Preliminary

Imports, Import Sources and Skill Utilization*

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Abstract

One of the primary benefits of international trade in a low-income context is the presumed ability, through trade, to access higher levels of technology through imports. Despite this important mechanism of development, very little research has been done on international trade in a low-income (as opposed to middle-income) context, and even less concretely exploring the role of imports, largely because of the paucity of data available. This paper explores the consequences of importing on the utilization of skills in the low-income context of Rwanda, utilizing a unique linked dataset. In particular, the causal impact of imports on skill utilization is explored, with particular attention to whether or not the imports are sourced from high-income countries (and therefore of higher quality/technology). The causal impact of imports is obtained through the use of an instrumental variable procedure where the changes in the exchange rates faced by a firm during the sample period on the basket of goods imported by the firm prior to the sample period are used as instruments for the changes in imports during the sample period. A theoretical model is built that incorporates the skill complementarity hypothesis (as well as a trade-related required services hypothesis due to Matsuyama (2007)), and this model is tested in the context of Rwanda, using data on all firms with registered payroll in Rwanda (not just manufacturing firms). We investigate the effects for different import souces, as well as importing within different sectors (manufacturing, hotel and restaurant services, wholesale & retail trade, etc.).

1. Introduction

There has been a significant expansion of empirical firm-level studies of international trade in the past decades. The predominant threads of this literature have explored the relationship between exports and firm productivity (Melitz, 2003; Bernard, Eaton, Jensen, and Kortum, 2003; Eaton, Kortum, and Kramarz, 2011), at times also exploring the relationship between export destination and productivity, the existence of an export wage premium[1] and the relationship between exports and the skill premium.[2] Although early work in this area uses U.S. data (Bernard and Jensen, 1995, 1999), the vast majority of the work in the past 10 years has been using European data.[3] In addition, some interesting work on trade and inequality and exporting and the skill premium has been done in Latin American countries (Verhoogen, 2008; Brambilla et. al., 2012; Harrigan and Reshef, 2012).

As acknowledged by Bernard et. al. (2007, p. 123), "the empirical literature on firms in international trade has been concerned almost exclusively with exporting, largely due to limitations in data sets. As a result, the new theories of heterogeneous firms and trade were developed to explain facts about firm export behavior and yield few predictions (if any) for firm import behavior." More recently, some studies have been performed on imports and firm behaviour. Goldberg et. al. (2010) find that lowered import tariffs on intermediate inputs result in the introduction of new products by domestic firms. Other studies of imports have examined their relationship more broadly to firm performance. The rationale for this relationship has been the importance of imports as a mechanism for gaining access to state-of-the-art technology and knowledge. In particular, a number of studies have explored the relationship between imports and firm productivity.[4]

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[1] See Eaton, Kortum, Kramarz, and Sampognaro (2011) for a brief survey of this literature.
[2] See Harrison, McLaren and McMillan (2011) for a recent survey of this literature.
[3] See Wagner(2012) for a survey.
[4] See Wagner (2012) for a survey.

The current study examines the relationship between importing and skill utilization in the context of Rwanda. As such, it expands the previous literature in a number of different dimensions. First, the prior literature that has examined imports at the firm level has focused largely on the relationship between imports and firm productivity, and has largely involved studies of correlations rather than causal impact studies. Moreover, this branch of the literature is focused almost entirely on high-income, particularly European datasets. Koren and Csillag (2011) focus on machine use in Hungary. The current paper expands the literature on imports in international trade by looking at the relationship between general imports and skill utilization, and in particular, by exploring this relationship in a low-income context.

In fact, there has been relatively little empirical exploration of international trade in a low-income context. While Harrison et. al. (2011) document the substantial increase in empirical exploration of international trade and income inequality in the past decade, much of this research has either been carried out in high-income context, often focused on offshoring versus importing, or in upper-middle-income contexts (such as Argentina, Brazil, Colombia, Mexico, Hungary). Goldberg et. al. (2010) focuses on the lower-middle-income context of India.[5]

This paper also stretches the previous literature by examining non-manufacturing sectors. While there has been some examination of international trade and firm performance in the context of business services, specifically examining the relationship between exports and firm profitability in the business service sector, this work has primarily occurred with high-income (European) data.[6] I am not aware of any examination of international trade and firm behaviour that looks beyond manufacturing in a lower-income context. I am also not aware of any

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[5] India is a middle-income country in 2013 by the World Bank definitions. See the categorization in the current World Bank Indicators at http://www.worldbank.org.
[6] See Wagner (2012).

examination of imports and firm behaviour outside of manufacturing in any context. [7]

The import side is particularly important in a low-income context. In low-income countries, exports are typically concentrated in the agricultural, mining and resource-based sectors. Manufactured exports are usually quite limited. As a result, to explore current international trade consequences outside of the agricultural and resource sectors, one should examine imports. As a corollary, if the impact of spreading knowledge and technology via imports should occur anywhere, it should occur in a low-income country context. This suggests that a context such as Rwanda is a sensible place to examine the impact of imports both for the sake of understanding low-income country contexts such as Rwanda, and also for the sake of understanding the validity of broader, general models, that have particular predictions for low-income settings like Rwanda, predictions that to this point have been little tested.

In exploring the connection between importing and skill utilization in Rwanda, this paper relates immediately to the input quality literature, the trade-related services literature, and the skill premium literature.

Verhoogen (2008) develops a model where exporting is related to quality upgrading, and involves a greater use of skilled labour. Here, higher-skilled workers are required, but this is in order to export to higher-income destinations. In a related vein, Kugler and Verhoogen (2011) in a paper not directly focused on international trade, demonstrate, theoretically and empirically, that more productive firms are more likely to use higher-quality inputs in order to produce higher-quality outputs. If imported inputs are more likely to be of higher quality, then this has direct implications for our setting. However, rather than focus on

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[7] This is a preliminary version of the paper, so let me just state that this is not a strong statement yet, in that I have not yet done a completely thorough review of all literature to be able to firmly state that such work does not publicly exist. For now, my lack of awareness of other papers is an invitation to the reader to update my ignorance.

the correlation between input and output prices as Kugler and Verhoogen (2011) do, we focus on the relationship between imports and the skill premium, or in other words the correlation between the quality of two different types of inputs: imported material inputs, and the skill level of the labour inputs.

