Offshoring and Skill-upgrading in French Manufacturing: A Heckscher-Ohlin-Melitz View*

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Abstract

We present a factor-proportions trade model in which heterogeneous firms can offshore intermediate inputs subject to fixed offshoring costs. Low-productivity firms produce all inputs domestically. Sufficiently productive firms offshore skill-intensive inputs to skill-abundant countries and labor-intensive inputs to labor-abundant countries. Differently from the traditional versions of factor-proportions trade theory, Heckscher-Ohlin forces operate at the within-industry level, leading to endogenous variation in domestic skill intensity across firms. Using French firm-level data for the years 1996 to 2007, we provide empirical support for the factor-proportions channel through which reductions in offshoring costs to labor-abundant countries have increased firm-level skill intensities of French manufacturers.

KEY WORDS: offshoring, heterogeneous firms, firm-level factor intensities, Heckscher-Ohlin.

JEL CLASSIFICATION: F11, F12, F14

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1 Introduction

How does international trade affect the relative demand for skilled to unskilled workers in industrialized countries? The Heckscher-Ohlin (HO) model, the traditional workhorse to address this question, predicts that freer trade leads countries to specialize in sectors that use their abundant factors intensively. This implies that in skill-abundant countries reductions in trade barriers should lead to a rise in the demand for skilled workers by shifting resources across industries.

However, empirical support for this prediction is limited. First, the HO model assumes that all firms within a given sector have identical factor intensities, and that all the variation in this variable is between industries. These assumptions are at odds with recent evidence. In France, for example, most of the variation in skill intensities occurs within 4-digit industries instead of between industries (Corcos et al., 2013). Second, the evidence shows increases in the skill intensities of all industries across the board in spite of a higher skill premium (e.g. Berman et al., 1994).

This paper makes the case that factor-proportions-based comparative advantage is perfectly capable of explaining the link between trade and the relative demand for skills. This requires two modifications of the HO model. First, since around 50 to 60 percent of world trade is in inputs rather than in final goods (WTO, 2013), we focus on firms' offshoring decisions (following Feenstra and Hanson, 1997). Second, we take the firm as the relevant unit of analysis and allow for firms to be heterogenous à la Melitz (2003). These modifications are motivated by the following novel evidence linking sourcing patterns and skill demand of French manufacturing firms. First, firms importing from labor-abundant countries are more skill intensive in their domestic production[1] than non-importing firms, while non-importers are in turn more skill-intensive than importers from skill-abundant countries. Moreover, the surge in French imports from labor-abundant countries that has taken place between the mid-1990s and the mid-2000s has been accompanied by an increase in the skill intensity of French industries, especially for firms that import from these countries.

In the model, intermediate inputs differ in their relative factor intensities and countries have different relative factor endowments, as in traditional HO theory. Firms are heterogeneous in terms of productivity, and offshoring of intermediates requires the payment of per-input fixed offshoring costs. Firms must therefore weigh the reduction in their marginal cost resulting from offshoring, say, a labor-intensive input to a labor-abundant country against the fixed costs implied

[1] That is, they employ a higher proportion of skilled relative to unskilled workers in their French plants.

by such a decision. Higher firm-level productivity implies that a given cost reduction from offshoring yields larger gains in variable profits.

The key sourcing patterns predicted by the theory are the following. From the perspective of a relatively skill-abundant country like France, low-productivity firms produce all inputs domestically. Sufficiently productive firms offshore the most skill-intensive inputs to very skill-abundant countries. Firms with even higher productivity levels find it profitable to also import labor-intensive inputs from labor-abundant countries, that are in general subject to larger trade frictions and lower productivity. Imports from skill-abundant countries substitute for domestic skilled workers and thus reduce the domestic skill intensity of importers relative to that of non-importers. By contrast, imports from labor-abundant countries substitute for domestic unskilled employment, making domestic production more skill intensive. Thus, selection into offshoring generates endogenous within-industry variation in skill intensities. Reductions in trade barriers vis-à-vis labor-abundant countries lead existing importers from these countries to source additional labor-intensive inputs and induce more firms to offshore to these countries. In comparison with firms not offshoring to labor-abundant countries, the domestic skill intensity of these firms will rise.

Our focus on firms' importing decisions generates a number of testable predictions on their sourcing patterns. This allows us to gauge the microeconomic channels that determine firms' domestic relative factor-input choices.

(i) HO comparative advantage: French firms import relatively larger values of more skill-intensive products from more skill-abundant countries.

(ii) The more productive firms located in France are, the more labor intensive are the marginal goods they import from a given skill-abundant source country. This is because offshoring of relatively more labor-intensive inputs to a skill-abundant country is associated with lower cost reductions. Thus, only sufficiently productive firms will find it optimal to import these inputs. By the same token, the more productive firms offshoring to labor-abundant countries are, the more skill-intensive are the marginal goods they import from there.

(iii) Within the group of firms that import from countries which are more skill abundant than France, low-productivity firms import exclusively from the most skill-abundant locations, whereas high-productivity firms also import from relatively less skill-abundant countries: since offshoring to less skill-abundant countries provides lower cost reductions, only sufficiently productive firms will find it optimal to source from them. Again, these patterns are reversed for French importers from the set of labor-abundant countries: low-productivity importers only source from the most labor-abundant locations, while high-productivity importers also source from relatively less labor-abundant ones.

The above predictions imply a connection between firms' imports and their domestic skill intensities. In particular, the model predicts that firms that increase imports from the set of labor-abundant countries experience an *increase* in their domestic skill intensities, while firms expanding imports from the set of skill-abundant countries experience a *reduction* in this variable. Moreover, firms that raise the skill intensity of imports from either set of countries simultaneously increase their domestic skill intensity.

We find strong empirical support for the predictions of our model using a quasi-exhaustive panel dataset of French manufacturing firms for the period 1996-2007. Using information on firm-level imports by product and source country, we first confirm that predictions (i)-(iii) on firms' sourcing patterns hold in the data. We then establish the link between firms' imports and their domestic skill intensity. We exploit supply shocks in France's trading partners and reductions in EU external tariffs to provide causal evidence that the surge in imports from labor-abundant countries has led to a substantial increase in the French manufacturing industry's skill intensity over the sample period. In fact, we find that most of the observed within-firm changes in skill intensity can be explained by increased offshoring to labor-abundant countries. Importers from labor-abundant countries raised their average domestic skill intensity from around 0.74 to 0.82, which corresponds to a 10-percent increase. Our IV estimates imply that this number can be exclusively explained by increased offshoring to labor-abundant countries.

There are several alternative explanations for the link between trade and the relative demand for skills that are consistent with two key features of the data: within-industry variation in skill intensity and a positive correlation between skill intensity and productivity. However, all of them focus on the connection between exporting and domestic skill intensity.[2] Instead, we emphasize the role of importing for skill upgrading and – while also controlling for the export channel in our empirical specifications – provide specific evidence for the corresponding theoretical mechanism. Specifically, we show that firms' sourcing patterns are in line with our model and that offshoring

[2]Burstein and Vogel (2016) use a hybrid Heckscher-Ohlin-Ricardo model with firm heterogeneity, where more productive firms are *exogenously* more skill intensive to study the impact of trade-cost reductions on the relative demand for skills. Crozet and Trionfetti (2013) and Harrigan and Reshef (2015) also impose within-sector heterogeneity in factor proportions by assumption. Several mechanisms to endogenize the connection between exports and the within-sector heterogeneity in skill intensities have been proposed. Helpman et al. (2010, 2015) develop assortative matching models, where more productive firms hire more skilled workers. In Verhoogen (2011) and Bustos (2012), trade liberalization induces more productive firms to self-select into quality upgrading and technology adoption, respectively. Ma et al. (2014) build on Bernard et al. (2011) and show that Chinese firms that start exporting expand the production of relatively labor-intensive products.

to labor-abundant countries increases domestic skill intensity, while offshoring to skill-abundant countries is associated with a decrease in this variable.

Our paper also contributes to the recent literature on offshoring. In particular, our model is inspired by the HO offshoring model in Feenstra and Hanson (1997), where firms offshore some of their labor-intensive activities in response to liberalization of capital markets, thereby reducing the demand for unskilled labor in the U.S. We extend their work by introducing firm heterogeneity, which enables us to derive and test implications at the firm level.[3]

Our theory delivers complementarities in sourcing decisions across countries, similar to those emphasized by Antràs et al. (2014).[4] Lower offshoring costs to other countries or for other inputs induces firms to import more from a given location. Moreover, we find that the impact of importing an additional country-product combination on a firm's global sourcing strategy depends on the country's factor abundance and the input's factor intensity: for French firms importing from the set of skill-abundant countries complementarities are stronger if the other source countries are more skill abundant or if the other imported products are more skill intensive because such imports imply larger cost reductions.[5]

Finally, we also contribute to the empirical literature on importing and domestic factor demand using firm-level data.[6] In contrast to this literature, which is purely empirical, we investigate the specific theoretical mechanisms through which skill demand at the firm level is affected by offshoring.

The rest of the paper is structured as follows. In section 2 we provide some motivating empirical evidence; in section 3, we set up the theoretical model and derive predictions on sourcing patterns and domestic skill intensity; section 4 describes the data and section 5 reports the

[3]Grossman and Rossi-Hansberg (2008) present an offshoring model with complementarities between domestically performed and offshored tasks where reductions in offshoring costs for unskilled tasks may benefit unskilled workers if complementarities are sufficiently strong to overturn standard HO forces. Gopinath and Neiman (2014) and Halpern et al. (2015) develop structural estimation methods for the productivity gains from importing, but remain silent on the distributional consequences of offshoring. Koren and Csillag (2011) provide empirical evidence for importing of skill-biased technologies. We focus on the HO sourcing patterns predicted by our model and show that domestic skill intensities *increase* with imports from labor-abundant countries and *decrease* with imports from skill-abundant locations.

[4]Using a model with heterogeneous firms but with no factor proportions trade that features complementarities between sourcing locations, Antràs et al. (2014) characterize offshoring patterns for U.S. firms. Other recent work with complementarities includes Blaum, Lelarge and Peters (2013).

[5]The symmetric results hold for firms offshoring to labor-abundant countries: in this case the effects are stronger if the other source countries are more labor abundant or if other imported products are more labor intensive.

[6]Kramarz and Biscourp (2007) discover that imports of finished goods from low-wage countries are associated with lower employment growth of French firms. Mion and Zhu (2013), using data on Belgian firms, present evidence that import competition from China induces skill upgrading of the domestic workforce. Hummels et al. (2014) employ data on Danish importers to provide evidence that employment and wages of high-skilled workers are positively affected by offshoring. Using French data, Carluccio et al. (2015) find that offshoring of finished goods increases the wages of managers but has no effect on the wages of blue-collar workers.

empirical results; finally we present our conclusions in section 6.

2 A Preliminary Look at the Data

In this section we describe some of the salient features of the French manufacturing employment and import data, which provide the motivation for our theoretical model. We use the administrative firm-level data that we describe in detail in section 4.

2.1 Intra-industry heterogeneity in skill intensity

Figure 1 illustrates the amount of intra-industry heterogeneity in firm-level skill intensities by plotting the kernel density of firm-level (log) skill intensity, defined as the proportion of non-blue-collar employment relative to blue-collar employment. The variable of interest has been demeaned at the 4-digit sector level, so that the density can be interpreted as pure within-industry heterogeneity in firm-level (log) skill intensity. The distribution is approximately normal, with a standard deviation of 1.628. Thus, there is evidence for pervasive intra-industry heterogeneity in skill intensity. We also decompose the variance of (log) skill intensity in French manufacturing into between and within 4-digit-sector variation and find that 80 percent of the variance of (log) skill intensity is explained by within-sector variation between firms, while only 20 percent of the variation is between sectors (result not reported).

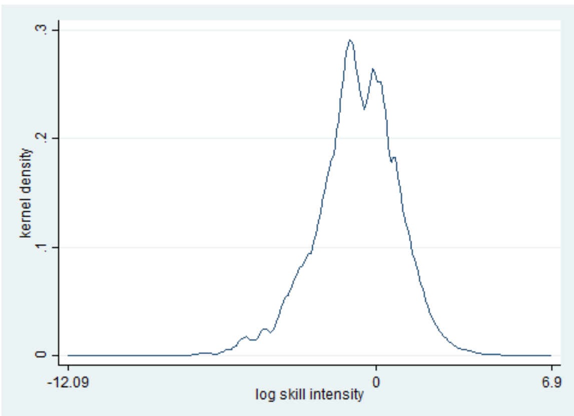

Figure 1: Distribution of log skill intensity.
The figure plots the distribution of the firm-level log skill intensity, defined as the ratio of employment of non-blue collar workers to blue-collar production workers per firm. Observations are deviations from the industry means. Thus, the distribution shows the within-sector dispersion in firm-level log skill intensity.

2.2 Imports and domestic skill intensity

During the same period, offshoring to labor-abundant countries has gained much relevance in French manufacturing. We define labor-abundant countries as those with less than 95 percent of the French level of secondary schooling in the population.[7] The left panel of Figure 2 presents the aggregate trend in offshoring to labor-abundant countries, measured as the fraction of firms' imports originating in labor-abundant countries (measured on the left axis): from 1996 to 2007 there was a large increase in the share of imports from these countries, from less than 16 to more than 20 percent of total French manufacturing imports. The left panel also provides some preliminary evidence that the trends in skill intensities and offshoring patterns might be related. It presents the aggregate trend in skill intensity in French manufacturing – defined as the ratio of total non-blue collar to blue-collar employment in French manufacturing (right axis). It is apparent that the aggregate skill intensity of manufacturing production tracks imports from labor-abundant countries quite closely. The aggregate skill intensity in French manufacturing increased by around 0.1 log points (around 8 percentage points) during the sample period.

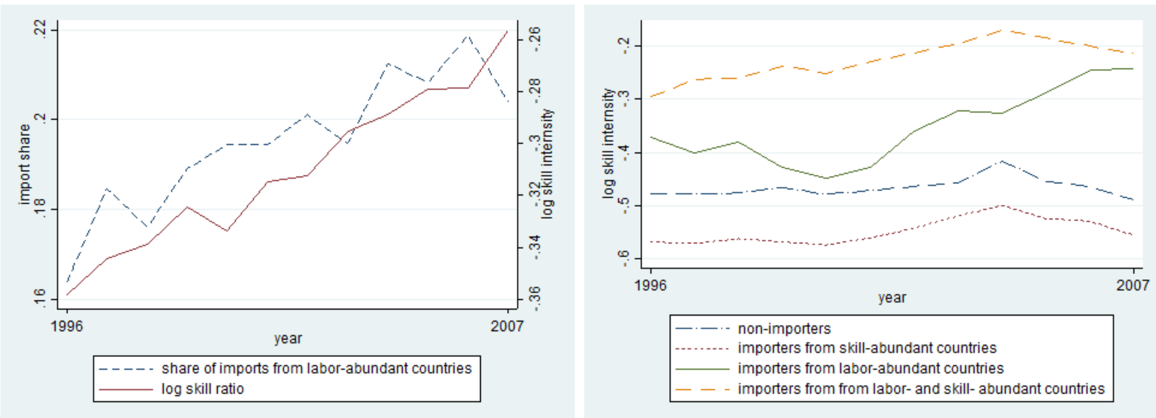

Figure 2: Trend in imports from labor-abundant countries and trends in skill intensity.
The left panel plots the share of imports originating in labor-abundant countries (countries with less than 95 percent of the French level of secondary schooling) in total French manufacturing imports (left axis) and the aggregate skill intensity, defined as the ratio of non-blue collar to blue-collar employment in French manufacturing (right axis). The right panel plots the average firm-level log skill intensity, separately for four categories of firms: firms that exclusively import from labor-abundant countries (with less than 95 percent of the French level of secondary schooling); firms that exclusively import from skill-abundant countries (with more than 95 percent of the French level of secondary schooling); firms that imports from both sets of countries; firms that do not import.

The right panel of Figure 2 plots the mean (log) skill intensity of French manufacturing firms by import status over time: firms importing only from labor-abundant countries and importers

[7] These results are not sensitive to the specific choice of the threshold. We have alternatively considered a 80 percent cutoff.

from both skill- and labor-abundant countries are more skill intensive in their domestic production than non-importers and have experienced a large increase in their domestic skill intensity over time. By contrast, firms exclusively importing from skill-abundant countries are more labor intensive than non-importers and the skill intensity of these two groups has not changed significantly during the sample period. This suggests that: 1) domestic skill intensity is related to the skill abundance of the offshoring destinations; 2) increases in domestic skill intensity are related to importing from labor-abundant countries.

