A Contemporary Study on Trade and Wage Inequality: The Case of Costa Rica

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Abstract: This paper sets out to examine the relationship between trade liberalisation and rising wage inequality in Costa Rica. More specifically, I explore whether increased exposure of the Costa Rican manufacturing sector to trade with the United States (US), the European Union (EU) and China, as a result of recently signed free trade agreements (FTAs), influenced the wage structure. Using household survey data spanning 2010 to 2018, matched with data on trade liberalisation of 2-digit industries, the results show heterodox impacts on wage inequality. Export penetration with the US and EU increased the relative wage of unskilled and semi-skilled workers. Import penetration from the US moderately increased the relative wage of skilled workers whereas import penetration from the EU significantly decreased the relative wage of skilled workers. The biggest contributor to wage inequality is Chinese import penetration, which significantly increased the relative wage of skilled workers.

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1 Introduction

Widening inequality is one of the most important challenges of our time. It is an issue that has garnered considerable attention over decades, yet the challenge of understanding changes in inequality is no smaller. The drivers of inequality can vary widely across countries. Among the most common drivers is a rising skill premium – an increase in the wage gap between skilled and unskilled workers – as a result of globalisation (Dabla-Norris, et al. 2015). Globalisation has progressed at a rapid pace in recent decades, driven by the integration of the world's economies through unilateral and coordinated reductions in barriers to trade - or trade liberalisation. As economies underwent trade liberalisation, many documented a rising wage gap between skilled and unskilled workers.

For economies in the developed world, rising inequality was ascribed to a relative decline in unskilled workers' wages due to trade with the developing world consistent with the predictions of the Hecksher-Ohlin model of international trade (Berman at al., 1994; Leamer, 1995). As the mirror image of developed economies in the Heckscher-Ohlin model, developing economies were expected to document falling wage inequality as a result of their own trade liberalisation efforts. However, events transpired quite differently. Some developing economies, such as those in East Asia, indeed documented falling inequality whilst others wandered onto a path towards surging wage inequality (Wood, 1997). As it happened, the developing economies to experience rising wage inequality were chiefly from Latin America. The experience of Latin American economies triggered a vigorous debate among economists who sought to understand why the region diverged from the predictions of the Heckscher-Ohlin model.

While the literature on trade and wage inequality in Latin America is not new, the bulk of it focuses on the 1980's and 1990's when economies in the region liberalised their trade regimes for the first time. Being the initial episode, this was a period when countries pursued liberalisation unilaterally, such as through unilateral tariff reductions. This meant that when considering exposure to trade, the world economy was treated as a single trading partner. This is reflected in the literature where trade liberalisation is usually measured at an aggregate level without differentiating trading partners (Robbins and Gindling, 1999; Galiani and Sanguinetti, 2003). I argue this provides little bearing on today's globalised context where trade liberalisation is pursued in a bilateral and multilateral fashion with trading partners of distinct developed and developing-country profiles such that each can play a very different role in the wage structure. From a policy perspective, not differentiating trading partners is arguably of little help to policymakers trying to discern the sources of trade-induced inequality.

Therefore, this paper is written to contribute to the literature by discriminating the contribution of different trading partners to wage inequality. The setting for this is a recent incidence of growing inequality in Costa Rica - a small, open economy in Central and Latin America. Belonging to a region that was plagued by inequality for decades, Costa Rica is the only Latin American country to record rising inequality during the first decade of the 21st Century, with its inequality having risen rapidly after 2010 (Pandiella and Gabriel, 2017; Messina and Silva, 2019). Intriguingly, this has coincided with a period of significant liberalisation of its domestic markets as the country entered into free trade agreements (FTAs) with the United States (US), the European Union (EU) and China, which together represent as much as 63% of its total trade volume (WITS, 2018). There is an apparent lack of research on the potential relationship between trade and inequality dedicated to Costa Rica. As a small, open economy the welfare of Costa Rican's is closely linked to its exposure to trade. Despite this, a paper by Robbins and Gindling (1999) is, to the best of my knowledge, the most recent notable work.

This paper aims to empirically investigate whether, and the extent to which, recent trade liberalisation has contributed to growing wage inequality in Costa Rica whilst discriminating between the impact of the US, EU and China. To this end, I exploit individual-level data obtained from the 2010 to 2018 waves of the National Household Survey (ENAHO) which includes information such as wages, educational attainment, industry affiliation and more. The individual-level dataset is then merged with a separate dataset containing data on trade liberalisation characteristics of each 2-digit manufacturing industry with the US, EU and China. Only the manufacturing sector is considered as this is the sector for which the trade liberalisation characteristics present any variability. Using the method of Ordinary Least Squares (OLS), this paper finds heterodox impacts of each trading partner. More precisely, export penetration with both the US and EU increases the relative wage of unskilled workers. With regards to import competition, import penetration from the US is associated with a moderate increase in the relative wage of skilled workers whereas import penetration from the EU is associated with significant decrease in the relative wage of skilled workers. I also find that import penetration from China is associated with a significant increase in the relative wage of skilled workers.

The remainder of this paper is organised as follows: Section Two provides background information on trade liberalisation and wage inequality in Costa Rica, Section Three forms the literature review which first introduces the conceptual framework for understanding the relationship between trade and wage inequality and reviews the prominent empirical literature. Section Four describes the data used in the analysis and Section Five outlines the empirical strategy. Section Six presents and discusses the empirical results and Section Seven provides some concluding remarks.

2 Costa Rica: Trade Liberalisation and Wage Inequality

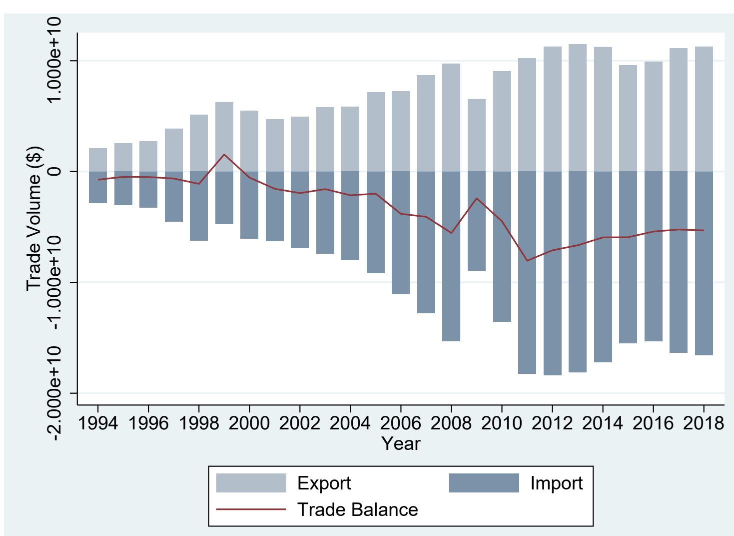
Costa Rica's trade liberalisation journey has been a long and necessary one. As with other countries in Central America, Costa Rica found itself in a desperate economic situation at the end of the 1970's. The economy was faced with increasing real interest rates, staggering inflation levels, increasing unemployment and swelling external debt (Cattaneo, et al. 1999). In the two-year period between 1980 and 1982, the number of Costa Rican's living below the poverty line soared by more than 20 percentage points to 54 per cent (Hidalgo, 2014). The crisis was attributed in large part to the import-substitution model - a protectionist model that replaces imports with domestic production - that had been the industrialisation model for decades prior. This created inefficiencies that overwhelmed public finances. Moreover, the economy had suffered a severe deterioration in the terms of trade as the oil it imported soared in price while the price of its limited range of agricultural export products (such as coffee, bananas, sugar cane and meat) fell through the floor. To steer the economy in a new direction, the government swiftly embarked on a comprehensive structural adjustment program.

A pillar of this program was a reform of the trade policy infrastructure and trade liberalisation. The first phase of which was characterised by efforts to transform a market previously operating an import-substitution model into one conducive to an outward-oriented development strategy. This included reducing and simplifying tariffs and eliminating quantitative import limitations in favour of a tariff structure (Robbins and Gindling, 1992). The tariff reductions were gradual, although between 1982 and 1989 the average tariff fell from 46.3 per cent to 16.8 per cent (Monge-Ariño, 2011). This was accompanied by mini devaluations of the exchange rate, aimed at providing certainty to exporters and enhancing the competitiveness of the export sector. Structural reforms, frequent tariff reductions and currency devaluations were successful in boosting exports, especially of non-traditional goods, a principle objective of the trade liberalisation program (Robbins and Gindling, 1992).

In 1990, Costa Rica's integration into global trade networks continued as it joined the General Agreement in Trade and Tariffs (GATT). Alongside this, another component of its trade liberalisation which cannot be understated was the establishing of free trade zones (FTZs) that gave tax-free incentives to firms whose sole activity was to export (Hidalgo, 2014). These incentives, along with the direction Costa Rica was headed, were rewarded in 1997 when Intel opened a manufacturing facility within its borders. This decision by a single firm would prove to be transformative to the productive structure of the economy, as Intel's semiconductor devices and computer electronics soon became the country's major export. In the early 2000's, other technology-intensive electronics and pharmaceutical firms followed suit and began manufacturing activity in Costa Rica's FTZs. With a transformed industrial base, and a competitive export sector, policymakers then sought to reduce barriers faced by its exports in destination markets through a pursuit of free trade agreements – the 'second phase' of trade liberalisation.

The second phase of trade liberalisation gained pace near the start of 2010 when Costa Rica completed free trade agreements with its three largest trading partners - the United States (US), the European Union (EU) and China – which together represent approximately 63% of the total trade volume of Costa Rica (WITS, 2020). Some key details of these agreements can be seen in Table 1. Free trade agreements were also signed with Singapore, Mexico, Peru and Colombia during this same period, although their share of Costa Rica's trade volume is relatively small. Whilst trade liberalisation has spanned decades, the signing of these free trade agreements was a significant step in not only enhancing market access for its export sectors but opening its domestic markets to international competition as well. The impact of recent trade liberalisation on export and import volumes can be seen in Figure 1. Attention is drawn to the period of interest to this paper between 2010 and 2018 where export and import volumes are at their highest historical level.[1] A surge in imports is especially visible.

Figure 1: Trade liberalisation



Source: Own calculations using UN Comtrade data

Three decades on from its economic crisis, through trade liberalisation and its openness to foreign direct investment, Costa Rica has achieved upper-middle income status with steady economic growth, accompanied by improvements in human development indicators such as poverty, healthcare, access to education and well-being (OECD, 2017). Despite these achievements however, especially in reducing poverty, Costa Rica remains a highly unequal society; a Gini index of 0.48 is the 5th highest in Latin America (3rd highest in Central America) and 19th highest in the world, and having recently joined the OECD, its income inequality remains approximately 50% above the OECD average (OECD, 2016).

[1] A more disaggregated look into trade liberalisation with the US, EU and China is postponed until this paper's measures of trade liberalisation are motivated in Section 4.2.

Moreover, Costa Rica was the only Central American nation to record rising inequality in the first decade of the 21st century (Messina and Silva, 2019). A recent decomposition of the Gini coefficient has shown that wage inequality is the major source, contributing 83% to the Gini coefficient. Moreover, wage inequality climbed rapidly after 2010 to reach its highest historical level (Pandiella and Gabriel, 2017).

This rise in wage inequality at a time when domestic markets have experienced significant exposure to international competition is a springboard for exploring the relationship between trade liberalisation and wage inequality. In the next section, I introduce the conceptual framework for understanding how trade and wage inequality interact.

