Innovating in a Global Economy

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Abstract

The past several decades saw remarkable growth in international trade. Operating in an increasingly globalized competitive environment, firms today face unique opportunities and challenges in deciding whether, when, and how to innovate. This chapter reviews the recent economics and management literature studying the link between trade liberalization and firms' innovation-related outcomes. We first classify trade shocks by direction and target market. We then summarize the theoretical predictions and empirical evidence on the impact of trade shocks on innovation. Finally, we discuss policy implications, empirical limitations, and opportunities for future research.

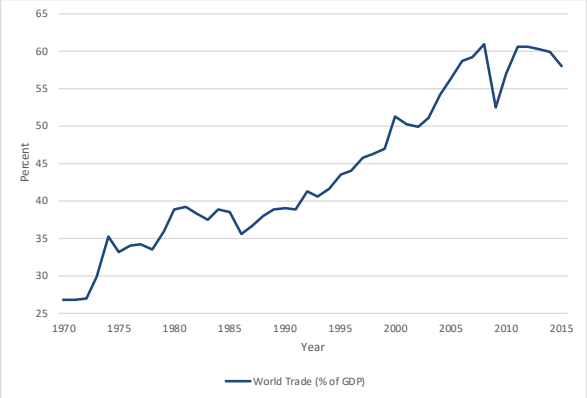
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1 Introduction

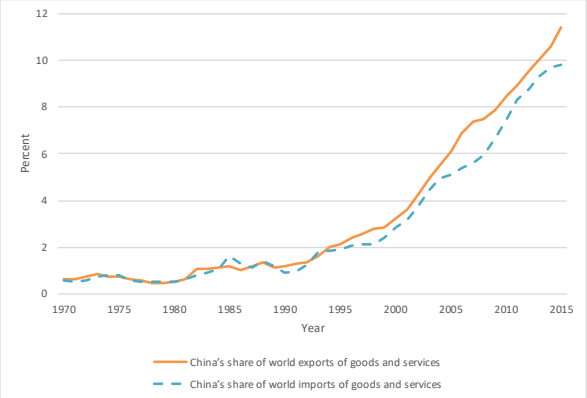
International trade has risen steadily in the past several decades. Between 1970 and 2015, the share of trade as a part of world GDP grew from 27 percent to 58 percent (Panel A of Figure 1). One of the most significant recent trade events is China's entry into the World Trade Organization in 2001, which propelled its integration into the global economy with a speed that perhaps exceeded many's expectations. In 2000, China's shares of world exports and imports were merely 3.3 percent and 2.8 percent, respectively. In 2015, the corresponding numbers are 11.4 percent and 9.8 percent (Panel B of Figure 1).

Figure 1: Growth in International Trade, 1970–2015

(a) Growth in World Trade (% GDP)



(b) Growth in China's Share of World Trade



Source: World Development Indicators (http://databank.worldbank.org/data/reports.aspx?source = world-development-indicators).

While economists have long argued that trade is overall productivity- and welfare-enhancing, there are growing disconcerting sentiments toward China's rise as a trade partner to the US (The Economist, 2017). A critical question in thinking about US trade policy is: How does trade affect US firms' incentives and capabilities to innovate? Innovation is fundamental to economic growth (Romer, 1990; Jones, 2005). The US manufacturing sector, a primary source of innovative activities in the US, has faced heavy import competition from China (Autor *et al.* , 2017). At the same time, US firms have also enjoyed increased access to foreign consumer markets and abundant low-cost labor in Asia. These different aspects of trade activities have complex effects on innovation. This chapter intends to unpack some of this complexity by surveying the recent theoretical and empirical literature examining the link between trade and innovation-related outcomes.

Table 1: Categorizing Different Types of Trade Shocks

		Entry direction	
		Foreign entering domestic	Domestic entering foreign
Entry target	Entering output market	*Import competition* *(Domestic and foreign firms competing in the domestic output market)*	*Export opportunities* *(Foreign and domestic firms competing in the foreign output market)*
	Entering input market	*Foreign input competition* *(Domestic and foreign firms competing in the domestic input market)*	*Access to intermediate inputs* *(Foreign and domestic firms competing in the foreign input market)*

Trade liberalization affects the environment in which the firms operate in a variety of ways. We start by introducing a simple framework that categorizes different types of trade shocks. From the perspective of a domestic firm, trade liberalization could bring an influx of foreign competitors in domestic markets as well as provide access to foreign markets. The increased competition and access could happen in both output and input markets. We thus categorize trade shocks by direction and target market, as illustrated in the 2 by 2 matrix in Table 1. **Import competition** is where the domestic firm faces the entry of a foreign firm in the domestic market, and both compete in the output market. For instance, in the U.S. consumer market for cellphones, Apple Inc competes against both domestic rivals such as Google and Microsoft as well as international rivals such as Samsung (South Korea), HTC (Taiwan), and Xiaomi (China). **Export opportunities** is where the domestic firm enters a foreign market to compete with the existing foreign firms. In 2015, Apple's total revenue in foreign markets was $140 billion, which was 49 percent more than its revenue in the US market ($94 billion); consumers from Greater China contributed to 42 percent of Apple's foreign sales ($59 billion).[1]

Similarly, trade may introduce competition in the domestic input market or provide access to foreign inputs. **Foreign input competition** is where a foreign firm purchases its inputs from a domestic supplier, thereby increasing the competition for inputs of the domestic supplier (e.g., domestic labor). For instance, Samsung's research-and-development (R&D) center in San Jose, California, may be competing with Apple to attract the same local engineering and science talent. **Access to intermediate inputs** is where a domestic firm imports its inputs from abroad through outsourcing (purchasing inputs from a foreign supplier) and/or offshoring (setting up own production facility abroad). Except for some Mac computers that are

[1]Source: Apple's annual 10-k filling to the Securities and Exchange Commission.

manufactured in the U.S., most of Apple's hardware products are manufactured by its outsourcing partners located in Asia. One of their most notable partners is Foxconn Technology Group, which in 2012 was estimated to have manufactured 40 percent of all consumer electronics sold worldwide (New York Times, 2012).

