewed studies report the positive influence of ICT tools such as the Internet, mobile phones, online trade portals, and fixed-telephones. The factors that are likely to fuel the demand in steel over the next decade, such as continuous urbanization, growing energy demand, and reducing carbon emissions, determine the importance of further empirical research on trade in steel. While there are a number of studies estimating ICT effects on aggregated trade flows, I have found few of those analyzing its effect on particular industries. Moreover, I am unaware of empirical papers that shed light on the relation of ICT and trade in steel. The possible explanation could be that steel manufacturing, as a non ICT-intensive industry, is thought to benefit less from ICT deployment, mainly in terms of productivity growth. Among the papers reviewed, I observe the wide use of the gravity model as a primary tool for trade analysis. Therefore, estimation of the ICT impact on trade in steel using the gravity theory appears to be most appropriate. Moreover, recent developments in the gravity theory now allow controlling for unobserved heterogeneity.

Chapter 3 Outline of the Modern Steel Industry

The global emergence of the steel industry is attributed to the invention of Bessemer steel-making process in 1855 in the United Kingdom (Allwood, 2009). This method made steel production much less expensive compared to those used previously; and for the first time – on an industrial scale. The key technology lied in removing impurities from pig iron by blowing air through it. Bessemer process triggered further advancements in steel-making technology. Among its successors were Siemens-Martin open hearth furnace, Gilchrist-Thomas converter able to eliminate excessive phosphorus, electric arc furnaces with a possibility to use a re-usable scrap, and Linz-Donawitz's oxygen converter process for production of low-carbon steel. These new steel melting technologies quickly spread around the globe and as a result brought "*greater efficiency gains"* for steel producers (Allwood, 2009, p.2).

Having started a new era in the steel industry, the United Kingdom gradually lost its role of the world's major exporter of steel in the beginning of the 20th century due to a number of structural problems such as inability to adapt to the changing business environment and the limitations of governmental policy (Allwood, 2009). Not surprisingly, driven by the fast-growing demand in the construction industry "*by 1913 German exports had exceeded British exports–with American exports not far behind–and Britain had become a major importer of steel*" (Allen, 1979, p.911). It turned out that U.S. producers such as Carnegie Steel Company scaled up European technological inventions and in turn invented a new business model of vertical integration, also known as consolidation of assets. As such, Carnegie Steel not only owned steel-producing mills, it also incorporated nearby companies such as iron ore and coal suppliers, wholesales, supported railroads and shipping transportation facilities. Further acquisition of Carnegie Steel Company together with Federal Steel and some other processing mills by U.S.

Steel created one of the first examples of an integrated mill. German steel producers later adapted American model of mass-production by creating German Steel Trust in 1926 to boost productivity and improve operational capacity.

Blonigen et al. (2013) observes the U.S. steel industry's decline since 1960s due to a number of reasons, namely increased competition from the European Community and Japan, strong U.S. dollar, and the discovery of substantial iron ore deposits outside of the U.S. Creation of the European Coal and Steel Community prevented competition among its member-nations for the resources and markets and, thus, strengthened exports from Europe. Due to the high dependency on steel during post-World War II reconstruction of Japan, significant investments in steel manufacturing were made. In addition, emergence and further application of logistics planning systems such as Kanban (Just-in-Time strategy) combined with rapid technological advancements of Japanese economy yielded additional gains in efficiency and increased firms productivity (Allwood, 2009). In response to the growing market penetration U.S. companies have been periodically filing cases for trade protection measures. Blonigen et al. (2013, p.370) notes that since 1980 "*one-third of the more than 1500 US anti-dumping and countervailing duties cases*" have been those to protect the U.S. steel industry. The measures taken by the U.S. government included trigger price mechanism, standard ad valorem tariffs, voluntary restraints agreements or quotas, anti-dumping and countervailing duties, and safeguard tariffs. Nonetheless, since 1960 the United States has transformed from being a leading exporter to a net-importer of steel, passing the leadership role to China (Blonigen et al., 2013).

In the last quarter of the 20th century the center of steel production shifted to the developing world. Developing countries such as China, India, Brazil, South Korea, and Russia mastered large-scale production of steel and became global players in the steel market.

Noteworthy, in the beginning of the 21st century Tata Group (India) acquired second-largest steel-manufacturer in Europe Corus Group (formed in 1999 by British Steel and Dutch Koninklijke Hoogovens), while Mittal Steel (India) merged with European largest producer Arcelor in 2006. One of the possible explanations for these actions was that developing countries have been using and still use their comparative advantage in cheaper labor force, looser environmental regulations, and supportive governmental policies. However, those factors are limited in time and cannot ensure competitiveness in the long-term due to observed convergence effect between developed countries and some rapidly developing ones (Acemoglu, 2007).

A series of mergers and acquisitions after 2000s has significantly altered the landscape of the world steel industry in terms of country of origin (see ranking of major steel manufacturers in Table 3-1). With the global output of nearly 1.5 bn tons of steel, the industry is characterized by relatively large number of manufacturers with international outreach (Allwood, 2009). This provides the ground for the assumption of a monopolistically competitive nature of the steel industry. While figure 3-1 depicts a simplified distribution of heterogeneous firms along the steel supply chain, Appendix 1 extends that with a global flow of steel, "*starting with metal ores and scrap as sources and ending with end-user products*" (Allwood et al., 2011, p.4).

Within the steel industry Blonigen et al. (2013) distinguishes 3 types of manufacturers: integrated mills, mini-mills, and steel processors. Among all, integrated mills are the most complex in terms of production cycle.[24] Integrated mill firstly melts pig iron from the mixture of iron ore and coke using blast open furnace (BOF), and then produces raw steel in the form of slabs, ingots, or billets. Integrated mills may also include downstream processors nearby: finishing or rolling facilities. US Steel and ArcelorMittal are the examples of an integrated mill.

[24] See Figure 2 for additional illustration.

Secondary steel producers are often referred to as mini-mills which melt recycled scrap steel into both semi- and finished products in electric arc furnaces (EAF). Nucor Corporation and Commercial Metals Company are the biggest mini-mills operating in the Unites States. The third type of manufacturers is so called processing facilities. These mills use semi-finished inputs manufactured at either integrated or mini-mills for production of finished products and articles of steel such as rails, wheels, tubes etc. Tenaris and Vallourec represent steel pipe manufactures that are primarily considered steel processing mills.

Table 3-1 Top Steel Producers and Exporters of Steel (HS72) and its Articles (HS73), 2012

Company, HQ	**Output** *1000 tons*
ArcelorMittal, LUX	93.6
Nippon & Sumitomo, JPN	47.9
Hebei Iron and Steel, CHN	42.8
Baosteel Group, CHN	42.7
POSCO, KOR	39.9
Wuhan, CHN	36.4
Jiangsu Shagang ,CHN	32.3
Shougang, CHN	31.4
JFE, Japan	30.4
Ansteel CHN	30.2
Shandong, CHN	23
Tata Steel, IND	23
US Steel Corp, USA	21.4
Nucor Corporation, USA	20.1
Gerdau, BRA	19.8

Exporter of *HS72*	**Exports,** *1000 USD*
Japan	39,473,911
China	37,117,672
Germany	30,768,531
Korea	25,375,017
Russia	22,607,920
USA	22,042,706
Belgium	17,890,983
France	16,876,190
Ukraine	15,328,328
Italy	15,327,687
Netherlands	14,576,705
Turkey	11,333,492
Brazil	10,711,044
UK	9,770,270
Spain	9,406,640

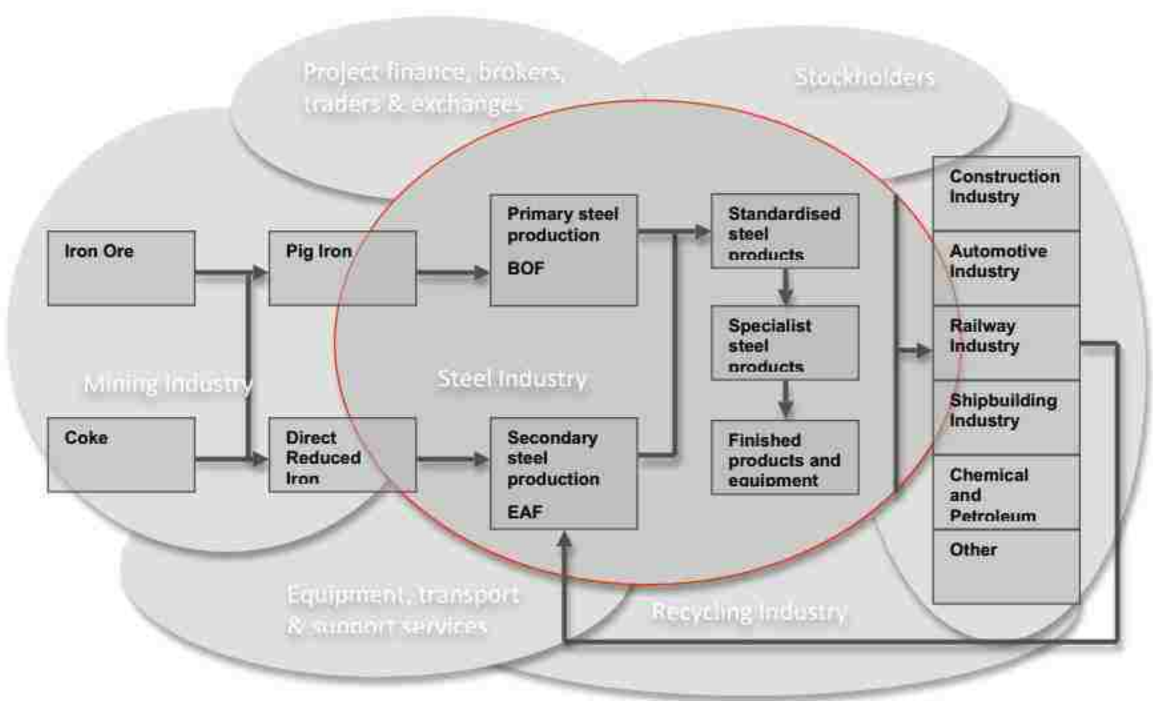
Exporter of *HS73*	**Exports,** *1000 USD*
China	56,156,107
Germany	30,759,923
Italy	19,574,112
USA	19,109,819
Japan	15,492,322
South Korea	12,467,431
France	8,554,076
India	7,677,706
Spain	7,146,990
Netherlands	6,856,579
UK	6,406,454
Czech Rep.	6,360,237
Poland	6,137,299
Turkey	6,100,707
Austria	5,841,312

Source: WSA (2013a), TRAINS

Due to the modern processes of globalization and consolidation some multinational conglomerates may include all of the above types of manufacturing facilities. Moreover, their assets might be spread out on the different continents pursuing the goals of maintaining competitiveness, avoiding trade protection measures, optimizing logistics and others.

As is shown, at different times the key to competitive advantage in the steel industry has been changing. It began with the invention of production technology in the UK, and then moved to mass-production and vertical integration applied in the U.S. Later governmental support and lean manufacturing altered the patterns of steel trade towards Europe and Japan. Lately emerging markets with relatively cheap cost of labor have started competing in steel trade, catching-up the developed world. Arrival of the Internet and proliferation of ICT in the beginning of 21st century have brought absolutely new capabilities for firms to boost productivity, increase international shipments, and manage assets in multiple locations.

Figure 3-1 Steel Supply Chain



Source: Allwood (2009)

Can ICT become a new gamechanger in capital-intensive industry such as production of steel pipes? The next chapter depicts a real-world example of how the firm harnesses the potential of ICT to maintain its competitiveness and boost international sales.

Chapter 4 Application of ICT in Trade: a Firm-level Case Study

Rationale

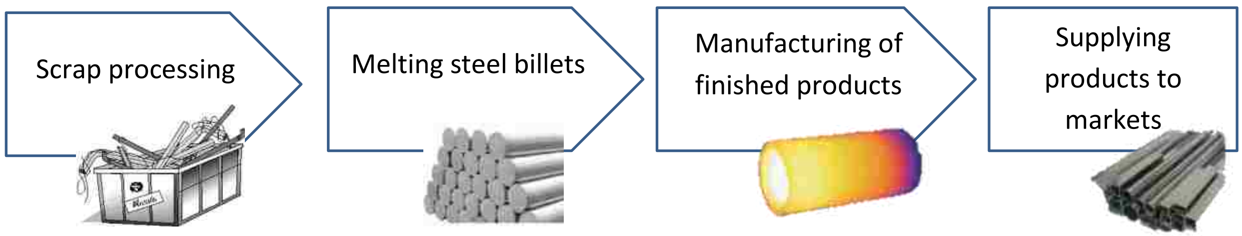
Today almost every company engaged in international trade extensively relies on ICT such as phone and Internet-based tools. As some trade literature suggests, ICT tends to reduce sunk costs of market entry. In particular, ICT may be used for conducting market research, advertising products, making "cold calls", negotiating purchase orders, tracking shipments and more. This section reviews a real-world firm-level case study on how ICTs are used by an Eastern European steel pipe manufacturer and its subsidiaries overseas to ensure quality trade processes.

Interpipe is a global producer of steel pipe (both welded and seamless), casing, tubing, and railway wheels. According to the company web-site, [25] Interpipe is "*one of the top ten largest manufacturers of seamless pipe in the world.*" The company is headquartered in the Dnipropetrovsk region in Ukraine and so are its main production facilities – Niznedneprovsky Tube Rolling Plant, Novomoskovsk Pipe-Production Plant, Niko Tube, and Interpipe Steel. Four of its main production assets – three steel pipe mills and one scrap-processing plant – were established in the late 19th – mid 20th centuries and were privatized after the fall of the Soviet Union in 1991. In 2005, new owners incorporated the aforementioned assets into a group of companies called Interpipe. In 2012, the company launched a new electric steel-melted complex – Interpipe Steel. The primary reason for investing $700mn into construction of the new mill was to create a vertically integrated agglomerate[26] with a full production cycle – "scrap-processing – steel melting – production of finished steel products" illustrated in Figure 4-1. This capital

[25] Interpipe's web-site; URL: http://interpipe.biz
[26] Emerged in 19th, vertical integration intends to reduce exogenous risks and consolidates assets under a common ownership.

investment, announced in 2007, was intended to increase the value of the business; however the economic recession of 2008 slowed down the global economy and caused losses to Interpipe.

Figure 4-1 A Simplified Structure of Vertically Integrated Steel Pipe Agglomerate



Since its creation, Interpipe has been an industry leader on Ukraine's steel pipe and railway wheel markets. Due to both returns to scale and above average levels of productivity in their home country, in recent years, Interpipe has drastically increased the volume of shipments to foreign markets. Figure 4-2 plots the recent dynamics of Interpipe's revenue sources by region. The company's web-site[27] states that in 2012 "*Interpipe sold over 1.2 million tons of steel pipe to clients in 80 different countries worldwide.*" Refocusing on foreign markets was a vital measure needed for business survival, while the demand in steel pipe in the former Soviet Union markets was shrinking. Ukraine's WTO accession in 2008 also created additional opportunities for Ukraine's exporters overseas.

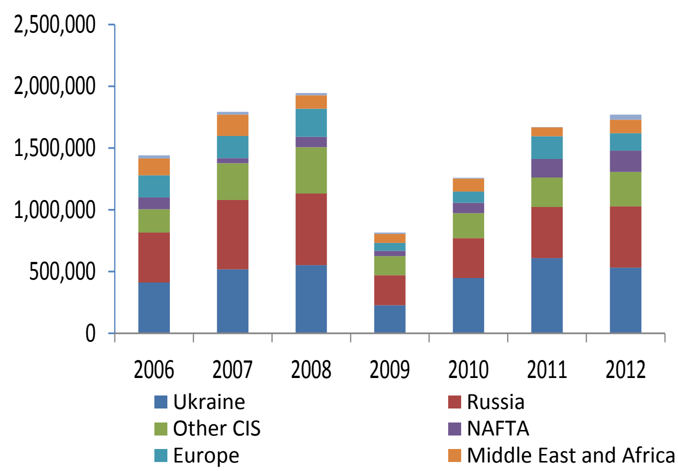
As Figure 4-2 depicts, Interpipe has been trying to find new customers overseas as well as deepen trade with existing ones. Indeed, in order to establish new relationships with customers in foreign markets, Interpipe diversified its product range and launched several trade companies based upon geographical representation (see Figure 4-3).