Table 1: Recently signed FTAs

Year	Partner	Agreement Highlights
2009	USA	- Immediate bilateral tariff elimination on over 80% of goods with remaining tariffs to be phased out within 10 years. - 2018 share of total manufacturing trade: 36%.
2011	China	- Immediate bilateral tariff elimination on 60% of goods with remaining to be phased out within 15 years. - 2018 share of total manufacturing trade: 13%.
2013	EU	- Immediate EU tariff elimination on 91% of goods and immediate Costa Rica tariff elimination on 48% of goods with 100% liberalisation aimed within 10 years. - 2018 share of total manufacturing trade: 14%.
Other new FTA partners		
2013	Singapore	
2013	Mexico	
2013	Peru	
2013	Columbia	
		Source of information: US: https://ustr.gov/ China: http://www.sice.oas.org/ EU: https://ec.europa.eu/info/index_en

3 Literature Review

This section describes a conceptual framework for understanding the relationship between trade and wage inequality, and reviews the empirical literature in the field. It concludes by establishing a hypothesis.

3.1 Conceptual Framework

The Hecksher-Ohlin (HO) model of international trade provides the framework for understanding the relationship between trade and wages.

The HO model shows that countries will export goods produced intensively using factors that are relatively abundant at home and import goods produced intensively using factors that are relatively scarce at home. In its simplest form, the HO model describes a 2x2x2 setting with two countries (developed and developing), two types of labour[2] (skilled and unskilled) and two goods (computers and textiles), and where the two countries are identical other than a difference in their relative factor endowments. A relative abundance of unskilled labour in the developing country gives it a comparative advantage in textiles whereas the developed country has a comparative advantage in computers. In the presence of trade barriers (e.g. tariffs), the price of the goods in both countries is distorted such that the price of textiles in the developing country is artificially low and similarly for computers in the developed country. When trade is liberalised, textile firms from the developing country will export to take advantage of

[2] In their original paper, the factors of production are labour and capital but this is commonly adapted in a trade-wage context.

the higher price in the developed country whose consumers can consume these textiles at a lower price than domestic textiles. This causes an expansion of the textile (export) sector in the developing country. Meanwhile, the computer (import-competing) sector contracts as computers are imported at a cheaper price from the developed country. The rise in the export demand for textiles in the developing country pushes up textiles prices whilst a fall in the demand for computers pushes down their price (the opposite mechanism plays out in the developed country), leading to a narrowing of their relative prices.

The Stolper-Samuelson (SS) theorem provides the link between these price changes and wages and stipulates that the direction of price changes in the developing country raises the wage of unskilled workers relative to that of skilled workers, resulting in a narrowing of the wage gap. The SS theorem builds on a key assumption in the HO model (henceforth HO-S) that technology is fixed and identical in both countries, such that there exists a one-to-one relationship between goods output and factor input, which implies a similar relationship between goods prices and factor prices (Wood, 1997). Importantly, unskilled wages in the developing country will gain due to trade and skilled wages will fall, irrespective of the industry it is located in. Due to rising textile prices firms in the export sector will seek expansion meanwhile firms in the import-competing sector will downsize. As a result, unskilled labour and skilled labour are both released from the import-competing sector and are demanded by the export sector. However, because the export sector uses unskilled-labour more intensively than the import-competing sector, this creates an excess demand of unskilled labour and an excess supply of skilled labour (Schmitz, 2012). As a result, unskilled workers in both sectors see their wages rise and skilled workers in both sectors see their wages fall.[3]

3.2 Empirical Evidence

The HO-S model implications have been the subject of empirical focus for some time. Early research found support for the model's predictions in explaining the rising wage inequality in developed countries during the late 20th Century where it had been established that rising inequality was in part caused by increasing relative demand of skilled labour due to a proliferation of trade with developing countries (Leamer, 1995). What was puzzling to researchers was the finding that many developing countries also experienced rising wage inequality alongside their trade regime liberalisation efforts, especially in Latin America. The Latin American experience attracted much criticism of the validity of the HO-S theorem, with Davis and Mishra (2007) going as far as saying "it is time to declare Stolper-Samuelson dead."

Argentina is one example where rising wage inequality was chronological to slashing trade reform. To determine causality, Galiani and Sanguinetti (2003) investigate whether 2-digit SIC manufacturing industries with higher import penetration were also the industries which saw the most increases in wage inequality. Their results show that an increase in import penetration of 10% is associated with an 1.4% increase in the wages of skilled workers in that industry, significant at the 1% level, whereas semi-skilled and unskilled wages increase by 0.6%, albeit with statistically insignificant coefficients, thereby contributing to a widening of the wage gap. Unfortunately, the authors do not hypothesise on why their results contradict HO-S predictions.

In Brazil, the largest economy in Latin America, the returns to college education increased disproportionately after a period of dramatic tariff cuts.[4] To investigate whether trade could explain it, Arbache, Dickerson & Green (2004) find that greater openness was associated with negative and statistically significant wages of the lowest two education groups whereas the wages of the highest two education groups

[3]The opposite happens in the developed country.

[4]Average nominal tariffs were cut from 55% in 1987 down to 14% by 1992.

were negative albeit statistically insignificant, thus resulting in a widening of the wage gap. Although the authors note that their findings show trade liberalisation can in very small part explain the rising returns to college education. Nevertheless, in Brazil too, the HO-S predictions failed to materialise. The authors state that their results are more consistent with the theory that imported technology during liberalisation favoured skilled labour.

Circling back to David and Mishra (2007)'s criticism, one could argue the Stolper-Samuelson theorem only provides a link between product prices and factor prices, and that wage inequality can only fall if relative prices in unskilled-intensive sectors increase. Several papers which investigate the impact of prices and relative wages find support for the theoretical predictions. In one example, Beyer et al. (1999) find increases in the relative price of textiles (an unskilled-intensive good) reduced the wage differential between college and elementary-educated workers in Chile.

In another example, Attanasio, Goldberg & Pavcnik (2003) find that the rise in wage inequality in Colombia was consistent with Stolper-Samuelson because, unlike in Brazil, the largest tariff cuts in Colombia were in those industries which employed the highest share of unskilled labour and had the lowest wages pre-reform.[5] The unskilled-intensive industries therefore experienced the largest relative declines in their output price. The authors also find that the share of skilled labour increased in every industry, in contrast to HO-S predictions, which is attributed to skill-biased technological change. Insofar as trade liberalisation caused this, they suggest it could be a defensive response from firms facing the highest tariff cuts and toughest foreign competition to invest in production technology that better economises on unskilled labour. This concept is known as 'defense innovation' and was first coined by Wood (1995).

In Mexico too, pre-reform tariffs were found to be higher in unskilled intensive sectors. Mexico slashed its tariffs most dramatically between 1985 and 1988[6] - a period during which inequality rose sharply. Using data on 2,354 manufacturing plants, Hanson and Harrison (1999) estimate that the ratio of white-collar to blue-collar earnings rose from 1.93 to 2.55. In search of Stolper-Samuelson effects in explaining this rise, their empirical results find weak evidence for a relationship between relative output price changes caused by the disproportionate tariff cuts and relative wages, albeit the authors stress that their chosen metric for price changes could be noisy and inaccurately reflect actual price changes. Instead the authors hypothesise the rising inequality is due to increased competition with the likes of China, with much higher shares of unskilled labour than Mexico, having suppressed prices in Mexico's unskilled intensive sectors.

Robertson (2004) extends upon these findings and further recognises that Mexico's trade reform occurred in two distinct periods - first, with mainly low-skill abundant developing economies upon joining GATT in 1985 and second, with high-skill abundant developed economies Canada and the United States upon joining The North American Free Trade Agreement (NAFTA) in 1994. The author finds that that the pattern of rising inequality upon joining the GATT found by Hanson and Harrison (1999) reversed itself after Mexico joined NAFTA. Using more detailed price data and by adopting two common methodologies from the price-wage literature, the author finds strong support of Stolper-Samuelson effects. More precisely, the find a strong connection between increases in the relative price of skill intensive goods and relative wage of skilled labour upon joining GATT and a similarly strong connection between the decline in the relative wage of skilled labour after a decrease in the relative price of skill intensive goods upon joining NAFTA. Furthermore, in what is the first evidence of the timing of Stolper-Samuelson

[5]If instead the largest tariff reductions were in sectors with the highest wage inequality, this would have reduced wage inequality.

[6]During this period, maximum tariffs fell from 100% down to 20% whilst the share of products subject to import license requirements fell from 92.2% down to 25.4% (Revenga, 1997; Hanson and Harrison, 1999).

effects - the author finds that it takes approximately three to five years for price changes to affect wages and that this affect grows stronger over time.

Gonzaga, Filho & Terra (2006) argue that strength of the pass-through from tariffs to prices is as important as the pattern of relative tariff cuts. Even homogeneous tariff cuts may change relative prices if the pass-through is different across sectors, which the authors show depends on import penetration. Because comparative advantage sectors are those with the lowest import penetration, which in developing countries are unskilled intensive, tariff reductions pass through to prices less in those sectors. Their empirical results show that tariff cuts indeed had a greater impact on skill-intensive sectors, and that changes in prices, adjusted for the pass-through coefficient, caused a decline in the skill-earnings differential of 23.5% - contributing to a reduction in the skill-based wage gap in Brazil. It should be noted that Brazil is unique in that tariff cuts were fairly uniform across all sectors. Therefore, a combination of both uniform tariff cuts and stronger pass through coefficients in skill-intensive sectors meant prices in skill-intensive sectors fell relatively more.

The final evidence comes from Costa Rica, in which Robbins and Gindling (1999) find that rising relative demand of skilled labour was the main cause of increasing wage inequality. In preliminary evidence, the authors eliminate supply-side causes by showing that relative supply of skilled-labour increased continuously throughout 1978 to 1993 however relative wages stopped falling and started to increase concurrent with trade liberalisation in 1984. Their empirical results show that imports of manufactured goods reduced the relative demand of skilled labour whereas exports of manufactured goods were associated with an increase in relative demand of skilled labour. However, Costa Rica's rising gross domestic product (GDP) and imported capital stock had the strongest impact on increasing the relative demand of skilled labour, which show that economic growth and rising stock of capital machinery during this period were skill-biased.

3.3 Heterogeneous Firm Theory

A more recent strand of literature explores trade-induced wage inequality at the firm level. Although firms do exist in the traditional trade theory, they have no role in influencing trade patterns, which occurs in sectors and is dictated by the relative factor endowments of trading partners. However, the availability of disaggregated data in recent years has led researchers to investigate trade at the firm level and uncover the important role firms play (after all, it is firms that trade with one another and not countries). These empirical observations, most notably the work of Bernard and Jensen (1995), brought to light the phenomenon that export and non-export firms co-exist in the same sectors and that a small number of export firms account for a substantial portion of a country's exports. Moreover, export firms were found to be fundamentally different to non-export firms. Therefore, the role of firms in determining trade patterns and the corresponding impacts on wage inequality cannot be understated.

In his seminal paper, Melitz (2003) provides a theoretical framework.[7] By incorporating firm heterogeneity and a fixed cost of exporting, Melitz (2003) showed that there exists a threshold cut-off productivity level that determines activity. The cut-off productivity required to engage in exporting is extremely high, and so only the most productive firms find it profitable to export whereas lesser productive firms serve only the domestic market. Trade liberalisation lowers the cut-off productivity for exporting and raises the threshold productivity required to serve the domestic market, causing an expansion of higher productive firms and a simultaneous exit of lesser productive domestic-serving firms. The

[7]Melitz extended the Krugman (1980) which itself explained the phenomenon of intra-industry trade. Under assumptions of increasing returns to scale, product differentiation, Krugman showed that even completely identical countries will trade because a wider variety of goods available to consumers with love-of-variety preferences.

result is a re-allocation of resources from lesser to more productive firms, thus raising aggregate industry productivity. Whilst the model provides no direct implication for wages, numerous research has shown that exporting firms are more capital and skilled labour intensive and pay higher wages than non-export firms (Mayer and Ottaviano, 2008; Frias et al., 2009) This means that trade liberalisation can increase wage inequality if skilled labour is disproportionately represented in export firms.

