The rise of low-wage countries and its effect on the EU manufacturing sector: what are the consequences for product and process innovation?

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Abstract
This study investigates the effects of import penetration from low-wage countries on product and process innovation in the European Union. The dataset includes 7 European countries over a period from 2007 till 2009. The results provide evidence for a negative relationship between imports from low-wage countries and product innovation. No evidence is found of a significant correlation between imports originating from low-wage countries and process innovation. However, there is a positive relationship between import competition from high-wage countries and process innovation.

Key words: product innovation, process innovation, import competition, low-wage countries, Europe, trapped factors, manufacturing sector

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1. Introduction

Over the past decade, trade with developing countries has increased rapidly, stimulated by the removal of trade barriers, lowering of transportation and communication costs. A large part of this increase is due to countries such as China joining the World Trade Organisation (WTO). The WTO stimulates trade worldwide and takes a special interest in these developing countries. Of the 150 members, nearly 100 are developing countries. They are of great importance due to their role in the worldwide economy. Furthermore, trade is essential for the growth of these individual countries\(^1\).

Moreover, trade patterns from 1990 till 2009 have changed. In the beginning the developed countries were producing more quality manufactured goods because they were further ahead in the process of industrialization. The developing countries were producing mostly low-skilled goods such as clothing as they were far less advanced in industrialisation. Recently, some developing countries have taken steps in that direction. This is illustrated in figure 1 below\(^2\).

\[\text{Figure 1: EU 15 trade with developing and developed countries (% of GDP)}\]

\[\text{EU 15 imports of manufactures from developing and developed countries}\]

\(^1\) Official website of the World Trade Organization
http://www.wto.org/english/thewto_e/whatis_e/tif_e/dev1_e.htm

\(^2\) Source: EUROSTAT; Trade as a driver of Prosperity
This figure shows the imports of manufactured goods, from developed and developing countries in manufactured goods as a percentage of EU 15 GDP. The developed countries represent OECD members, developing countries represent the rest of the world excluding EU member states. EU 15 represent members of the European Union prior to the acceptance of 10 candidate countries in May 2004. From 1999 till 2003 the developing countries were exporting less than the developed countries. This changed in 2004, when the developing countries reached nearly 4% of the EU 15 GDP. This change was not always considered a positive thing for the developed countries. More specifically, it has led people to believe that it caused more unemployment, unfair competition, wage cuts and job insecurity. Competition from developed countries is seen as less threatening to employment since they compete more or less on the same wage level.

The economic crisis, that started in 2008, hasn’t made things easier. Although this paper gives little attention to the subject, it is important to look at the recent economic situation. In short, the economic crisis has made unemployment rise from 7% to 10% in the EU in 2010. International trade receives a bad press in some countries, and is blamed for lower wages and less job security.

Increasing imports means increasing competition on the domestic market and so reducing profits of firms primarily operating on this market. They have to be more productive and efficient. A way for firms to respond to this competition is to innovate. This seems a likely option for firms who have already established a dominant position on the domestic market (Cantwell, 1992).

Some papers have investigated the impact of import competition from low-wage countries on firms in developed regions like the EU and US. Researchers like Autor et al. (2012) and Bernard and Jensen (2006) have investigated this in relation to firm survival, employment and product prices in the US. Khandelwal (2010) relates quality ladders with employment rates and import competition from China. And then there are researchers that investigate these effects in the EU. Bloom et al. (2010), Colantone et al. (2013) and Mion and Zhu (2012) relate import competition from low-wage countries to innovation, total factor productivity (TFP), firm exit and upgrading. Import competition is found to increase innovation rates, TFP
and firm exit. Also, in developing countries employment in low-tech industries has fallen and firms are investing more in skill upgrading.

Based on these facts, this paper tries to investigate the following:

*How does import competition from low-wage countries affect product and process innovation in the European Union?*

There are several researchers who have investigated the effects of trade liberalization on innovation (Aghion et al., 2006; Bernard and Jensen, 2006; Mion and Zhu, 2012). More specifically, little attention has been given to the incentives that can be different for product or process innovation. This distinction is important for several reasons. First, it is harder to protect process innovation than product innovation when looking at intellectual property rights (Levin et al., 1987). Firms may be less willing to invest large amounts of money if their protection from competitors can’t be guaranteed for a longer period of time. Second, process innovation lowers the cost of production and so increases efficiency compared to a product innovation that does not or merely expands or improves the product range. So the incentive to invest in product innovation is determined by profitability of the new product. The incentive to invest in process innovation is determined by the slope of the firms' profit with regard to its own costs (the steeper the slope, the more motivated a firm is to reduce its costs (Boone, 2000). Third, the size of the business could favour either process or product innovation. Larger firms may benefit more from a process innovation since it applies to all products. In light of all this, a change in import competition may have different implications for product and process innovation. Hence, this research will try to contribute to the existing literature by providing a more in-depth look at the consequences for European Union manufacturing industries of import competition from low-wage countries. In this paper the following definitions are used. Product innovation is seen as a upgrade of an existing product or the creation of a new one and process innovation is seen as a upgrade of an existing production method.
This empirical research is one of the first to use the European Firms in a Global Economy (EFIGE) dataset. This is one of the first datasets that combine qualitative and quantitative information on a firm level for seven European Countries, covering 150 topics. This data covers the years 2007 till 2009, but was collected in 2010. The trade flows for low-wage and high-wage countries, since high-wage trade flows controls for imports from the rest of the world, will be measured by using the percentage growth and taken from Eurostat Comext.

This research indicates a negative correlation between imports originating from low-wage countries and product innovation. This could be due to the within-brand cannibalization (Dhingra 2013), the difference between short and long term effect or due to the economic circumstances within the time spam when the data was collected. This paper finds no specific evidence between pressure on firms due to imports from low-wage countries and process innovation. However, there is evidence for a positive correlation between high-wage imports and process innovation. The latter is in line with the 'trapped factor' model from Bloom et al. (2011).

The remainder of this paper is organized as follows: chapter 2 is a literature review of theory and evidence linking import competition from low-wage countries with innovation. This will conclude into the two testable hypotheses that are central in this research. Chapter 3 contains an explanation of the datasets that were collected and the base model that is used to test the hypotheses. Next, in chapter 4 the results are provided for both hypotheses. In chapter 5 there will be a discussion of the results. Finally, chapter 6 concludes the research, defining the limitations and implications for further research.
2. Literature review

There is a large body of literature devoted to the effects of trade liberalization policies on innovation. This chapter contains the theoretical and evidence basis that links import competition from low-wage countries with innovation, and more specifically product and process innovation. To conclude, the two hypotheses that are the pillars of this research are explained.