North American Interpipe is located in Houston, "the energy capital of the world", and serves the customers in the United States, Canada, and other countries in South America (NAFTA and Latin America). The area of the former Soviet Union, now usually referred to as

[27] North American Interpipe's web-site; URL: http://na.interpipe.biz/en/company/nai

Commonwealth of Independent States (CIS), is covered by the three trade offices in Ukraine, Russia, and Kazakhstan. Interpipe's trade company in the United Arab Emirates addresses customers' needs in the emerging markets of the Middle East and North Africa (MENA). Finally, Interpipe owns two companies in Switzerland, namely Interpipe Europe S.A. and KLW Wheelco SA. The former plays the role of Interpipe's corporate office in Europe, while the latter is responsible for trade in railway wheels under the brand KLW.

Figure 4-2 Interpipe's Revenue in 2005-2012 by region[28]



Unit of Measure: thousand U.S. dollars

Additionally, the company is developing prospective markets through its agents – companies or individuals acting on behalf of the manufacturer under provisions of a signed agency agreement. Agents help to expand the sales network beyond the countries where trade companies have been already acting. For instance, North American Interpipe is currently engaged in signing such agreements with agents in Ecuador (Impexzul) and Mexico (Aceros Imperial). Besides that, Interpipe employs its own sales representatives who travel to designated countries such as Brazil or Venezuela, which are relatively abundant in oil and therefore exhibit demand in oil and gas equipment.

[28] Source of data: Consolidated Financial Statements (IFRS); URL: http://interpipe.biz/en/investment/figures/statement/

The global economic recession of 2008-2009 significantly increased the competition in the global steel market. This resulted in further pressure on the steel pipe industry. Firms with higher levels of productivity and revenue, such as the leading steel pipe producers– Tenaris (Italy-Argentina), OAO TMK (Russia), and Vallourec (France-Germany) –were able to soften market shocks as opposed to their smaller and less-productive competitors. Following Melitz (2003), big multinational players leverage their competitive advantage and market power due to returns to scale and high productivity, while small firms must either boost their productivity or exit the market and relocate to another industry.

Figure 4-3 Geographical Location of Interpipe's Trade Companies

To stay competitive, small and medium firms must compete by reducing their prices and markups. In return, foreign governments may start antidumping investigations and eventually impose duties on imports, such as the U.S. which imposed extra duties for Chinese steel producers in 2010 in order to protect local manufacturers from foreign competitors.[29] Other countries may apply trade restrictions following political or other interests. For instance, in

[29] Another example of that took place in June 2013. The United States International Trade Commission (USITC) launched the antidumping investigation on imports of tubular goods for oil industry from India, Korea, Saudi Arabia, Taiwan, Thailand, Vietnam Turkey, Ukraine, and the Philippines (URL: http://www.usitc.gov/press_room/news_release/2013/er0816ll1.htm).

response to Ukraine's willingness to sign a Free Trade Agreement with the European Union in 2013, the Government of Russian Federation immediately cancelled the quotas for Ukrainian steel pipe producers and banned the imports of Ukrainian chocolate makers. These policy measures were intended to prevent formation of a new EU-Ukraine trade agreement and instead force Ukraine's government to join the Customs Union of Russia, Belarus, and Kazakhstan.

Today's business challenge for Interpipe is how to achieve greater efficiency and increase and diversify international shipments. Along with product innovation and improving customer service, the aforementioned goals require having fast and secure ICT tools. They have become imperative to address all kind of challenges – whether it is managing an international supply chain or handling an antidumping case. The next sub-section reviews the recently implemented ICT instruments used by Interpipe in its relations with customers and trade subsidiaries overseas.

Trade-facilitation ICT Applications

The deployment of the Internet and phone connectivity in business today is so extensive that no one doubts their positive impact on facilitating business activities. A lot of jobs now require diverse IT skills. Most innovative companies encourage their employees to use ICT tools to make their work place more convenient and customized. Bring Your Own Device (BYOD) is a trending concept which allows employees to use their personal devices such as a laptop or smart-phone and connect those to a company's cloud computing services. Are there similar trends going on in less innovative or even "conservative" manufacturing industries? This section sheds light on the level of ICT penetration in a global steel pipe producer's trade infrastructure.

Interpipe's ICT tools can generally be divided into 3 main sub-categories: internal, operational, and external communication tools. The company facilitates its internal communication using Voice over Internet Protocol (VoIP), videoconferencing and corporate email server. Customer Relations Management (CRM) system, inventory database synchronized with accounting software, and smart postage equipment enhance the company's operational capabilities. Trade and marketing activities are boosted using the company's web-sites, Internet promotion and online subscriptions. Below I briefly describe the elements of Interpipe's ICT infrastructure which help boosting greater communication within the company and reduce distance effects between the company's locations.

(i) Internal communication tools

Voice over Internet Protocol. The arrival of the Internet has changed the way multinational entities use phones. It turns out that "carrying phone calls" over the Internet Protocol network has a number of advantages against regular phone or Skype. VoIP is a much cheaper tool for carrying international calls – the primary activity to get connected within a multinational firm. It also allows creating an internal network with internal numeration. To add, this network is usually more secure as a company's IT department can monitor information breaches. However, fixed and cellular phones are the most applicable for making domestic calls. Interpipe created its 6-digit VoIP internal network so every employee, whether in the sales department or back-office, has her unique phone number. VoIP not only reduces the communication costs but also assures secure, quality connectivity within Interpipe.

Corporate e-mail client is a must-have ICT tool for medium and large companies as a matter of information security. A good deal of business communication nowadays is going via e-mail. There is an emerging trend of switching towards paper-less government and business operations. This electronic exchange bears high risks. Information breaches caused by either insider or outsider agents may lead to significant financial losses or commercial espionage. In order to maintain acceptable levels of information security companies deploy e-mail clients that encrypt information flows.

In the first decade of 2000s, Interpipe deployed Lotus Notes[30], a mailing client on the IBM platform. This tool has a wide range of user's applications such as e-mail box, calendar, contact book, meeting organizer, and to do list. One the Lotus advantages is the ability to code-and-integrate other applications that fit the firm's needs. For example, Interpipe's IT department developed an internal corporate site and phone/picture book are available to only Lotus Notes account holders. The use of a secure e-mail platform also allows having remote access to the mailbox which speeds-up the process of making decisions and communicating with customers.

Videoconferencing. Since Interpipe's trade companies are scattered around the globe its employees experience challenges in communication caused by the time differences. In accordance with the Coordinated Universal Time scale, Interpipe's offices are located in 5 time zones. In fact, Interpipe employees in HQ have a total of between 2 (with Houston, USA) and 7 (with Lugano, Switzerland) hours of common working time (see Table 4-1).

Table 4-1 Time Difference among Interpipe Trade Offices (UTC)[31]

UTC (-6)	Houston, USA									9:00 AM	10:00 AM
UTC (+1)	Lugano, CHE		9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM
UTC (+2)	**Dnepropetrovsk, UKR (HQ)**	**9:00 AM**	**10:00 AM**	**11:00 AM**	**12:00 PM**	**1:00 PM**	**2:00 PM**	**3:00 PM**	**4:00 PM**	**5:00 PM**	**6:00 PM**
UTC (+4)	Moscow, RUS; Dubai, UAE	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM		
UTC (+6)	Almaty, KAZ	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM				

The set of equipment includes a screen panel, video camera, microphones, speakers, computer, and remote control. The data are transmitted via Internet protocol. According to Cisco

[30] In 2012 IBM decided to change the IBM Lotus Notes brand to simply IBM Notes.
[31] Coordinated Universal Time; URL: http://www.worldtimezone.com

Systems, videoconferencing creates so called "power of in-person" as people tend to believe more in things they see rather than hear.[32] This is very applicable in international trade as information may be distorted through the chain "customer-sales representative-HQ-mill." Interpipe uses TelePresence to conduct meetings of trade companies' sales teams with the HQ's back-office in Ukraine. In the future, it is planned to deploy this service at the mill level and at the department of logistics. Videoconferencing can also be used to talk to customers if they have installed similar equipment at their premises.

(ii) Operational ICT tools

Smart postage service. In its relationship with customers, where paper-copy exchange is required, Interpipe's subsidiary in the United States uses all kinds of postage services; however for domestic mail the company mostly uses remote mail station, a service jointly provided by the partnership between Pitney Bowes Inc. and USPS. The solution comprises just a mail machine connected to the Internet with a built-in weights and printer. Even though paper-less business is becoming more and more popular, conservative industries such as steel pipe still have a significant amount of "paper exchange." Certificates of quality, invoices, shipping tallies, or bills of lading are only several examples of the documents to be exchanged using regular mail. Smart mailroom solution is a significant time-saver as an employee is able to stamp any type of mail piece, such as a letter or a parcel, without going to the post office. The service also allows refilling the account using the phone or online-banking, so the likelihood of outage is minimized. Smart postage service increases employees' productivity ensuring that an employee spends less time on low-skill jobs and focuses primarily on trade-related functions.

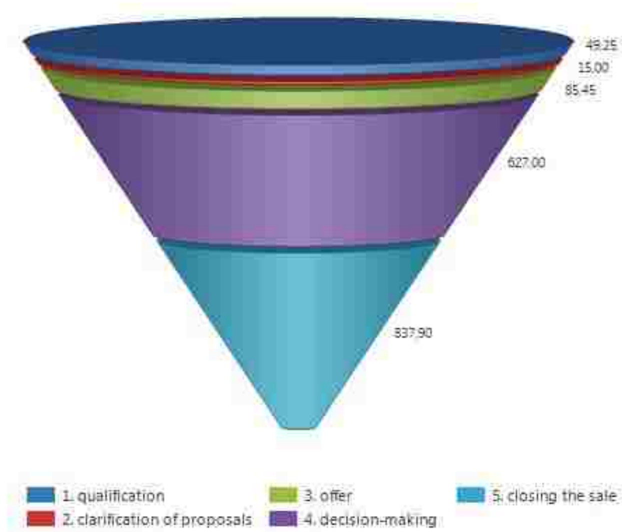
Customer Relations Management Module (CRM). Recently, Interpipe has started implementation of Microsoft Dynamics CRM to maximize sales performance and maintain

[32] Cisco Sytems; URL: http://www.cisco.com/web/telepresence/index.html

customer relationships. CRM users enter the data, namely leads, quotes, and invoices, on every account the company has a business with. Using this data, CRM reflects the current state of relationships with both existing and prospective clients. Figure 4-4 shows an example of so called "sales pipeline" – an instrument that allows the sales team to forecast future sales and keep track of day-to-day trade activities.

The CRM system at Interpipe operates using a cloud computing platform which means users can access the data via the Internet regardless of their location. This helps employees in different offices to stay up-to-date and reduces the amount of interaction required for doing so without online access. The nature of modern CRMs brings a number of additional opportunities for users such as integration of insights from popular social media and their immediate conversion into prospect leads without doing much research. Additionally, users have an opportunity to communicate via internal chat platforms and share their documents with co-workers.

Figure 4-4 Example of a CRM Sales Pipeline



Inventory database. North American Interpipe also uses the Internet to keep track of available in-stock material, as part of the sales in the U.S. come from storage facilities. The Microsoft Access database developed by internal specialists is stored on the server to which both HQ and trade companies in the U.S. have access. This solution is far from being perfect, though it synchronizes its data with an accounting program, Sage 50 (Peach Tree). As a result, all sales orders and invoices created in Sage correspond with the inventory database records, ensuring that material to be sold is available for pick-up from yards.

(iii) External communication tools

Corporate web-sites. Like every other global steel producer, Interpipe has its representation in the worldwide web. Today, quality web-site serves not only as a business card in the Internet, but provides a full set of services including online inventory, product mix, e-commerce, description of products and services etc. Interpipe's main web-site[33] is bi-lingual which follows the trend of globalization. Its interface is available in both Russian and English, so is the web-site of Interpipe's wheel brand KLW.[34] Interpipe North America also maintains a bilingual website[35] in both English and Spanish for its clients in North and South Americas. All of the websites allow a visitor to place an order or to request a quote. The request is automatically redirected to the respective sales department; however the effectiveness of this tool has not been studied yet.

Internet promotion and subscriptions. With the growth of social media, companies try to harness their audience, leveraging "network effects." Interpipe maintains several accounts in popular networks such as Facebook, Twitter, Instagram and the Russian social network "Vkontakte" (in English – "in contact"). Another advantage of the Internet is that it allows the firm to monitor prices of metal products and to keep track of current industry trends by providing an access to specialized portals such as Metal Bulletin. With a subscription license, a company or an individual can obtain historical data on prices and forecasts online 24/7.

[33] http://interpipe.biz
[34] http://www.klw.biz
[35] http://na.interpipe.biz

Best Practices: ICT Tools Used by Leading Producers of Steel Pipe

Multinational companies have always fueled the development of ICT as faster communication enhances their operational capabilities. The analysis of publicly available web-sites of the top-3 world steel pipe producers revenue wise[36] – Tenaris, Vallourec, and TMK – reveals that industry leaders, as compared with Interpipe, are up-to-date in application of ICT for managerial and commercial purposes (see table 4-2). It is worth mentioning that among all steel pipe producers only Tenaris made it to the list of most innovative companies in 2013[37], which in part supports the initial assumption that conservative industries are less advanced in the use of ICT and computing technologies.

Table 4-2 State-of-the-art ICT Tools at Top-3 Producers vis-à-vis Interpipe[38]

	E-commerce apps	Clients portal	Cloud ERP	Cloud CRM	Mobile apps	ICT education	Social media	Call-center
Tenaris	●	●	●	●	●	●	●	◔
TMK Трубная Металлургическая Компания	◔	○	●	◕	◑	○	◔	●
vallourec	◕	●	●	●	◑	●	◕	◔
INTERPIPE	◔	○	○	◑	○	○	◑	◔

The author's analysis suggests that companies with a longer history have much more developed ICT infrastructure and, therefore, serve as a role model for the entire industry. Among surveyed companies, only Tenaris and Vallourec launched their client portals where clients can find product catalogues, place an order, or find a technical certificate for purchased material. Moreover, clients receive free-of-charge training on how to operate the portals. Also, only

[36] Steel pipe industry can be characterized as monopolistically competitive; these 3 major producers are commonly recognized such as the industry leaders and trend setters.
[37] Forbes Magazine, The World's Most Innovative Companies; URL: http://www.forbes.com/innovative-companies/list/
[38] Estimates made by author in November 2013 and were based upon available information on the following websites: tenaris.com, tmk-group.com, vallourec.com, and interpipe.biz All estimates lie in the interval: 100% paint – full implementation and blank – not implemented.

Tenaris and Vallourec offer courses in information technology for their staff including on-line intra-firm education.

All top-3 companies implemented cloud-based ERP and CRM systems. The growing popularity of mobile and tablet applications was followed up by Tenaris that maintains TenarisLibrary for iPad and a mobile application for investors with financial information. Vallourec and TMK post digital versions of their corporate magazines in the Apple Store and Google Play. Today social media channels are a good way to reach customers at all levels – from students to CEOs. Therefore, most of the studied companies fully explore this communication channel and maintain accounts in Facebook, Twitter, YouTube, and LinkedIn.

Conclusion

Steel pipe producers use a wide range of ICT instruments to stimulate information exchange and communication both internally and externally. This fact supports the hypothesis of ICT having a positive impact on international trade. The more consumers of steel pipe get connected to the Internet and phone networks, the more chances a company has to convert the leads into closed deals. The industry leaders have already implemented state-of-the-art ICT tools such as E-commerce modules, cloud-based CRM/ERP, and online/phone customer service. Even though, Interpipe possesses certain ICT infrastructure within the company, it clearly lags behind the industry leaders. ICT tools used at Interpipe are considered standard if not "must have" for any multinational company. Interpipe may want to adopt some of the tools successfully implemented by the industry champions. The company's decision not to deploy new ICTs may cause a decline in both volumes of trade and market shares in the long-term.

Nevertheless, there is room for improvement for the entire industry in terms of ICT application for client-oriented services. Simply borrowing best practices from more ICT-intensive industries may create additional opportunities for growth in sales in extensive and intensive margins, and customer relations management. ICT tools using GPS/satellite may be utilized to create customer applications such as "track-my-order" on the map for international shipments. Radio Frequency Identification (RFID) chips may be applied to keep track of inventory and transportation logistics. Full application of e-commerce and Business-to-Business (B2B) integration has a potential to automate relationship with trading partners throughout the chain "*buy-sell-ship-pay*."[39]

The tight competition on the steel pipe market requires producers constantly boost their productivity by improving technology, business processes, and customer relationship. Deployment of ICT may affect all of the above in a positive way as it supports cooperative efforts, fosters communication, and promotes knowledge sharing.