Table 1 also reports the average skill intensity and total factor productivity (TFP)[8] by year separately for the same four categories of firms. Observe that the number of non-importers declined significantly during the sample period (from 30,806 to 23,658). Similarly, the number of exclusive importers from skill-abundant countries also contracted (from 11,889 to 7,503). By contrast, the number of exclusive importers from labor-abundant countries (from 690 to 1,257 firms) and the number of firms importing from both sets of countries (from 5,317 to 7,818) increased a lot. Thus, also at the extensive margin, there has been a substantial shift towards importing from labor-abundant countries. In addition, the table confirms numerically the patterns on skill intensity by import status visible in Figure 2. Moreover, Table 1 also shows that importers from all categories of countries display a larger dispersion in skill intensities than non-importers, as measured by the standard deviation of skill intensity.

2.3 Imports and productivity

Finally, Table 1 reports average TFP levels by import status. We normalize average TFP to zero for each 4-digit-sector-year pair, so that numbers are to be interpreted as TFP relative to the sector-year average. Non-importers are on average 3.5 percent less productive than the average firm in the sector, importers from skill-abundant countries are on average 4.5 percent more productive than the average firm, and firms that import from both sets of countries are on average 11.5 percent more productive. Thus, firms' import status can be ranked in terms of productivity: low-productivity firms do not import; sufficiently productive firms import from the set of skill-abundant countries; and the most productive firms import both from skill-abundant and from labor abundant countries.[9] Moreover, the productivity premium of firms importing from both sets of countries has fallen over time, from around 14 percent to around 9.5 percent,

[8]TFP is computed with the Levinsohn-Petrin (2003) methodology. See the data section for details.

[9]Exclusive importers from labor-abundant countries are a marginal category, since only between 600 and 1200 fall into this category. On average, they are around one percent more productive than non-importers.

while the relative productivity of all other categories has stayed roughly constant. This shows that the typical firm that imports from both sets of countries has become less productive over time. Together with the fact that the number of importers from both sets of countries has increased a lot over time, while the number of exclusive importers from skill-abundant countries has fallen, this suggests that offshoring costs to labor-abundant countries have declined disproportionately.

We now briefly summarize these stylized facts:

- *There is pervasive within-industry heterogeneity in skill intensity, which is larger for importers than for non-importers.*
- *Importers from labor-abundant countries are more skill intensive domestically than non-importers, whereas exclusive importers from skill-abundant countries are less skill intensive.*
- *There has been a shift in imports away from skill-abundant countries towards labor-abundant ones; simultaneously, firms importing from labor-abundant countries have become more skill intensive.*
- *Firms can be ranked in terms of productivity: low-productivity firms do not import; sufficiently productive firms exclusively import from skill-abundant countries; high-productivity firms also import from labor-abundant countries. Moreover, the typical importer from labor-abundant countries has become less productive over time.*

	Non-Importers				Importers labor-abundant countries				Importers skill-abundant countries				Importers both sets of countries			
Year	Obs.	Mean skill int.	St.d. skill int.	Mean TFP	Obs.	Mean skill int.	St.d. skill int.	Mean TFP	Obs.	Mean skill int.	St.d. skill int.	Mean TFP	Obs.	Mean skill int.	St.d. skill int.	Mean TFP
1996	30,386	-0.479	0.932	-0.036	690	-0.371	1.132	-0.030	11,889	-0.568	0.992	0.056	5,317	-0.296	1.046	0.133
1997	30,815	-0.478	0.933	-0.038	672	-0.402	1.101	-0.041	12,471	-0.571	0.974	0.055	5,783	-0.263	1.080	0.142
1998	29,296	-0.476	0.939	-0.036	758	-0.380	1.144	-0.041	12,552	-0.562	0.980	0.046	6,093	-0.261	1.084	0.129
1999	29,670	-0.466	0.94	-0.038	808	-0.428	1.091	-0.052	12,353	-0.568	0.972	0.050	6,402	-0.238	1.080	0.129
2000	28,298	-0.479	0.946	-0.035	833	-0.448	1.128	-0.052	11,980	-0.574	0.987	0.037	6,766	-0.252	1.077	0.122
2001	27,810	-0.472	0.944	-0.032	1,062	-0.429	1.066	-0.030	10,502	-0.560	0.968	0.040	6,769	-0.230	1.109	0.110
2002	29,110	-0.464	0.941	-0.031	1,210	-0.361	1.134	-0.014	10,429	-0.542	0.971	0.039	7,115	-0.213	1.093	0.109
2003	28,040	-0.456	0.943	-0.033	1,290	-0.323	1.105	-0.007	10,051	-0.519	0.979	0.040	7,163	-0.196	1.091	0.111
2004	27,328	-0.418	0.965	-0.035	1,254	-0.326	1.083	-0.017	9,799	-0.499	0.987	0.039	7,495	-0.170	1.077	0.112
2005	26,866	-0.454	0.949	-0.035	1,261	-0.288	1.077	-0.020	9,407	-0.524	0.973	0.038	7,878	-0.185	1.074	0.107
2006	26,971	-0.465	0.955	-0.036	1,436	-0.245	1.083	-0.012	8,717	-0.529	0.988	0.045	8,059	-0.201	1.062	0.104
2007	23,658	-0.490	0.957	-0.036	1,257	-0.243	1.093	-0.021	7,503	-0.556	0.980	0.045	7,818	-0.215	1.060	0.096
All	338,248	-0.466	0.945	-0.035	12,531	-0.341	1.102	-0.025	127,653	-0.550	0.980	0.045	82,658	-0.223	1.078	0.116

Table 1: Firm-level skill intensity and total factor productivity (TFP) by import status of firm.

The table shows the number of observations; means and standard deviations of firm-level log skill intensity of production (defined as non-blue-collar employment/blue-collar employment) and mean TFP (relative to the 4-digit-industry-year average) for the sample of French manufacturing firms by year. "Non-importers" includes firms that do not import in a given year. "Importers labor-abundant countries" includes firms that exclusively import from countries with less than 95 percent of the French level of secondary schooling. "Importers skill-abundant countries" includes firms that exclusively import from countries with more than 95 percent of the French level of secondary schooling. "Importers both sets of countries" includes firms that import from both sets of countries.

3 Model

In this section we present a multi-country model of offshoring with heterogeneous firms in a Heckscher-Ohlin environment, from which we derive the empirical implications we take to the data. Firms must decide whether to offshore or not; which range of inputs to offshore; and to which countries to offshore. There are N countries, denoted with $n = 1, 2, ..., N$, and ranked according to their relative factor endowments: $H_1/L_1 < H_2/L_2 < ... < H_N/L_N < 1$, where H_n and L_n denote country n's endowments of skilled ("skills") and unskilled labor ("labor"), respectively. Both factors are supplied inelastically. There is one final-good industry. Consumers in country n derive utility from a Dixit-Stiglitz aggregate of final-good varieties

$$C_n = \left[\int_{\omega \in \Omega_n} c_n(\omega)^{\frac{\sigma-1}{\sigma}} d\omega\right]^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where $\sigma > 1$. Ω_n denotes the set of available varieties of final goods and $c_n(\omega)$ is the quantity of final good ω consumed by country n.

Each firm located in a given country n produces a different variety of the final good, over which it has monopoly power. Varieties of final goods are made by assembling a continuum of intermediate inputs according to the following production function:

$$q_n(\gamma) = \gamma \left[\int_0^1 x_n(z)^{\frac{\varepsilon-1}{\varepsilon}} dz\right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{2}$$

where $1 < \varepsilon < \sigma$. (We discuss these restrictions on parameter values further below.) Here γ denotes a firm-specific productivity level, which is random and i.i.d. across firms within a country, and drawn from a distribution $G(\gamma)$, which is identical across countries. $x_n(z)$ denotes the quantity used of intermediate good $z \in [0, 1]$ in the production of a given final variety in country n.[10]

Intermediate inputs (or tasks) for use in country n can potentially be produced in any country $n' \in N$ according to the following Cobb-Douglas technology using skills and labor as inputs:

$$y_{n',n}(z) = \frac{Z(z)}{\tau} h_{n',n}(z)^z \, l_{n',n}(z)^{1-z}, \tag{3}$$

where $y_{n',n}(z)$ denotes the quantity produced of intermediate input z in country n' for use by a

[10]Note that intermediate inputs can alternatively be interpreted as production tasks. For example, one may think of a firm combining a set of relatively labor-intensive tasks corresponding to the physical production process of the final good with a set of relatively skill-intensive tasks, such as R&D, marketing or accounting.

country-n firm; $Z(z) = z^{-z}(1-z)^{z-1}$; and $h_{n',n}(z)$ and $l_{n',n}(z)$ denote, respectively, the skills and labor allocated to the production of intermediate input z in country n'. Notice that skill intensities are increasing in z, so that producing intermediates with higher z's requires relatively more skills. Finally, $\tau \in \{1, \tau^o_{n',n}\}$ relates to the way firms obtain intermediates: it takes value one if the firm produces the intermediate input in-house and value $\tau^o_{n',n} > 1$ if the input is sourced outside the firm. This variable outsourcing cost can be interpreted as a trade friction (in case goods are outsourced abroad, that is, offshored) or as a cost or productivity disadvantage due to the outsourcing process.[11] We allow $\tau^o_{n'n}$ to vary by importing firm.[12] Outsourcing of intermediate inputs is also subject to a fixed cost per outsourced input f^o in terms of the final good.

Factor and intermediate-input markets are perfectly competitive. Varieties of final goods are freely traded. Since we assume no fixed cost of production and exporting, all producing firms operate in both the domestic and all foreign markets. Finally, for each intermediate z, firms located in country n decide whether and to which locations n' to offshore production.

The version of the model presented in the main text takes factor prices and the number of firms in each country as given. In the Appendix, we present a general equilibrium version of the model that allows for free entry. In this case, final-good producers pay a fixed cost f^e (also in terms of the final good) before picking draws for γ. In practice, our arguments and the empirical analysis are based on partial-equilibrium arguments, as they rely on firms' optimizing behavior for a given set of factor prices and given the total number of firms in each country. However, the theoretical results remain valid in general equilibrium, as confirmed by (unreported) numerical simulations.

3.1 Offshoring decision

Following standard Heckscher-Ohlin intuition, countries' comparative advantages depend on their relative endowments: labor-abundant countries have a comparative advantage in low-z intermediates, very skill-abundant countries have instead a comparative advantage in high-z intermediates, whereas countries with intermediate skill-abundance levels have a comparative advantage in the production of inputs with intermediate skill intensity. The economic incentive for offshoring stems from reductions in the marginal cost of producing final varieties achieved by exploiting this com-

[11] We avoid modeling any type of contracting frictions that give rise to endogenous firm boundaries. See Antràs (2003) and Antràs and Helpman (2004).

[12] Since below we simply look at a firm's profit optimization problem, we avoid this additional notation.

parative advantage: a relatively labor-intensive input (with low z) can be most cheaply produced in a labor-abundant country (with low w_{ln}/w_{hn}, where w_{hn} and w_{ln} denote, respectively, the returns to skilled and unskilled labor in country n), and sourcing an input more cheaply reduces overall production costs and thus increases sales and profits.

3.1.1 Cost functions

We assume that the ranking of relative factor endowments translates into a ranking of factor prices (this would be true in general equilibrium): $w_{h1}/w_{l1} > w_{h2}/w_{l2} > ... > w_{hN}/w_{lN} \geq 1$. From the perspective of a country-n firm, different inputs, if offshored, will be sourced from different countries. Given factor prices, country-n firm's marginal cost of obtaining intermediate input z from country $n' \neq n$ is $p_{n',n}(z) = \tau^o_{n',n} w^z_{hn'} w^{1-z}_{ln'}$, whereas the marginal cost of producing an input in-house is $p_{n,n}(z) = w^z_{hn} w^{1-z}_{ln}$.[13] Figure 3 plots the logarithms of these cost functions against z, which determines the skill intensity of inputs. (We set $N = 5$ and consider the offshoring decision from the perspective of a firm from country $n = 3$.) The lower envelope of these lines represents the lowest marginal costs at which country-n firms can obtain the different intermediate inputs.

The cutoff points in Figure 3 define the ranges of inputs for which each country has the corresponding lowest production costs:[14]

$$\tau^o_{n'-1,n} w^{z_{n'-1,n'}}_{hn'-1} w^{1-z_{n'-1,n'}}_{ln'-1} = \tau^o_{n',n} w^{z_{n'-1,n'}}_{hn'} w^{1-z_{n'-1,n'}}_{ln'}. \quad (4)$$

Input $z_{n'-1,n'}$ is equally expensive to offshore to countries $n'-1$ and n', whereas inputs $z \in \left[z_{n'-1,n'}, z_{n',n'+1}\right)$ are cheapest to offshore to country n'. The range of inputs that are cheapest to produce by all country-n firms domestically is defined by

$$\tau^o_{n-1,n} w^{z_{n-1,n}}_{hn-1} w^{1-z_{n-1,n}}_{ln-1} = w^{z_{n-1,n}}_{hn} w^{1-z_{n-1,n}}_{ln}, \quad (5)$$

$$\tau^o_{n+1,n} w^{z_{n,n+1}}_{hn+1} w^{1-z_{n,n+1}}_{ln+1} = w^{z_{n,n+1}}_{hn} w^{1-z_{n,n+1}}_{ln}. \quad (6)$$

In the absence of the fixed cost of offshoring f^o, all firms in country n would import the range $[0, z_{n-1,n})$ from labor-abundant countries, of which $[0, z_{1,2})$ from country 1, $[z_{1,2}, z_{2,3})$ from country 2, etc. Similarly, country-n firms would offshore the range $[z_{n,n+1}, 1]$ to skill-abundant countries.[15]

[13]Given competitive factor markets and identical technologies across firms, the presence of outsourcing frictions makes outsourcing goods within the firm's own country unprofitable.

[14]We define $z_{0,1} = 0$ and $z_{N,N+1} = 1$.

[15]Suppose $\tau^o_{n'n}$ is prohibitively high for a country-n firm. Then the corresponding country-n' cost function would be so high up that no segment of it would be part of the lower envelope in Figure 3. In this case the country-n

However, once we take fixed offshoring costs f^o into account importing decisions will vary by firm within each country.

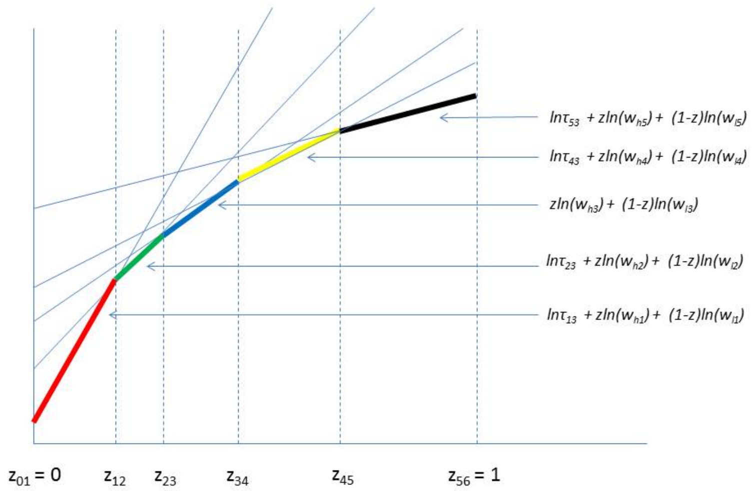

Figure 3: Minimum cost of sourcing vs. skill intensity

Notice that, within the set of countries that are more labor abundant than country n, offshoring the most labor-intensive inputs to the most labor-abundant countries yields the largest cost savings to a country-n firm. Similarly, offshoring the most skill-intensive inputs to the most skill-abundant countries yields the largest cost savings within the set of skill-abundant countries. Therefore, other things equal, we should expect firms to import rather more from the extremes of the distributions of inputs and countries. In other words, if a firm finds it profitable to offshore a given input from a given labor-abundant (skill-abundant) country, then it should be profitable for the firm to import more labor-intensive (skill-intensive) inputs as well.

Denote with z_n^- and z_n^+, respectively, the most skill-intensive input a country-n firm offshores to any country that is more labor abundant than n, and the most labor-intensive input offshored to any country that is more skill abundant than n. The range (z_n^-, z_n^+) is produced in-house by the country-n firm.[16] In the absence of fixed costs to offshoring, $(z_n^-, z_n^+) = (z_{n-1,n}, z_{n,n+1})$. For $f^o > 0$, $(z_{n-1,n}, z_{n,n+1}) \subseteq (z_n^-, z_n^+)$ instead: the presence of offshoring fixed costs might make it optimal for a country-n firm not to offshore all the inputs for which other countries present lower

firm would not offshore anything to country n'.

[16]Country-1 firms cannot offshore to a more labor-abundant country: $z_1^- = 0$ for all country-1 firms. Similarly, country-N firms cannot offshore to a more skill-abundant country: $z_N^+ = 1$.

costs.