2.1 Theory

2.1.1. Economic theories on trade liberalization and innovation

To begin with, there is a link between trade liberalization and competition. One of the effects of trade is that it increases competition since it opens up the domestic market for foreign firms, thereby increasing the amount of firms competing for the same customers (Bernard and Jensen, 2006 and Syverson, 2010). Due to this increase in competition, firms' profitability are likely to drop, thus stimulating firms to become more efficient. As seen in previous research (Bloom et al., 2011 and Arrow, 1962), this could be achieved through innovation. So there is a link between competition and innovation.

To summarize, the following section explains the most important theories and models on how trade liberalization can increase competition and so stimulate firms to invest more in R&D resulting in innovation. To start off, one of the first theories on how competition may increase innovation and how recent literature has extended this model are discussed, followed by a closer look at how trade policies may stimulate competition and how heterogeneous firms react with innovation.

One of the first theories on innovation and competition was the Schumpeterian view (1943). According to this theory, large firms are more willing to innovate because they benefit more from R&D. Hence, the latter has more market power and better resources compared to smaller firms. The main incentive for innovation is that expected earnings are higher than if the firm would not invest in R&D. A research that extends this view was done by Aghion et al. (2005). They found an Inverted-U relationship when examining the effect that product
market competition (PMC) has on innovation. On one hand there is the 'the Schumpeterian effect' and on the other the 'escape competition effect'.

According to them, incentives to innovate are related to the difference between ex-ante and ex-post innovation rents. In other words, the difference between the profits of a firm before they invested in a certain innovation and the profits after use of the innovation. If there are high levels of PMC, there is relatively little profit for the firms competing in the market with a similar technological level. Due to innovation, these so called 'neck and neck' firms may escape the competition, also called the 'escape competition effect'. On the other side, low levels of competition have little stimulus for leading firms to innovate. They already have good profits, so there is little need to invest. However, firms that are lagging have greater ex-post innovation rents and therefore will invest in innovation. They can gain more from innovation. This is called the 'Schumpeterian effect'.

These two effects combined, translates as follows into an inverted U-shape: starting with low levels of competition will only motivated laggard firms to innovate creating and overall low level of innovation. Then, medium levels of competition give a limited motivation for both leading firms and laggard firms to innovation resulting in high levels of innovation. Finally, when there are high levels of competition, there are high incentives for leading neck and neck firms to innovate but little for laggard firms, since they are too far behind. This results in low levels of innovation. This is illustrated in figure 2.

Figure 2: the Inverted U-shape relationship between innovation and competition

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3 Source: Lecture C. Helmers February 2009
So now we know that an increase in competition can have a positive effect on innovation. The next step is to look at trade specifically and its effect on the firms’ incentives to innovate. A research that focuses on how trade liberalization can encourage exporting firms to invest more in technology in order to improve their productivity, was done by Bustos (2007). First, she used the existing model by Melitz (2003) on technological choice. The main concept of the Melitz’s model is that trade liberalization increases the overall productivity through a selection effect. This means that the more productive firms will increase their market share and the less productive firms will exit or drop in market share. She added technological choice to this model and investigated the effect of the multilateral trade agreement (MERCOSUR) in this framework.

The model that Bustos (2007) created goes as follows: firms pay a fixed cost when entering a new export market. This will most likely be done by productive firms, since they have higher revenues. This is the same as in Melitz’s model. To this she adds that firms have the choice to pay a fixed cost to take on a new technology. This will either benefit the quality of the good or drop the proportional marginal cost of it. This will also be most likely done by the highly productive firms, since they have higher potential exporting revenues. The drop in marginal production costs will make the good cheaper and will thus increase their sales. The increase in sales is higher than the costs for the new technology, because in her model demand is elastic. In other words, the export cost are fixed and the same for all firms, but the exporting revenues are higher for highly productive firms.

Now the effect of trade liberalization is brought into this model. Tariffs will drop, increasing the revenues of firms. More specifically, the revenues will increase because of a drop in prices abroad, thus increasing the amount of products sold. As mentioned earlier, only high productive firms with high revenues will take on a new technology and make it profitable, and since this increases the revenues, more and more firms will be able to adopt the new technology.
The model also compares the productivity of different companies and divides them into three different groups: at the bottom end there are low productivity firms that only distribute to their home market and use old technology. The middle group consists of medium productivity firms that use old technology but do export to foreign markets, and the final group consists of highly productive firms that use innovative technology and export goods.

The above two models explain how an increase in competition, one due to trade, induces innovation in general within firms. These theories make no specific distinction between trade with developed or developing countries. A model that does take this into consideration was created by Bloom et al. (2011). They created the so called ‘trapped factor’ model that builds on existing theories of how a drop in import barriers against low-wage countries affects technical change in developed countries. These 'trapped factors' are specific knowledge (firm-specific skills), brand capital and organizational resources to produce certain goods which are stuck in firms because of sunk costs and cost of adjusting.

The main concept goes as follows: firms may use their resources to do two things: produce old goods or produce new, innovative goods. On average, developing countries are more likely to produce old goods, compared to developed countries which are producing innovative goods and also (for a larger part of the time) old goods. Before agreements (as for example the WTO agreements), there were trade barriers preventing countries such as China from exporting their goods to developed countries. In other words, firms in the developed countries were protected by the trade barriers, allowing them to produce old goods.

The moment the import barriers fall, i.e. liberalization of trade with low-wage countries, the profitability of the old goods is reduced, since these low-wage countries are now exporting there old goods to the developed countries. The market in which the old goods were competing is now under a lot of competition, which decreases the profits. This opens up the opportunity to use these resources to create a new innovative good. In other words, the opportunity cost for these 'trapped factors' drops, also meaning a drop in innovation costs. In addition, since it is less profitable to produce these old goods, the relative cost of
producing new innovative goods also drops. Firms will be more willing to invest in new goods since there is less competition with larger profits to be gained. This mechanism will increase even more with a higher rate of import competition from low-wage countries.