3.3.1 Empirical Evidence

Amiti and Davis (2011) investigate wage responses at Indonesian manufacturing plants to cuts in input and output tariffs between 1991 and 2000. Their paper recognises the importance of intermediary trade and utilises a rich firm-level dataset that allows identification of export, import and domestic-serving firms. Their results show that workers at domestic firms always suffer from trade liberalisation relative to globalised firms. More precisely, workers at domestic firms see their wages fall by 3% in response to a 10 percentage point cut in output tariffs. Whilst conversely, workers at export firms see their wages rise by 3% in response to the same cut in output tariffs. A 10 percentage point reduction in input tariffs has no meaningful impact on wages at domestic firms however wages at importing firms rise by 12%.

In Mexico, Verhoogen (2008) shows that the currency devaluation during the 1994 Peso crisis induced a differential response from export and non-export plants. The currency devaluation increased the incentive to export which initially-higher productive plants responded to by quality-upgrading their output.[8] These initially-higher productive firms were more likely to increase wages of white and blue-collar wages and, because these firms already pay higher wages than lesser productive firms, the currency depreciation caused a rise in within-industry wage inequality. Frias, Kaplan and Verhoogen (2012) compliment these findings and exploit the Peso crisis which they use as a source of exogenous shock on exports and examine within-plant wage responses at export firms. Their results show that exporting increases within-plant wage inequality by raising the wages of those at the 75th percentile and above whilst having no impact on wages at the 10th percentile.

Bustos (2007) proposes a model where trade liberalisation reduces the costs of adopting technology in all sectors which produces a heterogeneous response from firms of different productivity levels. The author uses the Argentinian trade liberalisation in the 1990's and finds that the subsequent rise in wage inequality in the country was caused by within-firm skill upgrading. This was due to new entrants in the export market who increased spending on technology by 43% post-liberalisation and, although these same firms had the same skill-intensity as non-exporters pre-liberalisation, actually upgraded skill-intensity 1.75 times faster five years after liberalisation.

Using data on Argentinian manufacturing plants between 1998 and 2000, Brambilla, Lederman and Porto (2012) find exporting per se did not determine differential skill-intensity between export and non-export plants, instead the profile of the export destination was the determining factor. They find that, conditional on the same export intensity, firms that exported a larger share of exports to high-income countries had a higher skill-intensity and paid higher wages. This is because quality requirements are greater in high-income countries, and so these firms engage the most in quality upgrading, which is associated with higher skill-intensity.

3.4 Hypothesis

Having introduced the conceptual framework and discussed the empirical literature, I now establish a hypothesis for the ensuing analysis in this paper. The objective of this research is to determine whether

[8] Verhoogen was the first to propose the quality-upgrading mechanism

trade liberalisation with the US, EU and China contributed to rising wage inequality in Costa Rica. The HO-S model provides the guiding tool for building a hypothesis. Under HO-S model assumptions, Costa Rica is relatively abundant in unskilled labour relative to the US and the EU and relatively abundant in skilled labour relative to China. From this, the following hypotheses is formed:

Table 2: Establishing hypotheses

Trade liberalisation with:	**Impact on Wage Inequality**
United States	Decrease
European Union	Decrease
China	Increase

4 Data & Methodology

To explore the hypotheses of this paper, I utilise two main types of data: individual-level data and trade data. This section lists the data sources, discusses the construction of important variables and concludes with some descriptive statics on the main variables used in the analysis.

4.1 Individual-level data

The data on individual characteristics used in this study is obtained from household surveys known as the National Household Survey (ENAHO) carried out by the National Institute of Statistics and Census of Costa Rica (INEC). The ENAHO surveys began in 2010 and are the latest iteration of the long-running nationally representative household surveys INEC has overseen since 1987. The surveys are carried out in July of each year (each wave) and interview approximately 13,400 households. This paper utilises each wave between 2010 to 2018.[9]

An advantage of utilising waves during this period is that no changes were made to the methodological approach of INEC's data collection. For example, the calculation of sample weights and the classification and measurement of educational attainment, industry affiliation, occupation group, hours worked and salary variables were unchanged.[10] Nevertheless, one minor problem was encountered in that the variable names were inconsistent across waves. For example, the name given to the variable indicating marital status could be 'A26', 'A5' and 'A6' depending on the wave. As a result, all such instances needed to be identified and made uniform which was achieved using data dictionaries accompanying each wave. The data dictionaries were also necessary for understanding the values of categorical variables since all disclosure is in Spanish.

This paper retains the following variables from the survey: age, gender, marital status, years of completed education, level of completed education, employment status, weekly hours worked, monthly income, industry affiliation (ISIC Revision 4 classification), occupation, rural/urban region and administrative region.[11] Using the relevant data, I further construct:

i) **Hourly wage**: Calculated as (monthly income $\div$ (weekly hours worked $\times$ 4.33)). To obtain the real wage, this is deflated using the consumer price index (CPI) provided by the Central Bank of Costa Rica (BCCR).[12]

ii) **Work experience**: Calculated as (age - years of completed schooling - 6).[13]

[9]The surveys can be accessed at: http://sistemas.inec.cr/pad5/index.php/catalog/REGENAHO

[10]It is perhaps worth mentioning that to access the data at a detailed level, a formal request to INEC was required via INEC's 'AAAML' data request form. Otherwise, the publicly available surveys contain data, most notably industry affiliation data, at a highly aggregate broad-group level due to sensitivity reasons.

[11]Further details on each variable is provided in Table 13 in the Appendix.

[12]Available at: https://www.bccr.fi.cr/indicadores-economicos

[13]Where 6 is considered to be the age at which mandatory schooling begins.

The final sample is restricted to individuals above the age of 15 who report a positive wage from their main occupation in the manufacturing sector.

In order to conduct analysis on the skill-based wage gap, the next necessary step is to group individuals by their level of skill. There are two broad approaches to this; one is to proxy for skill with occupation groups - such as using production/non-production and white/blue collar occupations to approximate skilled and unskilled activity. A second, and the preferred approach of this paper, is to define skill through educational attainment. This is generally accepted as superior as it is less restrictive and allows the researcher to incorporate several types of occupations (Winchester, Greenway & Reed, 2006). When using educational attainment, the boundaries of each skill group can also vary. For Gonzaga, Filho and Terra (2006), the unskilled group contains individuals with 10 or fewer years of completed education whereas the skilled group has 11 or more years of completed education. This approach is caveated by its implicit assumption that workers with secondary education are near perfect substitutes for university-educated workers and that the share of university-educated workers is low enough such that they can be grouped with secondary-educated workers (Robbins and Gindling, 1999). This would be problematic in Costa Rica where the share of university-educated workers in the manufacturing sector has almost quadrupled from 7% to 25% (Figure 4). Moreover, the evolution in their respective wages (Figures 2 & 3) is a sure indication their skills have very different rewards in the labour market. With these considerations in mind, this paper allocates individuals to three distinct skill groups based on educational attainment (Table 3). In order to group individuals in the dataset, [0,1] dummy variables are generated that are equal to 1 when an individual belongs to one of the below groups.

Table 3: Creating skill groups

Group	Definition
Unskilled	Complete primary education and less
Semi-skilled	Nearly complete and complete secondary education
Skilled	Complete undergraduate university education and more

4.1.1 Recent trends

With the skill groups defined, it is possible to view how their labour market outcomes have evolved over the analysis period.

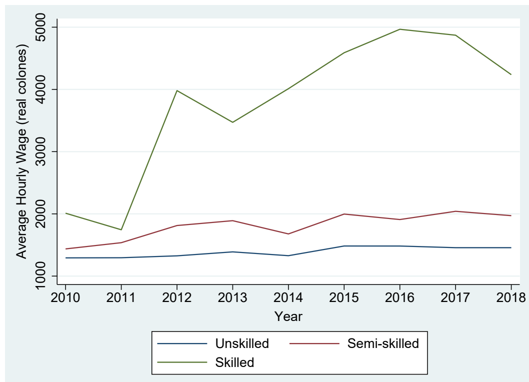
Figure 2 displays the growth pattern of average real wages for workers in each skill group. An upward trend in wages is visible for all three skill groups, although growth has been slowest for the unskilled group (2% on average per year). Wage growth for the semi-skilled group has been slightly faster (5% on average per year) whereas growth for the skilled group has been considerable (16% on average per year).

Figure 3 displays the relative wage gap between the groups in a more direct fashion using wage ratios. From the figure, the average wage for the skilled group is on average 2.82 times larger than the unskilled group and 2.12 times larger than the semi-skill group with the gap having grown 14% and 10% on average per year, respectively. The average wage for the semi-skilled group is on average 1.32 times larger than the unskilled group with the gap having grown 3% on average per year.

Lastly, Figure 4 displays changes in the employment shares of each group. From the figure, the share of skilled workers has risen from 7% to 25% meanwhile the share of unskilled workers has fallen from 73% to 46%. The employment share of semi-skilled workers has remained virtually unchanged.

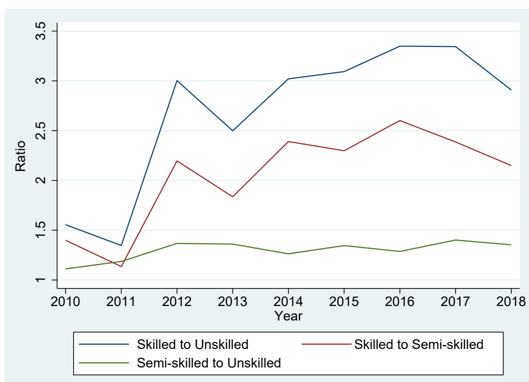
It is evident that skilled workers have received a disproportionate increase in their relative wage. Their wages have increased fastest relative to unskilled workers whilst their relative wage gap over semi-skilled workers is also large and has continued to widen. At the same time, the share of skilled workers in the manufacturing sector has increased, which indicates an increase in demand. In contrast, the relative wage gap between semi-skilled and unskilled workers has remained fairly constant. Therefore, the disproportionate growth in skilled wages is of prominent interest.

Figure 2: Growth in Hourly Wages by Skill Level



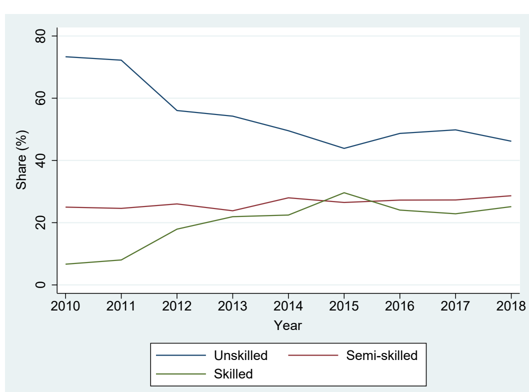
Source: Own Calculations using 2010-2018 waves of the ENAHO surveys

Figure 3: Growth in Wage Ratio by Skill Level



Source: Own Calculations using 2010-2018 waves of the ENAHO surveys

Figure 4: Change in Employment Shares by Skill Level



Source: Own Calculations using 2010-2018 waves of the ENAHO surveys

4.2 Trade data

Since the household surveys do not provide data on industry exports or imports, this data is sourced from the World Integrated Trade Solutions (WITS) database.[14] The WITS database allows for detailed queries into international trade patterns for over 160 countries by various product groups and nomenclatures and with a comprehensive level of coverage such that missing observations between country pairs can be interpreted as zero trade. The raw trade data collected include Costa Rica's exports and imports with

[14]Can be accessed at: https://wits.worldbank.org/

the United States, European Union[15], China and the rest of the world[16], disaggregated at the 2-digit (ISIC Revision 3) industry level. To use this raw trade data to construct this paper's trade liberalisation measures, described in the next subsection, data on the gross value added (GVA) of each industry was required. This was sourced from the Central Bank of Costa Rica (BCCR). The GVA data is disclosed in Colones and, in order to match the currency of the trade data, was converted from Colones to USD using exchange rates obtained from the United States Department of Agriculture (USDA) website.[17] All analysis in this paper relates to the 2-digit industry level as this is the most detailed availability of the GVA data.[18] The GVA data was deflated using the GDP deflator provided by the BCCR.[19]

The resulting dataset containing all trade data was then merged with the dataset containing all individual-level data using the 2-digit industry variable in both datasets. Before doing so, the industry variable in the individual-level dataset required conversion from ISIC Revision 4 to ISIC Revision 3 (the latest classification used in WITS) which was achieved using ILOSTAT Concordance tables.[20] Nearly all ISIC Revision 4 industries were a match with an ISIC Revision 3 industry with exception to industries 27 (Manufacture of electrical equipment) and 28 (Manufacture of machinery and equipment n.e.c). A look at more disaggregated industries within each of these two industries revealed a placement across three ISIC Revision 3 industries: 31 (Manufacture of electrical machinery and apparatus n.e.c), 32 (Manufacture of radio, television and communication equipment and apparatus) and 33 (Manufacture of medical, precision and optical instruments, watches and clocks). To resolve this, I combined ISIC Revision 4 industries 27 and 28 and combined the three ISIC Revision 3 industries 31, 32 and 33, resulting in one ISIC Revision 4 industry and one ISIC Revision 3 industry (which is labelled 33 in the data). Ultimately, this means that when calculating trade liberalisation measures for industry 33, trade data summed for the three industries was summed over GVA for two industries. The caveats are potentially inflated values for the trade liberalisation measures (for industry 33) and a loss in the number of industries used in the analysis. Unfortunately, this is the only workaround.