The actual cost function of any given country-n firm depends on its offshoring pattern. In general, a country-n final-good producer with productivity γ that offshores inputs to labor-abundant countries $\{1, 2, ..., n^-\}$, $n^- < n$, and to skill-abundant countries $\{n^+, n^+ + 1, ..., N\}$, $n^+ > n$, has the following marginal-cost function for the variety it produces:[17]

$$MC_n\left(\gamma, z_n^-, z_n^+\right) = \frac{1}{\gamma}\left[\sum_{n'=1}^{n^- -1}\int_{z_{n'-1,n'}}^{z_{n',n'+1}}\left(\tau_{n',n}^o w_{hn'}^z w_{ln'}^{1-z}\right)^{1-\varepsilon}dz + \int_{z_{n^- -1,n^-}}^{z_n^-}\left(\tau_{n^-,n}^o w_{hn^-}^z w_{ln^-}^{1-z}\right)^{1-\varepsilon}dz + \right.$$
$$\left. + \int_{z_n^-}^{z_n^+}\left(w_{hn}^z w_{ln}^{1-z}\right)^{1-\varepsilon}dz + \int_{z_n^+}^{z_{n^+,n^++1}}\left(\tau_{n^+,n}^o w_{hn^+}^z w_{ln^+}^{1-z}\right)^{1-\varepsilon}dz + \sum_{n'=n^++1}^{N}\int_{z_{n'-1,n'}}^{z_{n',n'+1}}\left(\tau_{n',n}^o w_{hn'}^z w_{ln'}^{1-z}\right)^{1-\varepsilon}dz.\right]^{\frac{1}{1-\varepsilon}} \quad (7)$$

The first term in the square brackets represents the cost of offshoring the most labor-intensive inputs to the set of most labor-abundant countries; the second term refers to the cost of the inputs offshored to the "marginal" labor-abundant country; the third term captures the cost of the inputs produced in-house; the fourth term refers to the inputs offshored to the "marginal" skill-abundant country; finally, the fifth term represents the cost of offshoring the most skill-intensive inputs to the set of most skill-abundant countries.

In the Appendix we show that the function MC_n is continuous and differentiable, with $\partial MC_n/\partial z_n^- < 0$ and $\partial MC_n/\partial\left(1 - z_n^+\right) < 0$.[18] The intuition for these results is rather straightforward: as z_n^- increases, for example, labor-intensive intermediate inputs produced in-house are substituted by imports of intermediates produced (inclusive of transport costs) at a lower price in labor-abundant countries. This reduces the costs of the country-n final-good producer. MC_n is convex in z_n^- and $(1 - z_n^+)$: continuing with our example, as z_n^- increases, the offshoring firm imports less and less labor-intensive products from labor-abundant countries. Thus, the resulting cost reductions become smaller as z_n^- grows.

3.1.2 Firm's optimal behavior

Given factor prices and other firms' prices, firms maximize total profits Π_n, given by

$$\max_{p_n, z_n^-, \left(1-z_n^+\right)} p_n q_n - \left[MC_n\left(\gamma, z_n^-, z_n^+\right)\right] q_n - \left[z_n^- + \left(1 - z_n^+\right)\right] P f^o. \quad (8)$$

We define variable profits $\pi_n \equiv \left(p_n - MC_n\right) q_n$. Demand for the final good is given by $q_n = p_n^{-\sigma} P^{\sigma-1} E_W$, where E_W denotes world expenditure on final goods and P is the ideal price index

[17]The function MC_n does not include the fixed costs involved in the offshoring of inputs.

[18]Framing the offshoring decision towards skill-abundant countries in terms of $\left(1 - z_n^+\right)$ rather than z_n^+ renders the analysis more symmetric.

of the aggregate final good C. Since varieties are freely traded, all countries have the same price P. The first-order condition with respect to p_n yields the standard constant mark-up pricing rule $p_n(\gamma) = \frac{\sigma}{\sigma-1} MC_n(\gamma)$. The first-order condition with respect to z_n^- is

$$\frac{\partial \Pi_n}{\partial z_n^-} = \frac{\partial \pi_n}{\partial z_n^-} - Pf^o = -\frac{\partial MC_n}{\partial z_n^-} \left(\frac{p_n^{-\sigma}}{P^{1-\sigma}} E_W \right) - Pf^o \leq 0, \tag{9}$$

with π_n increasing and concave in z_n^-. The first-order condition with respect to $(1 - z_n^+)$ is

$$\frac{\partial \Pi_n}{\partial (1 - z_n^+)} = \frac{\partial \pi_n}{\partial (1 - z_n^+)} - Pf^o = -\frac{\partial MC_n}{\partial (1 - z_n^+)} \left(\frac{p_n^{-\sigma}}{P^{1-\sigma}} E_W \right) - Pf^o \leq 0, \tag{10}$$

with π_n increasing and concave in $(1 - z_n^+)$.

In comparison with the frictionless situation ($f^o = 0$), firms weigh the marginal benefit of offshoring an additional input against the marginal cost of offshoring Pf^o. They might find it optimal not to offshore some of the inputs that can be more cheaply produced in other countries, as the corresponding gain in variable profits due to lower variable costs must cover Pf^o for offshoring to be profitable. In other words, we cannot rule out the strictly negative sign in equations (9) and (10). The condition $\partial \Pi_n / \partial z_n^- = 0$ evaluated at $z_n^- = 0$ implicitly defines the threshold-level γ_n^- of productivity where country-n firms start to offshore a positive measure of labor-intensive intermediates. Similarly, $\partial \Pi_n / \partial z_n^+ = 0$ evaluated at $z_n^+ = 1$ defines γ_n^+. Firms with $\gamma < \gamma_n^o = \min(\gamma_n^-, \gamma_n^+)$ source all inputs domestically.[19] It is easy to show that, other things equal, if $\tau_{n'n}^o$ is higher for $n' < n$ than for $n' > n$, then $\gamma_n^- > \gamma_n^+$: firms require a lower productivity level to import from skill-abundant countries than from labor-abundant countries.

Since higher-productivity firms have larger market shares, the reduction in marginal costs resulting from offshoring is translated into larger variable profits for them. In Appendix A we prove that $\partial z_n^-(\gamma) / \partial \gamma \geq 0$ and $\partial (1 - z_n^+(\gamma)) / \partial \gamma \geq 0$ under the sufficient condition $\sigma \geq \varepsilon > 1$.[20] The less substitutable inputs are, the larger the reduction of production costs from offshoring an additional one. The higher the elasticity of substitution between final varieties, the larger the amount by which the cost reduction is turned into additional profits. When $\sigma > \varepsilon$, a given cost reduction translates into a more than a one-to-one profit increase, and this effect is amplified by larger productivity γ with an elasticity of $\varepsilon - 1$.

[19] If $\tau_{n'n}^o$ varies by firm, this threshold is of course firm specific.

[20] It is easy to show that a country-n firm would never offshore to a factor-abundant country without offshoring to more factor-abundant countries, because sourcing from the latter would imply larger cost reductions.

3.2 Offshoring patterns

We now turn to the model's predictions connecting firm-level productivity with the specific types of intermediates offshored and their sourcing locations.[21] Consider a given source country n'. The import volume of a given intermediate z is

$$p_{n',n}(z)x_{n',n}(z) = (\tau^o_{n',n} w^z_{hn'} w^{1-z}_{ln'})^{1-\varepsilon} \gamma^{\sigma-1} [\gamma MC_n \left(z^-_n(\gamma), z^+_n(\gamma)\right)]^{(\varepsilon-\sigma)} \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} P^{\sigma-1} E_w.$$

Taking logs, we obtain

$$\begin{aligned} \log(p_{n',n}(z)x_{n',n}(z)) = \Delta + (1-\varepsilon)\log(\tau^o_{n',n}) + (1-\varepsilon)\log(w_{ln'}) + \\ +(1-\varepsilon) z \log(w_{hn'}/w_{ln'}) + (\sigma-1)\log(\gamma) + (\varepsilon-\sigma)\log[\gamma MC_n \left(z^-_n(\gamma), z^+_n(\gamma)\right)], \end{aligned} \quad (11)$$

where $\Delta \equiv -\sigma \log\left(\frac{\sigma}{\sigma-1}\right) + (\sigma-1)\log(P) + \log(E_w)$. Thus, given that $\varepsilon > 1$, the import volume of a given input z from country n' increases in productivity γ. When $\sigma > \varepsilon$ higher productivity also has an indirect positive impact on import volumes through its effect on the offshoring cutoffs $z^-_n(\gamma)$ and $z^+_n(\gamma)$ (captured by the term $(\varepsilon-\sigma)\log[\gamma MC_n \left(z^-_n(\gamma), z^+_n(\gamma)\right)]$). This reflects complementarities in sourcing decisions: higher productivity implies that more inputs are offshored, which reduces marginal costs and thus increases the volume of imports for a given input. In addition, the import volume decreases in offshoring costs $\tau^o_{n',n}$ and w_{ln}, which is larger for more skill-abundant countries, and decreases in the interaction of skill intensity z and relative factor prices $(w_{hn'}/w_{ln'})$. This term implies that more skill-abundant countries have a lower cost for and hence a comparative advantage in producing more skill-intensive inputs (intensive margin).

Prediction 1: *More skill-abundant countries have a comparative advantage in producing inputs with higher skill intensity. The import value of more skill-intensive inputs is thus larger when sourced from more skill-abundant countries.*

Note also that the skill intensity of the marginal input offshored to country n', $z^-_n(\gamma)$, increases in γ (extensive margin). Thus, when considering importers from a specific labor-abundant country n', the volume of imports of relatively skill-intensive products will be larger for more productive firms, since import values given by equation (11) are positive for $z \in$

[21] In general, our results apply to firms in any country except for those in the most skill-abundant and labor-abundant countries, that is countries 1 and N, where the offshoring patterns are rather "one-sided" for obvious reasons.

$[z_{n'-1,n'}, \min\{z_{n',n'+1}, z_n^-(\gamma)\}]$; also, the imports of more productive importers will be more heterogeneous in terms of skill intensities, as their imports span a wider range of inputs. (The symmetric result holds for imports from skill-abundant countries.) We summarize these observations in the following result:[22]

Prediction 2: *(i) Holding constant a given labor-abundant (skill-abundant) source country, the import value of relatively skill-intensive (labor-intensive) inputs is larger for more productive firms. (ii) In addition, more productive offshoring firms have more variation in the skill intensity of their imported goods from a given country.*

Next, we look at firms' decisions from which countries to source. Consider two firms with productivity levels $\gamma_1 < \gamma_2$ sourcing from country n', $n' < n'+1 < n$. According to equation (11), both firms will import smaller values from relatively more skill-abundant locations, since inputs produced in these locations are relatively more expensive. Moreover, if firm 2 is sufficiently more productive than firm 1, it will also source from more skill-abundant countries, whereas the less productive firm 1 will not. Hence import values are positive for $z \in [0, \min\{z_{n',n'+1}, z_n^-(\gamma)\}]$. This creates variation in the value of imports at the extensive margin and makes sourcing locations more heterogeneous in terms of skill intensity for more productive importers. (The symmetric result applies as well for importers from skill-abundant countries.)

Prediction 3: *(i) For firms offshoring to the set of labor-abundant (skill-abundant) countries, more productive firms have a larger import value from relatively more skill-abundant (labor-abundant) locations among them. (ii) Moreover, more productive offshoring firms have more variation in the skill abundance of countries from which they import.*

Finally, we demonstrate in Appendix B that in the presence of firm-specific variable offshoring costs there exist complementarities in sourcing decisions across products and countries: holding

[22] In our stylized model, the only country for which the marginal offshored input is a function of γ is actually country n^-. In the presence of input-country-firm-specific fixed offshoring costs, however, the skill-intensity of the marginal good sourced from each country would be a function of the importing firm's γ. In order for offshoring input z'_n to country n' to be profitable,

$$\frac{\partial \Pi_n}{\partial z'_n} = -MC_n^{1-\sigma}(\gamma)\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} B_{n',n}\left(\frac{E_W}{P^{-\sigma}}\right) \geq f^o.$$

Letting f^o be stochastic and input-country-firm-specific, drawn from a distribution $G(f^o)$, the probability of good z'_n being offshored would be $G\left[-\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} MC_n^{1-\sigma}(\gamma)B_{n',n}\left(\frac{E_W}{P^{-\sigma}}\right)\right]$, which is increasing in γ and decreasing in skill intensity z. Thus, the marginal input sourced from a given location would be different for different firms even for infra-marginal countries. Moreover, since the marginal gain from offshoring more skill intensive inputs is strictly increasing in γ as long as $\sigma > \varepsilon$, the skill intensity of the marginal input offshored to each labor-abundant country would be on average larger for more productive firms.

constant productivity γ, firms that have lower offshoring costs for more labor-intensive inputs (skill-intensive) or to more labor-abundant (skill-abundant) countries, import more from any given location (see Predictions 9 and 10 in Appendix B). The logic of this result is relatively straightforward: a lower variable offshoring cost $\tau^o_{n'n}$, $n' \leq n^-$, reduces MC_n and raises Π_n, thus increasing the import volume (11) and enhancing the incentive to extend the offshoring margins z_n^- and $(1 - z_n^+)$. These effects are stronger if the lower $\tau^o_{n'n}$ apply to very labor-abundant or very skill-abundant source countries, or to very labor-intensive or very skill-intensive inputs, as these are the ones that provide larger cost reductions from offshoring.

3.3 Firm-level predictions on domestic skill intensity

We now turn to the model's predictions on the domestic skill intensity of offshoring firms. First, the model predicts that self-selection into offshoring leads to within-industry variation in the skill intensity of domestic production, since firms choose to offshore different ranges of inputs which vary in their skill intensities. To see this, define the skill intensity of domestic production of a firm located in country n as

$$\frac{\int_{z_n^-(\gamma)}^{z_n^+(\gamma)} h_{n,n}(z)\,dz}{\int_{z_n^-(\gamma)}^{z_n^+(\gamma)} l_{n,n}(z)\,dz} = \frac{w_{ln}}{w_{hn}} \frac{\int_{z_n^-(\gamma)}^{z_n^+(\gamma)} z\left(w_{hn}^z w_{ln}^{1-z}\right)^{1-\varepsilon} dz}{\int_{z_n^-(\gamma)}^{z_n^+(\gamma)} (1-z)\left(w_{hn}^z w_{ln}^{1-z}\right)^{1-\varepsilon} dz} = \frac{w_{ln}}{w_{hn}}\Delta. \tag{12}$$

It is easy to see that $\partial\Delta/\partial z_n^- > 0$ and $\partial\Delta/\partial\left(1 - z_n^+\right) < 0$.

Prediction 4: *Given heterogeneity in firm-level productivity γ, there is variation in skill intensity within sectors.*

Moreover, according to the model, firms producing all inputs in-house will have the same skill intensity. These are the firms for which $z_n^-(\gamma) = 0$ and $z_n^+(\gamma) = 1$, that is, the firms with productivity $\gamma < \gamma_n^o$, for which the first-order conditions (9) and (10) hold with strict inequality at $z = 0$ and $z = 1$, respectively. These firms have all the same marginal-cost function (up to the constant γ), $MC_n(\gamma, 0, 1)$, and therefore the same skill intensity.

Prediction 5: *The variation in skill intensity of domestic production is larger across offshoring firms than across firms that source all inputs domestically.*

Given that $\partial\Delta/\partial z_n^- > 0$ and $\partial\Delta/\partial\left(1 - z_n^+\right) < 0$, the domestic skill intensity of offshoring firms increases in their offshoring to labor-abundant countries and decreases in their offshoring to skill-abundant countries.

Prediction 6: *Offshoring to labor-abundant countries raises the skill intensity of domestic production, while offshoring to skill-abundant countries reduces it.*

Define firm-level import intensity as the import share in total variable cost. A country-n firm's import intensity from labor-abundant countries is given by

$$\frac{\left[\sum_{n'=1}^{n^{-}-1}\int_{z_{n'-1,n}}^{z_{n',n'+1}} p_{n',n}^{1-\varepsilon}\left(z\right)dz + \int_{z_{n^{-}-1,n^{-}}}^{z_{n}^{-}\left(\gamma\right)} p_{n^{-},n}^{1-\varepsilon}\left(z\right)dz\right]}{\gamma^{1-\varepsilon}MC_{n}^{1-\varepsilon}}, \tag{13}$$

which increases in $z_{n}^{-}\left(\gamma\right)$. Similarly, the import intensity from skill-abundant countries increases in $1-z_{n}^{+}\left(\gamma\right)$. Above we showed that the skill intensity of domestic production increases in $z_{n}^{-}\left(\gamma\right)$ and decreases in $1-z_{n}^{+}\left(\gamma\right)$. It thus follows that:

Prediction 7 *The skill-intensity of domestic production is increasing (decreasing) in import intensity from labor-abundant (skill-abundant) countries.*

Note that lower offshoring costs $\tau_{n'n}^{o}$, $n' \leq n^{-}$, raise the import intensity from labor-abundant countries through both the intensive margin (a larger import share of infra-marginal offshored inputs) and the extensive margin (an increase in z_{n}^{-}).