The entry into the domestic or foreign markets can be done via directly purchasing and selling goods and/or services as well as via foreign direct investment (FDI), which is where a firm sets up a subsidiary in the other country. For the purpose of this paper, we do not distinguish between the two different types of entry in our definitions, though it is important to note that they may have different effects theoretically and empirically.

In each of the following sections, we discuss the intuition behind the theory on how each type of trade shock may affect firms' decision to innovate and summarize the empirical findings from the literature. We summarize the findings in Section 6, discuss the policy implications, and conclude by acknowledging the limitations of the existing literature and highlight opportunities for future research.

2 Impact of Import Competition on Innovation

2.1 Theory

Import competition does not change the size of the potential output market for a domestic firm, as all domestic firms still operate within the domestic market. As the size of the domestic market stays the same, the entry of new foreign competitors would thus increase the competitive pressure that individual domestic firms face. A large literature in industrial organization has studied how competition in general—not just import competition—affect firms' incentives to innovate.[2] They have identified three key mechanisms:

1. "Schumpeterian effect": Schumpeter (1934) and Schumpeter (1942) are the first to argue that by reducing a firm's market share, competition reduces the potential rents that a firm could capture from innovating. Similarly, Dasgupta & Stiglitz (1980) show that competition tightens profit margins and reduces firms' incentives to invest in research and development (R&D). The "Schumpeterian effect" thus implies that import competition could have a *negative* impact on firm innovation.

2. "Escape-competition effect": Arrow (1962) argues that a direct benefit of innovation is that it may allow a firm to capture the profits of its competitors. Thus in the absence of competition (and threats

[2]See Gilbert (2006) and Cohen (2010) for a detailed literature summary.

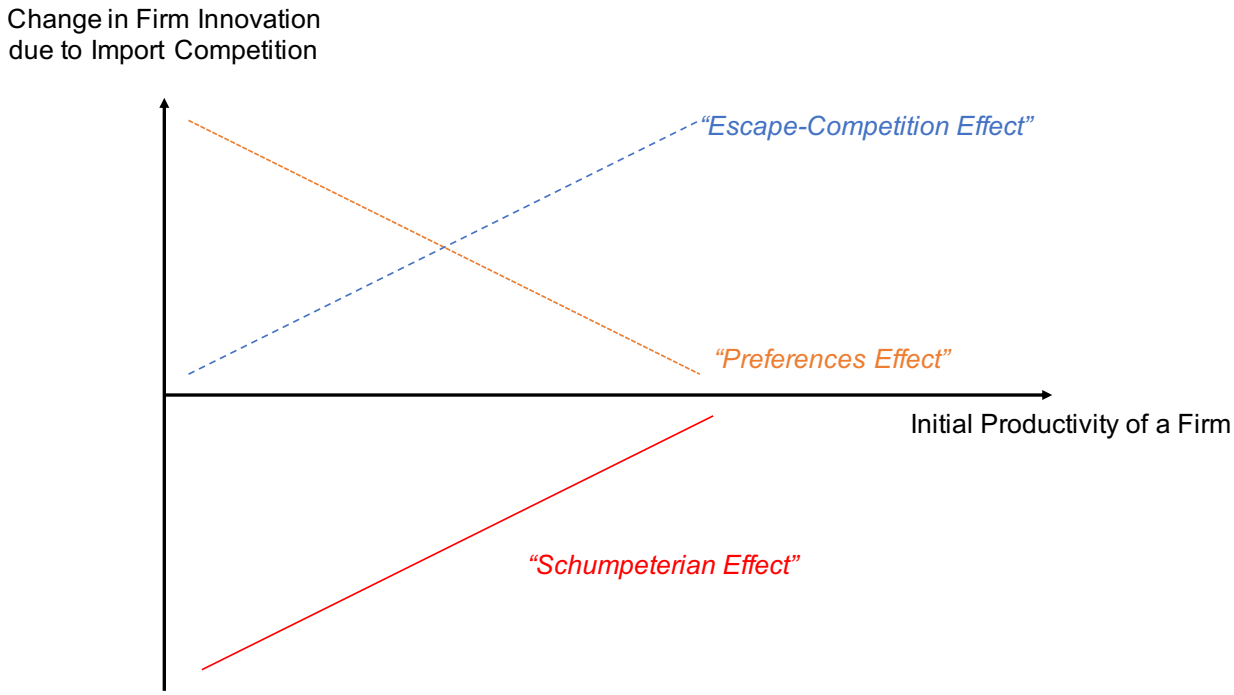
of new entry), a firm would have no incentives to innovate.[3] Aghion *et al.* (2005) build a model that illustrates more specifically the conditions under which competition would encourage innovation. The model predicts that when firms are similar in their levels of technological advancement (i.e., they are "neck-and-neck"), the returns to innovation could be increasing in the degree of competition, as innovation may help a firm overtake its competitors. The "escape-competition effect" thus implies that import competition could have a *positive* impact on firm innovation.

3. "Preferences effect": Both effects above assume that firms are profit maximizing. Hart (1983) challenges this assumption and shows that managers responsible for choosing how much to innovate may have preferences that include private benefits in addition to the firm's financial profits. When import competition threatens the existence of a domestic business, the managers may be afraid of losing some private benefits which are only present when the firm exists. In order to avoid this, the managers may start exerting effort and innovate (Chen & Steinwender, 2017).[4] Similarly, an older literature on X-efficiency shows that competitive pressure reduces managerial slack in firms (Leibenstein, 1978; Martin, 1978; Martin & Page, 1983; Holmes & Schmitz Jr, 2001). The "preferences effect" implies that import competition could have a *positive* impact on firm innovation.

[3] Arrow (1962) calls this the "replacement effect."

[4] The manager's preferences may be different from the preferences of the shareholders, in which this situation reflects an agency problem, but it may also be aligned with the preferences of owners when managers are owners (e.g., in the case of family firms as in Chen & Steinwender (2017)).