All in all, this paper exploits variation from a total of 16 2-digit industries. A list of all industries used in the analysis is provided in Table 14 in the Appendix.

4.2.1 Measuring trade liberalisation

Following the approach of Galiani and Sanguinetti (2003) this paper measures trade liberalisation using penetration measures. Where Galiani and Sanguinetti (2003) use only import penetration, this paper also finds it important to measure export penetration due to the bilateral nature of free trade agreements. For reasons noted previously, both variables are calculated at the 2-digit industry level and can be defined as follows:

$$\text{i. } ImportPenetration_{kt} = \left(\frac{imports_{kt}}{GVAkt} * 100\right)$$
$$\text{ii. } ExportPenetration_{kt} = \left(\frac{exports_{kt}}{GVA_{kt}} * 100\right)$$

Where GVA is gross value added, subscript k denotes the industry and t denotes time. Both variables are constructed to reflect trade liberalisation with the US, EU and China.

Import penetration and export penetration are intuitively appealing measures of trade liberalisation as they capture actual exposure to trade. This contrasts with tariffs, for instance, which fail to account

[15] Defined as EU-15 countries. Accessible at: https://stats.oecd.org/glossary/detail.asp?ID=6805
[16] Defined as all trade partners minus the US, EU and China.
[17] Available at: https://www.ers.usda.gov/data-products/agricultural-exchange-rate-data-set/
[18] GVA data at the 2-digit aggregation is not available on the BCCR website which only displays the data the 1-digit level. Therefore, the 2-digit data is available on request.
[19] Available at: https://www.bccr.fi.cr/indicadores-economicos
[20] Available at: https://ilostat.ilo.org/resources/concepts-and-definitions/classification-economic-activities

for the existence of constraints such as non-tariff barriers. Such constraints can prevent utilisation of low tariffs and ultimately lead to low levels of actual trade exposure. It follows that import penetration measures the intensity of competition, measured as a share of domestic production, faced by Costa Rican industries from manufactured imports. Correspondingly, export penetration measures the intensity to which Costa Rican industries, measured as a share of domestic production, export their output.

4.2.2 Recent trends

With the measures defined, it is possible to view the patterns of import and export penetration with the US, EU and China over the analysis period. This is represented in Figures 5, 6 and 7 which display import penetration and export penetration for the aggregate 1-digit manufacturing sector.

From all figures, import penetration values are larger than export penetration values for every trading partner. Moreover, the importance of the US as a trading partner is seen by its considerably larger penetration values than the values for EU and China, as seen by the values on the Y-axes of each figure.

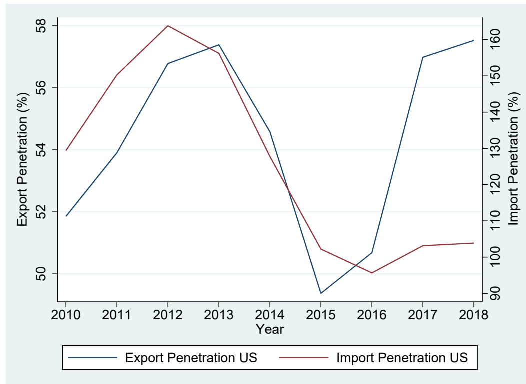
From Figure 5, export penetration US shows a steep upward trend for most of the analysis period with exception to 2014 and 2015. This sudden fall can be attributed to the closure of Intel's manufacturing plant in 2014, demonstrating the significance of Intel to Costa Rica's exports until that point. A look at export penetration US at the 2-digit level (Table 14 in the Appendix) reveals that export liberalisation with the US has been concentrated in industry 33 in the sample. Figure 5 shows import penetration US grew 34 percentage points between 2010 and 2012 after which there was a quite dramatic collapse, until 2016, with modest recovery afterwards. Sustained increases in import penetration US at the 2-digit level (Table 15 in the Appendix) have been concentrated in industries 19 and 34 in the sample.

From Figure 6, export penetration EU also shows an upward trend for most of the analysis period with notable exception to 2014 and 2015. As with the US, Costa Rica's exports to the EU were accounted for in a sizeable part by Intel until its closure. At the 2-digit level (Table 16 in the Appendix), sustained increases in export penetration EU are observed in industries 17, 25 and, most heavily so, industry 33. From Figure 6, import penetration EU increased shows an upward trend for most of the sample. At the 2-digit level (Table 17 in the Appendix), sustained increases in import penetration EU are observed in industries 15, 19, 26, 27 and 34.

From Figure 7, export penetration China is found to be very small in magnitude, with a value of just 6.4% at its peak.[21] Meanwhile, import penetration China is large and has grown considerably having almost doubled over the analysis period. At the 2-digit level (Table 18 in the Appendix), sustained increases in import penetration China are observed in several places, namely in industries 19, 25, 26, 28, 33 and 36.

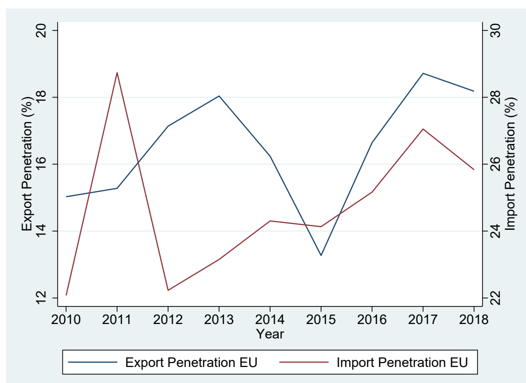
Figure 5: Trade Exposure with the US

[21] Given this, I do not expect export penetration with China to be influence product prices and wages in Costa Rica, and so will not pursue it as a variable of interest.



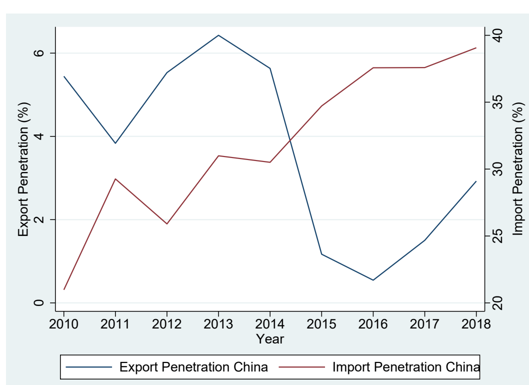
Source: Own Calculations

Figure 6: Trade Exposure with the EU



Source: Own Calculations

Figure 7: Trade Exposure with China



Source: Own Calculations

4.3 Descriptive Statistics

To conclude, Table 4 and Table 5 display some descriptive statistics for all variables introduced in this section that are to be used in the empirical model. From Table 4, the sample counts 5,419 unique observations for individuals and 198 unique observations for the trade liberalisation variables. The average hourly wage for unskilled workers is 1,412 colones, whereas semi-skilled and skilled workers earn an average hourly wage of 1,776 and 4,327 colones, respectively.

As expected, the largest values for the trade liberalisation measures are with the US. For the US and EU, import penetration values are larger than the export penetration values, which when taken with import penetration China, reflect the significant trade deficit observed in Figure 1. The maximum values for export penetration US and export penetration EU relate to industry 33.

Unskilled workers represent 40% of the sample, whereas semi-skilled and skilled workers represent 37% and 23%, respectively. To provide descriptive information on categorical variables, Table 5 displays the representation of each skill group in each category. The vast majority of workers from every skill group reside in the 'Central' administrative region, which itself represents 72% of the sample. The data also shows that smaller establishments tend to employ more unskilled workers whilst the largest establishments tend to employ more skilled workers. Lastly, as expected there is a higher representation of skilled workers towards the top end of the occupation categories.

Table 4: Descriptive statistics for variables used in the model: Mean values

Variable	N	Mean	SD	Min	Max
Hourly wage (local currency)					
Whole Sample	5419	2053.11	2128.65	52.75	34,492.38
Unskilled Sample	2352	1411.91	765.69	92.73	10,013.43
Semi-skilled Sample	1969	1775.77	1117.4	52.75	11,682.33
Skilled Sample	1098	4327.39	3858.24	321.32	34,492.38
Export Penetration US (%)	198	52.31	129.33	.20	698.02
Export Penetration EU (%)	198	15.25	37.75	.06	205.42
Import Penetration US (%)	198	76.34	106.95	.01	1225.09
Import Penetration EU (%)	198	21.71	51.53	0	850.55
Import Penetration China (%)	198	33.72	55.388	0	548.46
Openness(ROW) (%)	198	62.77	43.09	3.40	833.11
Age	5419	35.89	11.32	15	84
Age Squared	5419	1416.65	895.18	225	7056
Experience	5419	20.95	12.3	0	78
Experience Squared	5419	590.08	620.09	0	6084
Female	5419	.24	.43	0	1
Married	5419	.38	.49	0	1
Rural	5419	.31	.46	0	1
Unskilled (% share)	5419	.40	.49	0	1
Semi-Skilled (% share)	5419	.37	.48	0	1
Skilled (% share)	5419	.23	.42	0	1

Table 5: Descriptive statistics for variables used in the model: Representation of skill groups

	N	US	SS	S	Total
Region Controls (% share)					
Central	5419	.68	.72	.83	.72
Chorotega	5419	.07	.06	.04	.06
Pacifico Central	5419	.07	.05	.05	.06
Bruna	5419	.05	.05	.03	.05
Huetar Caribe	5419	.06	.06	.02	.05
Huerte Norte	5419	.07	.06	.03	.06
Establishment Size (% share)					
1-9 employees	5419	.28	.21	.12	.23
10-19 employees	5419	.12	.11	.08	.11
20-29 employees	5419	.06	.08	.05	.07
30-99 employees	5419	.16	.16	.17	.16
100+ employees	5419	.38	.44	.58	.43
Occupations (% share)					
Directors and managers	5419	.00	.01	12	.02
Scientific and intellectual professionals	5419	.00	.01	.30	.06
Technicians and mid-level professionals	5419	.04	.13	.22	.11
Administrative support staff	5419	.04	.11	.13	.08
Service workers and salespeople	5419	.06	.09	.06	.07
Officials, operators and craftsmen of mechanical arts	5419	.33	.24	.09	.26
Plant and machine operators and assemblers	5419	.27	.24	.04	.21
Elemental occupations	5419	.26	.17	.04	.19

Notes: Where US = unskilled, SS = semi-skilled and S = skilled. Occupation groups at the 1-digit level are used here for the purpose of providing descriptive information. The empirical analysis will exploit occupation groups at the 4-digit level.