Define now country-n firm's skill intensity of imports from labor-abundant countries as the average skill intensity of the imports from these countries: the skill intensity employed in the production of the imported input is weighted by the share of the firm's imports of such input in its total imports from labor-abundant countries:

$$\begin{aligned}&\sum_{n'=1}^{n^{-}-1}\int_{z_{n'-1,n}}^{z_{n',n'+1}}\frac{p_{n',n}^{1-\varepsilon}\left(z\right)}{\sum_{n'=1}^{n^{-}-1}\int_{z_{n'-1,n}}^{z_{n',n'+1}} p_{n',n}^{1-\varepsilon}\left(z\right)dz+\int_{z_{n^{-}-1,n^{-}}}^{z_{n}^{-}\left(\gamma\right)} p_{n^{-},n}^{1-\varepsilon}\left(z\right)dz}\frac{h_{n',n}\left(z\right)}{l_{n',n}\left(z\right)}dz+ \\ &+\int_{z_{n^{-}-1,n^{-}}}^{z_{n}^{-}\left(\gamma\right)}\frac{p_{n^{-},n}^{1-\varepsilon}\left(z\right)}{\sum_{n'=1}^{n^{-}-1}\int_{z_{n'-1,n}}^{z_{n',n'+1}} p_{n',n}^{1-\varepsilon}\left(z\right)dz+\int_{z_{n^{-}-1,n^{-}}}^{z_{n}^{-}\left(\gamma\right)} p_{n^{-},n}^{1-\varepsilon}\left(z\right)dz}\frac{h_{n^{-},n}\left(z\right)}{l_{n^{-},n}\left(z\right)}dz\end{aligned} \tag{14}$$

It is easy to show that $h_{n',n}\left(z\right)/l_{n',n}\left(z\right)$ increases in z (for a given n') and in n'. Thus, as $z_{n}^{-}\left(\gamma\right)$ increases, the firm's skill intensity of imports from labor-abundant countries also rises.[23] Moreover, firms importing a more skill-intensive mix of inputs from labor-abundant countries (that is, firms with a high $z^{-}\left(\gamma\right)$) are more skill intensive in their domestic production. (A similar result applies to imports from skill-abundant countries: firms importing a more skill-intensive mix of inputs from skill-abundant countries are more skill intensive in their domestic production.)

[23]Lower offshoring costs $\tau_{n'n}^{o}$, $n' \leq n^{-}$, raise the skill intensity of imports from labor-abundant countries through the extensive margin (an increase in z_{n}^{-}).

Prediction 8: *The skill intensity of domestic production increases in the skill intensity of imports.*

4 Data

Firm-level Data

Our empirical analysis is based on a detailed French firm-level dataset that we obtain by merging several administrative data sources using a common firm identifier.

Trade data: Firm-level trade data come from an exhaustive administrative file collected by the French Customs Office. The yearly value of imports (by country of origin and product) and exports (by country of destination and product) are reported for all firms over the period 1996-2007.[24] As explained in the model section, we interpret offshoring broadly as an activity that splits a production process across countries. This also includes extreme cases where the full physical production process is offshored, so that only typical headquarter inputs, such as marketing, accounting, and R&D are produced domestically. Thus, we do not restrict imports to be intermediates but instead consider firms' imports of all manufacturing products (including those of final goods).

Balance sheet data: The administrative BRN dataset ("Bénéfices Réels Normaux") is constructed from tax records and provides balance-sheet information by year. We use data on sales, value added, employment, material usage, capital stock and main sector of activity at the 5-digit NAF Rev2 level.[25] We deflate value added, and capital stocks using industry-level price indices provided by the French statistical agency. The dataset includes over 60% of French firms.

We use the BRN dataset together with information from DADS (see below) to estimate firm-level value-added-based total factor productivity (TFP) as the residual of a 3-factor Cobb-Douglas production function with skilled labor, unskilled labor and capital inputs. We estimate production functions separately for each 2-digit industry using data on 646,920 observations over the period 1996-2007. Our preferred measure uses the Levinsohn and Petrin (2003) method but we obtain very similar results with Wooldrige's (2009) approach. The coefficient estimates of the sector-specific production functions are reported in Table A-3.

[24] The data is virtually exhaustive. Flows with non-EU countries whose value is below 1,000 Euros are not in the dataset. In the case of EU countries, the threshold is larger, varying from 40,000 to 150,000 Euros depending on the year. These thresholds leave out a very small proportion of French trade flows.

[25] NAF = French classification of economic activities, the first four digits of which are identical to the NACE Rev2 classification

Employment by skill data: We obtain information on the occupational structure at the firm level using the DADS dataset ("Déclaration Annuelle de Données Sociales"). It is constructed from mandatory employer reports of their workers' characteristics. For every firm in France with at least one employee, we have information on the number of workers by year in each of five categories: 2= Firm owners receiving a wage; 3=Administrative and commercial managers (includes engineers); 4=Technicians and supervisors; 5=White Collar employees; 6= Production workers (Blue Collar). Categories are based on the French *Nomenclature des professions et catégories socioprofessionnelles*, PCS.[26] We construct our main measure of skill intensity at the firm level as the fraction of non-production workers in total employment. The skill intensity of firm f in year t is defined as $\textit{skill intensity}_{ft} \equiv (2 + 3 + 4 + 5)/(6)$. In Table A-4 we show that non-production workers are significantly more skilled than production workers, as proxied by their relative wages (skill premium).

Country- and Product-level Data

We complement our firm-level dataset with the following information:

Country-level human-capital data: We use information on country-level skill abundance from Barro and Lee (2013) to construct the set of countries which are more labor abundant than France. Our measure of skill abundance is the number of years of secondary schooling in the population older than 15. In the main text, we consider the set of countries that have less than 95 percent of the French level of secondary education as labor abundant and the remaining set of countries as skill-abundant. Note that our empirical results are not sensitive to this specific choice. In the robustness checks we consider various alternative ways to split countries into labor-abundant and skill-abundant: e.g., we also try an 80-percent threshold for labor-abundant countries and a 105-percent threshold for skill-abundant countries. The information on secondary education is available for the years 2000 and 2005; we use an average of the two data points. Table A-5 presents the set of countries.[27]

Product-level skill-intensity data: We use the NBER manufacturing database (Bartelsman and

[26] The nomenclature underwent a change in 2003. This change only affected the 3-digit disaggregation, while the 1-digit classification we are using remained unchanged. Although this variable refers to occupations, it has often been used to proxy for the workers' skill level (e.g., Cahuc et al., 2006). Caliendo et al., 2015, show that average wages are inversely linked to the position in the PCS.

[27] We consider as skill-abundant any old EU-member countries that fall below these cutoffs. We do this for two reasons: first, because we do not consider these countries as truly labor-abundant, since they are all marginal cases; second, in the IV exercise we use EU external tariffs to construct our instrument, so we cannot include these countries in the set of labor-abundant countries. However, most of the empirical results are robust to including them in the set of labor-abundant countries. Those countries are: Belgium, Denmark, Finland, Greece, Ireland, Italy, Luxemburg, Portugal, Spain and the UK.

Gray, 1996; available at http://www.nber.org/nberces/) to construct measures of skill intensity at the product level. We define skill intensity as the ratio of non-production to production workers. Both measures are available at the NAICS97 6-digit level. We map them into HS6 codes using the concordance table provided by Pierce and Schott (2009). When more than one NAICS97 code maps into a single HS6 code, we take a simple average. The advantage of using U.S. industry data is that it is exogenous to events in France. To further avoid endogeneity issues, we use factor intensity in the pre-sample year 1995.

Tariff data: We employ information on EU external tariffs at the importer-product level to obtain exogenous variation in import flows. We use information on applied tariffs (simple averages) at the 6-digit HS level from the Worldbank's WITS database for our sample period.

World export data: We use data from the BACI database (administered by CEPII) to construct exports by HS 6-digit product for each country from which French firms import for the years 1996 to 2007. We use this information to construct instrumental variables based on supply shocks in France's trading partners.

Measuring the Average Skill Intensity of Imports

The average skill intensity of firm-level imports is a central measure to our analysis (see equation (14)). It is constructed as follows. Denote the HS6 product-level skill intensity with $skillint_p$, and the share of imports of product p in firm f's total imports from labor-abundant countries in period t as $w_{f,p,t}$. The average skill intensity of imports from labor-abundant countries is defined as:

$$import\ skill\ intensity_{f,t} = \sum_{p \in I_{f,p,t}} skillint_p \times w_{f,p,t}.$$

$import\ skill\ intensity_{f,t}$ is a firm-level import-share-weighted average of factor intensities. $I_{f,p,t}$ is the set of products which firm f imports from the set of labor-abundant countries in that period. We define the average skill intensity of firm-level imports from skill-abundant countries in an analogous way. We construct $skillint_p$ using the U.S. industry data described above. The definition of product-level skill intensity (the ratio of non-production to production workers) corresponds quite closely to our firm-level measure of skill intensity. While we measure $skillint_p$ using U.S. data, theoretically, $h_{n',n}(z)/l_{n',n}(z)$ depends both on z and on local factor prices w_{hn}, w_{ln}. This will introduce measurement error in our explanatory variable, which may bias our estimates. We will thus use an IV strategy to correct for this bias.

Construction of Instrumental Variables

In our empirical analysis we would like to exploit exogenous variation in offshoring opportunities. We thus need to construct instruments for the value of imports by firm from the sets of labor- and skill-abundant countries as well as for the average skill intensity of imports. According to our model, changes in $\tau^o_{n',n}$ shift both $x_{n',n}(z)p_{n',n}(z)$ and the offshoring thresholds $z^-_n(\gamma)$ and $z^+_n(\gamma)$ and thereby change both the import intensity and the average skill intensity of imports. Observe that changes in $\tau^o_{n',n}$ capture both changes in offshoring costs (including import tariffs) and foreign export-supply shocks. Hence, we construct two types of instruments for the endogenous variables which exploit this variation.

Export-supply shock instruments. The first set of instruments for imports is based on world export-supply shocks, following recent work by Autor et al. (2013). These instruments are based on the following idea: an increase in world exports of product p by country c reflects a shock in country c's competitiveness for this product (due, for example, to exogenous variation in productivity, costs or product quality). French firms importing product p from country c would respond to this shock by increasing their imports of this product from this specific origin. Exogeneity is ensured by the fact that supply shocks in foreign countries are exogenous to firm-level decisions in France. To construct such firm-specific instruments, we rely on Hummels et al. (2014). For each firm, we compute the share of each (HS6) product-country pair in total imports in the first year the firm appears in the sample in order to avoid endogeneity concerns and then take an import-share-weighted average of foreign export supply shocks. Specifically, let $\log(X_{p,c,t})$ be the (log) export supply of product p by country c in period t (excluding exports to France) and let $w_{f,p,c,0}$ be the share of imports of product p from country c in firm f's imports from labor-abundant countries in the first period the firm is in the sample. Then the firm-specific instrument for the value of imports from labor-abundant countries is constructed as

$$\hat{imports}_{f,t,1} = \sum_{c \in I_{f,c,0}} \sum_{p \in I_{f,p,0}} w_{f,p,c,0} \times \log(X_{p,c,t}),$$

where $I_{f,c,0}$ and $I_{f,p,0}$ is the set of countries and products a given firm imports in the first year it is in the sample. All the time variation in the instrument is due to exogenous export-supply shocks. Moreover, given that we use initial imports as weights, the instrument operates only through the intensive margin of imports. We construct an instrument for the value of imports from skill-abundant countries in an analogous way. In order for the supply-shock-based instruments to have sufficient power, two conditions must be satisfied: the set of imported products must have sufficient variation across firms; and it must relatively stable over time for a given firm. Both conditions are met in our data.[28] In addition, we construct a supply-shock-based instrument for the average skill intensity of imports from labor-abundant countries. This instrument is defined as an average-import-shares × supply-shock-weighted average of product-level skill intensities.

$$import\ \widehat{skill}\ intensity_{f,t,1} = \sum_{p \in \bar{I}_{f,p}} skillint_p \times \left(\sum_{c \in \bar{I}_{f,c}} \bar{w}_{f,p,c} \times \log(X_{p,c,t}) \right).$$

Here we use average import weights $\bar{w}_{f,p,c}$ and consider the full set of product-countries ever imported by a given firm in order for the instrument to induce variation in the extensive margin $z_n^-(\gamma)$. Again, all the time variation in the instrument arises from country-product-specific supply shocks but these may shift weights to country-product pairs initially not sourced by a given firm.

Tariff instrument. Our second type of instrument exploits tariff reductions from the Uruguay round of multilateral trade liberalization, which was concluded in 1994 and implemented up to the early 2000s. Tariff reductions should increase offshoring to labor-abundant countries and provides exogenous variation in imports from these countries.[29]

To construct a tariff-based instrument for the average skill intensity of imports from labor-abundant countries, we first take the full set of country-product pairs from which a given firm sources during the sample period and hold it fixed. We then regress the (log of one plus) value of imports of product p from country c of firm f on the log of the applied EU external tariff $\log(tariff_{p,c,t})$ as well as firm, product and country fixed effects:[30]

$$\log(imports)_{f,p,c,t} = \beta_0 + \beta_1 \log(tariff_{p,c,t}) + \delta_f + \delta_p + \delta_c + \epsilon_{f,p,c,t}.$$

We then obtain predicted values from this regression, $\widehat{log(import_{f,p,c,t})}$. These are import values

[28]Carluccio et al. (2015) provide detailed evidence in favor of these points for the firms in our sample.

[29]As a result of multilateral trade negotiations, the European Union reduced its average applied most-favored-nation tariffs in manufacturing by around 3 percentage points (see Finger et. al, 1996), with a lot of variation across products. Most of these tariff reductions were implemented in the late 1990s. Moreover, during the same period substantial bilateral tariff reductions with several Eastern European countries took place. This was a consequence of the association agreements predating their accession to the EU – Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia became EU members in 2004, Bulgaria and Romania followed in 2007. Tariff reductions generally started in the early 1990s and were implemented in several steps until the early 2000s. Finally, the EU also signed several bilateral free trade agreements during our sample period which lead to further tariff reductions.

[30]The estimated coefficient of $\log(tariff_{p,c,t})$ for the set of countries with less than 95 percent of the French level of secondary schooling is -0.029 and significant at the one-percent level, implying that a 100 percent higher tariff reduces imports of a given product by a given firm by around 2 percent.

explained by firm, product and country means, as well as tariffs. Observe that, given that we hold the set of products and countries constant, all the time variation in predicted import values comes from changes in tariffs. Next, we sum predicted imports across countries to obtain firm-product-time-specific weights $\hat{w}_{f,p,t} = \frac{\sum_c \widehat{import}_{f,p,c,t}}{\sum_p \sum_c \widehat{import}_{f,p,c,t}}$. Finally, we multiply these with product-specific skill intensities and sum over products to obtain the tariff-predicted average skill intensity of imports of a given firm in a given year:

$$import\ \widehat{skill}\ intensity_{f,t,2} = \sum_{p \in I_{f,p,t}} skillint_p \times \hat{w}_{f,p,t}.$$

Note that even though we hold the set of products imported constant at the set of products ever imported by a given firm, reductions in tariffs may shifts weights towards products that where initially not imported by a given firm, creating extensive margin variation in the tariff-predicted skill intensity of imports (shifting $z_n^-(\gamma)$).

Estimating Sample

We restrict the sample to firms in manufacturing and we only consider imports of manufactured goods.[31] The estimating sample so obtained is an unbalanced panel covering 1996 to 2007 with 646,920 firm/year observations corresponding to 104,036 firms. Of these, 37,847 firms import at least once from skill-abundant countries and 25,296 import at least once from labor-abundant countries.[32] The average number of HS 6-digit products per firm sourced from skill-abundant (labor-abundant) countries is 10 (6), and the average number of countries per product is 1.74. Consistently with the model, the vast majority of firms sources a given product from only one country. Table A-2 presents summary statistics of firm-level variables.

5 Empirical Results

In this section we present evidence for the empirical predictions derived from our model.

[31] We keep firms in the two-digit NACE Rev2 industries 10-33, with the exception of natural resource-based codes 12 (Manufacture of tobacco products) and 19 (Manufacture of coke and refined petroleum products). We exclude imports of raw materials (HS01-15, 23, 25-27, 31 and 41) and services (HS97-99). Excluded import flows account for around 5% of total imports over the period.

[32] To mitigate measurement error, we consider firms as importers when they import for at least two consecutive years.