Figure 2: Potential responses of firm innovation to import competition



Importantly, the theory also predicts that a firm's innovation response likely depends on its initial level of productivity (or efficiency). As competitive pressure increases, the reduction in firm innovation due to the Schumpeterian effect may be more pronounced for initially less productive firms, and less so for more productive firms (Aghion *et al.* , 2005, 2017). The increase in innovation due to the escape-competition effect may be stronger for initially more productive firms that may be closer to the technology frontier (Aghion *et al.* , 2001; Bombardini *et al.* , 2017); the initially unproductive firms, having too long of a way to catch up to the technology frontier, may simply give up. In contrast, the increase in innovation due to the preferences effect may be stronger for initially less productive firms, which may face higher bankruptcy risk and have more managerial slack. Figure 2 plots three examples of the possible empirical patterns predicted by these key mechanisms. Of course, there are some refinements that one can make to each mechanism or adjust their relative positions, but the key insight here is that each mechanism predicts different patterns of firm responses, and thus the empirically observed heterogeneous responses at the firm level would help inform us which mechanism is the key driver behind the estimated effects of import competition on firm innovation.

It is worth mentioning that there has not been any theoretical studies (to our best knowledge) that explicitly examine the differences between import competition and domestic competition. For instance, the large influx of cheap foreign imports may shift domestic consumers' preferences from quality products to low-cost offerings in a way that is impossible to achieve with only domestic competitors. Moreover, foreign competitors could base their competitive advantage on the specific economic circumstances of their home country, such as access to different factors of production or being subject to different government regulations or home subsidies. The entry of foreign competitors could thus alter the competitive landscape in domestic market in unprecedented ways, making it difficult for domestic firms to adapt or compete. We believe that there is room in the literature to improve our understanding of the differences between foreign and domestic competition.

2.2 Empirical evidence

The empirical literature examining the impact of import competition on innovation-related outcomes mainly use reduced-form estimation strategies, where the sources of variations come from different types of trade liberalization episodes. Table 2 summarizes their key findings.

Table 2: Empirical Evidence on Import Competition and Innovation-Related Outcomes

Paper	Home Country and Sample Period	Sources of Trade Shock	Outcomes	Conclusions
Scherer and Huh (1992)	U.S., 1971-1987	Import penetration	R&D expenses/Sales	Negative; effects more positive for larger firms operating in more concentrated markets.
Tybout and Westbrook (1995)	Mexico, 1984-1990	Trade liberalization	Productivity, average production cost	Positive
Pavcnik (2002)	Chile, 1979-1986	Unilateral trade liberalization	Olley-Pakes productivity	Positive
Schor (2004)	Brazil, 1986-1998	Unilateral trade liberalization and part reversal	TFP (Levinsohn-Petrin)	Positive
Muendler (2004)	Brazil, 1986-1998	Unilateral trade liberalization and part reversal	TFP (Olley-Pakes variant)	Positive for medium and large firms
Trefler (2004)	Canada, 1980-1996	CUSFTA	Labor productivity	Positive but statistically insignificant
Schmitz (2005)	U.S. and Canada (iron ore sector), 1980-1995	Large drop in world prices leading to competition from Brazil	Labor/materials/capital productivity, work practices, technology, skill composition	Positive productivity effects driven by change in work practices
Amiti and Konings (2007)	Indonesia, 1991-2001	Indonesia's entry into WTO	TFP (Olley-Pakes)	Positive
Fernandes (2007)	Colombia, 1977-1991	Trade liberalization	TFP (direct approach)	Positive, stronger for larger plants and plants in less competitive industries
Teshima (2009)	Mexico, 2000-2003	Tariff changes	R&D expenditure, process innovation, product innovation, TFP	Positive (R&D expenditure on process innovation); insignificant (TFP, R&D expenditure on product innovation)
Gorodnichenko et al. (2010)	27 emerging countries, 2002 & 2005	n/a (self-reported measure of foreign competition)	Product innovation, technology acquisition	Positive for closest and farthest tercile from frontier (product innovation); positive without heterogeneity (technology acquisition)
De Loecker (2011)	Belgium (textile), 1994-2002	Import quota removal at EU level	TFP (corrected for price effects)	Positive but statistically insignificant
Iacovone et al. (2011)	Mexico, 1998-2004	Chinese import penetration; China's entry into WTO	Quality control; re-organization; just-in-time system; job rotation	Positive effects for productive firms; negative effects for unproductive firms
Topalova and Khandelwal (2011)	India, 1987-2001	1991 liberalization episode	TFP (Levinsohn-Petrin)	Positive but only for domestic firms
Iacovone (2012)	Mexico, 1993-2002	NAFTA	Labor productivity, R&D expenditure, technology transfers, investment	Positive, especially for frontier firms (labor productivity); insignificant (R&D expenditure, technology transfers, investment)

Paper	Home Country and Sample Period	Sources of Trade Shock	Outcomes	Conclusions
Bloom et al. (2016)	12 European countries, 1996-2007	Multi-Fiber Agreement	Patents, investment in IT, TFP	Positive
Autor et al. (2017)	U.S., 1975-2007	Chinese import penetration; China's entry into WTO	Patents, sales, employment, R&D expenditure	Negative; effects more negative for initially weaker firms
Bombardini et al. (2017)	China, 2000-2007	China's entry into WTO	Patents, TFP, R&D expenditure	Positive only for initially most productive firms
Chen and Steinwender (2017)	Spain, 1993-2007	EU level tariff reductions	Labor productivity	Positive for initially unproductive family firms, negative for initially productive family firms, insignificant for non-family firms
Gutierrez and Philippon (2017)	U.S., 1990-2014	Chinese import penetration; China's entry into WTO	Investment (property/plant/equipment; intangible capital)	Negative overall; positive for leaders, negative for laggards
Hombert and Matray (2017)	U.S., 1991-2007	Chinese import penetration	Sales growth, profitability, product differentiation,	Negative effects on sales growth and profitability; effects less negative for firms with larger initial R&D stock due to positive effects on product differentiation
Kueng et al. (2017)	Canada, 1999-2005	Chinese import penetration	Survival, profits, self-reported product and process innovation outcomes	Negative overall; effects more negative for process innovations
Pierce and Schott (2017)	U.S., 1990-2007	US grating PNTR to China	Investment	Negative & insignificant effects overall; positive effects for firms with high skilled labor intensity/higher productivity/higher capital intensity
Xu and Gong (2017)	U.S., 1995-2009	Chinese import penetration	R&D expenditure	Negative effects on average; reallocation of R&D from less productive firms to more productive firms
Brandt et al. (2017)	China, 1998-2007	China's entry into WTO	Productivity	Positive (especially for new entrants)