5 Empirical Strategy

In this section I discuss the empirical strategy and address potential econometric concerns.

5.1 Regression Specification

The objective of this paper is to uncover the impact of recent trade liberalisation on rising wage inequality in Costa Rica. Specifically, I ask if the industries that experienced higher import and/or export penetration were, ceteris paribus, those which experienced the largest increases in wage inequality, whilst discriminating the source of wage inequality from the US, EU and China. I set up the regression specification accordingly to be estimated using the method of Ordinary Least Squares (OLS). The regression specification takes the following form:

$$\log(\text{Hourly Wage})_{ikt} = \beta_0 + \beta_1 \text{ExportPenetration(US)}_{kt-1} + \beta_2 \text{ExportPenetration(EU)}_{kt-1} + \beta_3 \text{ImportPenetration(US)}_{kt-1} + \beta_4 \text{ImportPenetration(EU)}_{kt-1} + \beta_5 \text{ImportPenetration(China)}_{kt-1} \beta_6 \text{Openness(ROW)}_{kt-1} \beta_7 \text{Experience}_{it} + \beta_8 \text{Experience}^2{}_{it} + \beta_9 \text{Female}_{it} + \beta_{10} \text{Married}_{it} + \beta_{11} \text{Rural}_{it} + \delta \text{Region}_r + \gamma \text{Industry}_k + \theta \text{Occupation}_j + \lambda \text{EstablishmentSize}_s + \tau \text{Year}_t + \epsilon_{ijkt} \quad (1)$$

Where the dependent variable is the logarithm of hourly wage for individual i employed in industry k in year t. The coefficients on β_1 through β_5 are the parameters of interest. To isolate the impact of the parameters of interest, this paper incorporates a range of control variables:

Openness_ROW[22] is incorporated as a control variable to capture any impact on wages of trade openness with the rest of the world – that is, all trading partners minus the US, EU and China. Therefore, included are Singapore, Mexico, Peru and Colombia with whom Costa Rica also signed FTAs during the analysis period, however their individual contribution to Costa Rica's trade exposure is comparatively small and therefore not of central interest to this paper. Also included is exports to China.

[22]Calculated as = $\left(\frac{Importskt+Exportskt}{GVAkt} * 100\right)$.

The following set of individual-level variables are included to capture variation in wages attributed to personal characteristics:

Experience and **Experience^2** control for increasing wages associated with work experience and the decreasing rate at which this happens. It is worth noting that experience can be problematic if in developing economies individuals have low levels of schooling, including many with no schooling, such that they are assigned an unrealistically high work experience value (Arbache, et al., 2004). For this reason, **age** and **age^2** will also be considered.

Female is a [0,1] binary variable variable that indicates an individual's gender and controls for gender-based wage differences. Gender-based wage inequality remains a problem in Costa Rica despite parity in gender-based educational attainment (WEF, 2018).

Married is a [0,1] binary variable that indicates marriage status and controls for the so-called marriage premium. Married individuals may perceive greater financial responsibility and thus exert higher effort, however this relationship can also work in reverse (Ahituv & Lerman, 2007).

Rural is a [0,1] binary variable that captures the urban-wage premium, which can arise due to urban agglomeration, for instance. It is worth noting that the urban-rural wage gap in Costa Rica is the smallest in Central America (Gindling and Trejos, 2013).

Also included in the specification are the following set of dummies:

δ**Region**$_r$ (r = 6) captures any time-invariant, region-specific variation in wages which can be due to local labour market conditions, for instance. For example, if all else equal, higher wages are paid in San Jose (located in the Central administrative region) due to higher living costs in the capital.

γ**Industry**$_k$ (k = 26) are industry dummies included to capture inter-industry wage differentials. Such wage differentials have been widely documented and have been attributed to a range of factors, such as efficiency wages, rent-sharing or industry-specific knowledge (Lovely & Richardson, 2000).

θ**Occupation**$_j$ (j = 353) are occupation dummies included to capture occupation-specific wage differentials. In certain occupations, such as craftsmen, human capital is primarily occupation-specific and can be a key determinant of wages across individuals with an otherwise similar profile (Sullivan, 2010).

λ**EstablishmentSize**$_s$ (s = 6) are establishment-size dummies included to capture wage differentials which can be attributed to the size of the establishment, as measured by the total number of employees, where an individual works. Larger establishments may, all else equal, provide a higher reward for effort and the possession of firm-specific human capital (Belfield & Wei, 2004).

τ**Year**$_t$ (t = 9) captures time-specific shocks that impact wages homogeneously.

Finally, the idiosyncratic error ϵ_{ijkt} captures all other sources of variation in wages not captured by the model.

Specification (1) will be estimated separately for the unskilled, semi-skilled and skilled group. In every regression, robust standard errors will be used to correct for possible heteroskedasticity. Moreover, because this paper combines aggregate industry-level data on trade liberalisation with micro-level data on wages and personal characteristics based on industry affiliation, clustering of the standard errors at the industry level is necessary. If clustering is not used, the standard errors of the OLS estimates will be understated, causing their associated t-values to be inflated and ultimately a rejection of the null hypothesis of no significance (Moulton 1986; Cheah, 2009). Therefore, all standard errors will be adjusted for clustering at the 2-digit industry level.

5.2 Addressing potential econometric concerns

Before turning to the empirical results, it is important to address potential sources of endogeneity in the specification. A key issue in my specification is the risk of omitting factors that are correlated with the trade liberalisation variables and have a partial impact on wages - as this would lead to a correlation between the variables of interest and the error term, causing omitted variable bias (OVB) in their coefficients. The inclusion of a range of control variables is intended to reduce this risk as much as possible. For example, the inclusion of Openness_ROW will ensure that any impact on wages of trade liberalisation with other partners is controlled for in the model. As a different example, if policymakers in Costa Rica had protected unskilled-intensive industries due to an aversion to unemployment, this can influence both penetration and wages in that industry. Similarly, if policymakers had enacted initiatives, such as tax incentives, that favoured skill-intensive industries, this will influence penetration and wages in those industries. All industry-specific and time-invariant factors such as these are accounted for in the model with the industry dummies. Moreover, due to a good availability of data, this paper is able to incorporate detailed occupation dummies and establishment-size dummies which go beyond what is seen in the literature. A second issue is the potential presence of reverse causality in the specification. If higher wages induce manufacturing workers, who are also consumers, to consume more foreign goods, the causality may run from wages to import penetration instead. Reverse causality will also exist if lower (higher) wages increase (decrease) the export competitiveness of a particular sector's output and contribute to higher (lower) export penetration levels. Closely linked to this is the third potential issue - simultaneity between wages and the penetration variables. Simultaneity might exist because gross value added is used in the calculation of the penetration measures and is also part of the industry output (Paz and Kapri, 2019). To remedy the risk of reverse causality and simultaneity bias, the trade liberalisation variables will be lagged by one year. As an additional consideration, lagged values of the trade liberalisation variables also accommodate any delay for producers to react to trade exposure and for prices to feed through to wages.

6 Results and discussion

This section presents and discusses the findings of the empirical model.

Before interpreting the final results, I inspect the pairwise correlation of the trade liberalisation variables of interest. Because this paper is interested in several key variables, the inclusion of each also considered important for preventing omitted variable bias, the presence of multicollinearity could be especially problematic in the interpretation of results. Table 6 presents the output for the correlation matrix. As a general rule, a correlation coefficient of close to 0.8 indicates multicollinearity (Shrestha, 2020). From Table 6, the correlation coefficients are generally at an acceptable level, with exception to export penetration US and export penetration EU which exhibit a correlation of approximately 0.98 – well above any acceptable level. It follows therefore that the inclusion of both variables in the specification is likely to make any interpretation of their results unreliable.

Nevertheless, it is informative to view how each coefficient behaves in the presence of a collinear variable. To this end, I run specification (1) with export penetration US and export penetration EU included interchangeably and then together as part of the full specification. This also provides an opportunity to interpret the individual coefficients when unaffected by multicollinearity. The results are presented in Table 7. Each respective column within each panel reports the results for specification (1) regressed on the unskilled, semi-skilled and skilled group. The full set of control variables is included however their

Table 6: Correlation Matrix: Trade Exposure Variables

	(1)	(2)	(3)	(5)	(5)
(1) Export Penetration US	1.000				
(2) Import Penetration US	0.472	1.000			
(3) Export Penetration EU	**0.976**	0.421	1.000		
(4) Import Penetration EU	0.161	0.684	0.108	1.000	
(5) Import Penetration China	0.437	0.537	0.365	0.409	1.000

interpretation is postponed.

From Panel A, which omits export penetration EU, a 10 percentage point increase in export penetration US is associated with a 1.8% increase in semi-skilled workers' wages, significant at the 10% level. With no statistically significant wage responses of unskilled and skilled workers, an increase in export penetration US therefore reduces (widens) the relative wage gap between semi-skilled and skilled (unskilled) workers. However, when regressed together with export penetration EU in Panel C as part of the full specification, the coefficient on the semi-skilled wage response associated with export penetration US loses its statistical significance and its standard error is inflated by almost 50%. Puzzlingly, the unskilled workers' wage response associated with export penetration US (Column 7) now exhibits a negative sign and is even statistically significant.

From Panel B, which omits export penetration US, a 10 percentage point increase in export penetration EU is associated with a 6.4% (1% significance), 4.2% (5% significance) and 5.4% (5% significance) increase in unskilled, semi-skilled and skilled workers wages, respectively. Therefore, export liberalisation with the EU is highly beneficial for all skill groups. However, when regressed together with export penetration US in Panel C, the coefficients on semi-skilled and skilled wages associated with export penetration EU lose their statistical significance. Again, the standard errors are much inflated and large changes in the coefficients are noted on unskilled and semi-skilled wages.

To circumvent multicollinearity, I linearly combine export penetration US and export penetration EU to create a new variable, export penetration USEU. The linear combination solution is partially motivated the presence of an upward bias when one of the collinear variables is omitted – as seen in Panel C. Although the size of the bias can be discerned, the estimates in Panel C are nevertheless unreliable. Furthermore, a linear combination of the US and EU export penetration variables has no implications for the hypothesis of this paper because their developed-country profiles mean the results can still be interpreted within a HO-S a context. For these reasons, this is a suitable solution for the purposes of this paper.[23]

Table 8 presents the final empirical results. Columns 1, 2 and 3 present the results for the unskilled, semi-skilled and skilled sample, respectively.

The coefficients on the individual-level control variables have the expected sign. The log of hourly wage is increasing with a worker's potential experience, but at a decreasing rate, and with the return to an additional year of potential experience highest for skilled workers. Substituting age for experience, given the potential pitfalls noted previously in using experience for developing countries, produces very similar results (reported in Table 11 in the Appendix). Furthermore, unskilled rural dwellers earn less than their urban counterparts. The coefficients on the dummies (which are not reported) are statistically significant; the industry dummies present strong evidence of inter-industry wage premiums that are particularly prevalent for skilled workers whilst significant establishment-size dummies indicate larger establishments pay higher wages, all else equal, for every skill group. Lastly, the occupation dummies as well as being highly significant explain a sizeable portion of the variation in wages between individuals

[23] A definition of this variable and all trade liberalisation variables is provided in Table 12 in the Appendix.