Brambilla et. al. (2012) essentially test the relative importance of the Verhoogen (2008) mechanism as compared to the more general result of Matsuyama (2007) where "international trade inherently requires more intensive use of skilled labour with expertise in areas such as international business, language skills, and maritime insurance." (p. 237). Brambilla et. al. test the importance of "quality upgrading" versus "skills for trade-related required services" stories by examining the causal impact of increases in the overall level of exports (Matsuyama's hypothesis) compared to the intensity of exports to high-income countries (Verhoogen's quality-related hypothesis).

This paper will take a similar approach, but on the import side. Specifically, we develop a model that nests whether or not the overall level of imported inputs, or the share of imported inputs from high-income countries, requires increased skill utilization. The model is tested in Rwandan firms over the period from 2008 through 2010. The intuition relates to the literature on imports and firm productivity. If imports are an important means of obtaining new technology and knowledge, then it is quite likely that a more skilled workforce is required in order to take advantage of the knowledge embodied in these imported inputs. As such, the current paper is related to the work of Koren and Csillag (2011), Parro, (2012), Bursten, Cravino and Vogel (2012), who each explore a model of complementarity between imported capital and skill. The intuition for this effect varies by sector. In the manufacturing sector, higher-skilled workers might be required to use imported, higher-technology machinery. In the hotel sector, firms that use higher-quality (imported) materials might be catering to higher-income clients, and as such these higher-quality imports might be complementary to a higher-skilled (e.g. multilingual) workforce. In the construction sector, higher-

4

skilled workers might be required to work with imported construction materials than with domestic construction materials. The exact mechanism for the complementarity between imports and skills could vary by sector.

In terms of results, first, we find that skill utilization is correlated with both overall imports, and the fraction of imports coming from high-income, or higher income, countries. This correlation is a novel result, at least outside of manufacturing. Then, in order to develop a *causal* impact of imports on the skill utilization at the firm level, we track each firm's import products over a three-year period prior to our sample. The average exchange rate for this import product mix is used to calculate a firm-specific international exchange rate, essentially the international exchange rate that matters for the firm at its original, endogenous choice of import products. We then use exogenous *changes* in these firm-specific exchange rates as instruments for the changes in the levels of imports (at times by source country) at the firm level. With this IV approach, the impact of either imports in general, or imports from high-income countries, or higher-income countries, on the skill utilization at the firm level is measured. We find that when firms increase their overall imports in response to exogenous exchange rate fluctuations, this *causes* an increase in skill utilization at the firm. In contrast, the proportion of these imports coming from high-income countries does not *cause* a change in skill utilization.

2. Setup of the Model

The current model is a model of a small open economy, adapting the structures of Yeaple (2005) and Koren and Csillag (2011) to the current context, with the new dimensions outlined above.

2.1. Workers

There is a mass of L workers, with a skill level of s. A higher level of skill is captured by a higher s, and s is not unbounded so that it is normalized to [0,1]. The distribution of these skills in the population is given by H(s) with density h(s). Workers supply their labour inelastically, and receive a wage that is a function of their skill, w(s). Workers spend all of their income consuming the final good.

2.2. Production

Production occurs when a worker takes an input, and adds value to that input, based on their skill, in order to produce the output. There are three types of inputs: inputs that have been sourced domestically (θ_D), inputs that have been imported from low-income countries (θ_L), and inputs that have been imported from high-income countries (θ_H),. It is assumed that there is an ordering on input quality (in terms of contribution to the value of the final good) as follows: $\theta_H \geq \theta_L \geq \theta_D$. It takes γ units of the final good in order to produce a domestic input, and these are produced in a competitive market, so that the price of a domestic input is $p_D = \gamma$. Also, we assume that since both H and L inputs are imported, an additional cost must be paid to handle the logistics of importing. This cost is $C - \lambda s$. That is, following Matsuyama (2007), we allow for trade to be a skill-intensive activity where the cost of importing can be reduced with skill. Since the range of skills is normalized to [0,1], the level of λ will be restricted such that $C - \lambda s \geq 0$, to ensure that the cost of importing is always a cost. Skills can mitigate this cost, but the cost cannot be lowered below 0.

Since the economy is small, the prices of low-income and high-income imports are given as p_H and p_L. By assumption, since goods from highest-income countries are assumed to be of (possibly equally) highest quality, $p_H \geq p_L \geq p_D$. When the trade costs are added, the additional relationship follows directly: $p_H + C - \lambda s \geq p_H + C - \lambda s \geq p_D$.

Therefore, the firm will hire a worker of skill level s, and source an input, domestically, from a low-income country, or a high-income country. Firm production is given by:

$$Q_i = F(\theta_i, s_i) \tag{1}$$

where Q_i is the output of firm i, θ_i is the input quality, and s_i is the skill level of the employee. Skills are productive, so Q_i is increasing in s_i for each choice of input. To focus on the input-skill complementarity, we assume that the firm hires a single worker, and uses a single input, which are both hired in competitive markets. We also assume that $F_{\theta s} > 0$ (*), that the production function is supermodular in input quality and worker skill.