5.1 Predictions about sourcing patterns

We first test the results relating to the types of goods offshored and the characteristics of the sourcing locations. We think of France as being moderately skill abundant: most countries are more labor abundant than France, but some countries are more skill abundant. In the case of France the ranking of offshoring decisions is such that firms sourcing from skill-abundant countries are less productive than firms also sourcing from labor-abundant countries, because many skill-abundant countries are very close to France. Since our predictions on sourcing patterns are very different for labor-abundant compared to skill-abundant countries, we split the sample by skill abundance and run separate regressions for each set of countries. In our main specification, we consider countries with less than 95 percent of the French level of secondary schooling as labor abundant and the remaining set of countries as skill abundant. However, our results are robust to considering alternative thresholds.[33]

Prediction 1 states that more skill-abundant countries should have a comparative advantage in the production of more skill-intensive inputs and thus firms should import larger volumes. The regression specification follows directly from equation (11).

$$\log(imports)_{f,p,c,t} = \beta_0 + \beta_1 \log(TFP)_{f,0} + \beta_2 skillint_p + \\ + \beta_3 skillint_p * sec.schooling_c + \beta_4 X_{f,c,t} + \epsilon_{f,p,c,t}, \tag{15}$$

where $\log(imports)_{f,p,c,t}$ is the (log) import value of product p from country c by firm f in year t, $\log(TFP)_{f,0}$ is log TFP in the initial period of the sample (to mitigate endogeneity concerns), $skillint_p$ is the skill intensity of product p and $sec.schooling_c$ is the skill abundance (measured in terms of years of secondary schooling) of country c relative to France. The vector $X_{f,c,t}$ always includes country and year fixed effects. Country fixed effects control for unobserved characteristics of the country that affect offshoring costs $\tau^o_{n,n'}$ (e.g., distance from France).

We report the results for the set of labor-abundant countries in the first column and for skill-abundant countries in column (6) of Table 2. The coefficient of product-level skill intensity is negative for the set of labor-abundant countries and positive for the set of skill-abundant countries. More importantly, the interaction term between skill intensity and skill abundance is positive and significant. This shows that HO comparative advantage is an important determinant

[33] We have alternatively defined countries with less than 80 percent of French secondary schooling as labor abundant and countries with more than 1.05 percent as skill-abundant. Results are not presented due to space constraints but are available on request.

of firms' sourcing patterns.

Our model also predicts that, when considering importers from a specific labor-abundant country, the value of imports of relatively skill-intensive products should be larger for more productive firms. When considering instead importers from a specific skill-abundant country, the value of imports of relatively labor-intensive products from a given location should be larger for more productive firms. (Prediction 2, part (i)). To test this hypothesis, we run the following gravity regression:

$$\log(imports)_{f,p,c,t} = \beta_0 + \beta_1 \log(TFP)_{f,0} + \beta_2 skillint_p + \\ + \beta_3 \log(TFP)_{f,0} * skillint_p + \beta_4 X_{f,c,t} + \epsilon_{f,p,c,t}, \quad (16)$$

The vector $X_{f,c,t}$ always includes country and year fixed effects. In some specifications we also include employment, the capital-labor ratio and the value of exports (all in logs) in the vector of control variables to account for covariates that correlate both with TFP and imports.[34]

For labor-abundant countries, we expect the coefficient on skill intensity, β_2, to be negative, since the comparative advantage of these countries is in labor-intensive sectors. More importantly, we expect β_3, the interaction term between product-level skill intensity and firm-level TFP, to be positive. By contrast, for skill-abundant countries, we expect the coefficient of skill intensity, β_2, to be positive, while the coefficient of the interaction term, β_3, should be negative. By including country and year fixed effects we exploit the within-country variation in positive import values across firms and products: the value of imports should be relatively high if a firm is highly productive and the product is skill intensive; or if the firm has low productivity and the product is labor intensive. Thereby we are capturing variation in both the characteristics of imported products (extensive margin) and in the value of imports for a given set of products (intensive margin). Below we present additional evidence that the marginal product imported by more productive firms is more skill intensive (extensive-margin).[35]

We report the results for the set of labor-abundant countries in columns (2) and (3) of Table 2. The coefficient of product-level skill intensity is negative, while the interaction term between

[34]These variables proxy for factors outside of our model that impact on firms' unit costs and thus on their import decisions. We control for exports to account for potential complementarities between import and export decisions; we control for employment to control for increasing returns; and for capital intensity as an additional determinant of unit costs. In the reported regressions we don't include interactions between skill intensity and skill abundance in the set of controls, but results are robust to including them.

[35]Ideally, to estimate the extensive margin decision, we would use a discrete import choice model, including all zero observations by firm-product-country. However, due to the curse of dimensionality, we can only consider observations with positive import values.

skill intensity and $\log(TFP)_{f,0}$ is positive and highly significant. The outcomes for the set of skill-abundant countries are reported in in columns (6) and (7). As predicted by our theory, the coefficient on skill intensity is in this case positive, while the interaction term between skill intensity and $\log(TFP)_{f,0}$ is negative and highly significant.

While only sufficiently productive firms should import the relatively skill-intensive products from labor-abundant countries, our model also predicts that all firms offshoring to these countries should import the relatively labor-intensive ones (extensive margin). Similarly, only sufficiently productive firms should import the relatively labor-intensive products from skill-abundant countries, while all importers from these countries should import the relatively skill-intensive ones. We therefore expect more productive importers to have a larger variation in the skill intensity of imported products from a given source country (Prediction 2, part (*ii*)). We compute the firm-level dispersion of skill intensity of imports by source country by using the standard deviation.[36] We then regress this variable on firm-level productivity:[37]

$$dispersion_{f,c} = \beta_0 + \beta_1 \log(TFP)_f + \beta_2 X_{f,c} + \epsilon_{f,c}. \tag{17}$$

The vector of controls comprises our standard set of firm-level controls (averaged over periods), the number of products a given firm imports from a given country (in logs) and in some specifications also country fixed effects. We include the number of imported products in order to avoid any confusion with the mechanical result that firms sampling more products randomly from a given country will have a larger dispersion in the skill intensity of their sampled products. Results are reported in columns (1) and (2) of Table 3 for imports from labor-abundant countries and in columns (5) and (6) for imports from skill-abundant countries. In line with our hypothesis, in all specifications the coefficient of $log(TFP)$ enters positively and is strongly statistically significant.

[36]Using other measures of dispersion, such as the ratio of the 90th to the 10th percentile gives very similar results.

[37]Since the dispersion measure has no time variation, we average TFP over all years the firm is in the sample

	dependent variable is log(imports)$_{f,p,c,t}$									
	from labor-abundant countries					from skill-abundant countries				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
log(TFP)$_{f,0}$	0.1512**	-0.1394	-0.1340	-0.1882***	-0.2346***	0.0816***	1.1615***	1.0307***	0.4144***	0.2116***
	(0.067)	(0.091)	(0.089)	(0.068)	(0.083)	(0.030)	(0.076)	(0.078)	(0.063)	(0.073)
skill intensity$_p$	-3.0102***	-5.2876***	-4.1948***			0.5789**	6.6495***	7.1983***		
	(0.292)	(1.288)	(1.241)			(0.232)	(0.914)	(0.891)		
skill intensity$_p$ x sec. schooling$_c$	**3.9804*** **					**0.3125***				
	(0.429)					(0.162)				
log(TFP)$_{f,0}$ x skill intensity$_p$		**1.1276*** **	**0.7246** **				**-1.6220*** **	**-1.8383*** **		
		(0.319)	(0.312)				(0.234)	(0.227)		
sec. schooling$_c$				-2.5594***	-1.6945**				0.6183***	0.6308***
				(0.678)	(0.769)				(0.178)	(0.187)
log(TFP)$_{f,0}$ x sec. schooling$_c$				**0.3765** **	**0.3802***				**-0.2512*** **	**-0.2401*** **
				(0.170)	(0.197)				(0.046)	(0.048)
log(employees)$_{f,t}$			0.0135		0.0048			0.0683***		0.1060***
			(0.030)		(0.029)			(0.014)		(0.014)
log(capital/labor)$_{f,t}$			0.1035***		0.1128***			0.1313***		0.1524***
			(0.032)		(0.033)			(0.013)		(0.014)
log(exports)$_{f,t}$			0.2395***		0.2260***			0.3517***		0.3567***
			(0.016)		(0.016)			(0.006)		(0.006)
Observations	666,208	666,208	666,208	683,598	605,100	3,661,016	3,672,029	3,672,029	3,709,549	3,707,103
Country FE	YES	YES	YES	NO	NO	YES	YES	YES	NO	NO
Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Gravity Controls	NO	NO	NO	NO	YES	NO	NO	NO	NO	YES
Cluster	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm
R-squared	0.0314	0.0039	0.0291	0.0120	0.0388	0.0650	0.0184	0.0659	0.0032	0.0737

Table 2: Imports from labor-abundant/skill-abundant countries and skill-intensity/skill-abundance interactions with productivity.

In columns (1)-(5) the dependent variable is log imports from labor-abundant countries at the firm-product-country-year level. In columns (6)-(10) it is log imports from skill-abundant countries. We define countries with less than 95 percent of the French level of secondary schooling as labor abundant and the remaining countries as skill abundant. The main explanatory variable of interest in columns (2)-(3)and (6)-(7) is the interaction between product-level skill intensity (skill intensity$_p$) and firm-level productivity computed with the Levinsohn-Petrin method ($\log(TFP)_{f,0}$). The main explanatory variable of interest in columns (3)-(4) and (7)-(8) is the interaction between country-level skill abundance (sec. schooling$_c$) and firm-level productivity ($\log(TFP)_{f,0}$). Other controls are (all at the firm level and in logs): the number of employees, the capital-labor ratio, the value of exports. Columns (5) and (10) include gravity controls (GDP, GDP per capita, distance, area, dummies for border common language, colony). Standard errors are clustered at the firm level.

	dependent variable is standard deviation of							
	product skill-intensity$_{f,c}$		country skill-abundance$_f$		product skill-intensity$_{f,c}$		country skill-abundance$_f$	
	of imports from labor-abundant countries				of imports from skill-abundant countries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(TFP)$_f$	**0.0179*****	**0.0111*****	**0.0407*****	**0.0444*****	**0.0083*****	**0.0051*****	**0.0313*****	**0.0178****
	(0.000)	(0.001)	(0.011)	(0.011)	(0.000)	(0.000)	(0.007)	(0.007)
log(employees)$_f$		0.0034***		0.0012		0.0035***		-0.0196***
		(0.000)		(0.005)		(0.000)		(0.003)
log(capital/labor)$_f$		-0.0012***		-0.0088		0.0027***		-0.0076**
		(0.000)		(0.006)		(0.000)		(0.004)
log(exports)$_f$		0.0025***		-0.0135***		0.0005***		-0.0147***
		(0.000)		(0.003)		(0.000)		(0.002)
log(# products)$_{f,c}$	0.0125***	0.0100***			0.0114***	0.0083***		
	(0.000)	(0.001)			(0.000)	(0.001)		
log(# countries)$_f$			0.2628***	0.2763***			0.2296***	0.2703***
			(0.007)	(0.008)			(0.007)	(0.009)
Observations	48,469	48,469	14,573	14,573	149,719	149,719	31,218	31,218
R-squared	0.0794	0.1000	0.0827	0.0839	0.0763	0.0864	0.0575	0.0613
Country FE	NO	YES	NO	NO	NO	YES	NO	NO
Robust	YES	YES	YES	YES	YES	YES	YES	YES

Table 3: Dispersion of product skill intensity/country skill-abundance and firm-level productivity

The dependent variable is the standard deviation of product-level skill intensity by source country and firm (in columns (1)-(2) and (5)-(6)) and the standard deviation of the source countries' secondary schooling endowments by firm (in columns (3)-(4) and (7)-(8)). In columns (1)-(4) we consider imports from labor-abundant countries, while in columns (5)-(8) we consider imports from skill-abundant countries. We define countries with less than 95 percent of the French level of secondary schooling as labor-abundant and the remaining countries as skill abundant. The main explanatory variable of interest is log firm-level productivity averaged over the sample period computed with the Levinsohn-Petrin method ($\log(TFP)_f$). Other controls are (all at the firm level and in logs): the number of employees, the capital-labor ratio, the value of exports, the total number of products imported from a given country and the number of countries from which a given firm imports. Standard errors are robust to heteroscedasticity.

We now turn to Prediction 3, part (i): For firms offshoring to the set of labor-abundant (skill-abundant) countries, more productive firms should have a larger import value from relatively more skill-abundant (labor-abundant) locations among them. To test this prediction, we modify the specification of our gravity regression as follows:

$$\log(imports)_{f,p,c,t} = \beta_0 + \beta_1 \log(TFP)_{f,0} + \beta_2 sec.schooling_c + \\ + \beta_3 \log(TFP)_{f,0} * sec.schooling_c + \beta_4 X_{f,c,t} + \epsilon_{f,p,c,t}, \quad (18)$$

where $sec.schooling_c$ is the skill abundance (measured in terms of years of secondary schooling) of country c relative to France and where the vector $X_{f,c,t}$ always includes year fixed effects. In some specifications it also includes our standard set of firm-specific controls and a set of country-specific gravity controls that proxy for bilateral offshoring costs (distance from France, GDP, GDP per capita, area (all in logs), dummies for common language, common border, colony).

Conditioning on the set of labor-abundant source countries, we expect the coefficient of $sec.schooling_c$, β_2, to enter negatively, since cost advantages shrink as source countries become more skill abundant. Moreover, we expect the interaction term between $log(TFP)_{f,0}$ and $sec.schooling_c$, β_3, to have a positive coefficient: more productive firms should import relatively larger values from more skill-abundant countries. We expect the symmetric outcomes ($\beta_2 > 0$ and $\beta_3 < 0$) when conditioning on the set of skill-abundant source countries. We run regressions considering only positive import values. Since we only include year fixed effects, the identification comes from variation across firms and countries. We thus aim at capturing variation in the set of source countries across firms (extensive margin). Because the regression coefficients will also pick up variation in the value of imports across firms for a given set of source countries (intensive margin), we report results for a dispersion measure in skill abundance below.

Results for the specification are reported in columns (4) and (5) of Table 2 for labor-abundant countries and in columns (9) and (10) for skill-abundant ones. Indeed, in columns (4) and (5) $sec.schooling_c$ enters negatively and is statistically significant. More importantly, the interaction term between $sec.schooling_c$ and $log(TFP)_{f,0}$ is always positive and significant.[38] The results in columns (9) and (10) are also consistent with our theory: the coefficient of $sec.schooling_c$ is positive and the interaction term between schooling and productivity is negative and significant.

Prediction 3, part (ii) states that more productive firms have more variation in the skill

[38]The coefficient of $log/TFP)_{f,0}$ is negative and measures the impact of of higher productivity on imports for a hypothetical country without any schooling. The marginal effect of (log) TFP on imports is given by $-0.188 + 0.377 * sec.schooling_c$, which is positive for all countries with at least 50% of the French schooling level.

abundance of their source countries. In this way we also test if the results above are indeed due to differences in the characteristics of source countries (extensive margin) instead of being driven by variation in the value of imports from a given set of source countries (intensive margin). We measure skill-abundance dispersion with the standard deviation of skill abundance of those countries from which a given firm imports (out of the set of labor-abundant or skill-abundant countries). We then regress this measure of skill-abundance dispersion on firm-level productivity:

$$dispersion_f = \beta_0 + \beta_1 \log(TFP)_f + \beta_2 X_f + \epsilon_f. \tag{19}$$

The vector X_f includes our standard set of firm-level controls (averaged over periods) as well as the number of countries from which a given firm imports (in logs) in order to avoid any confusion with the mechanical result that firms sampling more countries randomly have a larger dispersion in the skill abundance of their sampled countries. Results are reported in columns (3) and (4) of Table 3 for imports from labor-abundant countries and in columns (7) and (8) for imports from skill-abundant countries. The coefficient of $log(TFP)$ is positive and significant in both specifications.

In Appendix D we show that there exist complementarities in sourcing decisions across products and countries: holding constant productivity γ, firms that import more labor-intensive (skill-intensive) inputs, or offshore to more labor-abundant (skill-abundant) countries, import more from any given location (Predictions 9 and 10 in Appendix B).

The above results have focused on the specific hypotheses regarding sourcing behavior from labor-abundant countries. We now show that importing from labor-abundant countries is also associated with significantly higher skill intensity of production in France.

5.2 Firm-level predictions on domestic skill intensity

We have already provided evidence for Predictions 4 and 5 in section 2 of the paper: there is pervasive within-industry variation in skill intensity; this variation is larger for offshoring firms than for non-importers. We thus turn to testing the predictions relating the skill intensity of production in France to imports from labor-abundant and skill-abundant countries.

Predictions 6 and 7 state that firms importing from the set of labor-abundant countries are more skill intensive in their domestic production compared to non-importers, whereas firms importing from skill-abundant countries are more labor-intensive domestically than non-importers.

The regression specification is:

$$\log(skillintensity)_{f,t} = \beta_0 + \beta_1 imports\ labor\text{-}abundant\ countries_{f,t} + \\ + \beta_2 imports\ skill\text{-}abundant\ countries_{f,t} + \beta_3 X_{f,t} + \epsilon_{f,t}, \quad (20)$$

where *imports labor-abundant countries*$_{f,t}$ is either a dummy for importing from the set of labor-abundant countries (Prediction 6) or the import intensity, measured as the ratio of imports from labor-abundant countries relative to total sales (Prediction 7).[39] Similarly, *imports skill-abundant countries*$_{f,t}$ is either a dummy for importing from the set of skill-abundant countries, or the ratio of imports from skill-abundant countries to total sales. The vector $X_{f,t}$ includes either 4-digit sector or firm fixed effects, as well as year fixed effects. In some specifications it also includes lagged TFP (to mitigate endogeneity concerns), employment, the capital-labor ratio (all in logs) and controls for exporting. The rationale for including exports in the specification is to control for the exporting-skill-upgrading channel (e.g., Bustos, 2011). We include $\log(TFP)$ to control for technology-based explanations of skill-upgrading (Acemoglu, 1998). We include the capital-labor ratio to control for capital-skill complementarity (Krusell et al., 2000) and the number of employees to control for skill-biased scale effects (e.g., Burstein and Vogel, 2016).