[39] The term suggested by IBM Smarter Commerce; URL: http://www-03.ibm.com/software/products/us/en/category/SW66A

Part II

Chapter 5 Empirical Models

To empirically determine the impact of ICT on export flows, I apply several specifications of the gravity model. Similar to Baier and Bergstrand (2007) and Mattes et al. (2012), the estimation procedure includes both the traditional gravity model and one accounting for multilateral resistance. I choose to use fixed effects rather than random effects for panel estimations as proposed by Baier and Bergstrand (2007). The entry point to the econometric analysis is a log-linearized basic specification of the gravity equation:

$$\text{Ln}\, T_{ijt} \;=\; \beta_0 \;+\; \beta_1 \ln\left(Y_{it} * Y_{jt}\right) + \;\beta_2 \ln D_{ij} + \beta_3\, \boldsymbol{F}_{\boldsymbol{i(j)}} + \beta_4\, \boldsymbol{F}_{\boldsymbol{it(jt)}} + \beta_5\, \boldsymbol{F}_{\boldsymbol{ij}} + \beta_6\, \boldsymbol{F}_{\boldsymbol{ijt}} + \;\varepsilon_{ijt} \qquad \text{Eq. (4)}$$

where exports from country *i* to country *j* is denoted by T_{ij}, *Y* is a country's economic mass (GDP), *D* represents distance and may capture other trade costs, *t* is a time subscript, ε_{ij} is a bilateral error term, and $\beta_1, \beta_2, \beta_3$ are unknown parameters. As Table 5-1 depicts, vectors $\boldsymbol{F}_{\boldsymbol{i(j)}}$, $\boldsymbol{F}_{\boldsymbol{it(jt)}}$, $\boldsymbol{F}_{\boldsymbol{ij}}$, and $\boldsymbol{F}_{\boldsymbol{ijt}}$ refer to the set of both dummy and individual or bilateral country characteristics that are ether time-variant ($\boldsymbol{F}_{\boldsymbol{it}}$, $\boldsymbol{F}_{\boldsymbol{jt}}$, and $\boldsymbol{F}_{\boldsymbol{ijt}}$) or constant over time ($\boldsymbol{F}_{\boldsymbol{i}}$, $\boldsymbol{F}_{\boldsymbol{j}}$, and $\boldsymbol{F}_{\boldsymbol{ij}}$). Notably, not all variables are included to estimate the basic gravity equation (Eq. 4).[40]

Table 5-1 Description of Factor Variables

Factor	Variables
$\boldsymbol{F}_{\boldsymbol{i}}, \boldsymbol{F}_{\boldsymbol{j}}$	Landlockness
$\boldsymbol{F}_{\boldsymbol{it}}, \boldsymbol{F}_{\boldsymbol{jt}}$	Quality of port infrastructure, real effective exchange rate, tariffs, and WTO membership
$\boldsymbol{F}_{\boldsymbol{ij}}$	Contiguity, common language, colonial ties, and experience of being the same country
$\boldsymbol{F}_{\boldsymbol{ijt}}$	Mutual WTO membership, mutual participation in regional trade agreements or customs unions (RTA), and non-tariff measures (NTM)

[40] To keep the specification as close as possible to the standard gravity equation, I include only the following variables from Table 5-1: contiguity, common language, colonial ties, experience of being formerly the same country, and RTA.

Theory suggests that common language, mutual RTA membership, and geographical adjacency are likely to increase bilateral trade (Mattes et al., 2012). Likewise, colonial ties and experience of being formerly the same country may predict higher volumes of bilateral trade (Yushkova, 2014).

The next specification endows Eq. 4 with a set of ICT variables as well as country-specific parameters:

$$\text{Ln}\, T_{ijt} = \beta_0 + \beta_1 \ln (Y_{it} * Y_{jt}) + \beta_2 \ln D_{ij} + \beta_3 \boldsymbol{F_{i(j)}} + \beta_4 \boldsymbol{F_{it(jt)}} + \beta_5 \boldsymbol{F_{ij}} + \beta_6 \boldsymbol{F_{ijt}} + \beta_7 \ln \boldsymbol{ICT_{it-1}} + \beta_8 \ln \boldsymbol{ICT_{jt-1}} + \beta_9 (\ln \boldsymbol{ICT_{it-1}} * \ln \boldsymbol{ICT_{jt-1}}) + \varepsilon_{ijt} \quad \text{Eq. (5)}$$

Because the effect of ICT deployment at the firm level may not be realized instantaneously, ICT variables are lagged by one year. In this specification vectors $\ln \boldsymbol{ICT_{it-1}}$ and $\ln \boldsymbol{ICT_{jt-1}}$ refer to countries' ICT characteristics, namely proliferation of the Internet, mobile phones, and fixed landlines. This specification extends vectors $\boldsymbol{F_{i(j)}}$, $\boldsymbol{F_{it(jt)}}$, and $\boldsymbol{F_{ijt}}$ by adding dummies for WTO membership and landlockness, and numeric measures of quality of ports, real effective exchange rates (REER), bilateral tariffs, and cumulative number of non-tariff measures (NTM) imposed against an exporter. The theory suggests that lower tariffs and fewer NTMs imply higher volumes of trade flows (Blonigen et al., 2013). Though, in the steel industry one may expect the problem of endogeneity as governments tend to address growing imports from major country-competitors by raising tariffs and imposing additional NTMs such as countervailing, antidumping and safeguard duties.

Having access to water transportation and better quality of ports are reported to have positive impacts on country's trade competitiveness (Schwab and Sala-i-Martín, 2013). Values of currency's real effective exchange rate (REER) above unity are likely to weaken a country's competitiveness on foreign markets and may cause a decrease in exports (Catão, 2012). Trade practitioners would also expect positive coefficients on WTO membership as that is reported to boost countries' trade performance.[41] According to Mattes et al. (2012, p.9), ICT network effects may enhance trade volumes "*when both countries have good ICT development.*" Therefore, to determine whether network effects are in place, I hereinafter supply Eq. 5 with an ICT interaction term $\ln \boldsymbol{ICT_{it-1}} * \ln \boldsymbol{ICT_{jt-1}}$.

Inclusion of multilateral resistance terms e_i and e_j transforms Eq. 5 into the following functional form:

$$\text{Ln}\, T_{ijt} = \beta_0 + \beta_1 \ln (Y_{it} * Y_{jt}) + \beta_2 \ln D_{ij} + \beta_3 \boldsymbol{F_{i(j)}} + \beta_4 \boldsymbol{F_{it(jt)}} + \beta_5 \boldsymbol{F_{ij}} + \beta_6 \boldsymbol{F_{ijt}} + \beta_7 \ln \boldsymbol{ICT_{it-1}} + \beta_8 \ln \boldsymbol{ICT_{jt-1}} + \beta_9 (\ln \boldsymbol{ICT_{it-1}} * \ln \boldsymbol{ICT_{jt-1}}) + e_i + e_j + \gamma_t + \varepsilon_{ijt} \quad \text{Eq. (6)}$$

Additionally, Eq. 6 contains a year dummy γ_t that captures year-specific unobserved characteristics. While inclusion of the individual country-specific terms may be a sufficient measure to control for multilateral resistance in a cross-section dataset, in the panel, one needs to account for time-varying country-specific characteristics (Baier and Bergstrand, 2007). For this purpose, Eq. 7 is augmented with the interaction variables of year and countries' fixed effects e_{it} and e_{jt}:

$$\text{Ln}\, T_{ijt} = \beta_0 + \beta_1 \ln D_{ij} + \beta_2 \boldsymbol{F_{ij}} + \beta_3 \boldsymbol{F_{ijt}} + \beta_4 (\ln \boldsymbol{ICT_{it-1}} * \ln \boldsymbol{ICT_{jt-1}}) + e_{it} + e_{jt} + \varepsilon_{ijt} \quad \text{Eq. (7)}$$

Noteworthy, variables that do not change over time or across all trade partners, such as GDP or country's quality of ports in a given year, will correlate with time-varying country fixed effects. Hence, these variables cannot be included into a model with multilateral resistance (Yushkova, 2014). The same condition applies to country specific ICT variables, therefore the impacts of ICT are only observed through ICT interaction variables.

[41] What we stand for, WTO; URL: http://wto.org/english/thewto_e/whatis_e/what_stand_for_e.htm

The concluding model (Eq. 8) is augmented with both bilateral[42] and country-and-time fixed effects to control for any country-pairs' unobserved characteristics in a given year. This specification allows inclusion of only interaction variables and those that vary with each trade partner over time.

$$\text{Ln}\, T_{ijt} = \beta_0 + \beta_1 \boldsymbol{F_{ijt}} + \beta_2 \left(\ln \boldsymbol{ICT_{it-1}} * \ln \boldsymbol{ICT_{jt-1}}\right) + e_{it} + e_{jt} + e_{ij} + \varepsilon_{ijt} \qquad \text{Eq. (8)}$$

Lastly, the estimation procedure for three different samples (hereinafter referred to as "total trade sample", "steel sample", and "articles of steel sample") starts with basic gravity equation and continues by adding various forms of fixed effects such as time, country, country-and-time, and country-pair effects. Specification (2-4) yield coefficients on both individual and interaction ICT variables, while (5-6) produce estimates only on countries' ICT interaction. The following chapter describes all the samples as well as variables and their data sources.

There are several issues that determine the estimation order and, thus, need to be clarified. First, to check the adequacy of the aforementioned model specifications, instead of steel exports I begin modeling with total exports as a dependent variable. This exercise permits (i) to find out whether obtained coefficients support theoretical findings discussed in Chapter 2; and (ii) to compare obtained coefficients with those of steel products later on. Second, due to the distinction between steel and articles of steel in the HS classifications[43] I estimate impacts of ICT on both "raw" and "processed" steel. This approach allows for finding differences in ICT impacts on both types of steel products.

[42] Bilateral fixed effect has the same value for both exports from country *i* to country *j* and exports from country *j* to country *i*, but only in a given year.
[43] The distinction is further explained in Chapter 6.

Chapter 6 Data

Estimation of the impact of ICT in all samples is conducted using panel data over the period of 12 consecutive years (2001-2012). The number of exporting countries depends on which export flow is selected. For the sample with total exports there are 153 exporting countries (see Table 3-1 in Appendix 3); for the sample with exports of steel – 127 reporters (see Table 3-2 in Appendix 3); and for the sample with exports of articles of steel, the number of exporting countries is 128 (see Table 3-3 in Appendix 3). Unavailability of historical data on ICT variables prior to 2000 hampers the extension of both the time period and country sample. Below I describe the dependent variable and independent variables as well as report their data sources. Summary statistics tables for each sample are reported below in Tables 6-1, 6-2, and 6-3 respectively.

Dependent Variable – Exports

I obtain data not only for exports of steel but also for total exports. There are several possible sources for trade flows disaggregated by industry. Among them are UN Comtrade, OECD STAN Bilateral Trade Database, and the World Banks's Trade Analysis and Information System (TRAINS). Because OECD Database contains data on 30 non-OECD countries, with 64 reporters in total, I choose to use TRAINS which reports a broader set of countries using the UN Comtrade database. This source is also used to extract data on total exports. TRAINS reports export values in current U.S. dollars ($ 1,000). Notably, only positive export values are included in the datasets.

United Nations Statistical Commission (UNSD)[44] states that "*currently most data are reported to UNSD according to the HS classification, version 1996*." HS clearly distinguishes 2-

[44] UNSD, Data Extract Service. URL: http://unstats.un.org/unsd/trade/dataextract/dataclass.htm

digit codes for steel and products of steel; therefore I choose two aggregated categories: 72 – Iron and Steel and 73 – Articles of Iron and Steel.[45]

Table 6-1: Summary Statistics –Total Trade Sample [46]

Variable	UoM	Obs	Mean	Std. Dev.	Min	Max
Total exports	Mn, US dollars	127,553	929.09	6,766.50	0.00	352,438.20
GDP (exp)	Mn, US dollars	127,553	608,995.10	1,737,114.00	144.26	16,200,000.00
GDP (imp)	Mn, US dollars	127,553	505,090.20	1,598,763.00	21.84	16,200,000.00
Distance (weighted)	Kilometers	127,553	7,220.77	4,526.18	94.27	19,650.13
Internet (exp)	Number per 100	127,553	8.99	10.55	0.01	38.99
Internet (imp)	Number per 100	127,553	7.47	9.89	0.01	38.99
Fixed phones (exp)	Number per 100	127,553	27.59	18.91	0.06	74.76
Fixed phones (imp)	Number per 100	127,553	24.85	18.86	0.01	74.76
Mobile phones (exp)	Number per 100	127,553	80.50	38.76	1.21	215.50
Mobile phones (imp)	Number per 100	127,553	75.63	40.50	0.66	215.50
Colonial ties	1=yes, 0=no	127,553	0.02	0.14	0	1
Common language	1=yes, 0=no	127,553	0.14	0.34	0	1
Contiguity	1=yes, 0=no	127,553	0.03	0.16	0	1
Landlockness (exp)	1=yes, 0=no	127,553	0.16	0.37	0	1
Landlockness (imp)	1=yes, 0=no	127,553	0.17	0.38	0	1
Exchange rate (exp)	Percentage (%)	127,553	101.58	10.58	63.62	161.81
Regional trade agrmt	1=yes, 0=no	127,553	0.21	0.41	0	1
Same country	1=yes, 0=no	127,553	0.01	0.11	0	1
WTO (both countries)	1=yes, 0=no	127,553	0.81	0.39	0	1
WTO member (exp)	1=yes, 0=no	127,553	0.92	0.27	0	1
WTO member (imp)	1=yes, 0=no	127,553	0.88	0.33	0	1

[45] Hereinafter I use terms “raw steel” and “processed steel” referring to 72 and 73 HS codes respectively.
[46] For modeling I take logarithms of exports measured in 1,000 U.S. Dollars and of GDPs in U.S. dollars.

Table 6-2: Summary Statistics – Steel Sample

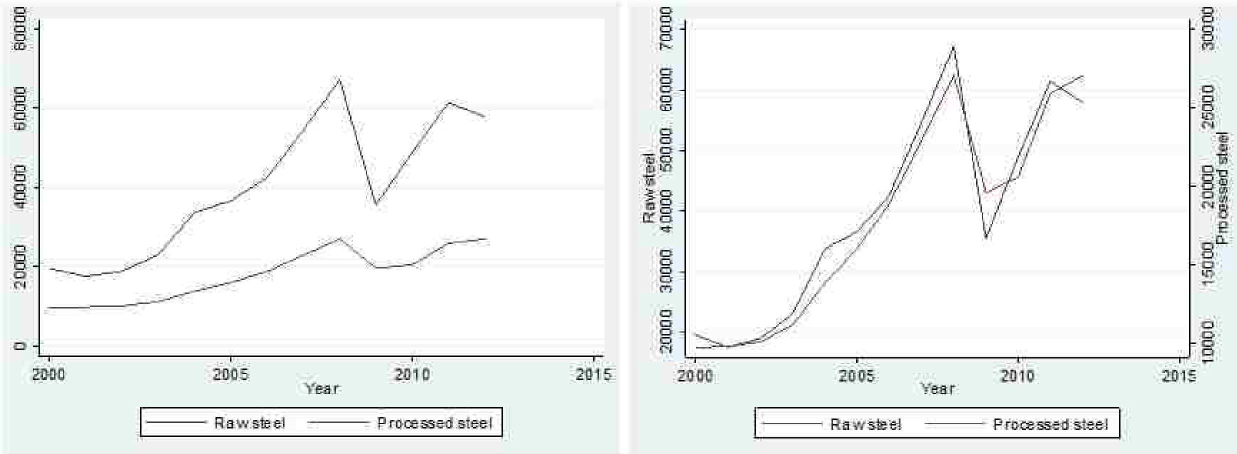
Variable	UoM	Obs	Mean	Std. Dev.	Min	Max
Exports (HS 72)	Mn, US dollars	29,499	53.69	290.39	0.00	9,733.45
GDP (exp)	Mn, US dollars	29,499	1,186,895.00	2,505,517.00	898.28	16,200,000.00
GDP (imp)	Mn, US dollars	29,499	954,636.10	2,316,340.00	898.28	16,200,000.00
Distance (weighted)	Kilometers	29,499	6,915.68	4,539.56	114.64	19,650.13
Internet (exp)	Number per 100	29,499	11.09	11.19	0.01	38.99
Internet (imp)	Number per 100	29,499	9.40	10.71	0.01	38.99
Fixed phones (exp)	Number per 100	29,499	33.21	18.62	0.19	74.76
Fixed phones (imp)	Number per 100	29,499	30.27	19.28	0.16	74.76
Mobile phones (exp)	Number per 100	29,499	83.60	35.68	1.21	215.50
Mobile phones (imp)	Number per 100	29,499	79.76	37.93	1.77	215.50
Colonial ties	1=yes, 0=no	29,499	0.04	0.20	0	1
Common language	1=yes, 0=no	29,499	0.14	0.35	0	1
Contiguity	1=yes, 0=no	29,499	0.05	0.22	0	1
Landlockness (exp)	1=yes, 0=no	29,499	0.14	0.35	0	1
Landlockness (imp)	1=yes, 0=no	29,499	0.12	0.33	0	1
Non-tariff measures	Number of cases	29,499	0.13	0.45	0	5
Quality of ports (exp)	Score 1-7	29,499	4.57	1.22	1.10	6.90
Quality of ports (imp)	Score 1-7	29,499	4.46	1.27	1.10	6.90
Exchange rate (exp)	Percentage (%)	29,499	100.08	10.54	63.62	161.81
Regional trade agrmt	1=yes, 0=no	29,499	0.28	0.45	0	1
Same country	1=yes, 0=no	29,499	0.02	0.15	0	1
Tariff rate (weighed)	Percentage (%)	29,499	3.63	5.18	0	50.00
WTO (both countries)	1=yes, 0=no	29,499	0.91	0.29	0	1
WTO member (exp)	1=yes, 0=no	29,499	0.95	0.22	0	1
WTO member (imp)	1=yes, 0=no	29,499	0.96	0.20	0	1