The above mentioned effects increases the profits that might be gained from innovating. Moreover, the effect of lowering trade barriers against low-wage countries has a positive effect on welfare through innovation. This extra innovation has a small lasting increase in consumption and aggregate output. The model has two additional empirical implications. First, trade with high-wage countries such as OECD countries, will not have the same effect on innovation. They do not reduce innovation costs for new products, so old goods will remain. Second, firms that have more trapped factors, will automatically respond better to trade liberalization policies. They can allocate more 'trapped factors' and so innovate more to increase the firms productivity.

2.1.2. Economic theories on trade liberalization and product & process innovation

As shown above, the effects of import competition on innovation in general is widely covered in recent literature. However, when looking at innovation in a more in-depth way, it consists of a product and a process part. This distinction has been given relatively little attention with regard to import competition. This is strange, considering the fact that there are different incentives for firms to invest in one or the other. Research done mostly focuses on other links.

For example, Bonnano and Haworth (1996) looks at the type of competition (Cournot or Bertrand), and what quality firms are more likely to innovate in one or the other. In short, a high quality firm is more likely to invest in product innovation and a low quality firm in process innovation. Other research by Rosenkranz (2001) investigates product and process innovation simultaneously in a two-stage duopoly model. He found evidence that in the early stages of the product-life cycle, firms are more likely to invest in product innovation. During this period, the market is still new and growing rapidly, creating a lot of opportunities, and mass production has not yet started due to process in the process. In the later stage of the life cycle the companies invest more in R&D activities for process
innovation. During this time the market is flooded with a variety of the product and the market is stagnating.

Arrow (1962) could provide a some theoretical basis. His model relates to import competition from low-wage countries as follows. There are two kinds of competitive advantage for firms when facing increasing competition: cost leadership and differentiation (Porter, 1980). The first choice of cost leadership may be obtained with a drastic process innovation. This may be obtained if the marginal cost for a good of a domestic firm is lower than the price of the imports from low-wage countries. This makes the product of the low-wage country worthless.

If a firm opts for differentiation, product innovation would be inline. A firm in a competitive market will invest in product innovation if there is a lot of competition for the existing product and, due to innovation, the existing product is to become outdated. Rising imports from low-wage countries increases competition on the domestic market and so decreases the profits. In other words, the profits that were made with the old product are low, so the profit loss is low. This effect is in line with the Bloom et al. (2011) trapped-factor model. Also, the product innovation will be more successful if the consumer can distinguish a better quality of the domestic firm compared to the imports from low-wage countries.

A more recent research that provides a possible framework on how trade policy affects a firm’s investment decisions on product innovation and process innovation was done by Dhingra (2013). She distinguishes between product and process innovation by so called cannibalization and economies of scale. A product innovation cannibalizes the old product compared to a process innovation that does not. Economies of scale leads to a drop in cost for a firm due to an increase in market size.

A trade shock affects the market in two ways. It gives local firms the opportunity to expand to a larger market. On the other hand, it is the start of intensive competition and a higher demand elasticity. Both these positive and negative market effects influence the way a firm innovates in process or product.
A process innovation is more likely chosen by firms that are exposed to high levels of import competition as these increase market expansion resulting in larger economies of scale. The quantity of a good will increase, making the investments in the production process more profitable for the firm.

The choice for product innovation depends on the balance between within-brand cannibalization (demand for the original product falls) and across-brand competition (competing with other brands for the same consumers). The rise of import competition will induce firms to lower their within-brand cannibalization, so these firms reduce their product lines. This reduction in product reduces the firms visibility in a certain brand, thereby exposing it to high across-brand competition. The strength of these two dynamics determines the impact of trade policies on product innovation.

2.2 Evidence

This sub-paragraph builds on the above mentioned theories with more empirical evidence. To start with, a research that concentrated on the effects of trade with low-wage countries on developed countries was done by Bernard et al. (2006). They investigated these effects in the US manufacturing sector within and across industries from 1977 to 1997 using plant-level data. In this period the imports from low-wage countries were the fastest growing part of US trade. The advantage of plant-level data is that it allows the researchers to examine firm exit and product upgrading. Another benefit of this data relates to reallocation within industries. They expected that firms using labour as their main source for production would be effected more by trade than capital - and skill intensive firms in the same industry. Hence, a shift towards this sector with a comparative advantage is expected. In their research they used a new approach for measuring the exposure that industries face through international trade by looking at their comparative advantage.

Generally, they found evidence in three ways for reallocation. First, for industries that are more exposed to imports from low-wage countries, the effect is negative in terms of survival and employment growth. Second, within an sector there are labour - and capital intensive firms. If this sector is exposed to higher levels of competition, the performance gap will
enlarge between these two kinds of firms. Third and final, there is a positive link between import competition and firms switching industry. More specifically, if a firm switches industry, it is more likely it moves to one with less competition from low-wage countries and a more skill and capital intensive industry. To conclude, these three dimensions all indicate that the US firms are moving more towards their comparative advantage using exit, growth and industry switching. Also, over the period they investigated, the trade with low-wage countries has increased capital-intensity within and across the manufacturing industries.

Similar findings as described above are provided by Khandelwal (2010). He investigates the quality of US imports but doesn't use the conventional method of ‘the higher the price, the better the quality’. This quality method entails both price - and market share information. So, products with large price differences can have narrow quality gaps. This is translated into two types of quality ladders; long and short. A long quality ladder refers to a market where there is a broad range of different types of qualities and a short quality ladder refers to a narrow scope of different qualities that are in the market. He uses the impact of low wage countries, using the same definition as Bernard et al. (2006), on the US markets to measure the effect through the quality ladders.

In line with Bernard et al. (2006), he exhibited clear evidence that low-wage countries import has negative effects on industry employment. This effect is, however, weaker in industries with long quality ladders. A ten percentage point increase in low-wage competition will decrease employment with 1.4%. The same amount of import competition will decrease employment by 6% in average quality ladders. Furthermore, import competition has a similar effect on the quality ladders as it has on low - and high capital intensive industries. So, quality ladders are also a crucial measurement of how vulnerable an industry is to low-wage competition. In other words, they help to identify markets that will be challenged more severely by competition from low-wage countries.

Research that also focuses on the effect of low-wage countries in the US manufacturing industry was done by Autor et al. (2012). In contrast to Bernard et al. (2006) and Khandelwal (2010), they focus more specifically on China and its effect on the labour market from 1990 to 2007. They chose China because of its large economic growth over the past decade. This
growth is largely due to changes in the country itself. They are using more of their comparative advantage by using their cheap labour. Also, because trade barriers are being lowered they can import better technology from developed countries and thus increase their productivity.