Much of the earlier literature (pre-2012) has focused on Latin American countries since those countries have experienced arguably exogenous trade liberalization episodes (Tybout & Westbrook, 1995; Pavcnik, 2002; Schor, 2004; Muendler, 2004; Fernandes, 2007; Teshima, 2009; Iacovone *et al.* , 2011; Iacovone, 2012); these studies have found positive effects of import competition on various measures of productivity (such

as total factor productivity and labor productivity), which we interpret as evidence on the positive effects of import competition on innovation. Studies on firm heterogeneity tended to find the strongest, positive effects for large firms (Muendler, 2004; Fernandes, 2007) or firms that were the most technologically advanced (Iacovone *et al.* , 2011; Iacovone, 2012). Outside of Latin America, there is also evidence of positive effects in Asia (Amiti & Konings, 2007 for Indonesia and Topalova & Khandelwal, 2011 for India). In North America and Europe, a small number of studies have found insignificant or negative effects (Scherer & Huh, 1992 for the US, Trefler, 2004 for Canada, De Loecker, 2011 for Belgium). A notable and interesting exception is Schmitz Jr (2005), which finds positive productivity effects of import competition in the North American iron ore sector that come from improved organizational methods. Overall, the earlier literature provides evidence consistent with the prediction of the escape-competition effect mechanism for firms in developing countries, though evidence on firms in developed countries is less conclusive.

More recently, a growing body of empirical evidence has emerged on the impact of import competition on the innovative activities of firms in developed countries, especially in the U.S. A key reason behind this renewed interest is the fast, drastic, and arguably unexpected rise of China as an exporter during the early 2000s. Compared to the earlier literature that mostly uses productivity as the key outcome, the recent literature uses more direct measures of innovation, such as R&D expenditure (which measure the input into innovation) and patents (which measure the output of innovation). This literature has found overwhelmingly negative evidence of the average impact of import competition on innovation-related outcomes for firms in North America (Autor *et al.* , 2017; Gutierrez & Philippon, 2017; Hombert & Matray, 2017; Kueng *et al.* , 2017; Pierce & Schott, 2017; Xu & Gong, 2017), which are more pronounced for initially weaker firms or firms that lag in technological advancement (Autor *et al.* , 2017; Gutierrez & Philippon, 2017). For firms that are more R&D-intensive, productive, or capital intensive, there is some evidence of positive effects of import competition from China on firm investment and product differentiation (Hombert & Matray, 2017; Pierce & Schott, 2017). These patterns suggest a predominant Schumpeterian effect for firms in North America. However, for the most productive and technologically advanced firms, the escape-competition effect could also be at play.

There is also some evidence of the escape-competition effect in Europe (Bloom *et al.* , 2016) and in China (Bombardini *et al.* , 2017; Brandt *et al.* , 2017). Chen & Steinwender (2017) provide evidence on the preferences effect by finding a positive impact of import competition on innovation for the initially unproductive Spanish family firms.

Comparing the findings across different regions shows that the heterogeneity in firm responses does

not only happen at the firm level, but also at the market and country level. The positive effects of import competition on innovation seem prevalent in countries that are less economically advanced (such as Latin American countries or China) or in countries that have relatively less competitive markets (such as Europe). In contrast, in North America, where the economy is well-developed and markets are already very competitive, import competition tends to have a negative impact on innovation. Within countries and industries, it is important to note that the negative impact on innovation is less pronounced on initially more productive firms (alternatively, the positive impact also more pronounced). This heterogeneity suggests a reallocation of innovation from unproductive firms towards productive firms.

3 Impact of Export Opportunities on Innovation

3.1 Theory

Export opportunities provide domestic firms access to new foreign markets, which increases the potential rents that a firm may capture from innovating. This "market-size effect" implies that export opportunities could have a positive effect on firm innovation (Aghion *et al.* , 2017). However, an indirect effect of having access to a larger market is that the domestic market now becomes more attractive, leading to new domestic entrants (Aghion *et al.* , 2017). Similar to import competition, the induced competition could also generate the three effects discussed in Section 2.1 (Schumpeterian effect, escape-competition effect, and preferences effect). The overall impact of export opportunities is thus a combination of the direct market-size effect and the indirect induced competition effect.

An important difference between import competition and export opportunities is that since import competition does not change the size of the potential output market, there is no market-size effect from import competition. Another difference is that import competition affects all domestic firms (though some may be affected more so than others), whereas the market size effect from export opportunities is only relevant for those that choose to export (or have the potential to do so). Traditional trade models (e.g., Melitz 2003) emphasize that only firms that are sufficiently productive and have sufficiently low marginal cost would export, since otherwise the fixed and variable cost of exporting would be too high. Therefore, we should expect the market size effect to be the strongest for the most productive firms, which would export, and weakest or even non-existent for the least productive firms. However, the induced competition effect from export opportunities also affects all domestic firms including exporters and non-exporters.