Table 6-3: Summary Statistics – Articles of Steel Sample

Variable	UoM	Obs	Mean	Std. Dev.	Min	Max
Exports (HS 73)	Mn, US dollars	40,426	28.13	200.08	0.00	10,731.60
GDP (exp)	Mn, US dollars	40,426	988,251.80	2,269,056.00	898.28	16,200,000.00
GDP (imp)	Mn, US dollars	40,426	856,846.40	2,239,758.00	898.28	16,200,000.00
Distance (weighted)	Kilometers	40,426	7,292.11	4,517.96	114.64	19,650.13
Internet (exp)	Number per 100	40,426	10.92	11.09	0.01	38.99
Internet (imp)	Number per 100	40,426	9.09	10.62	0.01	38.99
Fixed phones (exp)	Number per 100	40,426	32.12	18.67	0.19	74.76
Fixed phones (imp)	Number per 100	40,426	28.82	19.09	0.16	74.76
Mobile phones (exp)	Number per 100	40,426	84.45	35.99	1.21	215.50
Mobile phones (imp)	Number per 100	40,426	79.25	37.75	1.77	215.50
Colonial ties	1=yes, 0=no	40,426	0.03	0.18	0	1
Common language	1=yes, 0=no	40,426	0.14	0.34	0	1
Contiguity	1=yes, 0=no	40,426	0.04	0.19	0	1
Landlockness (exp)	1=yes, 0=no	40,426	0.13	0.34	0	1
Landlockness (imp)	1=yes, 0=no	40,426	0.14	0.35	0	1
Non-tariff measures	Number of cases	40,426	0.15	0.63	0	22
Quality of ports (exp)	Score 1-7	40,426	4.55	1.22	1.10	6.90
Quality of ports (imp)	Score 1-7	40,426	4.39	1.27	1.10	6.90
Exchange rate (exp)	Percentage (%)	40,426	100.79	10.62	63.62	161.81
Regional trade agrmt	1=yes, 0=no	40,426	0.24	0.43	0	1
Same country	1=yes, 0=no	40,426	0.02	0.13	0	1
Tariff rate (weighed)	Percentage (%)	40,426	7.00	6.89	0	59.89
WTO (both countries)	1=yes, 0=no	40,426	0.91	0.29	0	1
WTO member (exp)	1=yes, 0=no	40,426	0.95	0.22	0	1
WTO member (imp)	1=yes, 0=no	40,426	0.95	0.21	0	1

Figure 6-1 shows that exports of raw steel had similar patterns with those of articles of steel. However, I observe a more significant drop for raw steel exports in 2008-2009 caused by the economic downturn. I treat both codes separately, assuming that production of steel articles such as pipes and bridges might be more complex, technology wise. Thus, exports of processed steel may receive estimates different from those of exports of raw steel.

Figure 6-1: Exports of Raw Steel Versus Articles of Steel (means), 2000-2012



Following Baldwin and Taglioni (2006), De Benedictis and Taglioni (2011), UNCTAD (2012), and Shepherd (2013), I do not deflate trade flows but use their nominal values instead. These studies suggest that use of the U.S. price index to deflate trade values in pooled data may produce misleading results. These papers claim that time and country fixed effects should capture varying price terms. A similar approach is also applied towards data on GDPs.

ICT Variables

The economic literature suggests a number of options to proxy for ICT development. For example, Freund and Weinhold (2002, 2004) employ the number of Internet web-hosts registered in a country, which today may be replaced with more appropriate variables such as the number of fixed broadband subscriptions per 100 citizens. A cross-section model in Yushkova (2014) utilizes the extent of business Internet use reported by the World Economic Forum (WEF) reports. While Mattes et al. (2012) exploit a composite ICT Development Index (IDI) reported by the International Telecommunication Union (ITU), the studies by Thiemann et al. (2012) and Chung et al. (2013) choose disaggregated ICT variables such as Internet penetration and the number of mobile and landline connections. Below I analyze potential variables with the ultimate goal to use different kinds of ICT over the longest period and for as many countries as possible.

The Global Enabling Trade Report of the World Economic Forum attempts to measure "*the extent to which individual economies have developed institutions, policies, and services facilitating the free flow of goods over borders and to destination*" (Lawrence et al., 2012, p.6). The ICT variables listed in the report cover the Internet, mobile and landline connectivity. Accordingly, I choose to employ statistics on broadband Internet subscribers per 100 population, telephone lines per 100 population, and mobile telephone subscribers per 100 population. The advantage of using these three variables is the possibility to get separate estimates of their impact on trade. Data on these variables are obtained from the ITU database for 220+ countries over the period of 2000-2012.

As Figures 6-2 and 6-3 illustrate, besides the economic downturn of 2008-2009, some of the chosen ICT variables demonstrated similar growth patterns with those of trade in steel.

Figure 6-2: Exports of Steel Versus Mobile Phone Proliferation (means), 2000-2012

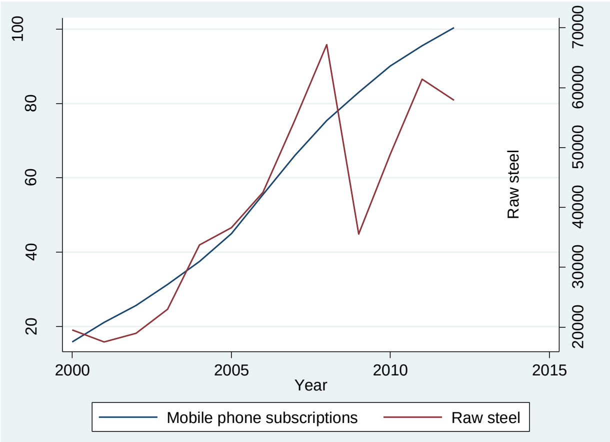
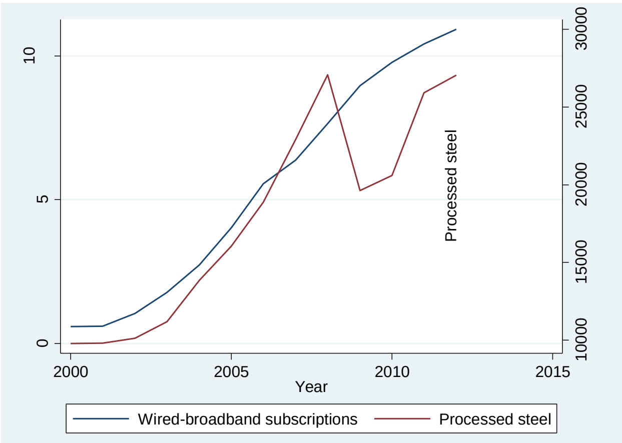


Figure 6-3: Exports of Articles of Steel Versus Broadband Proliferation (means), 2000-2012



Because trade in steel is usually carried out in offices with fixed broadband connection, I refrain from using variables percentage of individuals using Internet and Internet users per 100 population that are also available at ITU database. These variables cannot represent a steel company's workplace as they may include those using free public Wi-Fi on mobile devices which is not typically used by a sales team. The data on Internet use by business are only available since 2005. In addition to the variables discussed above, the composite ICT Development Index (IDI) employed in Mattes et al. (2012) includes international Internet bandwidth, percentage of households with computer and Internet access, mobile broadband, and level of education and computer literacy. However, this index would not allow estimates on different ICTs but rather provide a single coefficient for ICT infrastructure. Another drawback of IDI is that the index is reported only for 2002, 2007-2008, and 2010-2012.

Country-Specific and Dummy Variables

Most of the papers reviewed in the literature section employ GDP as a measurement of country's economic mass. The conventional source for data on GDP is the World Bank's World Development Indicators database (WDI). While some researchers also include population and GDP per capita variables as additional measurements of economic mass, I refrain from doing so. Due to the use of time-variant country fixed effects in some of the specifications, economic mass variables will eventually drop out. Instead, I include a set of variables of high importance to the steel trade such as quality of ports, tariffs, exchange rate volatility, and non-tariff measures.

The quality of port infrastructure is extracted from the WEF Global Competitiveness Report and "*measures business executives' perception of their country's port facilities*" (WDI, 2012). The variable's values lie on a scale between 1 (poor infrastructure) and 7 (very efficient). For landlocked countries, the variable shows how accessible are port facilities in neighboring countries. Values are ranged from 1 (extremely inaccessible) to 7 (highly accessible). In addition, using the CIA World Fact Book (CIA, 2014) I construct a dummy variable for landlocked countries which gets unity value when country has no access to ports and zero otherwise.

The steel trade is subject to frequent trade disputes which entail changes in tariff rates and imposition of trade protection measures (Blonigen et al., 2013). Data on tariffs for both steel and articles of steel products come from the TRAINS database. I choose to use applied import-weighted tariff rates over simple average. While simple average gives the same values for all imported goods regardless how much was imported, the use of the weighted average can partially fix this bias by accounting for the structure of imports (UNCTAD, 2012). Non-tariff measures (NTM) refer to a cumulative number of countervailing, antidumping, and safeguard duties imposed by an importer against an exporter. This variable aims to account for trade protection barriers as a form of both bilateral and multilateral resistance and is constructed by author using the WTO Integrated Trade Intelligence Portal (WTO, 2014). To handle the problem of zero-value observations in both tariffs and NTMs, I add unity to both variables which allows transforming larger amount of observations into the log-form.

As currency volatility may affect a country's trade performance, the real value of a country's currency must be accounted for. To retrieve data on real effective exchange rates (REER), I use a REER database for 178 countries maintained by Bruegel, a European think tank (Darvas, 2012). Data on participation in the free-trade agreements (FTA) is obtained from de Sousa, J. (2012), who maintains an RTA database for 199 countries over the period 1958-2014.

Finally, the CEPII gravity dataset of the French Research Center in International Economics (Head et al., 2010) serves as a primary source for the set of traditional dummy variables for common language, geographical border, colonial ties, and for the indicator reporting history of being the same country. Additionally, I use the CEPII distance database (Mayer and Zignago, 2011) to obtain bilateral distances. I also use data from the WTO web-site to assign a membership status to the countries included in the sample, including mutual WTO membership dummy.

Chapter 7 Estimation Results

Tables 7-1, 7-2, and 7-3 below report regression outputs of the total trade sample, steel sample, and articles of steel respectively. In all tables, column (1) presents OLS results for the standard gravity specification with no ICT variables included (Eq. 4). Column (2) reports OLS estimation results for the model augmented with ICT variables and a set of dummies and country-specific variables (Eq. 5). Columns (3)-(4) include OLS regression estimates where year dummies and countries' individual fixed effects are included (Eq. 6). Column (5) presents results for the OLS specification with time-varying country fixed effects (Eq. 7). Lastly, column (6) reports OLS estimates for the model augmented with both bilateral and country-by-time fixed effects (Eq. 8). The regression tables are followed by 3-digit the sub-tables (7-1-1, 7-2-1, and 7-3-1), which report marginal effects of individual ICT variables obtained in specifications (2)-(4).

Even though I discuss the results obtained in all six specifications across three samples, I typically interpret coefficients from the specifications that include all possible unobserved fixed effects (columns 4-6), unless otherwise stated. Because I employ log-liner models, all of the coefficients, with the exception of dummies, can easily be interpreted as a percentage change in respective export flow caused by percentage change in an independent variable. The results are laid out in the following order: I begin with traditional gravity parameters – economic mass and distance, and then continue with country-specific and dummy variables; finally, I report the results on the impacts of three ICT variables, namely the Internet, mobile phones, and fixed-telephones.

Table 7-1: Regression Output – Total Trade

VARIABLES	(1) Basic	(2) +ICT	(3) Yr FE	(4) Cn&Yr FE	(5) Cn*Yr FE	(6) Pair&Cn*Yr FE
ln (GDP_exp*GDP_imp)	1.071***	1.043***	1.039***	0.595***		
	(0.00598)	(0.00656)	(0.00656)	(0.0384)		
ln (Distance)	-1.111***	-1.192***	-1.186***	-1.641***	-1.640***	
	(0.0257)	(0.0262)	(0.0261)	(0.0279)	(0.0102)	
ln (Internet, exp)		**0.0880*** **	**0.151*** **	**0.0679*** **		
		(0.0113)	(0.0131)	(0.00980)		
ln (Internet, imp)		-0.0556***	-0.00405	0.00852		
		(0.0109)	(0.0119)	(0.00897)		
Internet interaction		-0.00745**	-0.00184	-0.00512*	-0.00571***	**0.00607*** **
		(0.00299)	(0.00313)	(0.00293)	(0.00173)	(0.00223)
ln (Mobile phones, exp)		-0.577***	-0.530***	0.0393		
		(0.0819)	(0.0832)	(0.0695)		
ln (Mobile phones, imp)		-0.453***	-0.443***	-0.00546		
		(0.0857)	(0.0873)	(0.0724)		
Mobile phones interaction		**0.0700*** **	**0.0907*** **	-0.000109	0.0165	0.00558
		(0.0204)	(0.0211)	(0.0178)	(0.0125)	(0.0132)
ln (Fixed phones, exp)		**0.190*** **	**0.0860** **	-0.0409		
		(0.0337)	(0.0350)	(0.0459)		
ln (Fixed phones, imp)		-0.00343	-0.0722**	-0.00956		
		(0.0358)	(0.0360)	(0.0461)		
Fixed phones interaction		**0.0320*** **	0.00843	0.00320	0.00249	-0.0216
		(0.0107)	(0.0111)	(0.0106)	(0.00533)	(0.0153)
Contiguity	0.816***	0.931***	0.937***	0.252*	0.253***	
	(0.122)	(0.134)	(0.135)	(0.147)	(0.0397)	
Common language	0.934***	0.929***	0.945***	0.893***	0.894***	
	(0.0513)	(0.0502)	(0.0503)	(0.0527)	(0.0199)	
Colonial ties	0.614***	0.488***	0.491***	0.772***	0.759***	
	(0.116)	(0.122)	(0.122)	(0.137)	(0.0430)	
Same country	1.230***	1.238***	1.241***	0.991***	0.974***	
	(0.177)	(0.180)	(0.184)	(0.207)	(0.0557)	
Regional trade agrmt	0.659***	0.476***	0.451***	0.453***	0.470***	-0.109***
	(0.0454)	(0.0481)	(0.0482)	(0.0475)	(0.0196)	(0.0323)
Exchange rate (exp)		-1.007***	-0.792***	-0.433***		
		(0.110)	(0.109)	(0.0824)		
WTO membership (exp)		0.388**	0.285	-0.488***		
		(0.193)	(0.196)	(0.169)		
WTO membership (imp)		-0.339*	-0.421**	-0.487***		
		(0.197)	(0.200)	(0.173)		
WTO mutual membership		0.626***	0.597***	0.612***	0.632***	-0.179
		(0.204)	(0.207)	(0.172)	(0.0643)	(0.148)
Landlockness (exp)		-0.173***	-0.151***			
		(0.0416)	(0.0413)			
Landlockness (imp)		-0.689***	-0.663***			
		(0.0418)	(0.0420)			
Constant	-35.58***	-26.99***	-26.55***	-7.841***	20.55***	5.379***
	(0.380)	(0.749)	(0.759)	(1.744)	(0.224)	(0.620)
Observations	127,553	127,553	127,553	127,553	127,553	127,553
R-squared	0.639	0.663	0.664	0.767	0.774	0.893

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7-1-1: Marginal Effects of ICT Variables - Total Trade

Column (2):