We present results for the extensive margin in the first four columns of Table 4. The dummy for importing from labor-abundant countries captures the relative skill intensity of production for firms importing from labor-abundant countries compared to non-importers. In columns (1) and (2), we report specifications including 4-digit sector fixed effects to use the cross-sectional variation in the data. Importers from labor-abundant countries are around 22 percent[40] (column (1)) to 28.3 percent (column (2)) *more* skill-intensive in their domestic production than non-importers; this effect is statistically significant. Importers from skill-abundant countries are somewhat *less* skill-intensive than non-importers (around 3.6 percent (column (1))). In columns (3) and (4), we report results including firm fixed effects, thereby identifying within-firm changes in import status: the result in column (3) indicates that importing from labor-abundant countries is associated with a 4-percent increase in skill intensity, while importing from skill-abundant countries is associated with a 1.2-percent decrease. The results based on within-firm variation suggest that an increase in lagged TFP reduces domestic skill intensity, conditional on firms' import status from labor-abundant countries.[41] Consistent with the theories emphasizing the link between exporting and

[39] We normalize imports by sales instead of total variable costs since we cannot measure the latter in our data.

[40] 22=100*(exp(0.1996)-1)

[41] According to our theory, once we control for offshoring, TFP should not have any direct impact on domestic

skill upgrading, increases in exports are associated with increases in skill intensity, while increases in employment and capital intensity are associated with reductions in skill intensity.

We now consider the import intensity of firms. We allow for a differential effect of importing from skill-abundant countries by including firm-level imports from skill-abundant countries normalized by sales as a separate regressor. Results are reported in columns (5)-(8) of Table 4. In columns (5) and (6) we include all firms (including non-importers), while in columns (7) and (8) we restrict the sample to importers from both sets of countries. For the sake of space, we only present specifications including firm and year fixed effects. Columns (5) and (6) suggest that an increase in import intensity from labor-abundant countries *increases* the skill intensity of domestic production and is highly significant. This effect stands in contrast with the impact of importing from skill-abundant countries, where a one-unit increase in the imports-to-sales ratio *reduces* firm-level skill intensity. Finally, the results for the sample of importers (columns (7)-(8)) are very similar to those obtained for the full sample of firms. Thus, as predicted by our theory, importing from labor-abundant countries is associated with large increases in the skill intensity of production in France, while importing from skill-abundant is associated with a moderate reduction of this variable.[42]

Next, we turn to the instrumental variables results. We need to instrument both for imports/sales from labor-abundant and from skill-abundant countries. We thus use supply-shock-based instruments to obtain exogenous variation in imports/sales.[43] Since the supply shock instruments provide exogenous time variation in imports for a given firm, we report results for the two-stage-least-square regressions with firm and year fixed effects for the sample of importers in Table 5. According to our theory, a positive supply shock from labor-abundant countries (which reduces $\tau_{n',n}$) for a given set of products reduces the firm's marginal cost and thus increases z_n^- and lowers z_n^+, increasing imports/sales from both labor-abundant and skill-abundant countries; a similar effect occurs for a reduction in $\tau_{n',n}$ from skill-abundant countries.

skill-intensity. However, alternative theories suggest a (positive) link between skill intensity and productivity other than that operating via offshoring. The unconditional within-firm correlation between TFP and skill intensity is positive, so any positive association between skill intensity and TFP is due to offshoring.

[42]In unreported regressions we have also regressed the employment of skilled and unskilled workers separately on imports relative to sales from labor-abundant and skill-abundant countries. Within-firm results indicate that firms which increase imports from labor-abundant countries reduce blue-collar employment and increase employment of white-collar workers, while the opposite happens for firms that increase imports from skill-abundant countries. Moreover, as our model suggests, these firms simultaneously increase their sales.

[43]We cannot construct tariff-based instruments for imports because the set of skill-abundant countries consist mostly of EU members, which have no tariff barriers vis-à-vis France.

	dependent variable is log(skill intensity)$_{ft}$							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
import status	**0.1996*****	**0.2975*****	**0.0388*****	**0.0392*****				
labor-abundant c.$_{f,t}$	(0.009)	(0.010)	(0.004)	(0.005)				
import status	**-0.0349*****	**0.0708*****	**-0.0124*****	**0.0117****				
skill-abundant c.$_{f,t}$	(0.006)	(0.007)	(0.003)	(0.005)				
imports/sales					**0.2500*****	**0.3572*****	**0.2152****	**0.1703****
labor-abundant c.$_{f,t}$					(0.096)	(0.101)	(0.099)	(0.083)
imports/sales					**-0.0086**	**-0.0109****	**-0.0231**	**-0.0354****
skill-abundant c.$_{f,t}$					(0.006)	(0.009)	(0.016)	(0.017)
log(TFP)$_{f,t-1}$		0.0965***		-0.0484***		-0.0493***		-0.0101
		(0.008)		(0.005)		(0.005)		(0.014)
log(employees)$_{f,t}$		-0.1550***		-0.1604***		-0.1603***		-0.2352***
		(0.003)		(0.006)		(0.006)		(0.024)
log(capital/labor)$_{f,t}$		0.0197***		-0.0163***		-0.0163***		-0.0490***
		(0.003)		(0.004)		(0.004)		(0.016)
export status$_{f,t}$		0.1002***		0.0159***				
		(0.006)		(0.004)				
log(exports)$_{f,t}$						0.0076***		0.0111***
						(0.001)		(0.004)
Observations	646,920	511,434	646,920	511,434	646,920	511,434	55,719	55,582
Firms	104,036	86,596	104,036	86,596	104,036	86,596	12,714	12,683
Sample	all	all	all	all	all	all	importers	importers
Firm FE	NO	NO	YES	YES	YES	YES	YES	YES
4-digit sector FE	YES	YES	NO	NO	NO	NO	NO	NO
Time FE	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm
R-squared	0.2039	0.2317	0.0040	0.0113	0.0042	0.0117	0.0465	0.0615

Table 4: Skill intensity of domestic production and importing from labor-abundant and skill-abundant countries (extensive and intensive margin).

The dependent variable is the firm-level (log) skill intensity of production, defined as the ratio of non-production workers to production workers. We consider countries with less than 95 percent of the French level of secondary schooling as labor abundant and other countries as skill abundant. In columns (1)-(4), the main explanatory variable of interest is a dummy for importing from the set of labor-abundant countries (import status labor-abundant c.) and a dummy for importing from the set of skill-abundant countries (import status skill-abundant c.). In columns (5)-(8), the main explanatory variable of interest is the ratio of imports from set of labor-abundant countries relative to sales (import/sales labor-abundant c.) and the ratio of imports from the set of skill-abundant countries relative to sales (imports/sales skill-abundant c.). Other controls are (all at the firm level and in logs): lagged TFP (constructed with the Levinsohn-Petrin method), the number of employees, the capital-labor ratio and the value of exports. Standard errors are clustered at the firm level.

These effects are exactly captured by the first-stage regressions, which regress imports/sales from each set of countries on both supply shocks. In the second stage, the shock-induced changes in imports/sales from labor-abundant and skill-abundant countries then impact on domestic skill intensity.

Focusing first on the first-stage regressions, we find that the shocks have the expected signs and are significant at the one-percent level. Moreover, there is indeed evidence that supply shocks from labor-abundant countries not only increase imports/sales from labor-abundant countries, but also from skill-abundant ones. The Angrist-Pischke F-statistic is always above 13 for the first-stage regressions with imports/sales from labor-abundant countries as dependent variable and above 10 when imports/sales from skill-abundant locations is instrumented, indicating that weak instruments are not a problem. Turning now to the second-stage results, the point estimate for the coefficient for importing from labor-abundant countries is now 5.51 (compared to 0.22 for the OLS estimator).[44] This large increase in the magnitude of the coefficient points to measurement error in the time variation of imports, which biases fixed effects results towards zero.[45] The coefficient for imports from skill-abundant countries is instead negative, large (-4.28 compared to -0.02 for the OLS estimator), and now also statistically significant. These results are robust to adding the standard set of controls. The IV estimates imply large economic effects of importing from labor-abundant countries. For firms importing from both sets of countries, the average skill intensity changed by around 0.85 log points between 1996 and 2007 (see Table 1). Evaluating the estimates for the effect of importing from labor-abundant and skill-abundant countries at the mean of imports/sales from each set of countries, we find that the skill intensity should have changed by around 0.93 log points. This corresponds to slightly more than the actual change in the log skill intensity of importers.[46] Thus, offshoring to labor-abundant countries can potentially explain the bulk of the observed within-firm increase in the skill intensity of importers.

[44]Hummels et al. (2014) find a similar increase in the magnitude of their point estimates when instrumenting for the effect of offshoring on wages of Danish workers using supply shocks.

[45]Another potential explanation is omitted variable bias: we conjecture that automatization and offshoring to labor-abundant countries might be substitutes at the firm level: firms may reduce costs either by offshoring labor-intensive inputs or by using new technologies that substitute machines for labor-intensive tasks. Goos et al. (2014) show that tasks amenable to offshoring are usually also routine and can thus be automatized relatively easily. This would introduce a negative correlation between offshoring and (unobserved) automatization, both of which lead to an increase in skill intensity of domestic production.

[46]Average imports/sales from labor-abundant countries increased from 0.053 to 0.07 from 1996 to 2007, thus the effect is given by 5.51*(0.07-0.053)=0.093. By contrast, imports/sales from skill-abundant countries stayed roughly constant at around 0.14.

First Stage	Dep. var.: imports/sales labor-abundant c.$_{f,t}$		Dep. var.: imports/sales skill-abundant c.$_{f,t}$		Second Stage	Dep. var.: log(skill intensity)$_{f,t}$	
	(1)	(2)	(3)	(4)		(5)	(6)
IV Supply Shock	**0.0026*** **	**0.0023*** **	0.0027*	0.0023	**imports/sales**	**5.5135** **	**5.0714***
labor-abundant c.$_{f,t}$	(0.0008)	(0.0008)	(0.0016)	(0.0016)	**labor-abundant c.$_{f,t}$**	(2.760)	(2.671)
IV Supply Shock	-0.0053*	-0.0050*	**0.0066** **	**0.0064** **	**imports/sales**	**-4.2816***	**-3.6571**
skill-abundant c.$_{f,t}$	(0.0029)	(0.0029)	(0.0027)	(0.0027)	**skill-abundant c.$_{f,t}$**	(2.376)	(2.401)
log(TFP)$_{f,t-1}$		-0.0005		-0.0034	log(TFP)$_{f,t-1}$		-0.0193
		(0.0022)		(0.0027)			(0.020)
log(employees)$_{f,t}$		-0.0250***		-0.0163***	log(employees)$_{f,t}$		-0.1613*
		(0.0032)		(0.0058)			(0.087)
log(capital/labor)$_{f,t}$		-0.0028		0.0042	log(capital/labor)$_{f,t}$		-0.0186
		(0.0026)		(0.0028)			(0.026)
log(exports)$_{f,t}$		0.0084***		0.0094***	log(exports)$_{f,t}$		0.0044
		(0.0006)		(0.0008)			(0.034)
F-statistic (Angrist-Pischke)	15.32	13.28	11.57	9.26			
Observations	52,766	52,637	52,766	52,637		52,766	52,637
Firms	9,761	9,738	9,761	9,738		9,761	9,738
Sample	importers	importers	importers	importers		importers	importers
Firm FE	YES	YES	YES	YES		YES	YES
Time FE	YES	YES	YES	YES		YES	YES
Cluster	Firm	Firm	Firm	Firm		Firm	Firm

Table 5: Skill intensity of domestic production and importing from labor-abundant and skill-abundant countries (IV estimates).
The dependent variable in the second-stage regression (columns (5)-(6)) is the firm-level (log) skill intensity of production, defined as the ratio of non-production workers to production workers. The main explanatory variable of interest is the ratio of imports from set of labor-abundant countries relative to sales (import/sales labor-abundant c.) and the ratio of imports from the set of skill-abundant countries relative to sales (imports/sales skill-abundant c.). We consider imports from countries with less than 95 percent of the French level of secondary schooling as labor abundant and the remaining countries as skill abundant. Other controls are (all at the firm level and in logs): lagged TFP (constructed with the Levinsohn-Petrin method), the number of employees, the capital-labor ratio and the value of exports. Both imports/sales from labor-abundant and skill-abundant countries are considered endogenous. Instruments are constructed from foreign supply-shocks (see data section for an explanation). First-stage regressions are reported in columns (1)-(4). We present Angrist-Pischke F-statistics for the joint significance of instruments with multiple endogenous variables. Standard errors are clustered at the firm level.

Our last theoretical result, Prediction 8, states that the average skill intensity of imports should be positively correlated with the skill intensity of firms' production in France. This should be true both for the skill intensity of imports from labor-abundant and skill-abundant countries:

$$\log(skillintensity)_{f,t} = \beta_0 + \beta_1 import\ skill\ intensity_{f,t} + \beta_2 X_{f,t} + \epsilon_{f,t}, \tag{21}$$

where *import skill intensity*$_{f,t}$ is the average skill intensity of imports from the set of labor-abundant or skill-abundant countries and $X_{f,t}$ is our vector of standard controls (sector or firm and year fixed effects as well as lagged TFP, employment, the capital-labor ratio, the value of imports and the value of exports (all in logs)).

The results for this specification are presented in columns (1)-(4) of Table 6 for imports from labor-abundant countries and in columns (5)-(8) for imports from skill-abundant countries. In columns (1), (2), (5) and (6) we report results for a specification including 4-digit sector-fixed effects. The result in column (1) indicates that a one-unit increase in the average skill intensity of imports from labor-abundant countries is associated with a significant 38-percent increase in domestic skill intensity. Adding further controls in column (2) leaves the results unaffected. Column (5) indicates that a one-unit increase in the average skill intensity of imports from skill-abundant countries leads to a 74-percent increase in domestic skill intensity. Exports and TFP continue to have a positive effect on skill intensity, while the capital/labor ratio and scale are negatively correlated with the dependent variable.

Results including firm fixed effects are reported in columns (3), (4), (7) and (8). Again, we find a positive partial correlation between the average skill intensity of imports and (log) skill intensity. The estimates imply that a one-unit increase in firms' skill intensity of imports from labor-abundant (skill-abundant) countries increases the skill intensity of production by around 3.46 (1.57) percent, but they are not statistically significant. However, the fixed-effects estimates are again likely to be downward-biased since changes in the skill intensity of imports are subject to substantial measurement error. We will correct for this below by employing an IV strategy. Finally, the estimates are unaffected by adding further controls. Note also that, for imports from labor-abundant countries, TFP is no longer significant when including firm fixed effects. This is consistent with our theoretical model: productivity is a sufficient statistic for the skill intensity of imports, so an increase in productivity should not have any separate effect on the skill intensity of production besides the one that operates via the skill intensity of imports.

	dependent variable is log(skill intensity)$_{f,t}$							
	Labor-abundant countries				Skill-abundant countries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
import	**0.3791*** **	**0.2770*** **	**0.0340**	**0.0415**	**0.7428*** **	**0.6395*** **	**0.0157**	**0.0317**
skill intensity$_{f,t}$	(0.069)	(0.067)	(0.029)	(0.029)	(0.050)	(0.047)	(0.022)	(0.022)
log(TFP)$_{f,t-1}$		0.3088***		-0.0099		0.1737***		-0.0347***
		(0.023)		(0.015)		(0.015)		(0.008)
log(employees)$_{f,t}$		-0.1978***		-0.2489***		-0.1944***		-0.1966***
		(0.010)		(0.024)		(0.006)		(0.012)
log(capital/labor)$_{f,t}$		-0.0576***		-0.0600***		-0.0748***		-0.0429***
		(0.011)		(0.016)		(0.007)		(0.008)
log(imports)$_{f,t}$		0.0840***		0.0232***		0.0702***		0.0110***
		(0.006)		(0.006)		(0.003)		(0.002)
log(exports)$_{f,t}$		0.0408***		0.0059*		0.0375***		0.0061***
		(0.004)		(0.003)		(0.002)		(0.002)
Observations	55,528	55,528	55,528	55,333	152,281	151,635	152,281	151,635
Firms	13,343	13,297	13,343	13,297	28,433	28,328	28,433	28,328
Firm FE	NO	NO	YES	YES	NO	NO	YES	YES
4-digit sector FE	YES	YES	NO	YES	YES	NO	NO	NO
Time FE	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm
R-squared	0.2644	0.3127	0.0419	0.0574	0.2655	0.3067	0.0151	0.0255

Table 6: Skill intensity of production and the skill intensity of imports: OLS estimates.