Figure 3: Potential responses of firm innovation to export opportunities

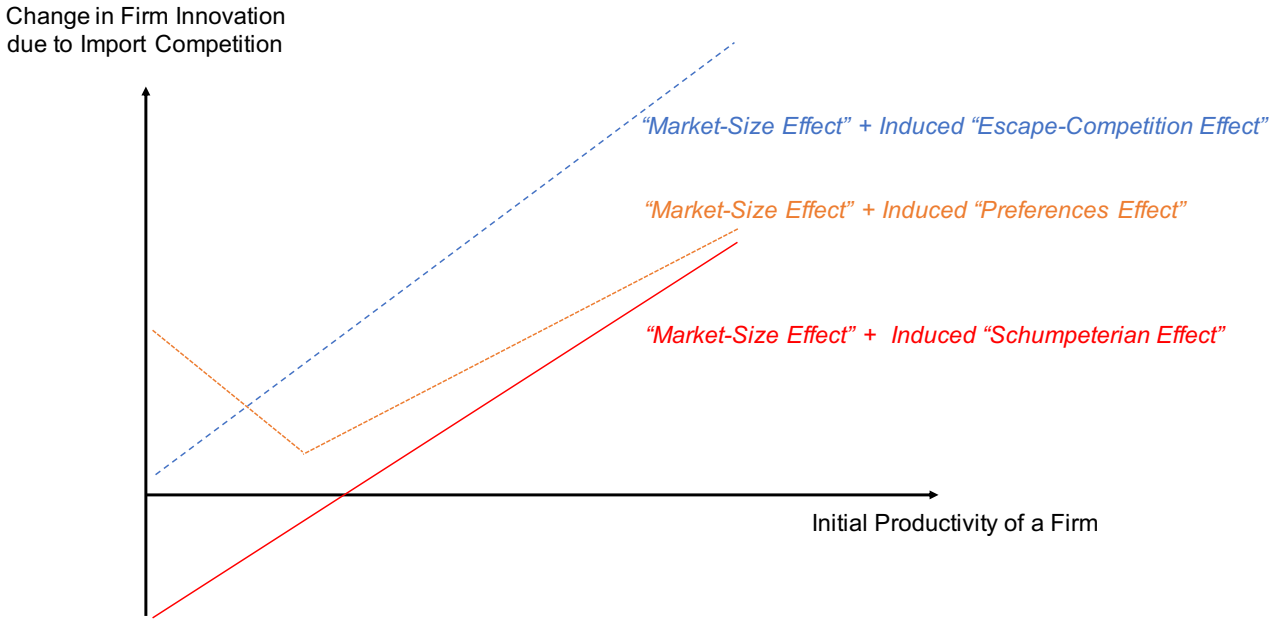


Figure 3 provides three examples of the possible innovation responses as a combination of the market-size effect and one of the different induced competition effects. The red line plots a scenario where the induced competition generates the Schumpeterian effect. In this case, the initially more productive firms that choose to export will increase their innovation due to the market size effect, but the initially less productive firms that do not export will reduce innovation due to the induced Schumpeterian effect. This is the pattern illustrated by the model of Aghion *et al.* (2017). The blue line plots a case where the induced competition generates the escape-competition effect. The most productive firms experience the largest market-size effect and also have the most incentives to escape competition, and thus they generate the largest increase in innovation. The least productive firms have the least increase in innovation since they benefit little from the increased market-size and are too far from the technological frontier to escape competition. The orange line plots a case where the induced competition generates the preferences effect. The preferences effect is strongest for firms closest to bankruptcy. In these firms, managers want to keep their private benefits and want to save the firm from going bankrupt by trying to become more efficient and innovating. The market size effect will still be most relevant for the top firms in the industry. Overall, this leads to a U-shaped pattern. In aggregate, one may expect export opportunities to generate positive effects on innovation for at least some firms, and the heterogeneity in firm responses from empirical studies will be helpful for disentangling

which of the induced competition mechanisms may be present.

3.2 Empirical Evidence

Table 3 summarizes the empirical findings on the effects of export opportunities. The first group of literature examines the effects of having access to export markets using different trade liberalization episodes or foreign demand shocks as natural experiments (Lileeva & Trefler, 2010; Bustos, 2011; Iacovone, 2012; Mayer *et al.* , 2016; Aghion *et al.* , 2017; Coelli *et al.* , 2018). Notably, all of these studies find positive effects—at least for some firms—of access to export markets on innovation, using a variety of measures of productivity and innovation. In line with the prediction of the market-size effect, the positive effects are found to be the strongest for the most productive and technologically advanced firms. These firms, who are likely exporters, increase their productivity via a number of ways, such as increasing R&D investment and hiring additional researchers (Aghion *et al.* , 2017 for France), increasing patent applications (Aghion *et al.* , 2017; Coelli *et al.* , 2018), increasing spending on technology more broadly (e.g., purchasing computers, software, and technology transfers as in Bustos, 2011 for Argentinean firms), adopting advanced manufacturing technologies (Lileeva & Trefler, 2010), and engaging in product and sometimes process innovation (Bustos, 2011; Lileeva & Trefler, 2010). The productivity gains could also come from firms re-optimizing their product mix and focusing on the most productive products (Mayer *et al.* , 2016) and reflect in increased labor productivity (Lileeva & Trefler, 2010; Iacovone *et al.* , 2011; Mayer *et al.* , 2016).

For non-exporters and less productive firms, these studies have found insignificant responses (Bustos, 2011) or even negative responses (Aghion *et al.* , 2017). There is no evidence of a positive response triggered by either the escape-competition effect or the preferences effect. If anything, these evidence suggests that the Schumpeterian effect from induced competition may discourage innovation activities or at least offset the market-size effect for the non-exporters and initially less productive firms.

Overall, the positive effects of access to export markets on productivity and innovation are similar across emerging economies like Mexico and Argentina as well as developed countries like Canada and France. Surprisingly, there is a noticeable gap in the empirical literature: there are no studies on how firms in the United States benefit from access to foreign markets, even though there is no shortage of potential natural experiments to explore (e.g., NAFTA, CUSFTA, access to China).[5] We hope that this gap in the literature will close in the future.

[5]Coelli *et al.* (2018) study firms in 60 different countries, but do not discuss heterogeneous results with respect to country or market characteristics.