Ex ante, firms are identical. Therefore, the firm's profit maximization problem is to solve:

$$\max_{\{\theta_D, \theta_H, \theta_F\}, s} F(\theta, s) - p(\theta) - w(s) \tag{2}$$

For ease of exposition, the firm will first decide which input to purchase, and then hires the optimal worker for that input, on the basis of which joint decision (worker, input) will maximize profits. Therefore the problem at (2) can be re-written:

$$Max \begin{cases} \pi_D = \max_s F(\theta_D, s) - p_D - w(s); \\ \pi_L = \max_s F(\theta_L, s) - p_L - w(s) - (C - \lambda s); \\ \pi_H = \max_s F(\theta_L, s) - p_H - w(s) - (C - \lambda s) \end{cases} \tag{3}$$

The first-order conditions for optimal worker hiring are:

$$\begin{aligned} F_s(\theta_D, s_D) &= w'(s_D) \\ F_s(\theta_L, s_L) &= w'(s_L) - \lambda \\ F_s(\theta_H, s_H) &= w'(s_H) - \lambda \end{aligned} \tag{4}$$

7

2.3 Equilibrium:

An equilibrium in this economy will be given by (i) a function $g\colon [0,1] \to \{\theta_D, \theta_L, \theta_H\}$, that maps worker skills to input type, (ii) a wage function $w\colon [0,1] \to \mathbb{R}$, (iii) a production function $q\colon [0,1] \times \theta_i \to \mathbb{R}$ that maps the skills of a firm's employee and the firm's input sources into a level of output, (iv) the price p_D of domestic inputs, as well as the quantity of domestic inputs produced in equilibrium X_D, and (v) the amount of imported inputs from low-income sources X_L and from high-income countries X_H.

Proposition 1: If a worker with skill level $\tilde{s}$ is hired to work with a domestic input (θ_D), then all workers with skill level less than $\tilde{s}$ will also work with a domestic input. If a worker with skill level $\hat{s}$ is hired to work with an input from a high-income country, then all workers with skill level higher than $\hat{s}$ will also work with that high-income country import.

The proof of Proposition 1 will be detailed through the construction of the equilibrium. Note that by this proposition, if any workers work with domestic inputs, then there will be a bounded set of the lowest-skilled workers that work with domestic inputs. Similarly, if any workers work with foreign inputs, there will be a bounded set of the highest-skilled workers working with the foreign inputs. An immediate implication is that if any workers work with low-income country inputs, they will form an intermediate skill-range between the lowest-skilled and highest-skilled workers. Therefore, if workers are working with each type of input, there will be the following mapping of skill set to input type:

$$g(s) = \begin{cases} \theta_D \ \ if \ s \leq s_1 \\ \theta_L \ \ if \ s_1 < s \leq s_2 \\ \theta_H \ \ if \ s > s_2 \end{cases} \tag{5}$$

8

Note that nothing in the restrictions imposed so far implies that all three types of inputs will be used. In the equilibrium, we may see any combination of input types that respects the above order of skill levels (e.g. only domestic inputs used, or only domestic and high-income foreign inputs used). It remains to be seen whether or not we see the three types of inputs used in equilibrium. For broadest generality, and because we do see the three types of inputs used in the data, we will assume for now that we do.

There is free entry for firms; this creates a zero profit condition. Profits are given by (3). Workers are going to work at a firm of type θ to receive the highest wage for their skill level. From the zero profit condition, and (3), we get the following wage schedule:

$$w(s) = Max \begin{cases} F(\theta_D, s) - p_D & (a) \\ F(\theta_L, s) - p_L - C + \lambda s & (b) \\ F(\theta_H, s) - p_H - C + \lambda s & (c) \end{cases} \tag{6}$$

Note that the wage difference for working with a H input (c) versus an L input (b) is given by: $F(\theta_H, s) - F(\theta_L, s) - (p_H - p_L)$. Since $F_{\theta s} > 0$, this wage gap is increasing in skill level. Similarly the wage gap between (b) and (a) is increasing in skill. As a result, there will be a separation of the workers based on skill, with low-skilled workers working with domestic inputs, and high-skilled workers working with foreign-sourced inputs. There will be two cutoff skill levels, s_1 and s_2, with s_2 separating workers of skill type (b) and (c) according to $F(\theta_H, s_2) - F(\theta_L, s_2) = p_H - p_L$, and skill level s_1 separating workers of skill type (a) and (b) defined by $F(\theta_L, s_1) - F(\theta_D, s_1) = p_L - p_D + C - \lambda s$. It is straightforward to verify that the derivative of the wage function satisfies the first-order condition of the profit maximization problem:

$$w'(s) = \begin{cases} F_s(\theta_D, s) & \text{if } s \leq s_1 \\ F_s(\theta_L, s) + \lambda & \text{if } s_1 < s \leq s_2 \\ F_s(\theta_H, s) + \lambda & \text{if } s > s_2 \end{cases} \tag{7}$$

So, the functions above characterize the equilibrium wage in the labour market. The sorting of workers between domestic inputs, low-income imported inputs, and high-income imported inputs is given in Figure 1. The wage function is going to be the upper envelope of the three curves above, and thus is a piecewise-defined curve with three pieces in the most general case.

Let us examine the equilibrium in the goods market. Here, the small, open economy plays a role as the prices of the imports from both high-income countries (p_H) and low-income countries (p_L) are exogenously given. As noted before, $p_D = \gamma$. Note that the supply of type-s firms is given by: $q(s) = F(\theta(s), s)l(s)$.

The total supply of the final good is given by:

$$Q = \int_0^{s_1} F(\theta_D, s)l(s)ds + \int_{s_1}^{s_2} F(\theta_L, s)l(s)ds + \int_{s_2}^{1} F(\theta_H, s)l(s)ds \tag{8}$$

The total demand for domestic inputs is:

$$I_D = \int_0^{s_1} l(s)\, ds \equiv L(s_1) \tag{9}$$

where, as noted previously, γ units of the final good are required in order to produce each domestic input. Therefore, the following fraction of domestic production is required for the production of domestic inputs:

$$Q_D = \gamma I_D = \gamma L(s_1) \tag{10}$$

The other inputs are imported from low-income countries and high-income countries. These imports are subject to a trade balance constraint, forcing their value to equal the value of exports of the final good. Labelling the demand for imports from low-income countries as I_L and the demand for imports from high-income countries as I_H, we get:

$$Value\ of\ imported\ inputs = p_H I_H + p_L I_L \tag{11}$$

These will be equal to the value of final goods exports in equilibrium (Q_X), since the price of the final good is normalized to 1.

$$p_H I_H + p_L I_L = Q_X \tag{12}$$

The input requirements for the L-type firms is:

$$I_L = \int_{s_1}^{s_2} l(s)\, ds \tag{13}$$

While the input requirements for the H-type firms is:

$$I_H = \int_{s_2}^{1} l(s)\, ds \tag{14}$$

The total demand for imported inputs will be given by:

$$I_L + I_H = L - L(s_1) \tag{15}$$

To recap, the production which is not required for domestic inputs or for exports will remain for consumption:

$$Q_C = Q - Q_D - Q_X \tag{16}$$

By Walras' law, this is exactly what is demanded for consumption. This is equal to the total wage bill, $\int_0^1 w(s)\, ds$, since profits are zero for every firm in the economy in equilibrium. This completes the description of the equilibrium.