Table 7

Dependent variable: log(hourlywage)	(1)	(2) **Panel A**	(3)	(4)	(5) **Panel B**	(6)	(7)	(8) **Panel C**	(9)
	Unskilled	Semi-skilled	Skilled	Unskilled	Semi-skilled	Skilled	Unskilled	Semi-skilled	Skilled
Export Penetration US	0.0008	0.0018*	0.0019	-	-	-	-0.0020*	0.0016	0.0003
	(0.0008)	(0.0010)	(0.0015)	-	-	-	(0.0011)	(0.0019)	(0.0017)
Export Penetration EU	-	-	-	0.0064***	0.0042**	0.0054**	0.0110***	0.0010	0.0050
	-	-	-	(0.0011)	(0.0019)	(0.0023)	(0.0034)	(0.0049)	(0.0036)
Import Penetration US	0.0007	-0.0015***	0.0008	0.0007	-0.0021***	0.0004	0.0006	-0.0015***	0.0005
	(0.0008)	(0.0005)	(0.0006)	(0.0006)	(0.0005)	(0.0004)	(0.0007)	(0.0005)	(0.0007)
Import Penetration EU	-0.0005	-0.0012	-0.0179***	-0.0008	-0.0005	-0.0172***	0.0004	-0.0012	-0.0175***
	(0.0021)	(0.0025)	(0.0084)	(0.0023)	(0.0019)	(0.0081)	(0.0026)	(0.0025)	(0.0084)
Import Penetration China	-0.0002	-0.0022*	0.0108**	-0.0002	-0.0024*	0.0103***	-0.0005	-0.0023	0.0103**
	(0.0013)	(0.0011)	(0.0038)	(0.0011)	(0.0013)	(0.0035)	(0.0010)	(0.0013)	(0.0036)
Openness ROW	0.0005	-0.0000	-0.0010	0.0003	0.0005	-0.0011	0.0007	-0.0001	-0.0011
	(0.0009)	(0.0022)	(0.0019)	(0.0009)	(0.0025)	(0.0019)	(0.0010)	(0.0023)	(0.0019)
Constant	6.2113***	9.0424***	6.8149***	6.2766***	9.0456***	6.8243***	6.4296***	9.0434***	6.8232***
	(0.0963)	(0.5935)	(0.2191)	(0.0579)	(0.5940)	(0.2132)	(0.1152)	(0.5930)	(0.2151)
Personal Characteristics	YES	YES	YES	YES	YES	YES	YES	YES	YES
Occupation Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Establishment Size Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	304522	284782	169163	304522	284782	169163	304522	284782	169163
R-squared	0.29	0.45	0.65	0.29	0.45	0.65	0.29	0.45	0.65

Notes: Preliminary regression results. All trade variables are lagged by one year. All individual-level control variables (personal characteristics) are included in the regression but are not reported. Empirical results are weighted using INEC sample weights which are designed to ensure the sample reflects the wider population. Robust standard errors (clustered at the 2-digit industry level) are in parentheses. ***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$.

Table 8: Regression results

Dependent variable: log(Hourly Wage)	(1)	(2)	(3)
	Unskilled	Semi-skilled	Skilled
Export Penetration USEU	0.0012*	0.0015**	0.0016
	(0.0005)	(0.0006)	(0.0010)
Import Penetration US	0.0008	-0.0016***	0.0007
	(0.0007)	(0.0004)	(0.0005)
Import Penetration EU	-0.0009	-0.0012	-0.0174***
	(0.0022)	(0.0023)	(0.0083)
Import Penetration China	-0.0001	-0.0023*	0.0105**
	(0.0012)	(0.0012)	(0.0037)
Openness ROW	0.0004	-0.0001	-0.0011
	(0.0009)	(0.0023)	(0.0019)
Female	-0.0967**	-0.0754**	0.0375
	(0.0395)	(0.0331)	(0.0244)
Experience	0.0098**	0.0089*	0.0191**
	(0.0041)	(0.0050)	(0.0066)
Experience^2	-0.0001*	-0.0001	-0.0003*
	(0.0001)	(0.0001)	(0.0002)
Married	0.1079***	0.0899***	0.1759***
	(0.0308)	(0.0219)	(0.0337)
Rural	-0.0236*	-0.0188	-0.0092
	(0.0128)	(0.0293)	(0.0546)
Constant	6.4049***	9.0822***	6.9754***
	(0.0578)	(0.5842)	(0.2070)
Region Dummies	YES	YES	YES
Occupation Dummies	YES	YES	YES
Establishment Size Dummies	YES	YES	YES
Industry Dummies	YES	YES	YES
Year Dummies	YES	YES	YES
Observations	304522	284782	169163
R-squared	0.24	0.43	0.62

Notes: Main regression results. All trade variables are lagged by one year. Empirical results are weighted using INEC sample weights which are designed to ensure the sample reflects the wider population. Robust standard errors (clustered at the 2-digit industry level) are in parentheses.
***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$

within groups, particularly for the skilled group; dropping occupation dummies reduces the R-squared value to 28% for the model estimated on the skilled sample, 21% for the semi-skilled and 14% for the unskilled sample, thus emphasising the importance of capturing occupation-specific idiosyncrasy in wages.

Given Costa Rica is unskilled-labour abundant relative to the US and EU, HO-S predicts a narrowing in the wage gap resulting from export penetration USEU. The results suggest that, all else equal, a 10 percentage point increase in export penetration with the US and EU is associated with a 1.2% increase in unskilled workers' wages, significant at the 10% level, and a 1.5% increase in semi-skilled workers' wages, significant at the 5% level. Because the coefficient on skilled workers' wages is statistically insignificant, export penetration with the US and EU increases the relative wage of both unskilled and semi-skilled workers over skilled workers, consistent with HO-S mechanisms.

This finding contrasts with the results of Robbins and Gindling (1999) who found an increase in the relative demand for skilled workers from export liberalisation of manufactured goods.[24] Nevertheless, this can be considered a somewhat surprising finding given that Costa Rica's manufactured exports with the US and EU are very concentrated in high-tech industries such as electronics and medical devices, due in large part to a long-standing bias towards exports of these skill-intensive industries as part of the trade liberalisation program. Moreover, it is such industries that experienced disproportionate growth during the analysis period. However, as Alfaro-Urena et al. (2019) find, the MNCs located in Costa Rica's FTZs, which account almost exclusively for exports of such high-tech industries, are not intensive in skilled labour contrary to common perception. Rather, as of 2017, as much as 82% of employees at MNCs had less than a university degree. Therefore, it is not an inevitable conclusion that expansion of MNCs, in these industries due to trade liberalisation would disproportionately favour skilled workers. Overall, it is a promising finding that export liberalisation with these developed partners reduces the relative wage gap.

With regards to import penetration, as skill-intensive US and EU imports penetrate a larger share of the domestic market, HO-S predicts the wages of skilled Costa Ricans in those industries should decline. The results provide strong evidence in favour of this prediction for EU import penetration; all else equal, a 10 percentage point increase is associated with a 17.4% reduction in skilled workers' wages, significant at the 1% level, whilst having no significant impact on the other wage groups. This means EU import penetration reduces the relative wage of skilled workers, with the magnitude of impact being quite striking. For the US case, a 10 percentage point increase in US import penetration is associated with a 1.6% fall in semi-skilled workers' wages, significant at the 1% level. Because no statistically significant coefficient is observed on unskilled and skilled workers' wages, US import penetration reduces the relative wage gap between semi-skilled and unskilled workers but widens the gap between semi-skilled and skilled workers.

The wage response of skilled workers to EU import penetration is consistent with HO-S mechanisms, which suggests that Costa Rica's import-competing industries with the EU are more intensive in skilled labour and this factor in these industries is hurt from import competition from EU manufactured goods in its domestic market. By the same token, it is surprising to note the very different response of skilled workers' wages to US import penetration, which exhibits a positive sign albeit being statistically insignificant.

In offering an explanation, it is useful to consider that Costa Rica has historically been an important offshoring destination for American MNCs in search of labour cost savings. As these firms fragmented

[24] It is worth noting that Robbins and Gindling (1999) study wage inequality through trade-induced changes on the relative demand for skilled workers, whereas this paper looks at wages.

stages of production in Costa Rica, this has meant US imports have been comprised in significant part of capital and intermediate goods destined for the industries in which these firms operate. This was initially amplified by CAFTA-DR, which made FDI inflows into skill-intensive sectors much more attractive (Alfaro-Urena, et al. 2019). Because these types of imports compliment skilled labour, they are associated with an increase in the relative demand and wage for skilled workers. However, whilst the US remains the most important source of capital goods, imports of capital goods from the US collapsed[25] over the analysis period which could explain the statistical insignificance. In contrast, a comparatively small amount of these imports is sourced from the EU[26], meaning EU manufactured imports have little element of complementarity with skilled Costa Rican labour.

Table A1	(1)
(1) Average Chinese import penetration	1.000
(2) Share of unskilled workers	0.029**
(3) Share of semi-skilled workers	0.094***
(4) Share of skilled workers	-0.083***

***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$

The surge in import penetration of Chinese manufactures produces quite an unexpected wage response. With China being abundant in unskilled labour, the hypothesis built on HO-S predictions is that the impact of larger import penetration of Chinese manufactures is a declining relative price of unskilled-labour intensive goods, and consequently an increase in the wage gap. The results show the wage gap indeed increased, however not through a suppression of unskilled workers' wages; the coefficient on which is negative but statistically insignificant. Rather, it is through an increase in skilled workers' wages; all else equal, a 10 percentage point increase in Chinese import penetration is associated with an increase in the wages of skilled workers by 10.5%, significant at the 5% level. It is semi-skilled workers that have been adversely impacted - the same magnitude increase in import penetration is associated with a 2.3% reduction in semi-skilled workers' wages, significant at the 10% level.

This finding on skilled workers' wages is surprising, as traditional trade mechanisms predict no impact on such wages in response to imports from an unskilled-labour abundant country, let alone an increase. Instead, it is more consistent with skill-biased technological change (or skill-enhancing trade). Numerous reasons as to why trade may induce skill-biased technological change have been suggested. For example, Acemoglu (2003) posits that a by-product of trade liberalisation is a lower price of capital goods and thus an increase in their imports. Certainly, the data supports this - China is Costa Rica's second largest source of capital goods imports, having doubled in volume immediately upon the implementation of the FTA and with steady growth since (WITS, 2020). Because capital goods complement skilled activity, their imports could have raised the demand for skilled labour. However, it is worth noting that skill complementarity of capital goods is usually associated with their imports from developed economies due to a technological superiority. Nevertheless, it is not unreasonable to think that in the current period, given China's ascent up the global value chain and its position as a manufacturing powerhouse for developed economies, its capital technology is of a developed-economy standard.[27]

Skill-biased technological change can also be due to defensive innovation as found in Colombia by Attanasio et al., (2003). When faced with increased exposure to cheaper Chinese imports, domestic firms in Costa Rica might invest in technology in order to protect themselves. This would initiate a

[25]This is seen in Figure 8 in the Appendix.
[26]This is seen in Figure 9 and Figure 10 in the Appendix.
[27]In fact, the surge in Chinese capital imports has coincided with a collapse in capital imports from the US (WITS, 2020). It would be interesting to explore whether imports of capital goods from China are replacing imports of capital goods from the US.

'skill-upgrading' of the production process where firms will seek to employ higher skilled labour and simultaneously release lesser skilled labour, leading to corresponding changes in the returns to their skill. The coefficients on semi-skilled and skilled workers' wages suggest this is very plausible. Notably, this mechanism is only valid if (as indeed HO-S predicts) domestic producers facing the most competition from Chinese imports are located in industries that intensively use unskilled and semi-skilled labour. To explore this further, I estimate a pairwise correlation between the average value of Chinese import penetration in an industry and the employment share of each skill group. Table A1 presents the results. Indeed, the data shows average Chinese import penetration is increasing with unskilled (5% significance) and semi-skilled (1% significance) labour intensity in an industry, with the strongest import penetration faced by the latter.