ICT VARIABLES	dy/dx	Std. Err.	t	P>t	[95% Conf. Interval]	
ln (Internet, exp)	**0.085**	0.011	7.62	0	0.063	0.107
ln (Internet, imp)	-0.061	0.010	-5.92	0	-0.081	-0.041
ln (Mobile phones, exp)	-0.291	0.029	-10.11	0	-0.347	-0.235
ln (Mobile phones, imp)	-0.159	0.023	-6.97	0	-0.204	-0.114
ln (Fixed phones, exp)	**0.276**	0.020	13.69	0	0.236	0.315
ln (Fixed phones, imp)	**0.089**	0.016	5.56	0	0.058	0.120

Column (3):

ICT VARIABLES	dy/dx	Std. Err.	t	P>t	[95% Conf. Interval]	
ln (Internet, exp)	**0.150**	0.013	11.45	0	0.125	0.176
ln (Internet, imp)	-0.005	0.012	-0.47	0.641	-0.028	0.017
ln (Mobile phones, exp)	-0.158	0.033	-4.85	0	-0.223	-0.094
ln (Mobile phones, imp)	-0.062	0.026	-2.38	0.018	-0.113	-0.011
ln (Fixed phones, exp)	**0.109**	0.026	4.22	0	0.058	0.159
ln (Fixed phones, imp)	-0.048	0.020	-2.42	0.016	-0.087	-0.009

Column (4):

ICT VARIABLES	dy/dx	Std. Err.	t	P>t	[95% Conf. Interval]	
ln (Internet, exp)	**0.066**	0.010	6.61	0	0.046	0.086
ln (Internet, imp)	0.005	0.009	0.51	0.61	-0.013	0.023
ln (Mobile phones, exp)	0.039	0.026	1.52	0.129	-0.011	0.089
ln (Mobile phones, imp)	-0.006	0.022	-0.27	0.783	-0.048	0.036
ln (Fixed phones, exp)	-0.032	0.034	-0.96	0.338	-0.098	0.034
ln (Fixed phones, imp)	0.000	0.032	-0.01	0.992	-0.063	0.062

Table 7-2: Regression Output – Steel

VARIABLES	(1) Basic	(2) +ICT	(3) Yr FE	(4) Cn&Yr FE	(5) Cn*Yr FE	(6) Pair&Cn*Yr FE
ln (GDP_exp*GDP_imp)	0.821***	0.861***	0.867***	0.666***		
	(0.0159)	(0.0191)	(0.0193)	(0.105)		
ln (Distance)	-1.046***	-1.144***	-1.147***	-1.706***	-1.727***	
	(0.0580)	(0.0590)	(0.0590)	(0.0598)	(0.0267)	
ln (Internet, exp)		0.0185	0.0291	-0.0372		
		(0.0309)	(0.0365)	(0.0280)		
ln (Internet, imp)		-0.0860***	-0.0851***	0.00518		
		(0.0290)	(0.0313)	(0.0257)		
Internet interaction		**0.0180****	**0.0279*****	**0.0204*****	**0.0326*****	-0.00924
		(0.00787)	(0.00856)	(0.00712)	(0.00576)	(0.00685)
ln (Mobile phones, exp)		0.232	0.0481	**0.741*****		
		(0.226)	(0.230)	(0.192)		
ln (Mobile phones, imp)		0.0735	-0.0956	**0.882*****		
		(0.243)	(0.248)	(0.201)		
Mobile phones interaction		-0.0518	0.0212	-0.172***	-0.158***	-0.0551
		(0.0575)	(0.0589)	(0.0478)	(0.0387)	(0.0456)
ln (Fixed phones, exp)		-0.637***	-0.613***	-0.716***		
		(0.109)	(0.109)	(0.148)		
ln (Fixed phones, imp)		-0.699***	-0.665***	-0.842***		
		(0.119)	(0.117)	(0.137)		
Fixed phones interaction		**0.189*****	**0.150*****	**0.227*****	**0.189*****	0.0861
		(0.0338)	(0.0356)	(0.0279)	(0.0210)	(0.0686)
Contiguity	1.704***	1.312***	1.314***	0.823***	0.811***	
	(0.148)	(0.155)	(0.155)	(0.158)	(0.0729)	
Common language	0.00773	-0.132	-0.135	0.294***	0.290***	
	(0.111)	(0.110)	(0.110)	(0.100)	(0.0489)	
Colonial ties	0.281*	0.411**	0.422**	0.811***	0.825***	
	(0.170)	(0.168)	(0.167)	(0.136)	(0.0722)	
Same country	0.733***	0.596**	0.616**	0.934***	0.966***	
	(0.263)	(0.265)	(0.268)	(0.254)	(0.105)	
Regional trade agrmt	0.101	0.143	0.133	0.485***	0.477***	-0.00854
	(0.110)	(0.110)	(0.109)	(0.0880)	(0.0449)	(0.0866)
Exchange rate (exp)		-2.777***	-2.720***	-1.179***		
		(0.267)	(0.268)	(0.228)		
WTO membership (exp)		-2.746***	-2.711***	-0.708*		
		(0.469)	(0.466)	(0.382)		
WTO membership (imp)		-1.147**	-1.169**	-0.637*		
		(0.481)	(0.476)	(0.385)		
WTO mutual membership		1.805***	1.774***	1.165***	1.104***	0.426
		(0.493)	(0.489)	(0.371)	(0.306)	(0.481)
Landlockness (exp)		-0.00359	0.00209			
		(0.105)	(0.105)			
Landlockness (imp)		-0.866***	-0.824***			
		(0.106)	(0.106)			
Non-tariff measures		0.699***	0.761***	0.291**	0.288**	0.326**
		(0.129)	(0.131)	(0.115)	(0.131)	(0.129)
Tariff rate (weighed)		0.197***	0.198***	-0.0723*		
		(0.0357)	(0.0361)	(0.0371)		
Quality of ports (exp)		-0.309**	-0.298**	0.594***		
		(0.145)	(0.149)	(0.183)		
Quality of ports (imp)		0.119	0.139	0.0465		
		(0.131)	(0.133)	(0.160)		
Constant	-26.96***	-11.24***	-11.31***	-13.28***	-74.69***	7.896***
	(0.844)	(1.862)	(1.928)	(4.367)	(13.88)	(1.311)
Observations	29,499	29,499	29,499	29,499	29,499	29,499
R-squared	0.307	0.351	0.354	0.595	0.628	0.818

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7-2-1: Marginal Effects of ICT Variables –Steel

Column (2):

ICT VARIABLES	dy/dx	Std. Err.	t	P>t	[95% Conf. Interval]	
ln (Internet, exp)	0.035	0.032	1.11	0.267	-0.027	0.097
ln (Internet, imp)	-0.062	0.027	-2.29	0.022	-0.116	-0.009
ln (Mobile phones, exp)	0.014	0.076	0.18	0.853	-0.134	0.162
ln (Mobile phones, imp)	-0.148	0.063	-2.35	0.019	-0.271	-0.025
ln (Fixed phones, exp)	-0.063	0.060	-1.05	0.295	-0.180	0.055
ln (Fixed phones, imp)	-0.086	0.049	-1.75	0.08	-0.182	0.010

Column (3):

ICT VARIABLES	dy/dx	Std. Err.	t	P>t	[95% Conf. Interval]	
ln (Internet, exp)	0.055	0.038	1.43	0.153	-0.020	0.130
ln (Internet, imp)	-0.048	0.031	-1.54	0.124	-0.110	0.013
ln (Mobile phones, exp)	**0.137**	0.082	1.67	0.096	-0.024	0.299
ln (Mobile phones, imp)	-0.005	0.074	-0.07	0.948	-0.150	0.140
ln (Fixed phones, exp)	-0.156	0.076	-2.06	0.04	-0.304	-0.007
ln (Fixed phones, imp)	-0.177	0.064	-2.75	0.006	-0.303	-0.051

Column (4):

ICT VARIABLES	dy/dx	Std. Err.	t	P>t	[95% Conf. Interval]	
ln (Internet, exp)	-0.018	0.029	-0.64	0.525	-0.075	0.038
ln (Internet, imp)	0.032	0.027	1.2	0.229	-0.020	0.084
ln (Mobile phones, exp)	0.019	0.071	0.27	0.785	-0.121	0.159
ln (Mobile phones, imp)	**0.148**	0.068	2.17	0.030	0.014	0.283
ln (Fixed phones, exp)	-0.025	0.119	-0.21	0.830	-0.258	0.207
ln (Fixed phones, imp)	-0.105	0.100	-1.05	0.296	-0.302	0.092

Table 7-3: Regression Output – Articles of Steel

VARIABLES	(1) Basic	(2) +ICT	(3) Yr FE	(4) Cn&Yr FE	(5) Cn*Yr FE	(6) Pair&Cn*Yr FE
ln (GDP_exp*GDP_imp)	1.025***	1.033***	1.034***	0.744***		
	(0.0116)	(0.0138)	(0.0138)	(0.0804)		
ln (Distance)	-1.271***	-1.422***	-1.424***	-1.959***	-1.959***	
	(0.0409)	(0.0415)	(0.0412)	(0.0479)	(0.0217)	
ln (Internet, exp)		**0.198*** **	**0.304*** **	**0.0481** **		
		(0.0232)	(0.0267)	(0.0203)		
ln (Internet, imp)		-0.300***	-0.216***	0.0108		
		(0.0239)	(0.0258)	(0.0203)		
Internet interaction		**0.0480*** **	**0.0600*** **	**0.0366*** **	**0.0441*** **	**0.0144*** **
		(0.00579)	(0.00604)	(0.00572)	(0.00437)	(0.00545)
ln (Mobile phones, exp)		-0.154	-0.323*	**0.338** **		
		(0.179)	(0.182)	(0.167)		
ln (Mobile phones, imp)		**0.586*** **	**0.441** **	**0.566*** **		
		(0.195)	(0.199)	(0.172)		
Mobile phones interaction		-0.112**	-0.0149	-0.0875**	-0.0674**	0.0520
		(0.0449)	(0.0465)	(0.0411)	(0.0311)	(0.0372)
ln (Fixed phones, exp)		-0.0259	-0.171**	-0.275**		
		(0.0786)	(0.0799)	(0.111)		
ln (Fixed phones, imp)		-0.386***	-0.503***	-0.489***		
		(0.0891)	(0.0887)	(0.113)		
Fixed phones interaction		**0.0884*** **	0.0357	**0.0562** **	**0.0314** **	-0.0276
		(0.0244)	(0.0252)	(0.0226)	(0.0152)	(0.0498)
Contiguity	1.216***	1.084***	1.073***	0.641***	0.673***	
	(0.139)	(0.155)	(0.153)	(0.174)	(0.0649)	
Common language	0.696***	0.581***	0.604***	1.031***	1.022***	
	(0.0797)	(0.0835)	(0.0829)	(0.0865)	(0.0390)	
Colonial ties	0.267*	0.421***	0.422***	0.680***	0.681***	
	(0.141)	(0.149)	(0.146)	(0.140)	(0.0636)	
Same country	1.016***	1.134***	1.133***	1.073***	1.075***	
	(0.235)	(0.267)	(0.269)	(0.257)	0.673***	
Regional trade agrmt	0.297***	0.218***	0.190***	0.305***	0.309***	-0.0464
	(0.0725)	(0.0740)	(0.0734)	(0.0739)	(0.0365)	(0.0716)
Exchange rate (exp)		-2.248***	-1.912***	-0.947***		
		(0.210)	(0.206)	(0.173)		
WTO membership (exp)		-0.684	-0.820**	-2.316***		
		(0.424)	(0.416)	(0.434)		
WTO membership (imp)		-1.978***	-2.092***	-2.331***		
		(0.431)	(0.424)	(0.433)		
WTO mutual membership		1.928***	1.875***	2.132***	2.116***	0.131
		(0.444)	(0.437)	(0.431)	(0.222)	(0.416)
Landlockness (exp)		0.0247	0.0176			
		(0.0777)	(0.0765)			
Landlockness (imp)		-0.559***	-0.520***			
		(0.0800)	(0.0804)			
Non-tariff measures		0.618***	0.691***	0.375***	0.473***	-0.186**
		(0.102)	(0.102)	(0.0892)	(0.0654)	(0.0733)
Tariff rate (weighed)		0.00336	0.00400	-0.107***		
		(0.0346)	(0.0344)	(0.0382)		
Quality of ports (exp)		0.422***	0.335***	0.249*		
		(0.113)	(0.113)	(0.141)		
Quality of ports (imp)		0.485***	0.397***	0.0855		
		(0.104)	(0.105)	(0.112)		
Constant	-36.38***	-25.07***	-24.46***	-15.31***	-76.58***	1.380
	(0.614)	(1.518)	(1.548)	(3.410)	(12.53)	(1.009)
Observations	40,426	40,426	40,426	40,426	40,426	40,426
R-squared	0.436	0.506	0.511	0.692	0.709	0.855

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Tables 7-3-1: Marginal Effects of ICT Variables – Articles of Steel

Column (2):

ICT VARIABLES	dy/dx	Std. Err.	t	P>t	[95% Conf. Interval]	
ln (Internet, exp)	**0.236**	0.023	10.110	0	0.190	0.282
ln (Internet, imp)	-0.239	0.022	-10.840	0	-0.283	-0.196
ln (Mobile phones, exp)	-0.624	0.061	-10.240	0	-0.744	-0.505
ln (Mobile phones, imp)	**0.104**	0.051	2.040	0.042	0.004	0.205
ln (Fixed phones, exp)	**0.236**	0.047	5.010	0	0.143	0.328
ln (Fixed phones, imp)	-0.104	0.036	-2.860	0.004	-0.175	-0.033

Column (3):

ICT VARIABLES	dy/dx	Std. Err.	t	P>t	[95% Conf. Interval]	
ln (Internet, exp)	**0.352**	0.027	12.9	0	0.298	0.405
ln (Internet, imp)	-0.140	0.025	-5.61	0	-0.188	-0.091
ln (Mobile phones, exp)	-0.386	0.067	-5.77	0	-0.517	-0.255
ln (Mobile phones, imp)	**0.377**	0.058	6.46	0	0.262	0.491
ln (Fixed phones, exp)	-0.066	0.056	-1.17	0.241	-0.176	0.044
ln (Fixed phones, imp)	-0.389	0.046	-8.51	0	-0.478	-0.299

Column (4):

ICT VARIABLES	dy/dx	Std. Err.	t	P>t	[95% Conf. Interval]	
ln (Internet, exp)	**0.078**	0.021	3.65	0	0.036	0.119
ln (Internet, imp)	**0.057**	0.021	2.77	0.006	0.017	0.098
ln (Mobile phones, exp)	-0.030	0.053	-0.56	0.574	-0.133	0.074
ln (Mobile phones, imp)	**0.191**	0.053	3.63	0	0.088	0.294
ln (Fixed phones, exp)	-0.108	0.084	-1.3	0.195	-0.273	0.056
ln (Fixed phones, imp)	-0.310	0.079	-3.93	0	-0.465	-0.155

Economic Mass and Distance

As expected, economy size of both trade partners predict higher volumes of trade in all samples. The obtained coefficients on countries' GDPs are traditionally close to unity across specifications (1-3), which implies that on average a 1 percent increase in the product of economic masses leads to a 1 percent increase in exports. Accordingly, one may assume that the volume of trade between the United Kingdom and France, which are comparable in terms of GDP, will be higher than that between France and Bulgaria. The coefficients on GDPs fall in all samples when time-variant country fixed effects are applied (column 4). For the total trade sample, log of GDP has coefficients between 0.6 and 1.07. The steel sample yields coefficients on economic mass below unity, ranging between 0.67 and 0.87. GDP coefficients in the articles of steel sample vary from 0.74 to 1.03. I observe slightly higher impacts of GDP coefficients on steel exports as compared with total exports, and even higher magnitude of economic mass on exports of articles of steel. In Yushkova (2014), GDP coefficients also received higher values in high-tech, medium-low tech, and medium-low technology group, in which the steel industry falls, but not in low-technology group. It can be assumed, that countries with higher GDPs require more capital and intermediate goods, such as drilling pipe or railways, to cover their infrastructure needs. Also, larger economies on average have more diversified economies and thus export more complex goods rather than low-technology products, such as food or textiles (Hausmann and Hidalgo et al., 2011).[47]

Distance remains a critical impediment for trade. In all samples, I observe statistically significant negative coefficients on distance close to traditional estimates of -1; which can be interpreted as 1 a percent decrease in exports, when distance between two countries rises by 1 percent. Notably, inclusion of both ICT variables and especially various fixed effects makes

[47] See the rankings of economic complexity (Hausmann, 2011). Available at http://www.atlas.cid.harvard.edu/rankings/

distance coefficients rise, contrary to the findings of Lendle at al. (2011) who report that ICT reduces the effect of geographical distance. Though, similar effects of ICT on distance were also observed in Mattes et al. (2012). The results underline the importance of distance for trade and create room for discussion whether the effect of distance varies among countries with respect to the level of ICT development.

Country-Specific and Dummy Variables

Some of the traditional dummy variables broadly used in gravity models, namely common border, colonial ties, and mutual experience of being the same country, receive positive coefficients in all specifications across three samples. When ICT variables are included (column 2), I clearly observe a decrease in contiguity coefficients in both steel samples as compared with a slight increase of those coefficients in the total trade sample. Overall, common border has a more significant impact on steel exports. When country-and-time effects are included (column 5), a change of contiguity dummy from 0 to 1 predicts an increase in exports by 29 percent for total exports, 96 percent for articles of steel, and 125 percent for steel. Besides possible similarities of technology standards in both neighboring countries, some features of the steel industry can help explain that difference in estimates. Because steel products are usually both heavy and massive, transportation requires having either direct access to ports or a developed system of railways. Bulk transportation by trucks or air is less efficient. The shortest destination for a steel exporter would be a neighboring country, which most likely has similar if not the same system of railroads.

Similar to contiguity, coefficients on colonial ties and mutual experience of being the same country suggest significant impacts on volume of trade. If two trade partners have ever been in colonial relationships, the volume of exports rises by 98-128 percent on average.

Interestingly, today colonial relationship may take a reverse form: Indian Tata Steel owns assets of British Steel Corporation, the largest steel manufacturer in the United Kingdom. A dummy variable for being a single country in the past gets even higher estimates: on average, exports to a "sister" country rise by 163-165 percent. The highest value of 193 percent increase is obtained for exports of articles of steel. It might be assumed that those "sister" countries may have similar, if not identical, technology standards, systems of water supply, gas pipelines, railroads, bridges etc. Therefore, local consumers in a "sister" country tend to choose familiar products from familiar suppliers.

Coefficients on common language and mutual participation in FTAs are less consistent. Predictably, common official language has positive coefficients among all samples. Even though, coefficients on language turn out to be insignificant in specifications 1-3 of the steel sample, those get significant values of 0.29, when I include fixed effects. Overall, language appears to have a higher impact on total exports (0.89), and even larger impact on exports of articles of steel (1.02). Surprisingly, when both country-by-time and country pair fixed effects are applied (column 6), coefficients on mutual participation in FTAs turn negative (-0.11) in the total trade sample and insignificant in two steel samples. Though, specifications (1)-(5) range in impact of FTA between 0.19 and 0.66. Noteworthy, if total trade and the articles of steel samples contain only one insignificant coefficient, the raw steel sample yields insignificant FTA coefficients in four specifications out of six. To check whether multilateral trade unions have similar effect on exports, I further unfold the estimates on individual (both exporter's and importer's) and mutual membership in WTO.

Unexpectedly, individual participation in WTO of both exporter and importer receives negative estimates. When I include country and year dummies, WTO membership status predicts

39 percent fewer exports in the total trade sample, from 47 to 51 percent drop in trade value in raw steel, and around 90 percent fall in exports of processed steel. It can be assumed that the impact of individual WTO participation is partly captured in the mutual WTO membership dummy. Though, when country-and-time dummies applied together with country pair fixed effects, coefficients on mutual WTO membership lose statistical significance in all samples.

I close up the discussion on dummy variables with the finding that landlockness has no particular impact on exporters in either steel sample. Though, it receives negative coefficients for importers (-0.82; -0.52). In total trade, change of this dummy from base value 0 to 1 leads to almost 14 percent lower value in total exports, and to 48 percent fall in total imports. In the real world, landlockness effect may be mitigated if a country has easy access to ports in neighboring countries. Good examples of that are Austria and Czech Republic, whose exports of steel and its articles in 2012 were higher in nominal values than of Romania and Bulgaria – countries with a coastline. It should be noted that many steel manufacturers are located not in a close proximity to water, therefore transportation of heavy steel products to ports might be carried out by railway or trucks. That is, mills often have to use at least two means of transportation to deliver their products regardless if a home country is landlocked or not.

Maritime transport is one of the major transportation tools for international shipments of steel and its articles. There are several reasons for that: (i) price of shipping by marine vessel per metric ton may be ten times cheaper as that by airfreight; (ii) marine transport has a comparative advantage against railway because railroads are limited by continent boundaries; and (iii) marine vessels can transport significant tonnage and by doing so increase returns to scale. To see whether quality of ports or ease of getting to the ports to landlocked countries has a significant effect on trade performance, I present estimation results on quality of ports infrastructure. In steel, quality of ports is only significant for exporters – a 10 percent increase in the ports index on average causes a 6 percent increase in steel exports. In articles of steel, the ports index improvement by 10 percent increases exports only by 2.5 percent. At the same time, an importer's quality of ports improvement of 10 percent predicts 0.9 percent higher imports of articles of steel. Thus, the importance of quality of ports for exporters is confirmed in both steel samples. Indeed, ports infrastructure basically determines how accessible ports are for other transportation means, how advanced storage yards are, whether cranes prevent cargo damages, and eventually how fast cargo will be loaded on board and shipped to customers.

Tariffs imposed by importers over the sample period were an import-barrier for both steel and its articles. Raising tariffs on HS72 code (steel) by 1 percent reduces volume of exports to importing countries by 0.07 percent on average. Exports of articles of steel shrinks even more – on average by 0.1 percent, when tariffs on HS73 code rose by 1 percent. Interestingly, in steel a cumulative number of NTMs imposed by importers received positive coefficients in all specifications. Column (6) finds that an increase in the number of NTMs leads to a higher volume of trade in steel by 0.33 percent. Notably, the largest amount of NTMs in the steel sample was imposed against China – 36, though Chinese exports continue to rise. A positive value of the NTM coefficient in steel might be caused by reverse causality, that is, NTMs were imposed by importers that had recently faced dramatic increases of imports from a certain country. Recent examples include U.S. antidumping duties against Chinese steel producers and producers of oil country tubular goods from 9 developing countries.[48] Similarly, positive coefficients on NTMs are observed in articles of steel in columns (2)-(5), however in column (6) NTM coefficient turns negative (-0.19), which implies the presence of positive unobserved

[48] US Trade Commission: http://www.usitc.gov/trade_remedy/731_ad_701_cvd/investigations/2014/welded_stainless_steel_pressure_pipe_from_china/reviewphase.htm; or http://www.usitc.gov/trade_remedy/731_ad_701_cvd/investigations/2013/octg/prelimphase.htm

bilateral bias. That is, bilateral fixed effects may have accounted for unobserved factors, such as bilateral trade history or trade partner's exchange rates.

As expected, real effective exchange rates (REER) coefficients receive negative values, ranging from -0.43 to -2.77. The specification with country and year fixed effects suggest that 1 percent stronger currency causes a decrease in total exports by 0.43 percent on average. Meanwhile, the same move in currency leads to a 1.2 percent drop in steel exports and 0.95 fall in those of articles of steel. Because those coefficients are higher in both steel samples as compared to total exports, it can be assumed that domestic steel manufacturers might be incentivized in making governments to keep their national currency weak rather than strong. One example from the real world supports this assumption: in the end of 2008, Ukraine's steel manufacturers saluted the devaluation of national currency Hryvnia by 80-90 percent, and as a result mitigated the effect of decreased demand in steel in 2009 and increased their competitiveness on the global market.

Internet

The number of fixed broadband subscriptions appears to be positively significant for exporters in all specifications in total trade and articles of steel samples. The coefficients on the Internet variable lie between 0.05 and 0.3. On average a 10 percent increase in the number of fixed broadband subscriptions in the exporting country leads to a 0.68 percent increase in total exports and 0.48 percent rise in exports of articles of steel, respectively. The same variable happened to have no effect on imports, giving significant estimates only in basic specifications.

Meanwhile, neither specification yields significant results for the exports of raw steel. There are several possible explanations to why the Internet has no impact on trade in raw steel. First, technological advancements in the industry are somewhat slow, that is, mills can successfully work using technological inventions of the early 20th century. Supposedly, those firms who have cheaper raw materials or low labor cost, not high Internet proliferation, get competitive advantage. Second, products like slabs, billets, ingots, and flat-rolled coils are rather homogenous and often used for further processing. Thus, quality control can supposedly be performed without having extensive information technology software as compared with drilling pipes for hydraulic fracking. Third, these products not only can be purchased from mills, but also on open exchanges,[49] which implies that the path from mill to customer may involve resellers in other countries and the use of transfer pricing schemes.

The most consistent positive effect of the Internet interaction variables of both exporter and importer in all six specifications is observed in articles of steel, confirming the hypothesis of positive influence of ICT network effects on trade (Mattes et al., 2012). The specification with a country-pair and time-varying effects implies that a 10 percent increase in the Internet interaction variable predicts 0.14 percent higher exports of articles of steel. In steel, coefficients on the same interaction variable receive positive values in columns (2)-(5). Though, in the last specification (column 6) the Internet interaction loses its significance, which implies the presence of negative unobserved bilateral bias. That is, bilateral fixed effects may have caught unobserved bilateral factors, such as long-lasting contract relationships, supply chains within multinational steel companies, or transportation costs from country *i* to country *j*. A slightly lower coefficient on the Internet interaction is reported in total trade sample: its 10 percent increase leads to 0.06 percent higher volume of exports. Noteworthy, in total trade the Internet interaction variable becomes positive only in the last specification, when country-pair effects are included. Thus, the

[49] Steel billet futures are traded on the London Metal Exchange, hot rolled coil futures – on the New York Mercantile Exchange (NYMEX), and rebar and wire rod futures on Shanghai Futures Exchange. Source: The Platts Steel Futures Guide, https://www.steelbb.com/steelfutures/

results demonstrate more significant impacts of Internet network effects on articles of steel rather than on total trade, and no particular effect on exports of raw steel.

As Mattes et al. (2012) point out, in the presence of interaction terms, marginal effects of the term's components need to be duly calculated. The marginal effect of the exporter's Internet variable must be evaluated as $\beta_7 + \beta_9 * \ln Internet_j$ (from Eq. 5). The obtained coefficient, thus, reports "*the effect of exporting country i's ICT level on its exports for given levels of destination country j's ICT endowment*" (Mattes et al., 2012, pp.14-15). Calculation of marginal effects gives some insight. The coefficient remains almost the same for the exporter's Internet endowment (0.066) in total trade. Coefficients in steel as reported earlier continue being insignificant. In articles of steel, the marginal effect of the Internet variable for the exporter rises to 0.08 as compared to previous coefficient's value of 0.05. Moreover, the marginal effect of the Internet for the importer is positive at 0.06.

Mobile Phones

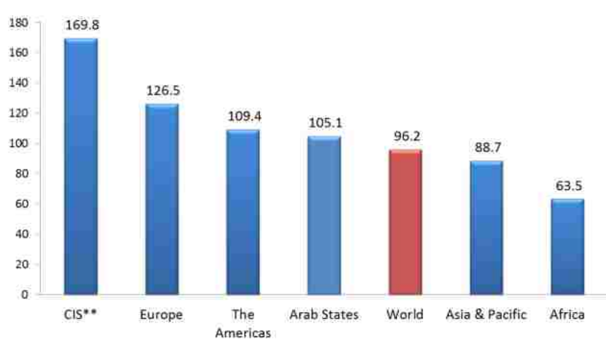
Increases in the number of mobile phone connections, which serves as proxy for mobile connectivity, positively affect exports capabilities of steel exporters. Notably, the estimates in steel are almost twice as high as those in articles of steel. On average a 10 percent increase in mobile usage in the exporting country leads to 7.4 percent more exports of raw steel and a 3.4 percent increase in exports of steel articles. Positive coefficients on mobile phone proliferation are also observed for importing countries. Again, higher values are reported in raw steel. A 10 percent increase in mobile phone use implies 8.9 percent higher imports of steel and a 5.7 increase in consumption of articles of steel. Mobile phone variables appear to be insignificant in total trade, when country and time effects are applied.

Unlike the Internet, network effects are not observed for the use of mobile phones when country-pair and time-varying fixed effects are included. Specifications yield somewhat mixed results with coefficients varying from -0.17 to 0.09. This might be explained by the high cost of international calls and that one would rather call to an office landline phone or would use Internet-supported applications such as Skype or a corporate Voice over Internet Protocol network.

The marginal effects of mobile phone variables are somewhat different from the ordinary coefficients. The marginal effects are insignificant in total trade, reflecting no impact of mobile phone use on total exports. Notably, the marginal effects of mobile connectivity in both steel samples turn insignificant for exporting countries; and those for importing countries become lower. Respectively, marginal effects of mobile phone use on imports get values of 0.15 in the steel sample and 0.19 in the articles of steel sample.

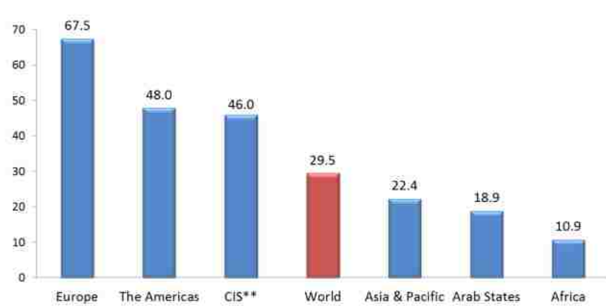
There are a couple of observations with respect to the results obtained. As Figure 7-1 reports, the highest number of mobile-cellular subscriptions was observed in the Commonwealth of Independent States (CIS). In fact, citizens in CIS countries would carry two or more sim-cards of different carriers because they are cheap (approximately 5 USD/each) and fixed-contracts are very uncommon in the region.

Figure 7-1: Mobile-cellular Subscriptions per 100 Inhabitants, 2013



Source: ITU World Telecommunication /ICT Indicators database

Figure 7-2: Active Mobile-broadband Subscriptions per 100 Inhabitants, 2013



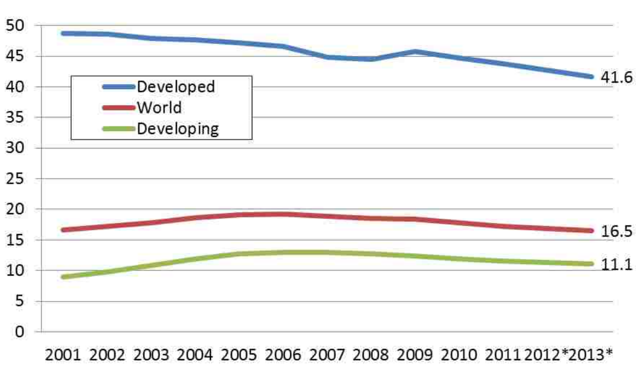
Source: ITU World Telecommunication /ICT Indicators database

Another insight can be seen in Figure 7-2, which depicts active mobile-broadband subscriptions per 100 inhabitants. CIS countries slide down to the third place after Europe and the Americas. That could imply that the number of mobile-cellular subscriptions does not account for capabilities that mobile phones can have. There is a big difference between basic cellular phone and a smartphone with Internet access in terms of productivity features. Therefore, when statistics on mobile-broadband will be available, it would be worthwhile to replace the basic number of cellular subscriptions by the number of active mobile-broadband subscriptions.

Fixed Phones

The number of fixed landline phones has negative coefficients in both steel samples and no particular impacts on total exports. However, it does not necessarily mean that higher level of fixed-telephone subscriptions reduces trade due to the presence of the interaction variable. While landline marginal effects were expected to be insignificant in the total trade sample, those turn insignificant in the steel sample. The only significant value of landline marginal effects is obtained for importers of articles of steel. Accordingly, marginal effects for importers receive a value of -0.31, somewhat lower than the ordinary importer's coefficient of -0.5.

Figure 7-3 Fixed-telephone Subscriptions per 100 Inhabitants, 2001-2013



Source: ITU, 2014

Unlike mixed coefficients on mobile phone interaction variables, I observe only positive values on networks effects in fixed phones in both steel samples; however, those lose statistical significance when both country-pair and country-by-time effects are controlled for.

Figure 7-3 depicts fixed phones' development trends over 2001-2013. The level of fixed-phone penetration both in the developed world and globally is lower than in 2001. Not surprisingly, a similar trend has been observed in developing countries.

It can be inferred that fixed phones do not play a critical role in trade anymore, and have eventually been replaced by other communication channels such as emails, mobile connectivity, and Internet-based voice applications. Even fax machines got their Internet-based software substitutes. Though, landlines are still in use by businesses and primarily serve their domestic needs and often are used in combination with email communication.

Robustness Checks

Table 7-4 reports the results of the correlations analysis between ICT variables – the Internet, mobile phones, and fixed phones – in both exporting and importing countries. It appears that all three pairs are highly positively correlated with coefficients ranging from 0.42 to 0.72. Relatively high correlation may be a source of bias in the coefficients.