In the case of the most general equilibrium, we can see from Figure 1 that both the wage and the returns to skill can be ranked by sector with the type-H firms having the highest wage, and the type-D firms having the lowest wage.

Proposition 2:

1) The wage is higher in firms that use imported inputs than in firms that use domestic inputs.
2) Among those firms using imported inputs, the wage is higher in those firms that use a higher-proportion of inputs from high-income countries.

This is the most general expression of the key result of the model, which incorporates both trading costs (Matsuyama) and input quality considerations (Verhoogen). Let us now consider the modified model where one of these two key components of the model is shut down.

2.4 Case 1) No Complementarity between Skill and High-Quality Inputs

To formally remove the complementarity between skill and input quality, we set $F_{\theta s} = 0$. What remains is the complementarity between skills and importing, in the Matsuyama sense. The wage schedule is still formally defined exactly as at equation (6). However, there is now no differential return to skill between the sectors. As a result, the w(s) curves for the L-type firms and the H-type firms (corresponding to Figure 1) are everywhere parallel. However, in equilibrium, workers of a given skill level must be working in the sector that returns the

highest wage. As a result, in equilibrium, the wage schedules for 6 (b) and 6 (c) for L-type and H-type firms, respectively, must be identical. Setting these wages equal to each other gives:

$$p_H - p_L = F(\theta_H, s) - F(\theta_L, s) \tag{17}$$

or that the constant import price gap is equal to the output gap between the import types equally at all levels of skill, s.

Nevertheless, there remains difference in returns to skill between imported (type-H and type-L) and domestic (type-D) inputs, related to the skill requirements of importing. Therefore, the wage schedule for skill is a modified version of Figure 1, where the wage schedule is again piecewise-defined, but with two instead of three components.

Overall, the important implications for this type of model are that skill utilization is higher when imported inputs are used than when non-imported inputs are used, but the skill utilization does not differ across source locations for imported inputs.

2.5 Case 2) No Skill Requirements for Trading

In this case, we formally remove the Matsuyama effect. Namely, international trade does not require skill any more intensively than domestic exchange. In our model, this is equivalent to setting $\lambda = 0$. Therefore, the modified wage schedule from equation (6) is now:

$$w(s) = Max \begin{cases} F(\theta_D, s) - p_D \ (a) \\ F(\theta_L, s) - p_L - C \ (b) \\ F(\theta_H, s) - p_H - C \ (c) \end{cases} \tag{18}$$

where C could be 0. Since there are still differential skill returns across firm types due to complementarity between skill and input quality $(F_{\theta s} > 0)$, the diagram for this case looks very similar to Figure 1, again with a piecewise defined wage schedule with 3 segments.

As in Case 1), we would expect a wage gap between domestic firms and foreign firms. However, in Case (2), we would also expect a wage gap between firms that import their inputs from high-income countries over firms that import their inputs from low-income countries. We will take these two propositions to the data to test them.

2.6) Case 3) Imports from all Destinations are of high quality

In this case, we assume that all imports are of roughly equal quality. This is equivalent to assuming that the input quality from all countries is the same and at the quality level $\theta_M (= \theta_H = \theta_L)$, and that these inputs are traded at a price of $p_M (= p_H = p_L)$. As a result the modified wage schedule from equation (6) is now:

$$w(s) = Max \begin{cases} F(\theta_D, s) - p_D & (a) \\ F(\theta_M, s) - p_M - C + \lambda s & (b) \end{cases} \qquad (19)$$

This is equivalent to removing the middle segment of the piecewise-defined wage function of Figure 1. Now, both the wage and the return to skill are higher in all firms that use imported inputs. This could either be as a result of the quality of the inputs, or as a result of a Matsuyama-based "trade-related required services" hypothesis.

Note that the empirical implications of this case are undistinguishable from Case 1. While the two cases arise from different theoretical underpinnings, the two cases have the same implications from a policy perspective. Namely, policy measures to liberalize trade with any country should result in an increase in the

demand for skill utilization across firms. Therefore, from a policy perspective, depending on the goal of interest, it may not be critical to differentiate between these two cases. This will be further discussed in the empirical results.

3. Empirical Analysis

3.1. Data

The data in the survey comes from three separate sources within Rwanda. The import and export data is recorded at the transaction level, and is obtained from the customs department for the period from 2005 through 2011. The firm account information (for our purposes, firm sales) is recorded annually for the years 2008, 2009, and 2010. Payroll information on the firm (in particular, the total wage bill and the number of employees) is obtained from the government department that handles payroll for the years 2008 through 2010. The information in these three datasets is linked by the tax identification numbers for each firm.

The dataset under investigation is the set of all firms in the payroll dataset that have more than one employee. This removes firms that have engaged in importing and exporting, but might be sole proprietorships without employees, since the focus here is on wages for employees.

As a result, the firms under investigation are representative of the registered (formal) sector firms with payroll in Rwanda. This is an important sector for the growth of the economy, particularly when it comes to international trade. However, it will be missing unregistered firms in the informal sector. For example, in the manufacturing sector, all informal sector firms will be missed, as will firms without employees (individual artisans without employees, for example). Although the conclusions should be thought of as applicable to the registered sector firms with payroll, since these are the firms that are most likely

15

to be engaged in importing behaviour, it is an interesting sample of firms to investigate.