6.1 Robustness Check

To check the robustness of the results, I change the dependent variable from hourly to weekly wages. The main analysis preferred to use hourly wages because it incorporates compensating differentials arising from the number of hours worked, thereby making it a more precise measurement of the returns to skill. The results are presented in Table 9. I find that the coefficients associated with skilled workers' wages retain their sign and statistical significance, even gaining significance (at the 10% level) in response to US import penetration. However, the coefficient on unskilled workers' wages associated with export penetration USEU loses its significance, whereas the semi-skilled coefficient retains its significance and is larger. The most puzzling change is on the unskilled workers' wage response to import penetration EU which gains significance (at the 5% level). Overall, the main findings of this paper appear robust to a change in the measurement of the dependent variable.

Table 9: Robustness Check

Dependent variable: log(Weekly Wage)	(1)	(2)	(3)
	Unskilled	Semi-skilled	High skilled
Export Penetration USEU	0.0009	0.0021**	0.0018
	(0.0007)	(0.0006)	(0.0010)
Import Penetration US	0.0004	-0.0012*	0.0009*
	(0.0007)	(0.0005)	(0.0005)
Import Penetration EU	-0.0041**	-0.0031	-0.0159***
	(0.0015)	(0.0027)	(0.0081)
Import Penetration China	-0.0009	-0.0016	0.0113**
	(0.0010)	(0.0014)	(0.0037)
Openness ROW	0.0024**	-0.0004	-0.0007
	(0.0009)	(0.0028)	(0.0020)
Constant	9.8875***	13.0051***	10.6667***
	(0.1353)	(0.4969)	(0.2108)
Personal Characteristics	YES	YES	YES
Region Dummies	YES	YES	YES
Occupation Dummies	YES	YES	YES
Establishment Size Dummies	YES	YES	YES
Industry Dummies	YES	YES	YES
Year Dummies	YES	YES	YES
Observations	304522	284782	169163
R-squared	0.28	0.49	0.63

Notes: Robustness check. All trade variables are lagged by one year. All individual-level control variables (personal characteristics) are included in the regression but are not reported. Empirical results are weighted using INEC sample weights which are designed to ensure the sample reflects the wider population. Robust standard errors (clustered at the 2-digit industry level) are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$ and $^{*}p < 0.1$.

7 Conclusion

In this paper, I examined the role of trade liberalisation on wage inequality in Costa Rica within the context of HO-S mechanisms. Interest in this research was motivated by a chronological coincidence of growing wage inequality in Costa Rica with a period of significant trade liberalisation. This was marked by the signing of free trade agreements with the United States, the European Union and China, which represent the majority of Costa Rica's total trade volume, within a short timeframe. This presented an opportunity to examine the potential role of trade liberalisation on wage inequality and discriminate the role of each trading partner.

My empirical results provide mixed evidence of HO-S mechanisms. With respect to export penetration with the US and EU, I find an increase in the relative wage of unskilled and semi-skilled workers, and a narrowing of the wage gap, consistent with HO-S mechanisms. This is different to Robbins and Gindling (1999)'s findings of an increase in the relative demand for skilled labour during Costa Rica's first phase of trade liberalisation. In further support of HO-S, my results show that import penetration from the EU, found to be increasing in several industries, considerably reduced the relative wage of skilled labour.

Less consistent with HO-S was the finding that import penetration from the US increased the wage of skilled workers relative to semi-skilled workers, albeit the wage response of skilled workers is insignificant. I attribute this to imports from the US consisting, to a much greater extent than imports from the EU, of capital and intermediate goods which favour skilled workers. This finding mirrors Arbache, et al. (2004) who find imports yielded a positive but insignificant wage response for the top education group and a negative and significant response for the two lowest education groups, concluding imported technology having raised the relative demand for skilled workers. Robbins and Gindling (1999) find that Costa Rica's first phase of trade liberalisation accelerated imports of capital stock which increased the relative demand for skilled labour. However, during the analysis period of this paper, capital imports from the US collapsed. I contend this results in the insignificant wage response. The major discrepancy with HO-S is found in response to import penetration from China – which widened the wage gap by increasing skilled workers' wages. Similar to Attanasio et al., (2003), I attribute this to skill-biased defensive innovation for which I provide preliminary support by demonstrating that average Chinese import competition in the Costa Rican manufacturing sector was increasing with an industries intensity in unskilled and semi-skilled workers.

My findings should be interpreted with some shortcomings in mind. For one, the analysis was conducted for 2-digit industries despite ENAHO surveys containing more disaggregated industry affiliation. This is because GVA data provided by the central bank, required to construct trade liberalisation variables, was available only at this aggregation. More detailed industry data, perhaps at the 3-digit or 4-digit level, could have helped circumvent issues faced in the industry matching process and also enabled a deeper analysis. Second, my analysis considers industry import data without sorting on the type of imports. In places, my reasoning for the skilled workers' wage response is indirectly attributed to capital and intermediate goods imports. If taken into account empirically, perhaps more concrete conclusions could be drawn. Lastly, this paper's analysis was confined to the traded-goods sector.

From a policy angle, these findings can assist policymakers in economies at a similar stage of development to Costa Rica to discern whether trade liberalisation contributes to wage inequality. This paper recommends any policy tools, such as protecting workers in certain industries, be adapted based on their direction of trade exposure as different trading partners contribute in different ways to the wage structure. Within the context of Costa Rica, the biggest contribution to rising wage inequality has been

Chinese import competition. As a direction for future research, a study into the firm-level responses in Costa Rica to Chinese import competition could be very insightful.

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9 Appendices

Table 10: Correlation Matrix: Control variables

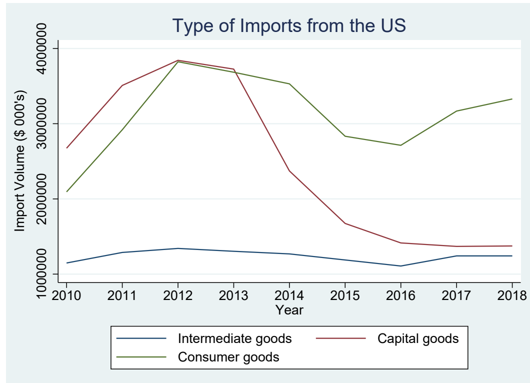
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Age									
(2) Age^2	0.984	1.000							
(3) Experience	0.966	0.952	1.000						
(4) $Experience^2$	0.930	0.963	0.957	1.000					
(5) Head	0.432	0.392	0.441	0.367	1.000				
(6) Female	-0.068	-0.082	-0.109	-0.115	-0.202	1.000			
(7) Married	0.365	0.339	0.321	0.274	0.333	-0.085	1.000		
(8) Years of schooling	-0.227	-0.229	-0.471	-0.434	-0.185	0.178	0.038	1.000	
(9) Rural	-0.027	-0.015	0.057	0.064	0.078	-0.126	-0.047	-0.309	1.000

Table 11: Regression results: Substituting experience for age

Dependent variable: log(Hourly Wage)	(1)	(2)	(3)
	Unskilled	Semi-skilled	Skilled
Export Penetration USEU	0.0010*	0.0014**	0.0015
	(0.0005)	(0.0006)	(0.0010)
Import Penetration US	0.0008	-0.0016***	0.0004
	(0.0007)	(0.0004)	(0.0005)
Import Penetration EU	-0.0009	-0.0012	-0.0173***
	(0.0022)	(0.0023)	(0.0081)
Import Penetration China	-0.0001	-0.0024*	0.0101**
	(0.0012)	(0.0012)	(0.0037)
Openness ROW	0.0004	-0.0001	-0.0010
	(0.0009)	(0.0023)	(0.0019)
Female	-0.0986**	-0.0764**	0.0441*
	(0.0397)	(0.0330)	(0.0238)
Age	0.0125**	0.0113	0.0278**
	(0.0058)	(0.0089)	(0.0110)
Age^2	-0.0001	-0.0001	-0.0002*
	(0.0001)	(0.0001)	(0.0001)
Married	0.1022***	0.0827***	0.1564***
	(0.0300)	(0.0206)	(0.0306)
Rural	-0.0229*	-0.0193	-0.0043
	(0.0128)	(0.0287)	(0.0545)
Constant	6.2411***	8.9011***	6.4989***
	(0.1163)	(0.6541)	(0.2796)
Region Dummies	YES	YES	YES
Occupation Dummies	YES	YES	YES
Establishment Size Dummies	YES	YES	YES
Industry Dummies	YES	YES	YES
Year Dummies	YES	YES	YES
Observations	304522	284782	169163
R-squared	0.24	0.43	0.62

Notes: Substituting experience for age. All trade variables are lagged by one year. Empirical results are weighted using INEC sample weights which are designed to ensure the sample reflects the wider population. Robust standard errors (clustered at the 2-digit industry level) are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$ and $^{*}p < 0.1$.

Figure 8: Type of US Imports

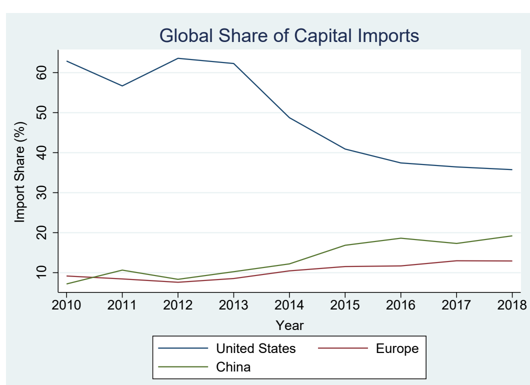


Source: UN Comtrade

Figure 9: Global Share of Intermediate Imports

Source: UN Comtrade

Figure 10: Share of Capital Imports



Source: UN Comtrade

Table 12: Definition of variables used in the analysis

Variable	Unit of Measurement	Definition / Calculation	Source
Hourly wage	Logarithm	Monthly income ÷ (weekly hours worked × 4.33)	INEC (ENAHO)
Export Penetration US	Percentage	Calculated as: $\left(\frac{ExportsUSckt}{GVA_{kt}} * 100\right)$	WITS & BCCR (for GVA)
Export Penetration EU	Percentage	Calculated as: $\left(\frac{ExportsEUkt}{GVA_{kt}} * 100\right)$	WITS & BCCR (for GVA)
Export Penetration USEU	Percentage	Calculated as: $\left(\frac{ExportsUSkt+ExportsEUkt}{GVA_{kt}} * 100\right)$	WITS & BCCR (for GVA)
Import Penetration US	Percentage	Calculated as: $\left(\frac{ImportsUS_{ckt}}{GVA_{kt}} * 100\right)$	WITS & BCCR (for GVA)
Import Penetration EU	Percentage	Calculated as: $\left(\frac{ImportsEU_{kt}}{GVA_{kt}} * 100\right)$	WITS & BCCR (for GVA)
Import Penetration China	Percentage	Calculated as: $\left(\frac{ImportsChina_{kt}}{GVA_{kt}} * 100\right)$	WITS & BCCR (for GVA)
Openness ROW	Percentage	Calculated as: $\left(\frac{ExportsROWkt+ImportsROWkt}{GVA_{kt}} * 100\right)$	WITS & BCCR (for GVA)
Female	Binary	0 = Male, 1 = Female	INEC (ENAHO)
Married	Binary	0 = Single, 1 = Married	INEC (ENAHO)
Rural	Binary	0 = Urban, 1 = Rural	INEC (ENAHO)
Region	Categorical	Administrative regions: 1 = Central, 2 = Chorotega, 3 = Central Pacific 4 = Brunca, 5 = Huetar Atlántica 6 = Huetar North	INEC (ENAHO)
Occupation	Categorical	Variable identifying occupation: Number of occupations = 353 Classification based on COCR 2011	INEC (ENAHO)
Establishment Size	Categorical	Categorical variable identifying number of employees at an individuals place of work: 1 = 1 to 9 employees, 2 = 10 to 19 employees, 3 = 20 to 29 employees, 4 = 30 to 99 employees 5 = More than 100 employees	INEC (ENAHO)
Industry	Categorical	2-digit industry of individual (see below)	INEC (ENAHO)

Table 13: List of 2-digit industries used in the analysis

Revision 4 industry/s	ISIC Revision 3 industry	Description
10 + 11	15	Manufacture of food products and beverages
12	16	Manufacture of tobacco products
13	17	Manufacture of textiles
14	18	Manufacture of wearing apparel; dressing and dyeing of fur
15	19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
16	20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17	21	Manufacture of paper and paper products
18	22	Publishing, printing and reproduction of recorded media
20	24	Manufacture of chemicals and chemical products
22	25	Manufacture of rubber and plastics products
23	26	Manufacture of other non-metallic mineral products
24	27	Manufacture of basic metals
25	28	Manufacture of fabricated metal products, except machinery and equipment
26 + 27	31 + 32 + 33 (Final variable in data is coded = 33)	Manufacture of electrical machinery and apparatus n.e.c.; Manufacture of medical, precision and optical instruments, watches and clocks; Manufacture of radio, television and communication equipment and apparatus
29	34	Manufacture of motor vehicles, trailers and semi-trailers
31 + 32	36	Manufacture of furniture; manufacturing n.e.c.