Columns (1)-(4) present OLS estimates for imports from labor-abundant countries and columns (5)-(8) present estimates for imports from skill-abundant countries. The dependent variable is the firm-level (log) skill intensity of production, defined as the ratio of non-production workers to production workers. In columns (1)-(4) the main explanatory variable of interest is the average skill intensity of imports from labor-abundant countries; in columns (5)-(8) it is the skill intensity of imports from skill-abundant countries. For an explanation of the construction of this variable see the data description. We consider imports from countries with less than/more than 95 percent of the French level of secondary schooling. Other controls are (all at the firm level and in logs): lagged TFP (constructed with the Levinsohn-Petrin method), the number of employees, the capital-labor ratio, the value of imports and the value of exports. Standard errors are clustered at the firm level.

Finally, we use the tariff-predicted skill intensity of imports as well as the supply-shock predicted skill intensity of imports from labor-abundant countries as instruments for the actual skill intensity of imports from these countries. We focus on imports from labor-abundant countries because we cannot construct the tariff-based instrument for skill-abundant countries since there were no significant tariff reductions for these countries. The results of the two-stage-least-squares regressions with firm and time fixed effects are reported in Table 7. We first present regressions with the tariff-predicted skill intensity as the sole instrument in columns (1) and (2).

In the lower panel of the table, we report the first-stage coefficients for the regression of the skill intensity of imports on the tariff-predicted skill intensity and the F-statistic for the excluded instrument. The first-stage coefficient for the tariff-predicted skill intensity of imports is around 0.38 and always significant at the one-percent level. Thus, the partial correlation of the instrument with the endogenous variable is positive and very strong. The F-statistics of the excluded instrument are extremely high, so weak instruments are not a concern.

In the second-stage regressions (upper panel of the table) we find that the coefficient on the skill intensity of imports is around 0.4, 10 times larger than the corresponding OLS estimates. Moreover, in comparison with the OLS estimates, the coefficients are all statistically significant. The fact that the IV estimates are larger than the OLS estimates is again possibly due to two effects: first, an omitted-variable bias might arise if firms increasing the skill intensity of their imports from labor-abundant countries also reduce the skill intensity of their imports from skill-abundant countries due to complementarities in offshoring decisions; second, an attenuation bias stemming from measurement error in the skill intensity of imports.

In columns (3) and (4) we use both instruments in the first stage and present over-identified results. The supply-shock instrument is positive and significant in the first stage, and the tariff instrument continues to be positive and highly significant. The point estimates in the second stage are similar to the specifications with tariff instruments only. This indicates that the regressions are mainly identified through the variation of the tariff instrument. Finally, we cannot reject the null hypothesis of the over-identification test that the instruments are uncorrelated with the error term. Thus, the IV results confirm a causal positive effect of the skill intensity of imports from labor-abundant countries on the skill intensity of production in France.

dependent variable is log(skill intensity)$_{f,t}$				
	IV Estimates			
	(1)	(2)	(3)	(4)
import	**0.4184***	**0.4046****	**0.4801*****	**0.4731****
skill intensity$_{f,t}$	(0.185)	(0.183)	(0.187)	(0.185)
log(TFP)$_{f,t-1}$		-0.0158		-0.0159
		(0.016)		(0.016)
log(employees)$_{f,t}$		-0.2596***		-0.2605***
		(0.027)		(0.027)
log(capital/labor)$_{f,t}$		-0.0595***		-0.0596***
		(0.018)		(0.018)
log(imports)$_{f,t}$		0.0286***		0.0285***
		(0.006)		(0.006)
log(exports)$_{f,t}$		0.0060		0.0060
		(0.004)		(0.004)
Observations	46,063	45,903	46,015	45,857
Firms	8,854	8,824	8,847	8,818
Firm FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
Cluster	Firm	Firm	Firm	Firm
R-squared	0.0390	0.0560	0.0394	0.0564
First-stage regression: dependent variable is skill content of imports$_{f,t}$				
tariff predicted skill intensity$_{f,t}$	0.3806***	0.3797***	0.3802***	0.793***
	(0.019)	(0.019)	(0.019)	(0.019)
supply-shock predicted skill intensity$_{f,t}$			0.0010***	0.0017***
			(0.0006)	(0.0005)
F-statistic	420.43	415.74	215.05	212.27
Hansen J statistic (p-value)	n.a.	n.a.	0.99	0.34

Table 7: Skill intensity of production and the skill intensity of imports from labor-abundant countries: IV estimates.

The dependent variable in the second-stage regression is the firm-level (log) skill intensity of production, defined as the ratio of non-production workers to production workers.The main explanatory variable of interest is the average skill intensity of imports from labor-abundant countries. For an explanation of the construction of this variable see the data description. We consider imports from countries with less than 95 percent of the French level of secondary schooling. Other controls are (all at the firm level and in logs): TFP (lagged 1 period and constructed with the Levinsohn-Petrin method), the number of employees, the capital-labor ratio, the value of imports and the value of exports. The skill intensity of imports is considered endogenous. The instruments are the tariff-predicted skill intensity of imports (columns 1 and 2) combined with the supply-shock predicted skill intensity of imports (columns 3 and 4). See the data section for a discussion of the IV strategy. We report F-statistics for the joint significance of the instruments and the P-value for the Hansen over-identification test in (H_0: instruments uncorrelated with the residuals). Standard errors are clustered at the firm level.

6 Conclusions

In this paper we have developed a factor-proportions theory of offshoring with heterogeneous firms. From the perspective of France, a relatively skill-abundant country, sufficiently productive firms self-select into offshoring skill-intensive inputs to skill-abundant countries, while firms with even higher productivity also offshore labor-intensive inputs to labor-abundant countries (that display higher trade barriers and lower productivity levels). This leads to within-industry variation in the skill intensity of production of firms. A reduction in offshoring costs to labor-abundant countries implies an increase in the skill intensity of domestic production, as the marginal input that can be profitably offshored becomes more skill intensive. Our theory generates precise predictions on firm-level import patterns: first, more productive firms offshoring to skill-abundant (labor-abundant) countries will source relatively more labor-intensive (skill-intensive) marginal inputs than less productive ones; second, out of the set of skill-abundant (labor-abundant) countries, more productive firms will source from the relatively less (more) skill-abundant ones.

Using a quasi-exhaustive panel of French manufacturing firms we show that the predicted offshoring patterns are strongly supported by the data. Finally, we use a foreign-supply-shock-based instrument and one based on the reduction in EU external tariffs to identify the causal impact of reduced offshoring costs to labor-abundant countries on the increase in the domestic skill intensity of French manufacturing firms. We find that the bulk of the observed within-firm increase in the domestic skill intensity of firms importing from labor-abundant countries can be explained by increased offshoring to these countries.

This work is a first step in an attempt to understand how Heckscher-Ohlin forces operate at the within-industry and within-firm level. Our empirical analysis has provided evidence that Heckscher-Ohlin-driven offshoring can be a powerful source of changes in the relative demand for skill within firms. An interesting avenue for future research is to develop a more structural version of our model in order to better understand its quantitative implications in general equilibrium.

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Appendix A: Function MC_n and Firm‘s Optimal Behavior

A-1 Function MC_n

The derivative of MC_n with respect to z_n^- is

$$\frac{\partial MC_n}{\partial z_n^-} = MC_n \left[\frac{\left(\tau^o_{n^-n} w_{hn^-}^{z_n^-} w_{ln^-}^{1-z_n^-} \right)^{1-\varepsilon} - \left(w_{hn}^{z_n^-} w_{ln}^{1-z_n^-} \right)^{1-\varepsilon}}{(1-\varepsilon)\,\gamma^{1-\varepsilon} MC_n^{1-\varepsilon}} \right] = MC_n B_{n^-,n} < 0, \tag{A-1}$$

where $z_n^- \in \left(z_{n^--1,n^-}, z_{n^-,n^-+1}\right)$. Notice that $\tau^o_{n^-n} w_{hn^-}^{z_n^-} w_{ln^-}^{1-z_n^-} < w_{hn}^{z_n^-} w_{ln}^{1-z_n^-}$ for a country-n firm to import from country n^-. Thus, $\left(\tau^o_{n^-n} w_{hn^-}^{z_n^-} w_{ln^-}^{1-z_n^-} \right)^{1-\varepsilon} > \left(w_{hn}^{z_n^-} w_{ln}^{1-z_n^-} \right)^{1-\varepsilon}$. (Similarly, one can show $\partial MC_n / \partial \left(1 - z_n^+\right) < 0$.)

It is easy to see that MC_n is continuous and differentiable. In particular, at the cutoff points $z_{n',n'+1}$,

$$\lim_{\varepsilon\to 0} MC_n|_{z_n^-=z_{n',n'+1}-\varepsilon} = \lim_{\varepsilon\to 0} MC_n|_{z_n^-=z_{n',n'+1}+\varepsilon}, \tag{A-2}$$

$$\lim_{\varepsilon\to 0} \left.\frac{\partial MC_n}{\partial z_n^-}\right|_{z_n^-=z_{n',n'+1}-\varepsilon} = \lim_{\varepsilon\to 0} \left.\frac{\partial MC_n}{\partial z_n^-}\right|_{z_n^-=z_{n',n'+1}+\varepsilon} < 0. \tag{A-3}$$

(Similar results apply to $1 - z_n^+$.)

A-2 Firm‘s Optimal Behavior

Imposing strict equality on equation (9) and manipulating it,

$$\frac{\partial \Pi_n}{\partial z_n^-} = \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} \frac{\left(\tau^o_{n^-n} w_{hn^-}^{z_n^-} w_{ln^-}^{1-z_n^-} \right)^{1-\varepsilon} - \left(w_{hn}^{z_n^-} w_{ln}^{1-z_n^-} \right)^{1-\varepsilon}}{(\varepsilon-1)\,\gamma^{1-\varepsilon} MC_n^{\sigma-\varepsilon}} \left(\frac{E_W}{P^{1-\sigma}}\right) - Pf^o = 0. \tag{A-4}$$

By the implicit function theorem,

$$\frac{\partial z_n^-}{\partial \gamma} = -\frac{(\sigma-1)\,\gamma^{-1} B_{n^-,n}}{(1-\sigma)\left(B_{n^-,n}\right)^2 + \partial B_{n^-,n}/\partial z_n^-} > 0 \tag{A-5}$$

if and only if the denominator $(1-\sigma)\left(B_{n^-,n}\right)^2 + \partial B_{n^-,n}/\partial z_n^-$ is positive. A sufficient condition for this is $\sigma \geq \varepsilon > 1$. (A similar result can be obtained for $\partial \left(1 - z_n^+\right)/\partial\gamma$.)

A-3 Second-order Condition

The second partial derivatives of the firm's profit function, evaluated at $p_n = \frac{\sigma}{\sigma-1} MC_n$, are:[47]

$$\frac{\partial^2 \Pi_n}{\partial p_n^2} = -\sigma \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma-2} P^{\sigma-1} E_W MC_n^{-\sigma-1} < 0, \tag{A-6}$$

$$\frac{\partial^2 \Pi_n}{\partial \left(z_n^-\right)^2} = -\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} P^{\sigma-1} E_W MC_n^{1-\sigma} \left(B_{n^-,n}^2 + \frac{\partial B_{n^-,n}}{\partial z_n^-} \right) < 0, \tag{A-7}$$

[47] The first-order condition with respect to p_n does not depend on the offshoring decision directly, but only to the extent that MC_n depends on z_n^- and $1 - z_n^+$.

$$\frac{\partial^2 \Pi_n}{\partial\left(1-z_n^+\right)^2} = -\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} P^{\sigma-1} E_W MC_n^{1-\sigma}\left(B_{n^+,n}^2+\frac{\partial B_{n^+,n}}{\partial\left(1-z_n^+\right)}\right)<0, \quad \text{(A-8)}$$

$$\frac{\partial^2 \Pi_n}{\partial p_n \partial z_n^-} = \sigma\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma-1} P^{\sigma-1} E_W MC_n^{-\sigma} B_{n^-,n}<0, \quad \text{(A-9)}$$

$$\frac{\partial^2 \Pi_n}{\partial p_n \partial\left(1-z_n^+\right)} = \sigma\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma-1} P^{\sigma-1} E_W MC_n^{-\sigma} B_{n^+,n}<0, \quad \text{(A-10)}$$

$$\frac{\partial^2 \Pi_n}{\partial z_n^- \partial\left(1-z_n^+\right)} = \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} P^{\sigma-1} E_W MC_n^{1-\sigma} B_{n^-,n} B_{n^+,n}>0. \quad \text{(A-11)}$$

The Hessian matrix of the profit function is

$$H=\left[\begin{array}{ccc}
\frac{\partial^2 \Pi_n}{\partial p_n^2} & \frac{\partial^2 \Pi_n}{\partial p_n \partial z_n^-} & \frac{\partial^2 \Pi_n}{\partial p_n \partial\left(1-z_n^+\right)} \\
\frac{\partial^2 \Pi_n}{\partial z_n^- \partial p_n} & \frac{\partial^2 \Pi_n}{\partial\left(z_n^-\right)^2} & \frac{\partial^2 \Pi_n}{\partial z_n^- \partial\left(1-z_n^+\right)} \\
\frac{\partial^2 \Pi_n}{\partial\left(1-z_n^+\right) \partial p_n} & \frac{\partial^2 \Pi_n}{\partial\left(1-z_n^+\right) \partial z_n^-} & \frac{\partial^2 \Pi_n}{\partial\left(1-z_n^+\right)^2}
\end{array}\right].$$

It is easy to see that $\partial^2 \Pi_n / \partial p_n^2<0$;

$$\frac{\partial^2 \Pi_n}{\partial p_n^2} \frac{\partial^2 \Pi_n}{\partial\left(z_n^-\right)^2}-\left(\frac{\partial^2 \Pi_n}{\partial p_n \partial z_n^-}\right)^2 = \quad \text{(A-12)}$$

$$= \sigma\left(\frac{\sigma}{\sigma-1}\right)^{-2(\sigma+1)}\left(P^{\sigma-1} E_W\right)^2 MC_n^{-2\sigma}\left[(1-\sigma)\left(B_{n^-,n}\right)^2+\frac{\partial B_{n^-,n}}{\partial z_n^-}\right]>0$$

for $\sigma \geq \varepsilon>1$; denoting the determinant of the Hessian matrix with $|H|$, and after some tedious algebra,

$$|H| = \sigma\left(\frac{\sigma}{\sigma-1}\right)^{-3\sigma-2}\left(P^{\sigma-1} E_W\right)^3 MC_n^{1-3\sigma} \times \quad \text{(A-13)}$$

$$\times\left[(\sigma-1)\left[B_{n^-,n}^2 \frac{\partial B_{n^+,n}}{\partial\left(1-z_n^+\right)}+B_{n^+,n}^2 \frac{\partial B_{n^-,n}}{\partial z_n^-}\right]+4\sigma B_{n^-,n}^2 B_{n^+,n}^2-\frac{\partial B_{n^-,n}}{\partial z_n^-} \frac{\partial B_{n^+,n}}{\partial\left(1-z_n^+\right)}\right]<0,$$

as the term $-\frac{\partial B_{n^-,n}}{\partial z_n^-} \frac{\partial B_{n^+,n}}{\partial\left(1-z_n^+\right)}$ is negative and one order of magnitude larger than the other terms. Thus, the Hessian is negative definite and the profit function is therefore strictly concave.[48] Thus, the first-order conditions identify a global maximum.

[48]The only (minor) caveat to this analysis is that, although the profit function is continuous and first-order differentiable, its second derivatives with respect to the offshoring margins z_n^- and $1-z_n^+$ are not well defined at the cutoff points $z_{n,n+1}$. This is due to the second derivative of MC_n not being defined at these points $z_{n',n'+1}$:

$$\begin{aligned}
\frac{\partial^2 MC_n}{\partial\left(z_n^-\right)^2} &= MC_n\left(B_{n^-,n}^2+\frac{\partial B_{n^-,n}}{\partial z_n^-}\right)>0, \\
\lim_{\varepsilon \rightarrow 0} \left.\frac{\partial^2 MC_n}{\partial\left(z_n^-\right)^2}\right|_{z_n^-=z_{n',n'+1}-\varepsilon} &> \lim_{\varepsilon \rightarrow 0} \left.\frac{\partial^2 MC_n}{\partial\left(z_n^-\right)^2}\right|_{z_n^-=z_{n',n'+1}+\varepsilon}>0.
\end{aligned}$$

However, the profit function is concave in the neighborhood of each cutoff point.

Appendix B: Complementarities

The markup-pricing rule and equation (9), with strict equality, yield

$$-MC_n^{1-\sigma} B_{n^-,n} = \left(\frac{\sigma}{\sigma-1}\right)^{\sigma} P^{-\sigma} f^o E_W^{-1}. \tag{A-14}$$

Plugging in (A-1),

$$\gamma^{\varepsilon-1} \frac{\left(\tau^o_{n^-n} w_{hn^-}^{z_n^-} w_{ln^-}^{1-z_n^-}\right)^{1-\varepsilon} - \left(w_{hn}^{z_n^-} w_{ln}^{1-z_n^-}\right)^{1-\varepsilon}}{(\varepsilon-1)\, MC_n^{\sigma-\varepsilon}} = \left(\frac{\sigma}{\sigma-1}\right)^{\sigma} P^{-\sigma} f^o E_W^{-1}. \tag{A-15}$$

Recall that $\tau^o_{n^-n} w_{hn^-}^{z_n^-} w_{ln^-}^{1-z_n^-} - w_{hn}^{z_n^-} w_{ln}^{1-z_n^-}$ decreases in z_n^-. For $\sigma > \varepsilon$, reductions in MC_n require increases in z_n^- for (A-15) to hold. (A similar result can be obtained for z_n^+.) The intuition for this result is similar to that of $\partial z_n^- (\gamma) / \partial \gamma \geq 0$.

Consider two country-n firms with the same productivity γ but different offshoring frictions. Assume that in comparison with firm 1, firm 2 faces larger variable offshoring frictions vis-à-vis imports from very labor-abundant countries or of very labor-intensive inputs. Firm 2's subsequent smaller amount of offshoring of labor-intensive inputs implies $MC_{n,1} < MC_{n,2}$ and $z_{n,1}^- > z_{n,2}^-$. The fact that firm 1 has better access to the inputs that provide the largest cost savings confers it an advantage in total cost, market share and size that it can afford to pay the fixed cost f^o for additional inputs that firm 2 cannot (even if both firms face the same offshoring frictions vis-à-vis these "marginal" inputs). We can translate this result into the following two predictions:

Prediction 9: *Holding firm-level productivity constant, offshoring firms sourcing from a more labor-abundant set of labor-abundant countries (that is, countries denoted with $n' < n$) import a larger volume from any given source country. Similarly, holding firm-level productivity constant, offshoring firms sourcing from a more skill-abundant set of skill-abundant countries (that is, countries denoted with $n' > n$) import a larger volume from any given source country.*

Prediction 10: *Holding firm-level productivity constant, offshoring firms importing a more labor-intensive set of labor-intensive products (that is, inputs denoted with $z < z_n^-$) import a larger volume from any given source country. Similarly, holding firm-level productivity constant, offshoring firms importing a more skill-intensive set of skill-intensive products (that is, inputs denoted with $z > z_n^+$) import a larger volume from any given source country.*

Appendix C: General Equilibrium

In addition to the assumptions in section 2, assume (*i*) that final-good producers must pay a fixed cost f_n^e in terms of the final good before picking a random draw from a known distribution and (*ii*) free entry. The firm's profit maximization problem discussed in the main text can be embedded into the following general-equilibrium conditions:[49]

1. Free entry condition:

$$\int_0^\infty \left[\left(\frac{\sigma}{\sigma-1} \right)^{1-\sigma} \frac{E_W}{\sigma P^{1-\sigma}} \left[MC_n \left(\gamma, z_n^- (\gamma), z_n^+ (\gamma) \right) \right]^{1-\sigma} - \left[z_n^- (\gamma) + \left[1 - z_n^+ (\gamma) \right] \right] P f_n^o \right] dG(\gamma) = P f_n^e, \tag{A-16}$$

   where $E_W \equiv \sum_n (w_{hn} H_n + w_{ln} L_n)$.

2. Price level:

$$P^{1-\sigma} = \left(\frac{\sigma}{\sigma-1} \right)^{1-\sigma} \left[\sum_{n'} M_{n'} \int_0^\infty \left[MC_n \left(\gamma, z_n^- (\gamma), z_n^+ (\gamma) \right) \right]^{1-\sigma} dG(\gamma) \right]. \tag{A-17}$$

3. Factor market clearing:

$$\sum_{n'} \left[M_{n'} \int_0^\infty \frac{\partial VC_{n'} \left(\gamma, z_{n'}^- (\gamma), z_{n'}^+ (\gamma) \right)}{\partial w_{hn}} dG(\gamma) \right] = H_n, \tag{A-18}$$

$$\sum_{n'} \left[M_{n'} \int_0^\infty \frac{\partial VC_{n'} \left(\gamma, z_{n'}^- (\gamma), z_{n'}^+ (\gamma) \right)}{\partial w_{ln}} dG(\gamma) \right] = L_n, \tag{A-19}$$

   where $VC_n \left(\gamma, z_n^- (\gamma), z_n^+ (\gamma) \right) = MC_n \left(\gamma, z_n^- (\gamma), z_n^+ (\gamma) \right) q_n (\gamma)$.

It is easy to find factor endowments and parameter values such that the general equilibrium prices coincide with what we assumed in our partial-equilibrium approach.

[49]For simplicity, we consider the case with no differences in variable offshoring frictions across firms.

Appendix D: Additional Results

A-1 Complementarities

According to Prediction 9, for importers from the set of labor-abundant countries – holding constant productivity – firms offshoring to a more labor-abundant mix of countries import more from a given country. Moreover, according to Prediction 10, for importers from the set of labor-abundant countries, firms offshoring more labor-intensive inputs to other countries import more from any given country.[50] For each firm-product-country, we compute the skill intensity of imports of other products sourced from both other labor-abundant countries (measured as the simple average of skill intensities of those products) and other skill-abundant countries. We also compute the skill-abundance of the other source countries separately for the sets of labor-abundant and skill-abundant countries (measured as the simple average over the levels of secondary schooling of those countries).[51] We then consider the following regression specifications:

$$\begin{aligned}\log(imports)_{f,p,c,t} =&\beta_0 + \beta_1 \log(TFP)_{f,0} + \beta_2 skillint_p + \\ &+ \beta_3 skillint\ other\ products_{f,p,t} + \beta_5 X_{f,c,t} + \epsilon_{f,p,c,t},\end{aligned} \tag{A-20}$$

where $X_{f,c,t}$ contains the total number of other imported products, our usual set of firm-specific controls, country and year fixed effects, and

$$\begin{aligned}\log(imports)_{f,p,c,t} =&\beta_0 + \beta_1 \log(TFP)_{f,0} + \beta_2 sec.schooling_c + \\ &+ \beta_3 sec.\ schooling\ other\ countries_{f,c,t} + \beta_5 X_{f,c,t} + \epsilon_{f,p,c,t},\end{aligned} \tag{A-21}$$

where $X_{f,c,t}$ contains the total number of other source countries, our usual set of firm-specific controls, year fixed effects, as well as bilateral gravity controls. When considering firms offshoring to labor-abundant (skill-abundant) countries, we expect β_3 to be negative (positive) in both specifications. The results are presented in Table A-1. In columns (1)-(4) we report results for importers from labor-abundant countries. In all cases, β_3 has the expected negative sign and is statistically significant. In columns (5)-(8), we instead report results for importers from skill-abundant countries. β_3 is now positive and significant.

The coefficients on the number of sourcing countries and imported products are negative, indicating that complementarities do not arise because firms importing from more countries or more products have lower costs. The existence of complementarities in import decisions is in line with Antràs et al. (2014), but the HO comparative advantage adds an important dimension to their nature.

[50] By symmetry, for importers from the set of skill-abundant countries – holding constant productivity – firms offshoring to a more skill-abundant mix of countries should import more from a given country, and firms offshoring more labor-intensive inputs to other countries should import more from any given country.

[51] Results are robust to considering instead an import share-weighted average of skill intensity or skill abundance.

	dependent variable is $\log(\text{imports})_{f,p,c,t}$							
	from labor-abundant countries				from skill-abundant countries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
skill intensity	**-2.2522*** **	**-2.9925*** **			**2.6716*** **	**1.9826*** **		
other products$_{f,p,t}$	(0.356)	(0.363)			(0.246)	(0.240)		
sec. schooling			**-1.0414*** **	**-1.2502*** **			**0.3010*** **	**0.2577*** **
other countries$_{f,c,t}$			(0.141)	(0.142)			(0.081)	(0.079)
skill intensity$_p$	-0.0035	-0.3986**			-0.0201	-0.1417		
	(0.239)	(0.193)			(0.113)	(0.096)		
sec. schooling$_c$			-1.0610***	-0.1442			-0.9251***	-1.1082***
			(0.120)	(0.106)			(0.059)	(0.256)
$\log(\text{TFP})_{f,0}$	0.1659*	0.0499	0.0289	-0.0619	0.6186***	0.4135***	0.5800***	0.4506***
	(0.088)	(0.088)	(0.082)	(0.077)	(0.045)	(0.044)	(0.055)	(0.054)
$\log(\text{employees})_{f,t}$		0.0864***		0.0784**		0.1729***		0.0877***
		(0.029)		(0.037)		(0.015)		(0.018)
$\log(\text{capital/labor})_{f,t}$		0.0501		0.0522		0.1098***		0.1451***
		(0.056)		(0.055)		(0.019)		(0.021)
$\log(\text{exports})_{f,t}$		0.2423***		0.2478***		0.3802***		0.3801***
		(0.017)		(0.023)		(0.009)		(0.010)
# products$_{f,t}$	-0.0036*	-0.0051**			-0.0022***	-0.0048***		
	(0.002)	(0.002)			(0.000)	(0.000)		
# countries$_{f,t}$			-0.0160*	-0.0300***			0.0323***	-0.0372***
			(0.008)	(0.009)			(0.010)	(0.012)
Observations	430,635	430,635	427,815	375,152	1,327,313	1,327,313	1,250,216	1,246,583
Country FE	YES	YES	NO	NO	YES	YES	NO	NO
Time FE	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm
R-squared	0.0118	0.0415	0.0176	0.0477	0.0961	0.0961	0.0234	0.0802

Table A-1: Imports from labor-abundant/skill-abundant countries: complementarities in import decisions.

In columns (1)-(4) the dependent variable is log imports from labor-abundant countries at the firm-product-country-year level. In columns (5)-(8) the dependent variable is log imports from skill-abundant countries at the firm-product-country-year level. We define countries with less than 95 percent of the French level of secondary schooling as labor-abundant and the remaining countries as skill abundant. The main explanatory variable of interest in columns (1)-(2) and (5)-(6) is the skill intensity of other imported products (skill intensity other products $_{f,p,t}$) . The main explanatory variable of interest in columns (3)-(5) and (7)-(8) is the skill abundance of other countries from which the firm sources (sec. schooling other countries $_{f,c,t}$). Other controls are (all at the firm level and in logs): the number of employees, the capital-labor ratio, the value of exports. Columns (4) and (8) include gravity controls (GDP, GDP per capita, distance, area, dummies for border common language, colony). Standard errors are clustered at the firm level.

A-2 Appendix Tables

Variable	Mean	Std. Dev.	5th Pct.	95th Pct.	Obs.
Skill intensity	1.18	4.50	0.14	3.50	646,920
Employees	53.51	336.58	3.00	174.00	646,920
(log) TFP	3.83	0.46	3.05	4.56	646,920
(log) Capital/labor	3.25	0.99	1.52	4.83	646,920
Imports (in 1000 euros)	1,908	24,403	0.0	4,047	646,920
Exports (in 1000 euros)	1,375	26,606	0.0	3,030	646,920
Number of products imported (all origins)	5.36	16.72	0.00	29.00	646,920
Number of products imported from skill-abundant countries	10.07	19.02	1.00	39.00	182,239
Number of products imported from labor-abundant countries	6.11	11.59	1.00	24.00	96,039
Number of countries per firm-product (all origins)	1.74	1.11	1.00	3.74	224,039
Number of countries per firm-product (skill-abundant countries)	1.21	0.39	1.00	2.00	182,239
Number of countries per firm-product (labor-abundant countries)	1.35	0.96	1.00	2.61	96,039

Table A-2: Summary Statistics Summary statistics for the baseline estimating sample. 95% cutoff refers to the group of countries with a level secondary schooling less than 95% of that of France. See Table A2 for the list of countries.

Table A-3: Production function output elasticity estimates by 2-digit sector (Levinsohn-Petrin)

2-digit code	Title	Unskilled labor	s.e.	Skilled labor	s.e.	Capital	s.e.
10	Food products	0.38	0.00	0.31	0.00	0.23	0.02
11	Beverages	0.31	0.02	0.41	0.02	0.25	0.05
13	Textiles	0.36	0.01	0.35	0.01	0.18	0.01
14	Wearing apparel	0.31	0.01	0.40	0.01	0.31	0.03
15	Leather and related products	0.42	0.01	0.33	0.02	0.25	0.04
16	Wood and products of wood and cork	0.42	0.01	0.29	0.01	0.17	0.02
17	Paper and paper products	0.35	0.01	0.32	0.01	0.19	0.03
18	Printing and reproduction of recorded media	0.34	0.01	0.39	0.01	0.15	0.01
20	Chemicals and chemical products	0.19	0.01	0.53	0.01	0.20	0.02
21	Basic pharmaceutical products	0.10	0.02	0.69	0.03	0.16	0.05
22	Rubber and plastic products	0.33	0.01	0.35	0.01	0.22	0.01
23	Other non-metallic mineral products	0.37	0.01	0.31	0.01	0.22	0.03
24	Basic metals	0.37	0.02	0.37	0.01	0.22	0.05
25	Fabricated metal products	0.40	0.00	0.32	0.00	0.20	0.01
26	Computers, electronic and optical products	0.17	0.01	0.53	0.01	0.19	0.05
27	Electrical equipment	0.27	0.01	0.45	0.01	0.19	0.01
28	Machinery and equipment n.e.c.	0.26	0.00	0.47	0.01	0.18	0.02
29	Motor vehicles, trailers and semi-trailers	0.38	0.01	0.36	0.02	0.18	0.02
30	Other transport equipment	0.39	0.02	0.45	0.02	0.17	0.03
31	Furniture	0.40	0.01	0.29	0.01	0.22	0.02
32	Other manufacturing	0.23	0.01	0.49	0.01	0.25	0.02

Table A-4: Average annual wages by worker category

	Firm owners receiving a wage	Admin. and commer. managers	Technicians and supervisors	White Collars	Blue Collars	Skill Premium
1996	34,181	36,482	20,728	13,852	13,913	1.672
1997	34,673	37,069	20,990	14,111	14,198	1.672
1998	35,634	37,337	21,146	14,374	14,359	1.678
1999	37,507	38,269	21,364	14,520	14,580	1.702
2000	39,377	39,474	21,717	14,672	14,854	1.709
2001	52,423	40,488	21,477	14,469	15,003	1.735
2002	59,210	41,197	21,884	14,771	15,395	1.754
2003	59,725	41,736	22,324	15,054	15,781	1.752
2004	62,391	42,400	22,692	15,313	16,195	1.739
2005	65,893	43,564	23,233	15,769	16,692	1.733
2006	69,410	44,387	23,710	16,063	16,887	1.749
2007	75,681	45,775	24,315	16,453	17,377	1.762

Table A-5: Country List

labor-abundant countries countries with less than 95 percent of secondary schooling relative to France		skill-abundant countries countries with more than 95 percent of secondary schooling relative to France
Afghanistan	Liberia	Armenia
Albania	Libya	Australia
Algeria	Macao	Austria
Argentina	Malawi	Belgium
Bahrain	Malaysia	Canada
Bangladesh	Maldives	Denmark
Barbados	Mali	Estonia
Belize	Malta	Finland
Benin	Mauritania	France
Bolivia	Mauritius	Germany
Botswana	Mexico	Greece
Brazil	Morocco	Ireland
Bulgaria	Mozambique	Israel
Burundi	Namibia	Italy
Cambodia	Nepal	Kazakhstan
Cameroon	New Zealand	South Korea
Central African R.	Nicaragua	Kyrgyzstan
Chile	Niger	Luxembourg
China	Pakistan	Lithuania
Colombia	Panama	Mongolia
Congo, Republic of	Papua New Guinea	Netherlands
Costa Rica	Paraguay	Norway
Cote d'Ivoire	Peru	Portugal
Croatia	Philippines	Russia
Cuba	Poland	Spain
Cyprus	Qatar	Sweden
Czech Republic	Romania	Switzerland
Dominican Republic	Rwanda	Tajikistan
Ecuador	Saudi Arabia	Ukraine
Egypt	Senegal	United Kingdom
El Salvador	Sierra Leone	United States
Fiji	Singapore	
Gabon	Slovak Republic	
Gambia	Slovenia	
Ghana	South Africa	
Greece	Sri Lanka	
Guatemala	Sudan	
Guyana	Swaziland	
Haiti	Syria	
Honduras	Taiwan	
Hong Kong	Tanzania	
Hungary	Thailand	
India	Togo	
Indonesia	Tonga	
Iran	Trinidad	
Iraq	Tunisia	
Jamaica	Turkey	
Japan	Uganda	
Jordan	United Arab Emirates	
Kenya	Uruguay	
Kuwait	Venezuela	
Laos	Vietnam	
Latvia	Yemen	
Lesotho	Zambia	
	Zimbabwe	