3.2. Skills and Import Origin: The Empirical Model

In order to test the basic relationships of our theoretical model, we use the following regression model:

$$s_{ijt} = \alpha_1 IMP_{ijt} + \alpha_2 HI_{ijt} + X'_{ijt}\beta + \gamma_i + \delta_{jt} + \epsilon_{ijt} \tag{20}$$

The dependent variable, s_{ijt}, is a measure of skill utilization at the level of the firm i in sector j in period t. In our estimation, this skill utilization is captured by the average wage at the firm. In a competitive labour market, increases in skill utilization at the firm will be reflected by an increase in the wage. In order to differentiate this from a firm size effect, the number of employees at the firm will be included as a control in all regressions.[8]

The two primary independent variables of interest are IMP_{ijt}, which is a measure of import utilization at the firm level, and HI_{ijt}, a measure of the fraction of the firm's imports that come from high-income countries.

The variable IMP_{ijt} measures the firm's imports in a given period as a fraction of firm's sales.[9] This variable is designed to capture whether or not firms that import use higher skill, and in the causal (IV) regressions, it is designed to

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[8] An alternative source of wage increases in an uncompetitive labour market would be rent-sharing with a firm's employees. To control for this possibility, firm sales are also included in the regression in Table 3b, to control for the possibility that firms share the benefits of sales increases with their employees. We see that this does not change the magnitude or significance of the results.

[9] An alternative normalization might be to capture imports as a fraction of firm purchases. Unfortunately, we do not have good data currently on firm purchases. Also, the importance of firm purchases in overall sales is likely to vary considerably by sector across the different sectors that we look at. The measured used here will capture the importance of imports to the overall sales activity of the firm, which is one very appropriate measure of the importance of imports.

capture whether or not importing requires higher skill. From our theoretical model, this coefficient should be positive in the case where there is a Matsuyama (2007) effect, that is where the act of engaging in international trade requires skill, or when imported inputs from all source countries are of a higher quality than domestic inputs.

The variable HI_{ijt} measures the fraction of a firm's imports in a given period that come from high-income countries. In the standard specification, high-income countries include all OECD and non-OECD high-income countries, as classified by the World Bank. This relatively strict definition is preferred, since this variable is designed to distinguish whether high-income country imports require more skill to utilize, and this is more likely to be true in the case of truly high-income (rather than middle-income) countries. Nevertheless, a broader definition of HI_{ijt} will also be used where this variable includes the fraction of imports from all high- and middle-income countries, as classified by the World Bank. This would essentially include both categories of income that are higher than that of Rwanda, which is a low-income country.

The additional variables are control variables designed to capture other variables of interest that might affect the dependent variable. For example, the vector $\boldsymbol{X}'_{ijt}$ will always include a firm size control, since it has been found that there is a firm-size effect on the wages (Brown and Medoff, 1989). The regressions will also include firm fixed-effects, γ_i, to capture differences *between* firms related to the average level of skill utilization at the firm level. Finally, industry-period fixed-effects, δ_{jt}, will capture effects related to the job market within a firm's industry sector in a given period. These will collapse into period (year) fixed-effects when the regressions are performed by sector. The remaining term is the random component of the error term, ϵ_{ijt}.

First, Table 2 explores the basic correlations between the variables of interest (IMP_{ijt} and HI_{ijt}) and s_{ijt}. From the positive coefficient on IMP_{ijt}, we see that

17

firms that import more use skills more intensively. Specifically, firms that import inputs at the average rate (.197) use 1.3% more skills, as captured in the average wage, compared to firms that do not import. From the positive coefficient on HI_{ijt}, we see that firms that obtain the average share of their imported inputs from high-income countries (.218) use 4.2% greater skill than firms that obtain all of their inputs from low- and middle- income countries. In short, the result that has been well-known in the literature on exports is confirmed for importers in this low-income context. *Importers pay higher wages, and importers from high-income countries in particular pay higher wages.* The results of this table are fully consistent with both propositions from our model: the Matsuyama effect, and the quality effect.

However, the results to this point make no causal claims. The correlation mentioned above could entirely be a selection effect. In particular, firms that are particularly successful on some unobservable dimension may be both more likely to use highly-skilled workers, and more likely to import, where the correlation between imports or import sources and skill reflects this underlying characteristic.

The first step to addressing this issue involves including firm fixed-effects in the estimation. This is done in column (1) of Table 3. This estimation now explores the correlation between the *changes* in imports and import sources at the firm level, and *changes* in skill utilization. Any fixed unobserved characteristics at the firm level are implicitly controlled for with this approach. Here, we see that the correlation between overall imports and skill utilization drops from 0.065 to 0.050. More significantly, the magnitude and significance of the correlation between HI_{ijt} and skill utilization vanishes.

One advantage of using the current dataset, and of examining imports, is the ability to explore the impact of international trade on multiple sectors, including those sectors that do not export, via imports. Table 5 explores the fixed-effect

results from Table 3 by sector for the five largest sectors in Rwanda. The major sector that is typically examined in international trade is manufacturing. This is the third column of the table. Here, we see that the results of Table 3 are replicated, as they are for the "wholesale and retail trade" sector of the final column. Firms that increase their import share of sales in either the manufacturing or the "wholesale and retail trade" sector also increase their skill utilization. There does not appear to be any correlation between import changes at the firm level and changes in skill utilization in any of the other sectors. Similarly, changes in the share of imports from high-income countries do not appear to be important in any of the sectors.

Still, while fixed-effects results handle any time-invariant unobservables at the firm level, these results can also increase the relative significance of measurement error. Therefore, an instrumental variable approach will be necessary to handle both remaining endogeneity and measurement error issues.

3.3 Instrumental Variable Results:

In order to be able to make a causal claim regarding the impact of import levels or import sources on skill utilization at the firm level, we need an instrument for the overall level of imports, as well as for the import sources. The instruments used for both these variables are exchange rate instruments, following Revenga (1992), Park et. al. (2008), and Brambilla et. al. (2012). For example, to deal with the endogeneity of overall firm imports over sales (IMP_{ijt}), we construct a measure of the average exchange rate faced by a given firm in international markets:

$$E_{it}^{IMP} = \sum_c erate_t^c \psi_{i\,pre}^c \tag{21}$$

where $\psi_{i\,pre}^c$ is the share of imports into firm i from country c during 2005-2007, the three years prior to our sample (2008 to 2010), and $erate_t^c$ is the exchange

rate of country c (currency units per Rwandan franc, normalized) at time t. It is important that the constructed shares, $\psi^c_{i\,pre}$, are predetermined to avoid any endogeneity with the changes during our sample period. With this definition, a higher exchange rate with country c would induce a firm to import more from country c. As a result we expect the instrument E^{IMP}_{it} to be positively correlated with IMP_{it} in the first-stage regressions. Fortunately from the perspective of our identification strategy, exchange rates of Rwanda's partner countries were changing fairly dramatically over this period, as seen in Figure 2.