Table 3: Empirical Evidence on Export Opportunities and Innovation-Related Outcomes

Paper	Home Country and Sample Period	Sources of Trade Shock	Outcomes	Conclusions
Effects of having access to export markets				
Lileeva and Trefler (2010)	Canada, 1984-1996	CUSFTA	Labor productivity, product innovation, advanced manufacturing technologies	Positive effects for exporters; only significant for smaller, least productive exporters
Bustos (2011)	Argentina, 1992-1996	MERCOSUR accession of Brazil	Technology spending, product and process innovation	Positive effects; only significant for firms in upper-middle range of firm size
Iacovone (2012)	Mexico, 1993-2002	NAFTA	Labor productivity	Positive effects; larger for frontier firms
Mayer et al. (2016)	France, 1995-2005	Foreign demand shocks	Labor productivity (value added per worker)	Positive effects for multi-product firms; insignificant for single-product firms
Aghion et al. (2017)	France, 1994-2012	Foreign demand shocks	Patent applications, R&D investment, # researchers	Positive effects for the initially most productive firms; negative effects for the initially least productive firms
Coelli et al. (2018)	60 countries, 1965-1985 and 1992-2000	Great Liberalization in the 90s (tariff cuts)	Patents	Positive effects
"Learning by exporting"				
Clerides et al. (1998)	Colombia, 1981-1991; Morocco, 1984-1991; Mexico, 1986-1990	before/after firm entry in exporting	Labor productivity, average variable cost	No significant effects
Bernard and Jensen (1999)	United States, 1984-1992	before/after firm entry in exporting	TFP, labor productivity	Negative/no effects
Van Biesebroeck (2005)	sub-Saharan Africa, 1992-1996	before/after firm entry in exporting	Productivity	Positive effects
De Loecker (2007)	Slovenia, 1994-2000	before/after firm entry in exporting	Productivity (Olley-Pakes)	Positive effects; larger when exporting to high-income countries
Atkin et al. (2017)	Egypt, 2011-2014	Randomized control experiment (access to foreign markets)	Profits, quality, output/hour	Positive effects on profits, quality, hourly output conditional on quality

An earlier literature on exporting and productivity gains has focused on a slightly different but related channel called "learning by exporting" (Clerides *et al.* , 1998; Bernard & Jensen, 1999; Van Biesebroeck, 2005; De Loecker, 2007; Atkin *et al.* , 2017). The idea is that exporters gain knowledge and expertise from foreign buyers which in turn increase their productivity and efficiency. While this mechanism, like the market-size

effect, also generates a similarly positive effect of exporting on firm outcomes, there are important conceptual differences between the two channels. The first source of differences is in firm intention. In learning by exporting, a firm exports first, and then generates knowledge almost "by accident", i.e., without active investment in innovation-related activities. This is different from the market-size effect, which prompts firms to make a conscious effort to increase innovation in order to reap the benefits from having access to an enlarged market. The second source of differences is in the timing of innovation. In learning-by-exporting, innovation happens *after* exporting, whereas in the market-size effect, firms may innovate or plan to innovate before export opportunities are realized. Due to these conceptual differences, Table 3 groups the "learning by exporting" papers in a separate category. The positive effects from "learning by exporting" are found to be mainly present on firms that export to buyers in more developed economies (e.g., Van Biesebroeck 2005; De Loecker 2007; Atkin *et al.* 2017). This makes intuitive sense, as there is more scope for firms to learn from technologically more advanced buyers. The lack of room for learning may explain why the one study on the United States, Bernard & Jensen (1999), finds no evidence of learning by exporting.

4 Impact of Access to Intermediate Inputs on Innovation

4.1 Theory

Access to imported intermediate inputs from abroad may allow domestic firms to source from new foreign suppliers instead of existing domestic ones, and consequently the domestic firms may purchase the same inputs at cheaper cost or get access to different and better (e.g., higher quality) inputs (Halpern *et al.* , 2015). It may also allow domestic firms to switch from producing inputs by themselves domestically to importing inputs from foreign suppliers or producing the inputs at a foreign location. As a result, domestic firms could reallocate across different tasks that it performs with different efficiencies, for example, by moving the less productive parts of the production process to a low wage country and keep the efficient parts of the production process at home (e.g., Grossman & Rossi-Hansberg 2008). If a domestic firm shifts part of its production abroad, but the production still remains within the boundaries of the firm as a multinational entity, this action is called offshoring. If the firm replaces domestic production by sourcing from a unrelated, foreign supplier, this action is called outsourcing.

There are three mechanisms through which access to intermediate inputs could have a *positive* impact on innovation. First, by improving the efficiency of the production process, access to imported intermediate inputs increases profit margins, which could have a positive impact on firm innovation (Dasgupta & Stiglitz,

1980). Second, through importing inputs, a firm may learn about new product design, new production processes, new materials or technologies, or even new organizational methods (Ethier, 1982; Markusen, 1989; Grossman & Helpman, 1991; Rivera-Batiz & Romer, 1991; Coe & Helpman, 1995). Third, after moving production abroad through offshoring or outsourcing, a firm may have "trapped" factors at home due to, for instance, moving costs or thin home market for resale. These factors may be redeployed towards innovation activities, resulting in increased innovation (Bloom *et al.* , 2014).

On the other hand, access to intermediate inputs could also have a *negative* impact on innovation. The efficiency gains in the production process due to access to imported inputs may eliminate some of the needs for a domestic firm to invest in process-improving technologies. Moreover, outsourcing the production part of a firm while keeping the R&D unit increases the geographic distance between production and R&D, which may hurt a firm's innovative capability when interactions between production process and product design are important (Pisano & Shih, 2012). Also, investing in cutting-edge technologies may become too costly after a firm moves production to countries with cheap labor that has limited technical skills (Fuchs & Kirchain, 2010),

4.2 Empirical Evidence

Table 4 summarizes the empirical findings on how access to intermediate inputs affect innovation-related outcomes. Overall, the vast majority of the studies find positive effects of importing inputs.

Most of the papers summarized in Table 4 examine emerging economies. Similar to the findings on the impact of import competition in developing countries, the studies also find positive effects of access to intermediate inputs. These results are not surprising, since domestic firms in those countries are often operating inside of the production frontiers and likely have ample room for improving their production processes and technologies. Interestingly, the magnitude of the effect of access to imported inputs is found to be larger than that of import competition. For example, using data on Indonesian firms between 1991 and 200, Amiti & Konings (2007) show that the productivity increases due to a reduction in input tariffs are twice as large as those from a reduction in output tariffs (which leads to increased import competition). They also show that not controlling for input tariffs when studying import competition grossly overestimates the estimated effects of import competition. Using data from India, Topalova & Khandelwal (2011) also find that access to inputs has a more positive effect on productivity than import competition.

Table 4: Empirical Evidence on Access to Intermediate Inputs and Innovation-Related Outcomes

Paper	Home Country and Sample Period	Sources of Trade Shock	Outcomes	Conclusions
Schor (2004)	Brazil, 1986-1998	Unilateral trade liberalization and part reversal	TFP variant	Positive (input tariffs)
Muendler (2004)	Brazil, 1986-1998	Unilateral trade liberalization and part reversal	TFP variant	No effect (use of foreign intermediates or equipment)
Amiti and Konings (2007)	Indonesia, 1991-2001	Indonesia's entry into WTO	TFP variant	Positive (larger than import competition)
Kasahara and Rodrigue 2008	Chile, 1979-1996	-	TFP variant	Positive for importers
Teshima (2009)	Mexico, 2000-2003	Tariff changes	R&D expenditure, process innovation, product innovation, TFP variant	Insignificant
Lileeva and Trefler (2010)	Canada, 1984-1996	CUSFTA	Labor productivity	Positive for exporters
Topalova and Khandelwal (2011)	India, 1987-2001	1991 liberalization episode	TFP variant	Positive (larger than import competition), only for domestic firms; especially in sectors which also liberalize FDI
Iacovone (2012)	Mexico, 1993-2002	NAFTA	Labor productivity	Positive, especially for frontier firms
Halpern et al. (2015)	Hungary, 1992-2003	Structural model	TFP variant	Positive for importers, especially for foreign owned importers
Bena and Simintzi (2017)	U.S., 1995-2004	1999 U.S.-China bilateral agreement	Patents	Negative effects on patents on new production methods; insignificant effects on patents on new products
Brandt et al. (2017)	China, 1998-2007	China's entry into WTO	TFP variant	Positive (stronger for new entrants)
Juhasz and Steinwender (2018)	75 countries, 1845-1910	Expansion of telegraph network	Technology adoption	Positive

Halpern *et al.* (2015) highlight a channel that may be particularly relevant for firms in emerging economies: the interaction effect between foreign ownership and access to imported inputs. Halpern *et al.* (2015) find that the positive effects of imported inputs are particularly strong for firms that have been foreign owned, which serves as evidence that foreign ownership provides the necessary knowledge about foreign input markets and enables domestic firms to access foreign suppliers. Consistent with this explanation, Topalova

& Khandelwal (2011) also find particularly strong effects in sectors with liberalized FDI policies (i.e., sectors that allowed foreign acquisition of domestic firms). These findings highlight the need for understanding the impact of access to intermediate inputs in the context of global production networks and multinationals, especially for firms in developing countries.

For firms in developed economies, the main benefits of having access to imported inputs are more likely to be cost-saving than learning by importing. Lileeva & Trefler (2010) and Bena & Simintzi (2017) provide the only systematical empirical evidence that we are aware of on this topic in the context of developed economics. Lileeva & Trefler (2010) study Canadian firms after CUSFTA and find positive effects for exporters that have improved access to inputs from the US. In contrast, Bena & Simintzi (2017) provide evidence suggesting that US firms with better access to cheap labor in China have fewer incentives to invest in cost-saving technologies. These studies suggest that where the inputs are coming from, i.e., from a low wage country versus a technologically developed country, may matter for which type of productivity effects should be expected, and this should be explored in further studies.

Most of the studies summarized in Table 4 use productivity as the key outcome. The two exceptions are Teshima (2009), who finds insignificant impact of imported inputs on Mexican firms' R&D expenditures, and Juhász and Steinwender (2018), who find positive effects on technology adoption using historical data from the 19th century on the expansion of the telegraph network. Since gains from productivity could result from a reallocation towards more efficient task without the firm investing in innovation, understanding the sources of productivity gains is a useful next step. Another area for future investigation is to examine the possible technological spillover effects of importing inputs. For instance, Amiti & Konings (2007) also find positive effect of access to intermediate inputs on non-importers, though the effects are smaller than those for importers, and spillover effects from importers to non-importers may be able to rationalize this finding.

5 Impact of Foreign Input Competition on Innovation

Foreign input competition means that foreign firms enter the domestic market as buyers and compete against domestic firms for the same inputs by domestic suppliers. We are not aware of any theoretical or empirical work that studies this trade shock or link it to firm innovation. In this section we propose a simple starting framework for thinking about the impact of foreign input competition on innovation.

Foreign input competition affects the input cost of a domestic firm. In the short-run, the input cost likely increases, due to domestic suppliers having a higher demand (due to the entry of foreign buyers) and more

bargaining power.[6] Some of the mechanisms from access to imported inputs thus also apply here: on the one hand, higher input cost reduces profits margins and subsequently firms' incentives to invest in innovation, on the other hand, it may also increase the need for investing in process-improving technologies. Different from access to imported inputs, there is no learning by importing or "trapped factors" in foreign input competition.

In the long-run, it is possible for the input cost of a domestic firm to fall, for instance due to domestic suppliers exploiting increasing returns to scale for both the domestic and foreign buyers. The opposite effects would then apply. Formalizing these different effects using theoretical models would be helpful. Given the inherent theoretical ambiguity, more empirical studies are also needed for understanding which effects would dominate under which circumstances.

6 Conclusion

Overall, this paper shows that trade liberalization has both positive and negative effects on innovation, and the direction of the effect depends on the firm, industry, and country. The literature review highlights interesting differences at the country level. In emerging economies such as Latin American countries, most of the evidence shows positive effects of trade on innovation, driven by import competition, access to export markets, and/or access to intermediate inputs. Although not all industries and firms will participate in innovation activities to the same extent, and some of the productivity gains may be due to reallocation, we believe that the overall evidence points to a positive effect of trade on innovation. This makes sense since firms in those firms are typically far from the technological frontier and have ample room for improving their technologies.

For a technologically advanced country like the U.S., the findings are more nuanced. On the one hand, productive exporters are found to increase innovation when they get access to more foreign markets, and access to intermediate inputs may have some additional positive effects on innovation for some firms. On the other hand, import competition may discourage some firms from innovation by squeezing profit margins. Nevertheless, import competition may still result in aggregate productivity gains due to the exit of unproductive firms and a reallocation of resources towards more efficient firms in the industry. We are not aware of a study trying to estimate the overall effect of all types of trade shocks on productivity and innovation for US firms. Future studies should address this question as it is of wide interest to policy makers.

[6] Note that foreign firms may also set up own production plants in the domestic country and directly hire domestic labor, in which case they would compete in the domestic labor market. This would result in an increase in input prices of labor and have the same effect on input cost.

From the policy perspective, there is ample evidence suggesting that trade liberalization that allows domestic firms to access foreign markets will increase innovation and productivity of the domestic firms. In contrast, the benefits of a protectionist policy is less clear. While it may be argued that protectionism is (temporarily) necessary for the development of *infant industries*, which need time to develop technologies and become competitive internationally, especially in developing countries, our review point to a clear downside of protectionist policies: Reduced access to more and higher-quality, more technologically advanced inputs may hinder the technological development of an industry. Another risk of protectionism is that foreign countries may retaliate by imposing their own protectionist policies, so then domestic firms would lose the benefits associated with access to export markets.

It is important to note here that trade policy is not the only tools for affecting the innovation activities of domestic firms. For example, Akcigit *et al.* (2017) examine and highlight important trade-offs in the welfare consequences of two types of policies: protectionist policies that raise trade barriers unilaterally (such as tariffs) versus policies that incentivize innovation such as R&D credits. Their conclusions are that protectionism may have short-run benefits but is bad for long-run innovation, whereas R&D credits have long-run benefits.

In interpreting all the evidence, it is important to keep in mind some of the limitations of the current literature. First of all, while most of the papers we reviewed focused on examining the effect of a single type of trade shock, empirically trade liberalization episodes typically induce some or even all of the four trade shocks described in Table 1. For example, regional trade agreements (e.g., EU, CUSFTA, NAFTA) usually involve lowering tariffs of all partner countries, so a specific country would experience trade shocks in the output and input markets simultaneously (though not to the same extent by all industries, but often in a correlated way across trading partners). But even in unilateral trade liberalization episodes, where one country lowers or increases tariffs unilaterally, it will have effects on both its input and output markets—lowering tariffs will increase import competition as well as improve access to intermediate inputs.

For the empirical analysis using tariffs as measures of trade shocks, it is therefore important to include three tariff measures into the regression: output tariffs of the domestic country (as a measure of import competition), input tariffs of the domestic country (as a measure of access to intermediate inputs), and tariffs of foreign country (as a measure of export opportunities).[7] Moreover, for making valid causal inferences, all three tariff measures must be exogenous to the firm (or instrumented for in an appropriate way to address

[7]If product level imports are available at the firm level, then it is possible to construct a weighted average of the tariffs of the imported inputs of a firm. Often, however, this is not the case, and empirical studies then resort to using a proxy at the industry level, using input-output tables.

endogeneity concerns). Several studies have demonstrated that including more than one tariff measure in the regression can change the estimated effects significantly. For example, Amiti & Konings (2007) show that the effect of import competition is severely overestimated when studying import competition by using changes in output tariffs without controlling for input tariffs.

Second, there are also measurement issues with respect to the outcomes. The studies we have reviewed use either productivity measures like labor productivity or residual TFP or measures that are more directly related to innovation, such as R&D spending (input into innovation) or patents (output of innovation). There are advantages and drawbacks to using either measure. Although productivity measures are closely linked to the actual profitability of the firm, changes in measured productivity could be due to changes in markups (arising from for instance changing market power) instead of changes in actual productivity. De Loecker (2011) finds that only a quarter of estimated productivity gains due to increased import competition results from actual productivity changes. Even with actual productivity gains, it is somewhat of a black box as to whether the gains come from changes in the product or task mix of the firm or actual innovation activities. For instance, Mayer *et al.* (2016) find that exporters' productivity gains are mainly due to reallocation towards more productive products; Atkin *et al.* (2017) show that increased productivity and profitability are due to reallocation towards goods with high-quality and high-price.

Measures such as R&D expenditure and patenting are more closely related to innovation, but they also have their own drawbacks. Given the uncertainty of the innovation process, R&D spendings do not always translate into innovation output, and can in fact occur in duplication (Dasgupta & Stiglitz, 1980). It may be difficult to associate patenting with specific trade shocks, since patent applications appear at the end of an often lengthy R&D process. Moreover, changes in patenting could be driven by not only changes in underlying innovative activities but also changes in firms' propensity to patent, so it is empirically important to consider/control for the latter. It is also important to control for differences and trends in patenting, both across sectors and over time (Lerner & Seru, 2017). In addition to R&D expenditure and patenting, studies have also used responses to survey questions where firms self report their adoptions of certain types of technology and/or their involvement in product or process innovation. Compared to R&D expenditure and patenting, these measures help study the impact of trade shocks on different types of innovations. However, these responses tend to generate very crude measures of innovation outcomes (i.e., dummy variables), and the measures may not be easily comparable across firms due to the self-reporting nature.

Our review has also identified several important gaps in the literature to be addressed by future work. First, we see a clear need for more studies on the impact of export opportunities and access to intermediate

inputs for US firms. Second, we need more studies that link productivity outcomes to innovative activities, and understand how much of the productivity gains from trade are due to reallocation versus innovation. Third, most of the studies focus on trading goods, but market access via FDI is also an important but understudied channel of trade. The optimization problems of multinationals, where the location choices of R&D and production are endogenous, are complex and their relationship to trade shocks deserve additional attention from the literature. Fourth, foreign input competition is an area that needs both theoretical and empirical work. Last but not least, we need studies that decompose and compare the effects of different types of trade shocks. We believe that the topic of how trade affects innovation is of immense importance, and there is a lot more to learn.

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