Notes: The ISIC Revision 3 industries are those used in the analysis. Source: International Labour Organisation (ILO) ILOSTAT.

Table 14: Export Penetration US

Industry					**Year**					**Employment Share (%)**		
	2010	2011	2012	2013	2014	2015	2016	2017	2018	Unskilled	Semi-skilled	Skilled
15	8.57	13.22	11.97	14.21	13.51	13.20	12.64	12.35	13.43	42.8	37.8	19.4
16	1.64	2.03	1.92	1.45	2.40	2.20	2.24	2.06	3.70	19.0	37.2	43.8
17	33.57	42.82	45.07	44.18	54.36	71.13	54.56	40.33	54.24	49.4	41.7	8.9
18	81.50	87.69	90.24	78.08	47.50	33.04	11.14	10.02	4.63	47.7	43.1	9.2
19	17.74	21.38	20.18	11.73	15.25	17.06	16.72	18.04	19.25	57.8	38.8	3.4
20	17.25	19.01	20.73	21.64	22.37	25.95	20.24	23.51	26.15	65.2	26.6	8.2
21	3.89	4.36	4.68	4.54	3.94	3.77	4.40	5.43	5.68	40.9	32.5	26.6
22	0.40	0.87	0.56	9.39	0.37	0.46	0.33	0.20	0.27	21.4	44.0	34.6
24	4.72	5.39	7.44	3.94	3.72	3.48	2.85	3.68	4.42	25.1	35.4	39.5
25	84.20	87.31	85.58	79.16	84.67	78.54	70.50	66.05	86.98	34.3	43.1	22.6
26	4.33	1.08	2.64	7.43	4.99	2.47	2.17	1.20	3.10	45.5	35.8	18.8
27	33.20	36.96	38.19	29.46	29.01	28.70	30.96	35.08	71.71	31.9	48.1	20.0
28	13.80	14.55	15.24	19.45	12.60	10.32	9.67	9.59	17.18	50.5	36.3	13.2
33	196.58	236.01	253.87	259.19	279.29	302.96	559.87	698.02	644.74	15.3	42.5	42.2
34	169.33	191.26	188.21	205.13	129.06	132.81	102.75	6.51	16.96	50.3	37.2	12.5
36	48.15	53.75	55.23	48.71	50.00	46.22	39.84	29.38	33.45	64.4	26.7	8.8

Table 15: Import Penetration US

Industry	**Year**									**Employment Share (%)**		
	2010	2011	2012	2013	2014	2015	2016	2017	2018	Unskilled	Semi-skilled	Skilled
15	8.21	11.85	13.96	23.72	17.48	13.56	13.65	17.13	16.60	42.8	37.8	19.4
16	0.74	0.13	0.99	1.10	0.73	0.33	0.03	0.01	0.05	19.0	37.2	43.8
17	170.35	182.21	189.18	242.70	199.14	178.37	146.63	118.10	100.11	49.4	41.7	8.9
18	17.52	22.21	21.79	29.94	26.18	21.62	28.38	26.67	31.13	47.7	43.1	9.2
19	54.01	65.19	70.87	111.76	132.24	130.77	136.37	157.08	145.92	57.8	38.8	3.4
20	6.35	7.44	8.41	5.53	5.30	5.47	4.57	5.98	6.75	65.2	26.6	8.2
21	148.52	152.52	149.63	129.33	167.92	171.67	161.03	173.98	161.20	40.9	32.5	26.6
22	19.31	17.58	22.70	38.34	38.28	20.98	23.47	11.44	13.33	21.4	44.0	34.6
24	172.93	181.25	195.61	166.00	136.34	140.23	118.62	114.62	116.99	25.1	35.4	39.5
25	87.69	92.21	90.54	97.08	114.14	113.53	112.65	109.54	127.22	34.3	43.1	22.6
26	17.25	15.34	20.55	11.45	12.11	10.88	10.49	10.40	11.94	45.5	35.8	18.8
27	128.90	131.21	140.19	132.71	149.09	120.16	139.48	116.09	104.59	31.9	48.1	20.0
28	198.12	210.27	213.71	172.54	180.22	166.73	137.00	142.71	154.01	50.5	36.3	13.2
33	314.66	348.17	354.32	396.54	373.23	240.31	268.52	251.79	214.07	15.3	42.5	42.2
34	793.18	856.65	892.05	841.15	775.41	765.78	889.93	892.88	1225.10	50.3	37.2	12.5
36	68.49	75.35	79.42	59.62	57.93	59.60	69.40	59.71	78.69	64.4	26.7	8.8

Table 16: Export Penetration EU

Industry	**Year**									**Employment Share (%)**		
	2010	2011	2012	2013	2014	2015	2016	2017	2018	Unskilled	Semi-skilled	Skilled
15	8.94	7.63	8.04	7.28	9.96	8.67	9.00	11.14	10.35	42.8	37.8	19.4
16	0.22	0.29	0.44	0.46	0.50	0.83	2.22	2.34	4.29	19.0	37.2	43.8
17	2.12	2.34	2.78	36.37	16.74	23.55	18.35	14.46	11.19	49.4	41.7	8.9
18	1.48	2.97	1.53	3.63	2.22	2.43	3.70	4.75	3.78	47.7	43.1	9.2
19	13.88	16.47	14.84	14.00	8.96	2.45	1.52	2.69	3.39	57.8	38.8	3.4
20	0.97	1.41	1.20	1.21	0.82	0.94	0.31	0.37	0.38	65.2	26.6	8.2
21	0.31	0.72	0.44	1.78	1.16	1.73	0.41	0.19	0.08	40.9	32.5	26.6
22	0.81	1.05	0.10	2.07	0.08	0.29	0.11	0.06	0.13	21.4	44.0	34.6
24	0.23	0.63	0.49	0.56	0.48	0.61	0.68	0.69	1.10	25.1	35.4	39.5
25	1.71	2.14	2.89	5.11	5.65	6.64	4.72	5.73	7.61	34.3	43.1	22.6
26	0.82	0.74	0.35	1.56	0.24	0.30	0.29	0.06	0.07	45.5	35.8	18.7
27	5.31	4.78	6.61	5.54	3.51	7.75	4.90	8.53	4.33	31.9	48.1	20.0
28	2.85	3.74	3.16	5.21	1.70	1.42	0.86	1.16	3.57	50.5	36.3	13.2
33	64.29	73.51	79.96	86.28	91.22	90.71	132.29	194.35	205.42	15.3	42.5	42.2
34	5.52	8.19	7.95	34.04	7.32	0.84	0.49	0.81	2.96	50.3	37.2	12.5
36	2.52	3.10	2.56	3.45	1.21	2.02	1.19	0.98	1.15	64.4	26.7	8.9

Table 17: Import Penetration EU

Industry	**Year**									**Employment Share (%)**		
	2010	2011	2012	2013	2014	2015	2016	2017	2018	Unskilled	Semi-skilled	Skilled
15	2.56	3.34	3.85	3.91	4.03	4.16	4.54	4.59	5.34	42.8	37.8	19.4
16	0.11	0.17	0.14	0.45	0.39	0.26	0.00	0.06	0.04	19.0	37.2	43.8
17	35.77	28.16	84.51	28.65	20.58	28.67	19.21	20.22	16.86	49.4	41.7	8.9
18	2.99	3.32	3.29	3.24	3.11	2.66	3.40	3.33	3.44	47.7	43.1	9.2
19	10.02	10.89	12.12	19.95	19.57	21.65	21.98	31.28	32.49	57.8	38.8	3.4
20	9.22	9.84	69.48	9.04	9.14	7.48	4.39	6.96	7.81	65.2	26.6	8.2
21	11.8	13.79	12.85	10.63	13.03	11.01	12.09	13.52	13.67	40.9	32.5	26.6
22	5.11	7.93	6.75	6.11	4.18	5.18	4.47	3.63	5.17	21.4	44.0	34.6
24	65.79	64.15	71.27	68.62	66.52	77.29	68.70	72.22	77.81	25.1	35.4	39.5
25	16.09	15.13	15.07	12.01	15.60	15.88	15.28	16.08	18.22	34.3	43.1	22.6
26	6.91	6.77	7.04	7.82	8.51	7.71	8.24	9.99	10.54	45.5	35.8	18.7
27	19.61	22.98	20.37	24.73	20.11	25.16	35.27	47.26	58.31	31.9	48.1	20.0
28	33.49	35.94	31.55	34.60	40.26	35.38	33.52	31.95	47.22	50.5	36.3	13.2
33	27.59	35.70	31.07	19.30	20.86	28.36	45.88	56.21	53.87	15.3	42.5	42.2
34	549.47	578.55	850.55	598.74	521.15	402.82	500.75	489.01	751.08	50.3	37.2	12.5
36	14.86	19.74	22.38	13.60	15.79	15.62	14.43	15.32	17.39	64.4	26.7	8.9

Table 18: Import Penetration China

Industry	**Year**									**Employment Share (%)**		
	2010	2011	2012	2013	2014	2015	2016	2017	2018	Unskilled	Semi-skilled	Skilled
15	1.07	1.10	1.13	1.00	7.01	1.35	1.37	1.43	1.60	42.8	37.8	19.4
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.0	37.2	43.8
17	86.75	114.25	159.09	95.42	117.43	144.02	116.10	125.10	125.31	49.4	41.7	8.9
18	41.66	53.08	47.45	49.27	51.68	56.78	67.90	68.16	77.72	47.7	43.1	9.2
19	260.87	271.36	251.18	377.69	421.95	439.59	521.15	529.53	548.46	57.8	38.8	3.4
20	15.90	10.44	11.30	14.62	10.09	12.06	11.05	11.19	12.00	65.2	26.6	8.2
21	4.90	5.97	5.39	5.40	7.34	8.13	10.01	9.53	10.47	40.9	32.5	26.6
22	2.86	2.19	4.14	2.46	2.39	2.16	2.34	2.40	3.59	21.4	44.0	34.6
24	24.43	27.89	23.33	18.80	23.25	28.71	26.14	26.07	26.40	25.1	35.4	39.5
25	23.57	28.14	27.71	29.79	31.05	33.84	37.47	39.51	41.72	34.3	43.1	22.6
26	5.81	6.92	7.95	8.68	9.45	11.33	12.86	16.74	14.59	45.5	35.8	18.7
27	36.55	41.36	45.51	51.22	46.23	69.92	127.36	159.89	156.29	31.9	48.1	20.0
28	39.20	47.66	42.93	44.88	47.15	48.68	55.68	67.47	68.84	50.5	36.3	13.2
33	35.59	43.64	48.50	45.46	55.06	57.96	128.56	163.04	136.69	15.3	42.5	42.2
34	173.20	198.01	192.35	175.49	175.89	164.21	173.92	330.89	389.21	50.3	37.2	12.5
36	54.56	65.08	68.39	74.59	78.18	85.03	83.98	91.24	111.67	64.4	26.7	8.9