Exchange rates are also used to construct the instrument for the share of imports from high-income sources (HI_{ijt}), according to the following definition:

$$E^{HI}_{it} = \sum_c erate^c_t \mu^c_{i\,hi-pre} \tag{22}$$

where $\mu^c_{i\,hi-pre}$ is the share of the imports from country c as a fraction of all of the imports into firm i from *high-income countries* during 2005-2007, and $erate^c_t$ is defined as above. Note the differences between these instruments corresponds to the differences between IMP_{ijt} and HI_{ijt}. E^{IMP}_{it} will capture the impact of exchange rate changes that matter for the overall level of imports by firm i, while E^{HI}_{it} will capture the impact of exchange rate changes that matter for imports from high-income countries into firm i, according to the predetermined shares of imports faced by firm i on its imports from high-income countries prior to the sample period.

Good instruments need to be correlated with the endogeneous variables, and satisfy the exclusion restrictions. Since the dependent variable here is identical here to Brambilla et. al. (2012), with the only difference being the measuring of the impact of imports rather than exports on this dependent variable, the arguments they use to justify this instrument apply exactly here. For an individual firm, the pre-sample (2005-2007) shares of imports from various

markets (either high-income or overall) are endogenous choices by the firm. However, these are predetermined, and the exchange rate changes are arguably exogenous at the firm level, and are likely to affect the overall level of imports. The exclusion restrictions are justified in Brambilla et. al. (2012); the measurable impact of the changes in the exchange rate for a firm's imports should occur through changes in those imports.

The first-stage results for the IV procedure are given in Table 4. The first stage regressions demonstrate that the first required condition of the instruments, the correlation with the endogenous variables certainly holds. The t-statistic of 89.07 on the E_{it}^{IMP} instrument in the IMP_{ijt} first-stage regression, and 166.14 on the E_{it}^{HI} instrument in the E_{it}^{HI} first-stage regression suggest that the correlations between the instrumented variables and their instruments are strong.

The IV-results are presented in column (2) and column (4) of Table 3. In column (2), we see that increasing imports has an impact on skill utilization at the firm. Specifically, an increase in the import share of sales from 0 to the average level (0.197) would result in an increase in skill utilization (average wage) of 1.5%.[10] The result is virtually identical in Column (4) when the HI variable includes imports from all high- and middle-income countries. However, we notice that there continues to be no evidence of any impact of the share of imports from high-income countries on the level of skill utilization. Naturally, this is consistent with the results in the fixed-effect regressions. One potential cause of this insignificance result which we can rule out is a weak instrument, given the first-stage results of Table 4.

We also examine this result by sector, in Table 6. We see that, following the fixed-effect results, the primary impact of importing occurs within the manufacturing and the "wholesale and retail trade sectors". These are also the

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[10] Equivalently, an increase in imports from 0 to 100% of sales would result in an increase of 7.4% to the average wage.

sectors where imports play the largest role, at 36.4% and 32.5% of sales, respectively. In manufacturing, an increase in the import share of sales from 0 to the average would result in an increase in skill utilization (average wage) of 4.5%. In wholesale and retail trade, an increase in the import share of sales from 0 to the average would result in an increase in the average wage of 2.1%.

In summary, it appears that in the context of Rwanda, we find evidence that skills are required for the importation and utilization of any imported inputs, and find no evidence that imports from high-income countries *require* more skill (although there is definitely a correlation between importing from high-income countries and skill utilization). In particular, it requires skill to import the inputs required in the manufacturing and "wholesale and retail trade" sectors. Before we become overly specific in these sectoral conclusions, it should be noted that manufacturing and "wholesale and retail trade" are sectors that are intensive in the use of imported inputs. Therefore, the simplest interpretation of this result at this point is that importing requires skill in those sectors that do a lot of importing.

3.4 Alternative Explanations

While the causal relationship between imports and wage changes has been established through the exogenous (at the firm level) shifts in exchange rates, we should consider other explanations than skill utilization for the changes in wages. Wages are a transfer from the firm to the worker. Worker skills relate to the characteristics of the worker that in a competitive labour market should result in differences in worker compensation. However, firm characteristics might also relate to the wages. The two most frequent firm-related differentials in wages are the firm-size wage effect (which may include rent sharing), and rent sharing that is independent of firm size. As mentioned all of the empirical estimation in this paper include controls for firm size, and the results still hold.

22

Rent sharing could be a factor in the results if firms that experience a productivity or demand shock i) increase their use of imported inputs, ii) increase their profitability, and iii) share part of these increased profits with their workers. This is a plausible scenario. While we don't have a satisfactory measure of profits at the firm level, we do have a measure of firm sales, and we control for firm sales in the regression in Table 7. The overall magnitude and significance of the results do not change.

4. Conclusions

We constructed a model of importing inputs that incorporated both a component of skill utilization for trade-related required services, and a component for complementarity between skill utilization and quality of inputs. This model was tested using data from Rwanda, including all firms with registered payroll in Rwanda. The endogeneity of import levels and sources with skill utilization was handled by constructing firm-specific exchange rate instruments, based on the firm's level of overall imports, and its level of imports from high-income countries prior to the sample period, and then using the changes in the exchange rates for these country sources as instruments for a firm's overall level of imports.