Table 7-4: Results of the Correlation Analysis[50]

Pair	Total trade sample	Steel sample	Articles of steel sample
Internet – Fixed phones	0.71; 0.72	0.67; 0.68	0.69; 0.69
Internet – Mobile phones	0.63; 0.61	0.58; 0.62	0.59; 0.61
Mobile – Fixed phones	0.49; 0.50	0.40; 0.47	0.42; 0.48

To check the robustness of the results reported earlier in this chapter, I re-run specifications (5) and (6) with the ICT variables included alternately. The regression outputs are reported in Tables 7-5, 7-6, and 7-7. The robustness checks yield identical results on the Internet variable for both the total trade sample and articles of steel. In particular, when both time-varying country effects and bilateral fixed effects are applied, the broadband interaction variable

[50] In each column, values on the left are correlation coefficients (*r*) between two ICT variables in the exporters sub-sample, while values on the right are those in the importers sub-sample.

gets positive values of 0.006 for total trade and 0.0170 in articles of steel.[51] However, in the raw steel sample the Internet variable coefficient turns out to be negative contrary to the results when all three ICT variables are included.[52] It can be assumed that omitted-variable bias may over-estimate the effect of the Internet in the raw steel sample and thus turns the insignificant coefficient into the negative one (see Table 7-6). Similar argument may be used to explain a positive coefficient obtained on mobile phones in articles of steel (see Table 7-7). The coefficients on fixed phones proliferation confirm no significant influence of landlines on trade in neither sample.

Table 7-5: Regression Output – Total trade

VARIABLES	Cn*Yr FE (5)			Pair&Cn*Yr FE (6)		
ln (Distance)	-1.641***	-1.638***	-1.640***			
	(0.0102)	(0.0102)	(0.0102)			
Internet interaction	-0.00425***			**0.00587*** **		
	(0.00107)			(0.00205)		
Mobile phones interaction		-0.0102			0.0130	
		(0.0106)			(0.0116)	
Fixed phones interaction			-0.00921***			-0.0110
			(0.00350)			(0.0143)
Contiguity	0.253***	0.249***	0.253***			
	(0.0397)	(0.0397)	(0.0397)			
Common language	0.894***	0.896***	0.895***			
	(0.0199)	(0.0199)	(0.0199)			
Colonial ties	0.759***	0.762***	0.759***			
	(0.0430)	(0.0430)	(0.0430)			
Same country	0.975***	0.975***	0.976***			
	(0.0557)	(0.0557)	(0.0557)			
Regional trade agrmt	0.471***	0.460***	0.464***	-0.109***	-0.110***	-0.109***
	(0.0196)	(0.0195)	(0.0195)	(0.0323)	(0.0323)	(0.0323)
WTO mutual membership	0.633***	0.626***	0.622***	-0.177	-0.170	-0.161
	(0.0642)	(0.0642)	(0.0642)	(0.148)	(0.148)	(0.148)
Constant	20.80***	20.94***	20.82***	5.316***	5.066***	5.415***
	(0.125)	(0.203)	(0.126)	(0.565)	(0.611)	(0.577)
Observations	127,553	127,553	127,553	127,553	127,553	127,553
R-squared	0.774	0.774	0.774	0.893	0.893	0.893

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[51] See Tables 7-1 and 7-3 for comparison.
[52] See Table 7-2 for comparison.

Table 7-6: Regression Output – Steel

VARIABLES	Cn*Yr FE (5)			Pair&Cn*Yr FE (6)		
ln (Distance)	-1.737***	-1.752***	-1.727***			
	(0.0267)	(0.0268)	(0.0267)			
Internet interaction	**0.0613*** **			-0.0108*		
	(0.00351)			(0.00609)		
Mobile phones interaction		**0.203*** **			-0.0588	
		(0.0332)			(0.0384)	
Fixed phones interaction			**0.257*** **			0.0226
			(0.0135)			(0.0619)
Contiguity	0.826***	0.885***	0.811***			
	(0.0729)	(0.0732)	(0.0729)			
Common language	0.295***	0.304***	0.295***			
	(0.0490)	(0.0492)	(0.0489)			
Colonial ties	0.793***	0.740***	0.821***			
	(0.0722)	(0.0725)	(0.0722)			
Same country	0.993***	1.085***	0.987***			
	(0.105)	(0.105)	(0.105)			
Regional trade agrmt	0.467***	0.484***	0.470***	-0.0115	-0.00722	-0.0138
	(0.0448)	(0.0452)	(0.0448)	(0.0865)	(0.0866)	(0.0866)
WTO mutual membership	0.972***	1.182***	1.228***	0.425	0.388	0.372
	(0.306)	(0.307)	(0.306)	(0.481)	(0.481)	(0.481)
Non-tariff measures	0.266**	0.225*	0.284**	0.313**	0.321**	0.306**
	(0.131)	(0.132)	(0.131)	(0.129)	(0.129)	(0.129)
Constant	18.57***	15.62***	17.09***	7.963***	8.821***	7.752***
	(0.435)	(0.666)	(0.443)	(1.059)	(1.193)	(1.226)
Observations	29,499	29,499	29,499	29,499	29,499	29,499
R-squared	0.627	0.623	0.628	0.818	0.818	0.818

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The rest of the non-ICT variables, namely common border, official language, colonial links, same country experience in the past, reciprocal participation in RTAs, and mutual WTO membership, received coefficients identical to those reported in Tables 7-1, 7-2, and 7-3.

Table 7-7: Regression Output – Articles of Steel

VARIABLES	Cn*Yr FE (5)			Pair&Cn*Yr FE (6)		
ln (Distance)	-1.961***	-1.980***	-1.962***			
	(0.0217)	(0.0217)	(0.0217)			
Internet interaction	**0.0476*** **			**0.0170*** **		
	(0.00254)			(0.00489)		
Mobile phones interaction		**0.207*** **			**0.0834*** **	
		(0.0269)			(0.0315)	
Fixed phones interaction			**0.149*** **			0.0403
			(0.00929)			(0.0448)
Contiguity	0.675***	0.721***	0.673***			
	(0.0648)	(0.0650)	(0.0650)			
Common language	1.021***	1.029***	1.032***			
	(0.0390)	(0.0391)	(0.0390)			
Colonial ties	0.677***	0.641***	0.680***			
	(0.0636)	(0.0638)	(0.0637)			
Same country	1.083***	1.152***	1.083***			
	(0.0902)	(0.0904)	(0.0903)			
Regional trade agrmt	0.306***	0.329***	0.313***	-0.0440	-0.0486	-0.0443
	(0.0364)	(0.0366)	(0.0364)	(0.0716)	(0.0716)	(0.0716)
WTO mutual membership	2.104***	2.226***	2.251***	0.125	0.180	0.186
	(0.222)	(0.223)	(0.222)	(0.416)	(0.416)	(0.416)
Non-tariff measures	0.477***	0.461***	0.452***	-0.183**	-0.189***	-0.185**
	(0.0653)	(0.0656)	(0.0654)	(0.0733)	(0.0733)	(0.0733)
Constant	16.83***	13.80***	16.20***	1.851**	0.674	1.472
	(0.343)	(0.535)	(0.347)	(0.827)	(0.941)	(0.935)
Observations	40,426	40,426	40,426	40,426	40,426	40,426
R-squared	0.709	0.707	0.709	0.855	0.855	0.855

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Estimation Results Recap

The various specifications of the gravity model were applied to determine the impacts of ICTs on countries' export performance. In addition to the ICT variables, a number of non-ICT individual country characteristics as well as the set of conventional dummy variables were embedded on the right-hand side of the equations. Moreover, four different fixed effects were applied to account for multilateral resistance.

The regression outputs confirm that the volume of exports is proportional to economic mass of trade partners and inversely proportional to the distance between them, supporting the intuition behind the gravity theory. As expected, common border, colonial link, common language, and mutual experience of being the same country receive positive coefficients in all samples. Landlockedness, however, had no effect on export perfomance in neither raw steel nor articles of steel. The steel industry's specific variables such as quality of ports appear to have a positive influence on export volumes. While, higher tariffs were successful in reducing imports of both steel and its articles, imposition of non-tariff measures did not cause a decline in steel imports. I also observe a negative effect of stronger currency on exporters' trade performance.

The main finding of the analysis is that Internet proliferation boosts exports in general and in articles of steel in particular. Accordingly, a 10 percent increase in the number of fixed broadband subscriptions in the exporting country causes a 0.48 percent rise in exports of articles of steel. Moreover, I observe network effects. That is, countries with relatively developed Internet infrastructure tend to have higher volumes of bilateral trade. The Internet, however, had no impact on trade in raw steel. The results on mobile phones and fixed landlines are somewhat mixed. The analysis suggests country's individual mobile-cellular proliferation also facilitates trade, though the network effects have not been captured. The level of fixed-phone penetration turns out to be irrelevant to export facilitation in all samples, providing evidence of diminishing importance of landlines in the Internet age.

Conclusion

The intent of this research was to discover whether ICTs have positive impacts on countries' steel exports, given both the high estimates of steel consumption in the nearest decade and the overall importance of steel for global development. I have reviewed the literature in the field, analyzed the structure of the steel industry, and reported a firm-level case-study on ICT proliferation. Lastly, I have performed an econometric analysis of how ICTs affect export performance in three samples – total exports, exports of steel, and exports of articles of steel.

The literature section has reviewed different aspects of the relationships between ICT and international trade. The majority of the studies report positive effects of ICT tools such as the Internet, cellular phones, e-trade platforms, and landlines on aggregated trade. While there are several papers analyzing the effect of ICT on industry-level trade, I have not found any of those estimating ICT impacts on trade in either steel or its articles. The literature suggested using the gravity model as a reliable instrument for analyzing bilateral trade flows. The recent studies on the gravity theory have created theoretical foundation that allow capturing unobserved heterogeneity and multilateral resistance terms by using various forms of fixed effects.

The analysis of the steel industry has revealed its rich history and complex structure with 3 types of manufacturers: integrated mills, mini-mills, and steel processors. Firms in the industry may possess different production methods and ship a wide range of products, starting with basic slabs and ending with sophisticated tankers, rails, and bridges. Accordingly, I chose to treat steel (HS72 code) and articles of steel (HS73 code) as separate trade flows, implying technological differences between those. The firm-level case study has outlined the ICT infrastructure at Interpipe, a global steel pipe manufacturer. The firm enjoys using conventional ICT tools, such as Voice over Inter Protocol, customer relationship management system, corporate email client, though I have identified some gaps as compared with the leading firms in the industry – Tenaris, Vallourec, and TMK.

The empirical analysis has found that the Internet penetration positively affects countries' capabilities to export articles of steel: a 10 percent increase in the number of fixed broadband subscriptions would lead to about a 0.48 percent growth in exports. Furthermore, the Internet network effects are observed in articles of steel, that is, one would expect higher volumes of trade if both partners are Internet advanced. Mobile phones also appeared to have positive influence on export performance. Accordingly, a 10 percent increase in mobile usage in exporting country would lead to approximately a 7.4 percent rise in steel exports and to about a 3.4 percent growth in exports of steel articles. The results on fixed-telephone use did not confirm the importance of landlines on exports of neither steel nor its articles.

The results confirm that volume of exports is proportional to the product of their GDPs and inversely proportional to bilateral distances. Common border, colonial ties, common language, and experience of being the same country received positive coefficients in all samples. It appeared that landlocked exporters of both steel and its articles were in the same position as those who had access to water. Quality of ports received positive coefficients and thus enhances export performance. Raising tariffs on both steel and its articles predictably received negative coefficients, which is consistent with the theory and practice. The effectiveness in reducing imports by non-tariff measures was detected only in articles of steel.

Potential avenues for further research may include employing firm-level data to examine whether the impacts of ICTs vary among individual firms different in size, revenue, location of assets etc. Additionally, as more companies deploy tablets and smartphones, estimation of the mobile-broadband impacts may produce some interesting results to fuel further discussion.

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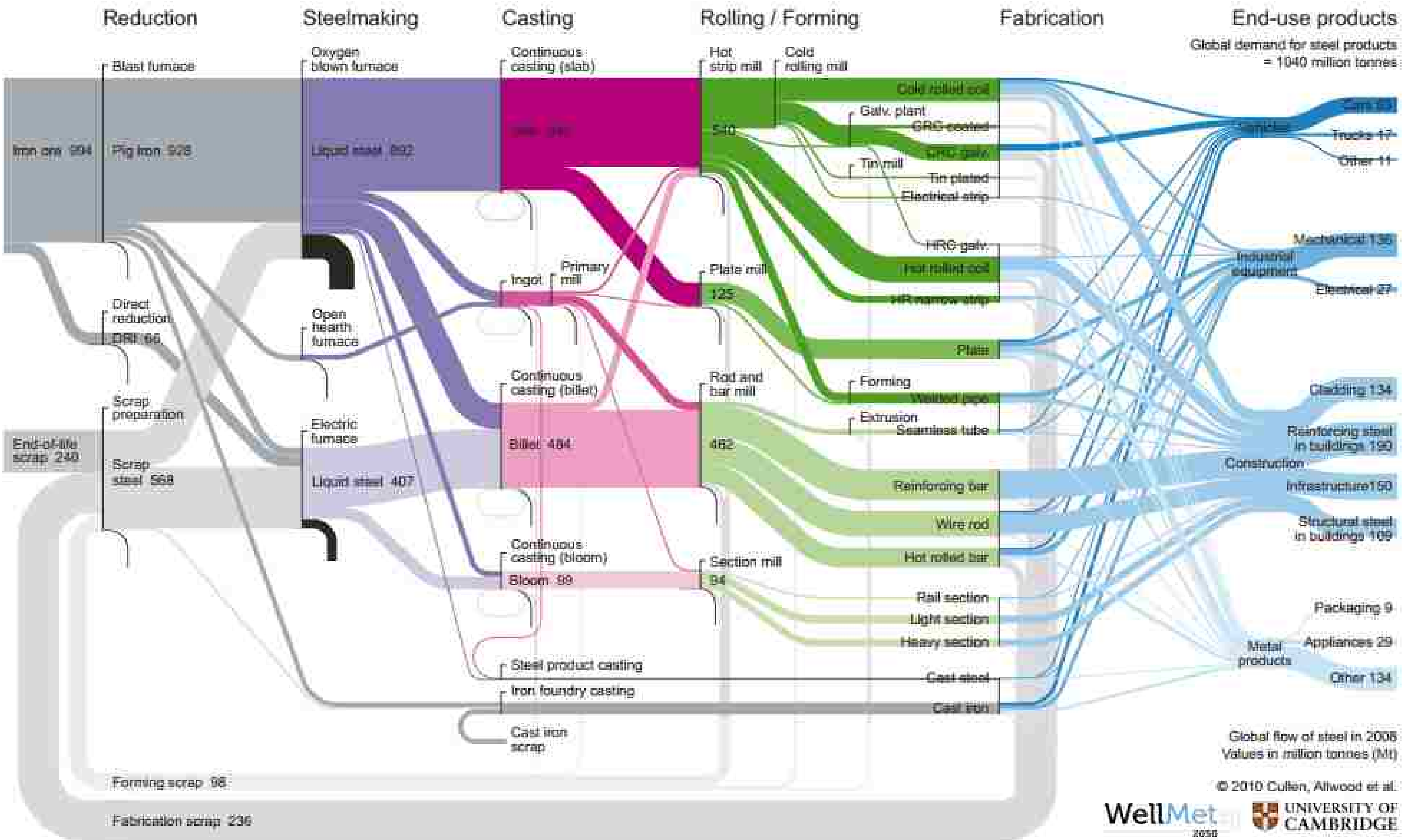
Appendices

Appendix 1: Global Flow of Steel (2008)



Source: Going on a metal diet. Department of Engineering, University of Cambridge, 2011.

Appendix 2: Harmonized System Classification (72, 73 codes)

Table 2-1: HS Classification – Iron and Steel (HS72)

HS 4-digit code	Product description
7201	Pig iron and spiegeleisen in pigs, blocks or other primary forms
7202	Ferro-alloys
7203	Ferrous products obtained by direct reduction or iron ore, in lumps etc.
7204	Ferrous waste, scrap, remelting scrap ingots or iron or steel
7204	Ferrous waste, scrap, remelting scrap ingots or iron or steel
7205	Granules and powders, of pig iron, spiegeleisen, iron or steel
7206	Iron, non-alloy steel in ingots/other primary forms(except of Head 72.03)
7207	Semi-finished products of iron or non-alloy steel
7208	Flat-rolled products of iron/non-alloy steel, of width >600mm, hot-rolled
7209	Flat-rolled products of iron/non-alloy steel, of width >600mm, cold-rolled
7210	Flat-rolled products of iron/non-alloy steel, of width >600mm, clad, plated
7211	Flat-rolled products of iron/non-alloy steel, of width <600mm, not clad
7212	Flat-rolled products of iron/non-alloy steel, of width <600mm, clad
7213	Bars and rods, hot-rolled, in irregular wound coils, of iron/non-alloy steel
7214	Other bars and rods of iron or non-alloy steel, not further worked than forged, hot-rolled, hot-drawn or hot-extruded, but including those twisted after rolling.
7215	Other bars and rods of iron or non-alloy steel
7216	Angles, shapes and sections of iron or non-alloy steel
7217	Wire of iron or non-alloy steel
7218	Stainless steel in ingots etc. semi-finished products of stainless steel
7219	Flat-rolled products of stainless steel, of a width of 600mm or more
7220	Flat-rolled products of stainless steel, of a width of less than 600mm
7221	Bars and rods, hot-rolled, in irregular wound coils, of stainless steel
7222	Other bars and rods of stainless steel/etc. sections of stainless steel
7223	Wire of stainless steel
7224	Other alloy steel in ingots etc. semi-finished products of other alloy steel
7225	Flat-rolled products of other alloy steel, of a width of 600mm or more
7226	Flat-rolled products of other alloy steel, of a width of less than 600mm
7227	Bars and rods, hot-rolled, in irregulary wound coils, of other alloy steel
7228	Other bars and rods of alloy steel/angles etc. hollow drill bars and rods
7229	Wire and other alloy steel

Source:UNCTAD

Table 2-2: HS Classification – Articles of Iron and Steel (HS73)

HS 4-digit code	Product description
7301	Sheet piling or iron or steel modified or assembled, welded etc.
7302	Rail, tramway tracks, other accessories for constructions of iron or steel
7303	Tubes, pipes and hollow profiles, of cast iron
7304	Tubes, pipes and hollow profiles, seamless, of iron or steel
7305	Other tubes and pipes, having circular cross-sections, extern. diam >406.4mm, of iron or steel
7306	Other tubes, pipes and hollow profiles, of iron or steel
7307	Tubes or pipe fittings, of iron or steel
7308	Structures and parts of structures (bridges and bridges sections, etc.)
7309	All types of reservoirs with or without thermal equipment, capacity >300l
7310	Tanks, casks, drums, cans, boxes and any containers, of iron or steel, not >300L
7311	Containers for compressed or liquefied gas, of iron or steel
7312	Stranded wire, ropes etc. of iron or steel, not electrically insulated
7313	Barbed, twisted, single wire of iron/steel used for fencing
7314	Cloth (including endless bands), grill, netting and fencing, of iron or steel wire/ expanded metal of iron or steel.
7315	Chain and parts thereof, of iron or steel
7316	Anchors, grapnels and parts thereof, of iron or steel
7317	Stationery pins (except in heading 83.05)of iron/steel with heads different
7318	Screws, bolts, nuts, screw-hooks, rivets, similar articles of iron or steel
7319	Sewing needles, for hand use needles of iron/steel(not elsewhere specified)
7320	Springs and leaves for springs, of iron or steel
7321	Non electric domestic appliances, stoves, parts thereof of iron or steel
7322	Non electrical heating equipment, motor-driven fans, parts, of iron/steel
7323	Table, kitchen, other household articles, parts thereof of iron or steel
7324	Sanitary ware and parts thereof, of iron or steel
7325	Other cast articles of iron or steel
7326	Other articles of iron or steel

Source:UNCTAD

Appendix 3: Number of Observations per Exporter

Table 3-1: Number of Observations per Exporter[53] – Total Exports Sample (N=153)

Exporter ISO-3	Min year	Max year	N	Exporter ISO-3	Min year	Max year	N	Exporter ISO-3	Min year	Max year	N
AFG	2011	2011	35	GEO	2002	2012	840	NER	2010	2012	210
ALB	2006	2012	454	GHA	2006	2012	750	NGA	2008	2011	442
ARE	2001	2011	1,204	GMB	2008	2011	177	NIC	2001	2012	852
ARG	2002	2012	1,376	GRC	2004	2012	1,229	NLD	2001	2012	1,476
ARM	2005	2012	527	GRD	2003	2008	137	NOR	2001	2012	1,429
ATG	2005	2012	131	GTM	2006	2011	644	NPL	2009	2011	348
AUS	2002	2012	1,267	GUY	2006	2012	451	NZL	2001	2012	1,453
AUT	2001	2012	1,450	HKG	2001	2012	1,383	OMN	2004	2011	749
AZE	2003	2012	650	HND	2011	2012	184	PAK	2006	2012	1,024
BEL	2001	2012	1,467	HRV	2004	2012	1,112	PAN	2002	2011	638
BEN	2007	2010	241	HUN	2001	2012	1,382	PER	2003	2012	1,196
BFA	2007	2011	307	IDN	2002	2012	1,436	PHL	2002	2012	1,350
BGR	2005	2012	1,125	IND	2003	2012	1,383	PNG	2011	2012	134
BHR	2002	2011	723	IRL	2003	2012	1,350	POL	2002	2012	1,398
BHS	2002	2012	251	IRN	2003	2011	428	PRT	2001	2012	1,421
BIH	2003	2012	923	ISL	2001	2012	1,064	PRY	2002	2012	964
BLR	2005	2012	928	ISR	2002	2011	1,243	QAT	2003	2011	647
BLZ	2004	2011	296	ITA	2001	2012	1,470	ROU	2002	2012	1,335
BOL	2003	2012	800	JAM	2002	2012	758	RUS	2003	2012	1,271
BRA	2001	2012	1,465	JOR	2002	2012	1,089	RWA	2005	2012	469
BRB	2004	2012	848	JPN	2001	2012	1,471	SAU	2002	2007	391
BRN	2002	2012	192	KAZ	2004	2012	865	SDN	2008	2012	338
BTN	2009	2011	86	KEN	2006	2010	639	SEN	2003	2012	893
BWA	2006	2012	646	KGZ	2005	2012	517	SGP	2001	2012	1,208
CAN	2001	2012	1,458	KHM	2005	2012	884	SLV	2004	2012	805
CHE	2001	2012	1,469	KNA	2003	2011	152	STP	2007	2012	94
CHL	2001	2012	1,334	KOR	2001	2012	1,478	SUR	2009	2011	218
CHN	2002	2012	1,442	KWT	2006	2009	356	SVK	2003	2012	1,270
CIV	2006	2010	546	LBN	2003	2012	1,186	SVN	2002	2012	1,283
CMR	2011	2012	194	LBY	2009	2009	40	SWE	2001	2012	1,468
COL	2001	2012	1,323	LCA	2004	2008	177	SYC	2005	2008	135
COM	2008	2009	60	LKA	2004	2012	1,226	SYR	2006	2010	560
CPV	2005	2012	103	LSO	2008	2009	53	TGO	2008	2012	296
CRI	2003	2012	1,025	LTU	2002	2012	1,291	THA	2004	2012	1,292
CYP	2002	2012	1,199	LUX	2002	2012	1,341	TON	2008	2012	105
CZE	2001	2012	1,424	LVA	2001	2012	1,325	TTO	2003	2010	694
DEU	2001	2012	1,476	MAR	2003	2012	1,136	TUN	2005	2011	818
DMA	2001	2012	181	MDA	2002	2012	798	TUR	2002	2012	1,427
DNK	2001	2012	1,466	MDG	2007	2012	645	TZA	2008	2012	591
DOM	2004	2012	941	MDV	2003	2012	304	UGA	2008	2012	529
DZA	2004	2012	775	MEX	2001	2012	1,412	UKR	2006	2012	981
ECU	2002	2012	1,158	MKD	2006	2012	570	URY	2005	2012	1,011
EGY	2008	2012	700	MLI	2007	2012	333	USA	2001	2012	1,479
ESP	2001	2012	1,466	MLT	2001	2012	1,186	VCT	2002	2012	204
EST	2002	2012	1,239	MNG	2004	2007	235	VEN	2001	2011	805
ETH	2012	2012	118	MOZ	2008	2012	440	VNM	2004	2012	942
FIN	2001	2012	1,444	MRT	2007	2012	291	VUT	2006	2011	190
FJI	2006	2012	522	MUS	2003	2012	1,001	WSM	2005	2006	40
FRA	2001	2012	1,472	MWI	2008	2011	411	YEM	2006	2012	514
GAB	2004	2009	461	MYS	2002	2012	1,436	ZAF	2003	2012	1,348
GBR	2001	2012	1,414	NAM	2006	2012	807	ZMB	2007	2011	500

[53] N includes all exporter's trade partners (relations) over 2001-2012. The same applies to Tables 3-2 and 3-3.

Table 3-2: Number of Observations per Exporter – Steel Sample (N=127)

Exporter ISO-3	Min year	Max year	N	Exporter ISO-3	Min year	Max year	N(yr)	Exporter ISO-3	Min year	Max year	N
ALB	2006	2012	72	GMB	2008	2011	13	NAM	2006	2012	54
ARE	2004	2011	261	GRC	2004	2012	219	NGA	2008	2011	17
ARG	2002	2012	409	GTM	2006	2011	83	NIC	2003	2012	48
ARM	2005	2012	52	GUY	2006	2012	25	NLD	2001	2012	529
AUS	2002	2012	453	HKG	2001	2012	125	NOR	2001	2012	549
AUT	2001	2012	463	HND	2011	2012	14	NZL	2001	2012	311
AZE	2006	2012	35	HRV	2004	2012	229	OMN	2007	2011	36
BEL	2001	2012	562	HUN	2001	2012	256	PAK	2006	2012	142
BEN	2007	2010	46	IDN	2002	2012	463	PAN	2002	2011	126
BFA	2007	2011	13	IND	2003	2012	753	PER	2003	2012	244
BGR	2005	2012	178	IRL	2003	2012	182	PHL	2002	2012	199
BHR	2004	2011	125	IRN	2010	2011	39	POL	2002	2012	423
BIH	2004	2012	180	ISL	2001	2012	174	PRT	2001	2012	295
BOL	2004	2012	47	ISR	2002	2011	389	PRY	2002	2012	78
BRA	2001	2012	696	ITA	2001	2012	550	QAT	2005	2011	27
BRB	2006	2012	19	JAM	2002	2011	93	ROU	2002	2012	407
BRN	2012	2012	1	JOR	2002	2012	79	RUS	2003	2012	684
BWA	2006	2011	14	JPN	2001	2012	744	RWA	2010	2012	6
CAN	2001	2012	670	KAZ	2005	2012	262	SAU	2007	2007	38
CHE	2001	2012	734	KEN	2006	2010	61	SEN	2003	2012	91
CHL	2001	2012	351	KGZ	2005	2012	60	SGP	2001	2012	475
CHN	2002	2012	868	KHM	2005	2012	14	SLV	2004	2012	110
CIV	2008	2010	46	KOR	2001	2012	775	SUR	2009	2011	8
CMR	2011	2012	16	KWT	2006	2009	35	SVK	2003	2012	297
COL	2001	2012	291	LBN	2010	2012	51	SVN	2002	2012	300
CPV	2010	2011	8	LBY	2009	2009	10	SWE	2001	2012	543
CRI	2003	2012	190	LKA	2004	2012	72	SYR	2007	2010	22
CYP	2005	2011	27	LTU	2002	2012	142	THA	2004	2012	504
CZE	2001	2012	447	LUX	2003	2012	326	TTO	2003	2010	189
DEU	2001	2012	612	LVA	2001	2012	159	TUN	2005	2011	112
DNK	2001	2012	379	MAR	2003	2012	212	TUR	2002	2012	792
DOM	2004	2012	184	MDA	2005	2012	65	TZA	2008	2012	33
DZA	2004	2012	108	MDG	2007	2012	31	UGA	2008	2012	19
ECU	2002	2012	156	MEX	2001	2012	499	UKR	2006	2012	484
EGY	2008	2012	209	MKD	2006	2012	162	URY	2005	2012	52
ESP	2001	2012	543	MLI	2007	2012	17	USA	2001	2012	823
EST	2002	2012	123	MLT	2003	2012	26	VEN	2001	2011	225
ETH	2012	2012	1	MNG	2005	2007	6	VNM	2004	2012	269
FIN	2001	2012	404	MOZ	2008	2012	33	YEM	2011	2012	3
FRA	2001	2012	546	MRT	2008	2012	7	ZAF	2003	2012	653
GBR	2001	2012	553	MUS	2003	2012	68	ZMB	2007	2011	35
GEO	2004	2012	159	MWI	2008	2011	9				
GHA	2008	2012	46	MYS	2002	2012	418				

Table 3-3: Number of Observations per Exporter – Articles of Steel Sample (N=128)

Exporter ISO-3	Min year	Max year	N
ALB	2006	2012	92
ARE	2004	2011	445
ARG	2002	2012	679
ARM	2005	2012	46
AUS	2002	2012	655
AUT	2001	2012	600
AZE	2006	2012	149
BEL	2001	2012	615
BEN	2007	2010	37
BFA	2007	2011	25
BGR	2005	2012	306
BHR	2004	2011	50
BIH	2004	2012	279
BLZ	2011	2011	3
BOL	2003	2012	88
BRA	2001	2012	842
BRB	2006	2012	67
BRN	2012	2012	5
BWA	2006	2012	46
CAN	2001	2012	869
CHE	2001	2012	887
CHL	2001	2012	485
CHN	2002	2012	876
CIV	2008	2010	46
CMR	2011	2012	24
COL	2001	2012	369
CRI	2003	2012	311
CYP	2004	2012	93
CZE	2001	2012	602
DEU	2001	2012	643
DNK	2001	2012	565
DOM	2004	2012	140
DZA	2004	2012	100
ECU	2002	2012	265
EGY	2008	2012	330
ESP	2001	2012	606
EST	2002	2012	249
ETH	2012	2012	18
FIN	2001	2012	552
FRA	2001	2012	633
GBR	2001	2012	632
GEO	2004	2012	164
GHA	2008	2012	102

Exporter ISO-3	Min year	Max year	N
GMB	2008	2011	12
GRC	2004	2012	334
GTM	2006	2011	187
GUY	2006	2012	18
HKG	2001	2012	445
HND	2011	2012	37
HRV	2004	2012	480
HUN	2001	2012	434
IDN	2002	2012	684
IND	2003	2012	785
IRL	2003	2012	344
IRN	2010	2011	64
ISL	2001	2012	320
ISR	2002	2011	627
ITA	2001	2012	617
JAM	2002	2012	61
JOR	2002	2012	145
JPN	2001	2012	849
KAZ	2005	2012	265
KEN	2006	2010	117
KGZ	2005	2012	43
KHM	2005	2012	95
KOR	2001	2012	837
KWT	2006	2009	63
LBN	2010	2012	136
LBY	2009	2009	1
LKA	2004	2012	445
LTU	2002	2012	269
LUX	2003	2012	383
LVA	2001	2012	228
MAR	2003	2012	388
MDA	2005	2012	111
MDG	2007	2012	83
MEX	2001	2012	698
MKD	2006	2012	184
MLI	2007	2012	32
MLT	2003	2012	137
MNG	2005	2007	44
MOZ	2008	2012	41
MRT	2009	2010	2
MUS	2003	2012	157
MWI	2008	2011	19
MYS	2002	2012	722

Exporter ISO-3	Min year	Max year	N
NAM	2006	2012	114
NGA	2008	2011	70
NIC	2001	2012	89
NLD	2001	2012	604
NOR	2001	2012	724
NPL	2009	2011	12
NZL	2001	2012	646
OMN	2007	2011	93
PAK	2006	2012	382
PAN	2002	2011	98
PER	2003	2012	406
PHL	2002	2012	438
POL	2002	2012	545
PRT	2001	2012	565
PRY	2002	2012	123
QAT	2005	2011	31
ROU	2002	2012	533
RUS	2003	2012	675
RWA	2010	2012	7
SAU	2007	2007	37
SEN	2003	2012	96
SGP	2001	2012	727
SLV	2004	2012	124
SUR	2009	2011	13
SVK	2003	2012	379
SVN	2002	2012	422
SWE	2001	2012	597
SYR	2007	2010	123
THA	2004	2012	754
TTO	2003	2010	143
TUN	2005	2011	275
TUR	2002	2012	842
TZA	2008	2012	87
UGA	2008	2012	39
UKR	2006	2012	453
URY	2005	2012	198
USA	2001	2012	887
VEN	2001	2011	261
VNM	2004	2012	485
YEM	2011	2012	2
ZAF	2003	2012	746
ZMB	2007	2011	48