To estimate the effects of trade on the local labour market, Commuting Zones (CZs) were developed. Commuting Zones are logical geographic units for defining local labour markets (Tolbert and Sizer, 1996), with a total of 722 for this research covering both metropolitan and rural areas. This allowed the researchers to test the trade shocks among different labour markets in the US. More specifically, these CZs are constructed in a way that allows to test for a number of labour effects such as employment wages and - levels, industry employment shares, unemployment and labour-force participation rates, but still allows for differences across age, gender and education.

They concluded that due to competition from low-wage countries, the US manufacturing sector sees increased unemployment rates, lower labour force participation and reduction in wages for employees. These effects explain one quarter of the total decline in the US manufacturing employment. They also concluded that import competition is associated with benefits in payments for unemployment, disability, retirement and healthcare. And yet, the welfare benefits gained from trade are still higher compared to the losses.

Their main focus was on China, but they also compared imports from China with other low-wage countries including China, and its effects on the US labour market. The effects of imports from both are nearly the same, suggesting that import competition from low-wage countries may have similar impacts on the US labour market.

In contrary to Autor et al. (2012) and Bernard et al. (2006), Schott (2008) investigates the rise of China’s export to the US including and comparing exports from OECD countries. He distinguishes between two dimensions. First, he compares a set of manufactured goods exported by China and by OECD countries to the US. Second, he investigates the export prices of goods sold by Chinese and OECD countries. This shows the competition between
these two parts on the markets. He uses US product level import data in the manufacturing industry ranging from 1972 to 2005.

His paper concludes with several important and surprising results. There is an overlap of China and OECD countries across products. A possible explanation may be found in recent trade models. There is a growing demand for variety in consumer products and demand for countries that are able to supply this. The supply comes from large economies that produce and export a wide range of goods.

Furthermore, in most industries the Chinese export prices are lower compared to countries of the same level of development, although they increase over time. This suggests that competition on a price level between China and OECD countries may be less direct. This could be due to the fact that firms in developed countries are exiting the market or upgrading their products to escape the competition from low-wage countries. The last reaction, upgrading of products, would be most in line with the existing models of product cycling. In other words, countries will focus on their skill or capital abundant advantage and make products accordingly. If this is indeed the case, there is a chance that high technology countries will continue to survive the competitive pressure from low-wage countries.

This is in line with the research from Bernard et al. (2006) mentioned earlier. They also find evidence that firms are moving up because of increasing competition. Furthermore, firms are more likely to move to skill - and capital intensive industries. Moreover, with firms that are exposed to the same amount of import competition, the firms that are relatively more capital intensive are more likely to stay in the market and grow. This means that firms change the goods they produce in line with the US comparative advantage. In other words, these adjustments of firms suggest they are moving towards a more sophisticated product mix.

Another research that investigates the effects of import from China on a country level was done by Bugamelli et al. (2010). They use Italian manufacturing firm level data for the period 1990 to 2006 to investigate the effects of China on firms pricing strategies in different technological sectors and different firms sizes. They estimated this by using a firm level pricing model that allows for cost shocks, domestic competition and import penetration,
firms size and productivity, and for time and sector effects. The advantage of using firm level prices compared to sector prices is, that it leads to more detailed results. Another advantage of this research is that disaggregated data was used, which allows them to control for heterogeneity across sectors and firms. In line with Mion and Zhu (2012), they use an instrumental variable to address the endogeneity biases. They instrument the share of Chinese exports to Italy in the industry of interest and the exports to Italy from the world in total. This is done so they can isolate factors on China’s exports with regard to industry dynamics and trade policies. In other words, firms in Italy that are shrinking do not influence export from China.

They conclude the following. The increase of trade with China has a negative impact on firms’ prices and mark-ups. This effect is stronger for firms that sell most of their product on the domestic market and also relatively small firms in sectors like textile, apparel and leather, where the price is more important for the consumer. Hence, small firms are less likely to compete because of large cost in R&D, innovation and other marketing activities. According to Bugamelli et al. (2010), these results are among the first to provide evidence for a recent international trade theory, that states that increased foreign competition, like that from low-wage countries, impacts domestic firms’ prices and profits. This will eventually lead to some less productive firms leaving the market, thus leaving only the productive ones and so increasing the overall productivity of the industry.

So far, the above mentioned researchers have investigated the effects of low-wage import competition on firm survival, exit, skill upgrading, pricing and employment in developed countries. There is a stream of literature that looks at the effects of import competition from low-wage countries on innovation in general. Bloom et al. (2011) belongs in this category. They examined the effects from Chinese import competition on 12 EU countries from 1996 through 2007. They investigated what the effects were on IT, R&D and TFP, using a dataset containing half a million firms. In their approach they differ from other research, in that they investigated import competition from low-wage countries on the above mentioned facts by addressing three major problems of previous research. First, they used recent data to examine the role that trade has on technical change in developed countries. Second, they also included off shoring to China, and third they examined the effects of trade with China
on IT, R&D and TFP by using a large dataset containing firms. Moreover, they did not only look at the effect of trade on technology within firms, but they also examined the reallocation effect.

They tackled the endogeneity issue that exists, due to an unobservable technology shock correlating with the rise of Chinese imports, by using several strategies. First, they used the entry of China into the WTO, and the agreement before that (Multi Fiber Agreement), as an additional instrumental variable. Second, they controlled for different liberalization policies in China and its effects on the EU. It turned out there was a larger impact on the EU firms where China had a comparative advantage. Last Bloom et al. (2011) controlled for different industry-specific effects. In general, all these strategies are in line with the conclusion that trade with China stimulates technical change.

They found several important results. Chinese import competition has a positive effect on TFP and innovation within companies, meaning that companies that are exposed to high levels of import competition from China, apply for more patents, invest more in R&D and have a higher TFP. Another result they found was that Chinese import competition has a negative effect on employment and firm survival in low-tech industries. More specifically, firms that invest less in R&D and IT and that have a lower TFP, are more likely to shrink and exit compared to high-tech firms under the same circumstances. These two results lead to an increase in technological upgrading for firms that are most affected by import penetration from China. They also found evidence that competition from China leads to lower prices, lower profitability and less demand for unskilled labour. This is translated into the following statistics. From 2000 to 2007 China accounted for nearly 15% of the increase for firms patenting, IT intensity and productivity. This percentage rose to 20% in the period from 2004 to 2007. This growth suggests that import competition with developing countries has an important impact on the above mentioned factors.

Relating to the previously mentioned 'trapped factor' model, they concluded two implications. In line with Schott (2008), import penetration from low-wage countries has a more significant effect on innovation in the EU compared to import from developed countries. It means that import from low-wage countries has a disproportionate effect on
profits in low-tech firms, so they have great incentives to invest in R&D to innovate. Second, a firm that has more trapped factors, will be more affected by import competition from low-wage countries. In other words, the more trapped factors a firm has, the more it produces old goods. When there is a trade shock, these factors will no longer be trapped.

Increasing R&D is supposed to go parallel with skill intensity. To increase the level of R&D, firms will need to upgrade their existing workers or employ high tech workers. A research that investigates this link was done by Mion and Zhu (2012). They investigated the effects of import competition from China and other low-wage countries on the Belgian manufacturing industry over the period 1996 to 2007, using firm level data. This data allows them to also distinguish the different kind of effects from off shoring and import competition. They use similar analyses to Bernard et al. (2006), but apart from focussing on firm employment growth and exit, they also focus on skill upgrading.

Mion and Zhu (2012) state that technological upgrading and skill upgrading are in the same group. It is hard to keep the two apart, since skill upgrading requires an upgrade of technology and the other way round. However, they did control for technology expenditure, and found that skill upgrading gives a more significant explanation as to how firms respond to import competition from China.

They used different firm level imports to distinguish between intermediate and final goods by country of origin. Using firm level data has a drawback, since there could be an endogeneity problem. They addressed the endogeneity problem by applying an Instrumental Variable (IV) strategy, utilizing product country level tariffs and trade weighted exchange rates. This strategy can indeed reveal if there is a causal relationship. To construct this, the nominal exchange rates and ad valorem tariffs variables are taken. Compared to other research, Mion and Zhu (2012) were able to measure the workers’ skill by education level. This enabled them to make a more specific distinction between production and non-production workers.
At industry level, import from China has a negative impact on firm employment growth, but it also stimulates firms to upgrade their skill level in low-tech manufacturing industries. Contrary to research mentioned earlier, import from goods originating from China has no effect on firm survival. On the other hand, a firms’ chances to survive increase through offshoring the production of finished goods to China. They also found a large effect on skill upgrading. Due to import competition from China, they determined a 27% increase in the share of highly educated workers in low-tech Belgian manufacturing sectors. This is in line with the results from Bloom (2011), who also found within firm technological upgrading.
3. Hypothesis

The previous section described the theoretical and empirical evidence that surround innovation and import competition. This section will provide the hypotheses that form the pillars of this empirical paper.

As stated in the introduction, the rise of low-wage countries has increased dramatically over the last decade. These low-wage countries are exporting more and more products to European countries. This increases the competition in the domestic market, reducing profits gained by local firms. As stated earlier, there are several theories supporting a positive link between competition and innovation (Aghion et al., 2005). More specifically, trade liberalization may increase competition and firms’ choices to upgrade their technology (Bustos, 2007). Finally, there is a specific theory from Bloom et al. (2011) that distinguishes between imports from developed and developing countries and their effect on innovation. This theory predicts an even stronger effect on innovation for low-wage trade. When looking more in-depth at innovation, there are several theories supporting a positive link between trade liberalization stimulating competition and a firm’s motives for product and process innovation. In particular the model by Dhingra (2013) predicts that trade liberalization has a positive effect on process innovation through economies of scale. Also, firms in developed countries are challenged by lower prices of goods from low-wage countries. To compete on this level, they will have to become more efficient. Therefore, process innovation could be an appropriate action.

Dhingra (2013) states that trade liberalization can have either a positive or negative effect on product innovation. This depends on the balance between within-brand and across-brand cannibalization. However, I expect that trade from low-wage countries will have a positive effect on product innovation since it opens up ‘trapped factors’ (Bloom et al, 2011).
Motivated by the above mentioned facts, there are good reasons for expecting a positive impact on both product and process innovation. I therefore expect the following;

Hypothesis 1

*Increasing import competition from low-wage countries induces European manufacturing firms to increase product innovation.*

Hypothesis 2

*Increasing import competition from low-wage countries induces European manufacturing firms to increase process innovation.*
3. Data and Methodology

The first part of this chapter offers an explanation of how the data was collected. In the second section the methodology and model will be presented and explained in relation to the research. Moreover, a short description of a probit model will be given.

3.1. Data description

For this empirical research two rich datasets are used. 'EFIGE – European Firms in a Global Economy' is the first dataset for the dependent variables, namely product innovation and process innovation, and was collected from Bruegel\(^4\), an independent European think tank specializing in economics, established in 2005. It combines quantitative and qualitative information on roughly 150 items divided over 6 subsections including 'workforce' and 'investment, technological innovation, R&D' which are important for this paper. This dataset contains 14,759 firms (over 10 employees) in the manufacturing industry for the following seven European countries: Austria, France, Germany, Hungary, Italy, Spain and the United Kingdom. Special attention has been given to make sure that this dataset is a proper representative. For the large countries, 3,000 firms were sampled and for the smaller ones 500. Also, for some key questions a minimum response rate of 85-90% was established. A total of 135,000 firms were contacted to construct the final dataset. The data was collected in 2010, covering the years 2007 through 2009 and contains 2-digit NACE (rev.1.1.) industry information on the industries in which firms compete. NACE codes are the European classification of economic activities. More specifically, these codes range from 15 to 37 for the manufacturing sector.

The second dataset was collected from Eurostat Comext. From this dataset the international trade flows from low-income countries and the rest of the world were collected, also using the NACE 2-digit industry codes. Thus, the two datasets were combined using the same NACE 2-digit industry codes. To measure the effect of import competition from both low- and high-wage countries the following years were taken into account. Since the data

\(^4\) The methodology of Breugel variables is provided on 'The EU-EFIGE/Breugel-Unicredit Dataset, October 2012' http://www.bruegel.org/publications/publication-detail/publication/753-the-eu-eFIGE-breugel-unicredit-dataset/
considering the dependent variable covers the years 2007 till 2009, trade flows before 2007 are of importance. To get a more respective analysis, a 5 year time frame was taken (2002 - 2006). Then the percentage growth, so the trade flows from 2006 relative to 2002 were calculated to get a good estimation of the total trade flows. The definition and list of low-wage countries is taken from Bernard et al. (2006). A country is defined as low-wage if it has a GDP lower than 5 percent of the U.S. per capita GDP. The 'rest of the world' are all the countries except the low-wage countries. Furthermore, various control variables were collected from EU Klems, namely: domestic production, materials, capital and number of employees.

For more specific information about the data, a list of countries with number of firms that were questioned, representation of the NACE 2 digit industries and Bernard et al. (2006) list of low-wage countries can be found in tables A1, A2, A3 and A4 respectively in the appendix.

3.2. Methodology

The base model for this empirical research for analysing the two hypotheses is as follows:

\[ Y_{ij} = \beta_0 + \beta_1 \Delta \text{IMP-LOW}_{ij} + \beta_2 \Delta \text{IMP-HIGH}_{ij} + \beta_3 \text{CAP-INT}_{ij} + \beta_4 \text{MAT-INT}_{ij} + \beta_5 \text{DOM-PRO}_{ij} + \beta_i + \beta_j + \varepsilon_{ij} \]

The first variable \( Y_{ij} \) stands for the two possible dependent variables: product innovation and process innovation. Also, \( z \) stands for firms, \( i \) industries and \( j \) countries. \( \text{IMP-LOW} \) stands for the import change originating from the low-wage countries and \( \text{IMP-HIGH} \) represents import change from the rest of the world, excluding the low-wage countries. \( \beta_i \) represents the industry-specific effects and \( \beta_j \) the country-specific effects, and \( \varepsilon_{ij} \) is an error term. They are included in the model to control for unobserved heterogeneity. The control variables are represented by \( \text{CAP-INT} \) for capital intensity, \( \text{MAT-INT} \) for material intensity and \( \text{DOM-PRO} \) stands for domestic production. All the variables are explained at length in the remaining of this section.

For the regression the following measures were taken to make sure the results are correct. In short, to control for heteroskedasticity robust standard errors were used. Also, to control for correlation of the error term across observations, the standard errors were clustered at a country level. Finally, correlation between certain variables was tested. In particular,
Correlation between import low income countries and high income countries is 0.39, which does not reveal a cause for concern.

**Dependent Variables:**

**Product Innovation:** is a binary variable taking the value 1 if the firm invested in a product innovation and 0 otherwise. In the Breugel EFIGE dataset there is a subsection 'investment, technological innovation, R&D'. The following question captures the product innovation: ‘On average in the last three year, did the firm carry out any product innovation?’ A total of 7,120 firms carried out a product innovation, which is 49.16% of the total. The other 7,363 firms did not carry out a product innovation, representing 50.84%.

**Process Innovation:** is a binary variable taking the value 1 if the firm invested in a process innovation and 0 otherwise. In the EFIGE data this variable was covered by the following question: 'On average in the last three years, did the firm carry out any process innovation?' A total of 6,355 firms did indeed carry out a process innovation, which represents 43.88% of all firms. The other 8,128 did not perform a process innovation, a total of 56.12%.

**Independent variables:**

**Imports originating from low-wage countries (IMP-LOW):** the percentage change in imports from low income countries between 2002 and 2006. This variable is taken from Eurostat. It is constructed using the following formula:

\[ \Delta \text{IMP-LOW} = \frac{\text{IMP}_\text{LOW} 2006 - \text{IMP}_\text{LOW} 2002}{\text{IMP}_\text{LOW} 2002} \]

This is the most important independent variable for the two hypothesis.

**Imports originating from the rest of the world (IMP-HIGH):** the percentage change in imports from low-wage countries between 2002 and 2006. This variable was also accumulated from the Eurostat and it measures the amount of competitive pressure from the rest of the world, excluding the low income countries. This variable is taken into this model to control for import competition from other countries that might be correlated with low-wage countries. It is calculated by the following equation:

\[ \Delta \text{IMP-HIGH} = \frac{\text{IMP}_\text{HIGH} 2006 - \text{IMP}_\text{HIGH} 2002}{\text{IMP}_\text{HIGH} 2002} \]
**Control variables**

**Capital intensity (CAP-INT):** is calculated by dividing capital compensation over domestic production and taking the log. It is expected that capital intensive industries invest more in R&D, which could lead to firms innovating. This variable is taken from EU Klems for the year 2006.

**Material intensity (MAT-INT):** this variable is calculated by dividing materials over domestic production and also taking the log. This variable controls for industries that are relatively more material-intensive. This variable is also taken from EU Klems for the year 2006.

**Domestic production (DOM-PRO):** this is a proxy for size of the industry in logs. It could be expected that a larger industry may be more innovative and more productive (Bloom et al., 2011). The variable controls for this effect. The source for this variable is EU Klems and also represents the year 2006.

**3.2.1. Probit model**

In this research the two dependent variables are binary. Hence, a probit regression is implemented, which is a binary outcome model. The problem with a OLS regression is that the predicted probabilities will not be within the interval [0, 1]. In other words, it could take on the value of -0.5, for example. This has no meaning for this research. For a probit model the dependent variable can only take two categories. This is interesting for both hypothesis, where the binary dependent variable can take either the value “yes” or “no”. A disadvantage of using a probit model, as compared to a linear regression, is that it is not possible to interpret the magnitude of the coefficient directly. However, this may be done by calculating the marginal effects of the regressors.
4. Results

In this chapter the empirical results will be provided and discussed. The estimation procedure is as follows: at first a probit regression is run with only the main independent variable of low income trade flows, also including country and industry specific effects. The second step is a probit regression with high-wage trade flows beside the previously mentioned variables, and all three control variables. Both the estimated coefficients and marginal effects are shown. To start off, the results for the first hypothesis concerning product innovation will be examined an then for process innovation.

4.1. Product Innovation

Table 1 shows the results of the probit regression and the average marginal effects for hypothesis 1 as relating to product innovation. The first and third column only include the most important independent variable (change of import from low-wage countries). In the second and fourth regression all control variables are included. The coefficient of import from low-wage countries is always negative and significant and thus does not provide evidence for a positive relationship between the import from low-wage countries and product innovation in the EU countries. More specifically, when looking at the marginal effects, the following can be concluded: a one unit change in import competition from low-wage countries means firms in EU countries are 0.7 % less likely to invest in a product innovation, ceteris paribus.
### Table 1:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ IMP Low wage countries</td>
<td>-0.007* (0.004)</td>
<td>-0.010** (0.004)</td>
<td>-0.007* (0.004)</td>
<td>-0.009* (0.004)</td>
</tr>
<tr>
<td>Δ IMP High wage countries</td>
<td>0.066 (0.043)</td>
<td>0.067 (0.043)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ln Capital Intensity</td>
<td>0.026 (0.031)</td>
<td>0.026 (0.031)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ln Material Intensity</td>
<td>-0.215 (0.157)</td>
<td>-0.215 (0.157)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ln Domestic Production</td>
<td>0.025** (0.012)</td>
<td>0.025* (0.012)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Country Dummies</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Industry Dummies</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Observations</td>
<td>14,483</td>
<td>14,398</td>
<td>14,483</td>
<td>14,398</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.042</td>
<td>0.043</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 1 Notes:** ** denotes 1% significance; * denotes 5% significance; + denotes 10% significance. The estimation is done by using standard errors clustered by country in parentheses. This sample consist of seven EU countries, with a change in import from 2002 to 2006.

### 4.2. Process Innovation

Table 2 reports the results on hypothesis 2, the impact from trade with low-wage countries on process innovation. Again, the same estimation procedure has been taken. Columns one and three just show the most important independent variable and two and fourth the complete model.

The variable low-wage trade is insignificant with and without control variables. So, no specific evidence could be found to support a relationship between import competition from low-wage countries and incentives for firms to invest in process innovation. However, import from the rest of the world is positive and significant at a 10% level. In other words: a one unit change in import competition from the rest of the world means that firms in EU countries are 6.4% more likely to invest in a product innovation, ceteris paribus.
Table 2:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Probit</td>
<td>Probit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ IMP Low wage countries</td>
<td>0.002</td>
<td>0.001</td>
<td>0.002</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Δ IMP High wage countries</td>
<td>0.063*</td>
<td>0.064+</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.039)</td>
<td>(0.039)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In Capital Intensity</td>
<td>0.007</td>
<td></td>
<td>0.007</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.032)</td>
<td></td>
<td>(0.032)</td>
<td></td>
</tr>
<tr>
<td>In Material Intensity</td>
<td>-0.047</td>
<td>-0.047</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.080)</td>
<td>(0.080)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In Domestic Production</td>
<td>-0.003</td>
<td>-0.003</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.010)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Country Dummies</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Industry Dummies</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Observations</td>
<td>14,483</td>
<td>14,398</td>
<td>14,483</td>
<td>14,398</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.016</td>
<td>0.016</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2 Notes:** ** denotes 1% significance; * denotes 5% significance; + denotes 10% significance. The estimation is done by using standard errors clustered by country in parentheses. This sample consists of seven EU countries, with a change in import from 2002 to 2006.
5. Discussion

In contrast to some literature, this paper finds a negative effect between imports originating from low-wage countries and the product innovation rates for EU firms. This means that no specific evidence was found to support hypothesis 1, but rather that the opposite effect seems true. A research done by Bloom (2011) found that trade with a low-wage country has a positive effect on innovation rates in general. Firms invest more in IT and R&D. Also, Bugamelli (2010) concluded that trade with a low-wage country will have a positive effect on large firms’ investments in innovation.

When looking at the theory, a possible explanation for the negative relationship can be found in the model from Dhingra (2013). It could be that the within-brand cannibalization is dominant. Imports mean fiercer competition and high demand elasticities. An appropriate measure for firms facing this fierce competition is to invest in process innovation due to its economies of scale. There is a larger market to export the existing product to without facing the within-brand cannibalization. In other words, firms are cutting back on internal competition within their own brand and choose to decrease product innovation. When looking at this practice, a quote by Steve Jobs (2004), founder of Apple is relevant: “What’s the point of focusing on making the product even better when the only company you can take business away from is yourself?”. In other words, he refers to losses that could arise when producing a new good, especially when your existing product is generating profits.

There are several other intuitive explanations for the above result. One possible explanation is the difference between a short and a long term effect of import competition. Previous research measured the effect over a longer period of time, normally around 10 years. This research looks at firms investing in product and process innovation between 2007 till 2009, but has only one observation per firm. In other words, this is a cross-section data set. As mentioned earlier, trade flows before 2007 are of importance. To get a more respective analysis, a 5 year time frame was taken, starting from 2002 and ending in 2006. Firms may be at the start of their analysing process of the possible impact on the market and may still be wondering how to respond, a process which takes time. Once they have done their analysis, they might decide to react with product innovation(s). And then it takes time for
the outcome (innovation) to be measurable. A decision taken today will materialise in the future.

A different explanation could lie in the economic circumstances that firms in the EU find themselves in. One of the largest economic crises in recent history started around 2007, which falls in the period of the dataset by BREUGEL. This extreme shock might well have caused firms to become less willing to invest in products. Their main aim might well be to just stay alive and drop costs, rather than invest in a new product without guarantees for success.

Based on the statistical data used, this paper doesn’t find evidence between import penetration from low-wage countries and process innovation for EU firms in the manufacturing industry. So, hypothesis 2 cannot be confirmed. However, what can be concluded is that import competition from high income countries does induce EU firms to invest more in process innovation. This is in line with the results from Bloom et al. (2011), who used the trapped factor model. They conclude indeed that trade with both developed and developing countries will induce EU firms to invest more in innovation in general.
6. Conclusion

This research is one of the first that attempts to give a more in depth view of the impact of import from low-wage countries on product and process innovation separately on the EU manufacturing industry. This distinction is important, since there are different incentives to invest in one or the other. Recent literature has covered this subject, but only by looking at innovation in general, concluding that trade has a positive effect on innovation in the manufacturing industry, and even more so in case of trade with low-wage countries.

To investigate the import effects on product and process innovation separately, a cross section dataset was used and collected over the years 2007 till 2009. This dataset contains information of 7 EU countries with a total of nearly 15,000 firms in the manufacturing industry. A product innovation is defined as an upgrade of an existing product or the creation of a new one. A process innovation is seen as an upgrade of an existing production method. These two dependent variables are measured by a dummy variable that takes the value 1 if the firm has implemented a type of innovation and 0 if the firm has not done so. The empirical model also contains imports from high-wage countries, and several control variables. Moreover, country and industry specific effects were taken into account to control for unobserved heterogeneity.

In short, this research finds evidence of a negative correlation between imports originating from low-wage countries and product innovation. This could be due to the within-brand cannibalization (Dhingra 2013), the difference between short and long term effect, or due to the economic circumstances within the time span of the data collection. This paper finds no specific evidence between pressure on firms due to imports from low-wage countries and process innovation. However, there is evidence for a positive correlation between high-wage imports and process innovation. The latter is in line with the ‘trapped factor’ model from Bloom et al. (2011).

This paper may be seen as a first step towards further investigation into product and process innovation in relation to import from low-wage countries. More research needs to be done before any policy implications can be stated.
As in most research, there are several limitations to this paper that are important to mention here. The most serious limitation is that the kind of data used for this research is cross sectional. The disadvantage of using this kind of data is that the firms are only counted at one point in time. A better judgement could have been given with a dataset containing information of the same firms at several points in time. This would be a better approach to finding the correlation over a longer time frame, since it may take a few of years before a firm responds to changes in import. Unfortunately, such a panel dataset was not available.

Another limitation is, that only seven European countries were taken into consideration. They represent only one fourth of the total number of members of the EU. There might be specific dynamics in different parts of the EU, resulting in different reasoning for investing in a product or process innovation.

There are several aspects that haven’t been investigated in this paper, that are interesting for future research. It would be worth investigating the motives for choosing either process or product innovation. In other words: what are the mechanisms that drive product and process innovation? And what type of firms in what industries, i.e. low, medium or high tech industries, are more likely to use product or process innovation and for what reasons?

Finally, this research could be broadened by incorporating more countries, such as the U.S.A. and other EU countries, providing that the necessary datasets are available. Indeed, countries (and even regions) might respond differently to the imports from low-wage countries.
References


Appendix A

Table A1: The EFIGE dataset by country

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>443</td>
</tr>
<tr>
<td>France</td>
<td>2,973</td>
</tr>
<tr>
<td>Germany</td>
<td>2,935</td>
</tr>
<tr>
<td>Hungary</td>
<td>488</td>
</tr>
<tr>
<td>Italy</td>
<td>3,021</td>
</tr>
<tr>
<td>Spain</td>
<td>2,832</td>
</tr>
<tr>
<td>UK</td>
<td>2,067</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14,759</strong></td>
</tr>
</tbody>
</table>

Table A2: Distribution of firms by country and size class

<table>
<thead>
<tr>
<th>Class size</th>
<th>AUT</th>
<th>FRA</th>
<th>GER</th>
<th>HUN</th>
<th>ITA</th>
<th>SPA</th>
<th>UK</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employees (10-19)</td>
<td>132</td>
<td>1,001</td>
<td>701</td>
<td>149</td>
<td>1,040</td>
<td>1,036</td>
<td>635</td>
<td>4,694</td>
</tr>
<tr>
<td>Employees (20-49)</td>
<td>168</td>
<td>1,150</td>
<td>1,135</td>
<td>176</td>
<td>1,407</td>
<td>1,244</td>
<td>805</td>
<td>6,085</td>
</tr>
<tr>
<td>Employees (50-249)</td>
<td>97</td>
<td>608</td>
<td>793</td>
<td>118</td>
<td>429</td>
<td>406</td>
<td>519</td>
<td>2,970</td>
</tr>
<tr>
<td>Employees (over 250)</td>
<td>46</td>
<td>214</td>
<td>306</td>
<td>45</td>
<td>145</td>
<td>146</td>
<td>108</td>
<td>1,010</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>443</td>
<td>2,973</td>
<td>2,935</td>
<td>488</td>
<td>3,021</td>
<td>2,832</td>
<td>2,067</td>
<td>14,759</td>
</tr>
</tbody>
</table>
Table A3: NACE 2 Digit codes by industry

<table>
<thead>
<tr>
<th>Nace Code 2</th>
<th>Version Nace</th>
<th>Description Nace Code 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>2.0</td>
<td>Manufacture of leather and related products</td>
</tr>
<tr>
<td>16</td>
<td>2.0</td>
<td>Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials</td>
</tr>
<tr>
<td>17</td>
<td>2.0</td>
<td>Manufacture of paper and paper products</td>
</tr>
<tr>
<td>18</td>
<td>2.0</td>
<td>Printing and reproduction of recorded media</td>
</tr>
<tr>
<td>19</td>
<td>2.0</td>
<td>Manufacture of coke and refined petroleum products</td>
</tr>
<tr>
<td>20</td>
<td>2.0</td>
<td>Manufacture of chemicals and chemical products</td>
</tr>
<tr>
<td>21</td>
<td>2.0</td>
<td>Manufacture of basic pharmaceutical products and pharmaceutical preparations</td>
</tr>
<tr>
<td>22</td>
<td>2.0</td>
<td>Manufacture of rubber and plastic products</td>
</tr>
<tr>
<td>23</td>
<td>2.0</td>
<td>Manufacture of other non-metallic mineral products</td>
</tr>
<tr>
<td>24</td>
<td>2.0</td>
<td>Manufacture of basic metals</td>
</tr>
<tr>
<td>25</td>
<td>2.0</td>
<td>Manufacture of fabricated metal products, except machinery and equipment</td>
</tr>
<tr>
<td>26</td>
<td>2.0</td>
<td>Manufacture of computer, electronic and optical products</td>
</tr>
<tr>
<td>27</td>
<td>2.0</td>
<td>Manufacture of electrical equipment</td>
</tr>
<tr>
<td>28</td>
<td>2.0</td>
<td>Manufacture of machinery and equipment n.e.c.</td>
</tr>
<tr>
<td>29</td>
<td>2.0</td>
<td>Manufacture of motor vehicles, trailers and semi-trailers</td>
</tr>
<tr>
<td>30</td>
<td>2.0</td>
<td>Manufacture of other transport equipment</td>
</tr>
<tr>
<td>31</td>
<td>2.0</td>
<td>Manufacture of furniture</td>
</tr>
<tr>
<td>32</td>
<td>2.0</td>
<td>Other manufacturing</td>
</tr>
<tr>
<td>33</td>
<td>2.0</td>
<td>Repair and installation of machinery and equipment</td>
</tr>
<tr>
<td>35</td>
<td>2.0</td>
<td>Electricity, gas, steam and air conditioning supply</td>
</tr>
<tr>
<td>36</td>
<td>2.0</td>
<td>Water collection, treatment and supply</td>
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Table A4: Low-wage countries by Bernard

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