First, we find that importers, as well as importers from high-income countries, pay higher wages (use more skill). In the IV regressions, we find a causal relationship between overall level of importing and skill utilization, but we do not find any evidence of a causal link between fraction of imports from high-income countries and skill utilization. In short, in the particular low-income context of Rwanda, importing of any kind requires additional skill. This may either be because all imported goods are of higher quality than domestic goods, or because of a Matsuyama "trade-related required services" effect. Which of these two effects is operable is naturally of academic interest, but not for first-order policy questions. Specifically, the results of this paper suggest that for Rwanda (and

23

any low-income countries that are similar enough to it), reductions of import tariffs with any source country will result in increased skill utilization at the firm level.

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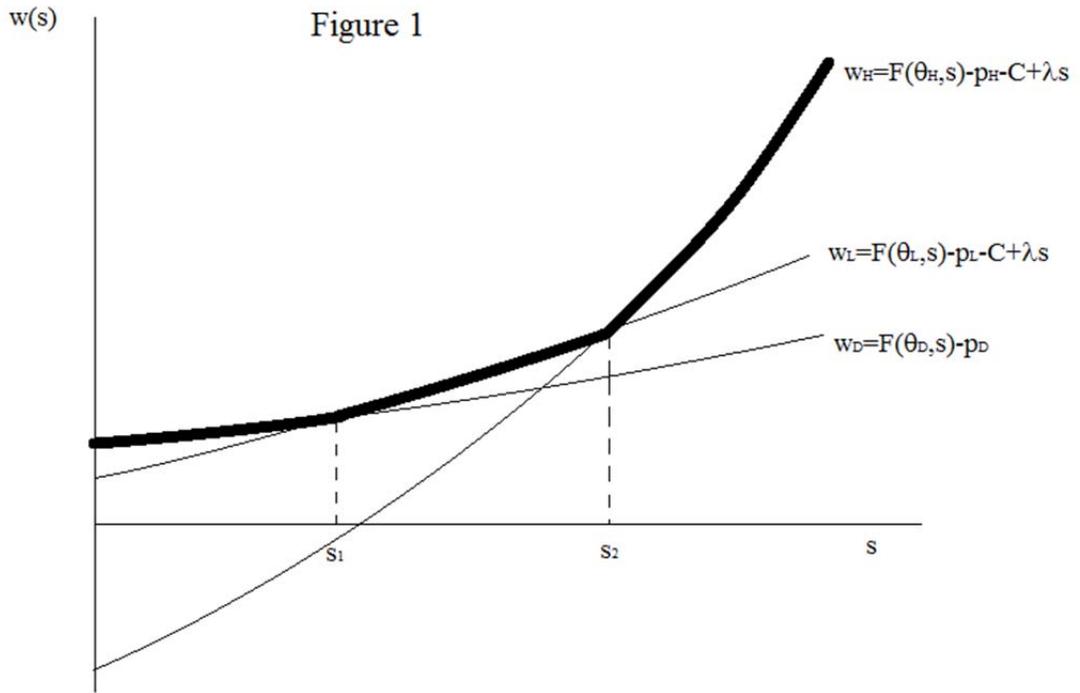
w(s)

Figure 1

$w_H = F(\theta_H, s) - p_H - C + \lambda s$

$w_L = F(\theta_L, s) - p_L - C + \lambda s$

$w_D = F(\theta_D, s) - p_D$

s_1

s_2

s

Fig. 2 - Exchange Rate Changes
Top 10 Import Origin Countries
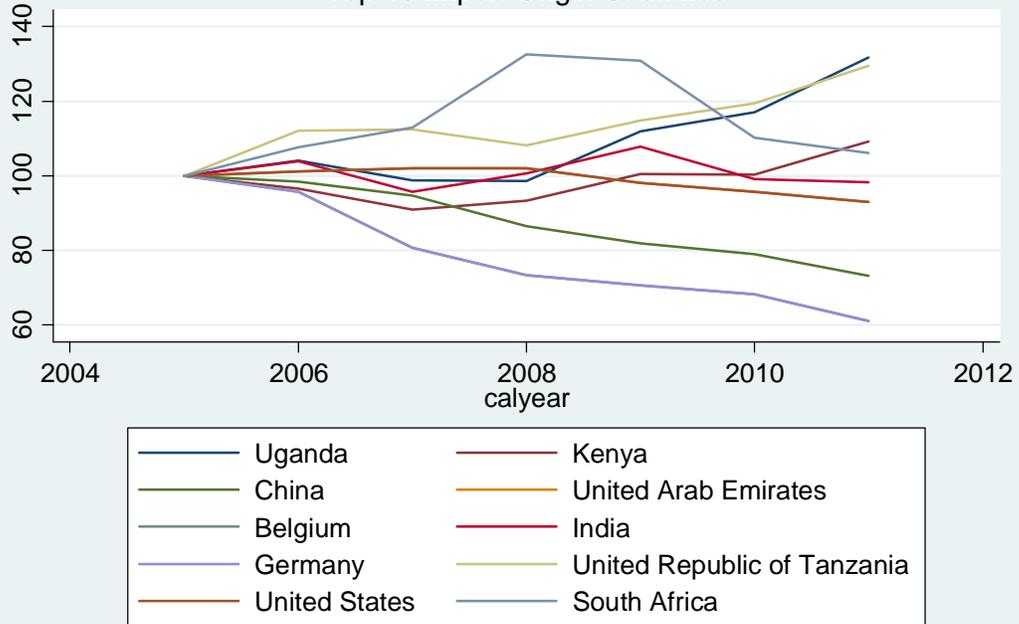
Table 2 - Imports, Import Sources and Skill Utilization in the Cross Section
Dep Var: Log(Average Wage)

	(1)	(2)	(3)
Imports/Sales (IMP)	0.107		0.065
	(0.028)***		(0.029)**
High-income imports (HI)		0.209	0.192
		(0.033)***	(0.034)***
R^2	0.14	0.15	0.15
N	6,224	6,224	6,224

* $p<0.1$; ** $p<0.05$; *** $p<0.01$
All regressions include industry-year fixed effects and controls for firm size.
Standard errors, clustered at the firm level, are in parentheses.
Significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively

Table 3 - Imports, Import Sources and Skill Utilization
Dep Var: Log(Average Wage)

	(1)	(2) IV	(3)	(4) IV
Imports/Sales (IMP)	0.050	0.074	0.050	0.074
	(0.017)***	(0.019)***	(0.017)***	(0.019)***
High-income imports (HI)	0.009	-0.005		
	(0.016)	(0.023)		
Higher-income imports (HI)			0.009	0.001
			(0.015)	(0.022)
R^2	0.04		0.04	
N	6,224	6,224	6,224	6,224

* $p<0.1$; ** $p<0.05$; *** $p<0.01$
All regressions include firm fixed-effects, industry-year fixed effects and controls for firm size.
Standard errors are bootstrapped with a block bootstrap, with the sampling unit being the firm.
Significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively
Columns (1) and (2) use the narrow definition of high-income countries.
Columns (3) and (4) use the broad definition of high- and middle-income countries.
Columns (2) and (4) use the IV procedure described in the text.

Table 4 - Imports, Import Sources and Skills - First Stage of IV Results

	High inc IV IMP variable	High Inc IV HI variable	High and Mid Inc IV IMP variable	High and Mid Inc IV HI variable
β_{ft}^{IMP}	104.439	0.968	104.439	0.968
	(89.07)***	(0.81)	(89.07)***	(0.81)
β_{ft}^{HI}	0.006	1.012	0.006	1.012
	(1.18)	(166.14)***	(1.18)	(166.14)***
R^2	0.70	0.45	0.70	0.45
N	6,235	6,235	6,235	6,235

* p<0.1; ** p<0.05; *** p<0.01
Standard errors are bootstrapped with a block bootstrap, with the sampling unit being the firm.
T-statistics are reported below the coefficients.
Significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively
Columns (1) and (2) use the narrow definition of high-income countries.
Columns (3) and (4) use the broad definition of high- and middle-income countries.

Table 5 - Imports, Import Sources and Skill Utilization By Industry
Dep Var: Log(Average Wage)

	Accomm & Food Serv	Constrn	Manuf	Other Services	Wholesale & Retail Trade
Imports/Sales (IMP)	0.015	0.012	0.114	0.059	0.052
	(0.066)	(0.042)	(0.053)**	(0.076)	(0.020)***
High-income imports (HI)	0.042	0.009	0.011	-0.010	-0.014
	(0.057)	(0.037)	(0.044)	(0.063)	(0.031)
R^2	0.03	0.05	0.10	0.13	0.04
N	447	698	385	604	2,009

* $p<0.1$; ** $p<0.05$; *** $p<0.01$
All regressions include firm fixed effects, year fixed effects and controls for firm size.
Standard errors, clustered at the firm level, are in parentheses.
Significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively

Table 6 - Imports, Import Sources and Skill Utilization By Industry - IV Results
Dep Var: Log(Average Wage)

	Accomm & Food Serv	Constrn	Manuf	Other Services	Wholesale & Retail Trade
Imports/Sales (IMP)	0.005	0.057	0.124	-0.061	0.067
	(0.126)	(0.083)	(0.033)***	(0.129)	(0.024)***
High-income imports (HI)	-0.018	0.025	0.024	-0.230	-0.031
	(0.079)	(0.069)	(0.060)	(0.152)	(0.036)
N	447	698	385	604	2,009

* $p<0.1$; ** $p<0.05$; *** $p<0.01$
All regressions include firm fixed effects, year fixed effects and controls for firm size.
Standard errors are bootstrapped with a block bootstrap, with the sampling unit being the firm.
IV Procedure is escribed in the text.
Significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively

5

Table 7 - Imports, Import Sources and Skills - Including Sales Control
Dep Var: Log(Average Wage)

	(1)	(2) IV	(3)	(4) IV
Imports/Sales (IMP)	0.054	0.079	0.053	0.078
	(0.017)***	(0.019)***	(0.017)***	(0.019)***
High-income imports (HI)	0.009	-0.004		
	(0.016)	(0.023)		
Higher-income imports (HI)			0.009	0.001
			(0.015)	(0.022)
R^2	0.04		0.04	
N	6,195	6,195	6,195	6,195

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

All regressions include firm fixed effects, industry-year fixed effects and controls for firm size and sales.

Standard errors are bootstrapped with a block bootstrap, with the sampling unit being the firm.

Significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively

Columns (1) and (2) use the narrow definition of high-income countries.

Columns (3) and (4) use the broad definition of high- and middle-income countries.

Appendix Table 1 - First Stage of Table 6 IV Results for IMP variable
By Industry

	Accomm & Food Serv	Constrn	Manuf	Other Services	Wholesale & Retail Trade
β_{it}^{IMP}	105.832	114.804	99.834	94.698	106.015
	(52.58)***	(27.34)***	(23.18)***	(21.12)***	(102.08)***
β_{it}^{HI}	-0.001	-0.003	0.001	-0.015	0.006
	(0.13)	(0.32)	(0.03)	(0.76)	(0.67)
R^2	0.57	0.46	0.89	0.36	0.78
N	449	699	386	606	2,013

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

All regressions include firm fixed effects, year fixed effects and controls for firm size.

Standard errors are bootstrapped with a block bootstrap, with the sampling unit being the firm. T-statistics are reported below the coefficients.

Significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively

Appendix Table 2 - First Stage of Table 6 IV Results for HI variable
By Industry

	Accomm & Food Serv	Constrn	Manuf	Other Services	Wholesale & Retail Trade
B_{it}^{IMP}	6.525	3.319	-2.336	-3.500	0.625
	(1.52)	(0.98)	(0.80)	(1.50)	(0.73)
B_{it}^{HI}	1.020	1.025	1.058	1.052	1.007
	(60.98)***	(73.02)***	(35.58)***	(25.75)***	(131.88)***
R^2	0.40	0.43	0.62	0.16	0.60
N	449	699	386	606	2,013

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

All regressions include firm fixed effects, year fixed effects and controls for firm size.

Standard errors are bootstrapped with a block bootstrap, with the sampling unit being the firm. T-statistics are reported below the coefficients.

Significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively