Heterogeneous Globalization: Offshoring and Reorganization*

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Abstract

This paper examines the role of globalization on firm reorganization. We study the effects of offshoring on firm importing and domestic activities such as production and innovation. Unique survey data provide a direct measure of offshoring and its links to firms' trading decisions. Rather than hollowing out their domestic production, offshoring firms are likely to produce and import the same products, even after offshoring begins. A new measure of offshoring based on a firm's imports of its domestically produced goods allows the separation of imports into competing flows and those under its control. The paper exploits these differences to identify the impact of offshoring on firms' decisions to reallocate labor from production work to technology and innovation-related occupations. This reallocation of workers is accompanied by increases in offshoring firms' product development and R&D spending. Firm reorganization reveals a new channel through which offshoring affects innovation, and may ultimately affect economic performance and growth.

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1 Introduction

A growing number of studies conclude that low-wage imports, and Chinese imports in particular, are reducing US manufacturing employment (Autor et al., 2013, 2014; Pierce and Schott, 2016).[1] A potential puzzle for these papers, however, is that even as manufacturing employment has declined, real value added has continued to rise at about the same rate as GDP. Moreover, this output growth has occurred in some of the same sectors in which import penetration has been rising. One potential explanation for the role of trade in the divergence between manufacturing employment and output is that imports reflect not only the import competition channel emphasized in the papers above, but also foreign sourcing and production fragmentation decisions made by firms that continue their domestic operations.

In this paper, we study the effects of offshoring by analyzing its relationship with importing and its effects on firms' remaining domestic activities. We use detailed new data to provide a clear measure of offshoring and to document how it relates to firms' trading decisions. Rather than hollowing out their domestic production, offshoring firms are likely to produce and import the same products, even after offshoring begins. We propose a measure of offshoring based on a firm's imports of goods that it produces domestically, which differs markedly from measures based on imported goods that the importer does not produce. Standard measures of import competition contain both types of imports, thereby confounding the effects of import competition and offshoring. We exploit these differences between offshoring and import competition to identify the impact of offshoring on firms' decisions to reallocate labor away from direct production work towards technology and innovation-related occupations.

We measure a firm's offshoring decision using novel data from a survey in which Danish firms were directly asked whether they relocated their core activity to a foreign location between 2001 and 2006. This relocation could occur within or outside the boundary of the

[1] Negative effects of Chinese imports are not limited to the US, see Mion and Zhu (2013) for evidence from Belgium and Ashournia et al. (2014) for Denmark.

firm, i.e. inside multinationals or between arm's length firms, and explicitly covers only those activities that were previously performed in Denmark. The survey was administered in 2007 by Statistics Denmark and sent to all private firms with at least 50 employees, and to firms with 20-50 employees in selected industries. We combine these data with information on firm employment, sales, production, input usage, R&D expenditure, imports, and exports to create a rich new dataset for studying the ramifications of globalization.

The data show that nine percent of surveyed Danish firms relocated their core activity to a foreign region between 2001 and 2006. Among these offshorers, Eastern European countries that joined the European Union in 2004 and 2007, collectively referred to as the EU12, were the most popular destinations. 54 percent of Danish offshoring firms located to these EU12 countries. One third of the offshoring firms relocated their core activity to China, making it the second most popular destination. We use the new offshoring data to assess the extent to which offshoring is associated with importing. As expected, we find that the majority of firms that relocate production to a particular region re-orient their imports towards that region. When we delve into importing further, we find that offshoring firms disproportionately grow their imports of the same detailed products that they produce domestically. In contrast to common perceptions about offshoring displacing domestic activities, however, we do not see significant declines in these firms' domestic production of those same goods. Instead, offshorers seem to focus domestic production on higher quality versions of the same products that they import.

An important contribution of the paper is to show how the decision to offshore relates to a firm's innovative activities. A major policy concern with the rise of production fragmentation and offshoring is that innovative, productivity-enhancing activities will also move offshore. To assess this relationship, we first provide descriptive evidence that shows offshoring firms increase their share of technology workers in total employment from 17 percent in 2001 to 24 percent by 2008. In contrast, non-offshorers' share of technology workers remains below 15 percent. While this evidence is suggestive of an important role for offshoring in

a firm's allocation of resources towards R&D and innovation, it is unclear what drives the relationship. Firms that want to re-focus their domestic attention on innovation may relocate their core activity to a foreign region to facilitate this transition. Alternatively, firms that face new challenges and competition from imports may select into offshoring as a way to lower costs and remain competitive. These firms may also plan to cut back on innovation as a way to shore up resources and avoid exit altogether. In line with this type of negative selection, we find that increased Chinese import competition in a firm's industry is associated with an increased likelihood of offshoring to China and the EU12.

To address these issues, we implement an instrumental variables (IV) strategy in which we identify changes in a firm's offshoring decisions due to factors external to both the firm and Denmark. Specifically, we exploit the fact that the 12 new EU member states underwent significant productivity growth, and therefore changes in comparative advantage, during the offshoring period due to internal requirements for accession to the EU. We measure variation in their comparative advantage growth across detailed product categories using changes in six-digit HS product export shares by the EU12 countries to the rest of the world (ROW), excluding Denmark. Using changes in EU12's export shares rather than changes in levels rules out growth that might be driven by aggregate demand or technology shocks that could increase trade in particular products across all countries. We assign these product-level shocks to firms based on the firm's pre-period production shares across products.

Our IV strategy identifies firms that began offshoring to the EU12 as a result of improved productivity in products relevant to the firm. The key identifying assumption is that the common within-product component of the relative increase in regional productivity is due to increases in EU12 productivity. The exclusion restriction requires that the foreign region's increased productivity only affects a firm's innovative activities through its impact on the offshoring decision. This restriction would be violated if improvements in EU12 comparative advantage also led to increased competition from the EU12, and that increased competition directly affected firms' innovative activities (e.g., as in Bloom et al., 2015). We therefore

construct a comparable measure of import competition from the EU12 into Denmark in the firm's pre-period products. All specifications are run in first differences and also include industry fixed effects, which capture broad industry-level changes, such as increases in import competition. Our identification strategy thus precisely exploits the variation we document in the first part of the paper on the important distinctions between imports of products the firm also produces domestically (i.e., offshoring) and import competition.

The IV estimates point to a positive impact of offshoring on firms' share of technology workers. They suggest that a ten percentage point increase in the share of EU12 imports of goods also produced domestically leads to a 6.5 point increase in the firm's share of technology workers. This represents almost a 40 percent increase relative to the average offshoring firm's pre-offshoring technology worker share. The IV results also show that offshoring firms increase their share of high skilled workers (those with at least a Bachelor's degree), and, perhaps most surprisingly, that they introduce more new domestically-produced goods relative to non-offshorers. These results are indicative of an important role for offshoring in firms' allocation of resources towards innovative activities.

Many papers have focused on imports of intermediate inputs as a way to measure offshoring (see Hummels et al., forth, for an in-depth review of these papers). Here, we exploit a unique new survey to show that imports of goods that the firm produces domestically is another way to identify offshoring. If one conceptualizes the production function as a set of tasks that includes not only physical transformation activities, but also the design, product development, advertising, and marketing of those goods, it is clear that production only represents a subset of those tasks (as in Grossman and Rossi-Hansberg, 2008). A number of other papers measure offshoring as any imports by a manufacturing firm. The key distinction we make is to show that a firm's imports of six-digit HS goods that it also produces domestically, as opposed to goods for which it may only be a distributor, is a good measure of offshoring. This offshoring definition is similar to the one in Hummels et al. (2014), though those authors focus on four-digit HS products and use level growth in imports as opposed

to growth of produced good imports over total imports.[2]

A key message of this paper is to highlight the fact that the same underlying trade shock can have heterogeneous effects across firms. Amiti and Konings (2007) emphasize that *input* tariff reductions have bigger effects on firm productivity than decreased output tariffs. More recently, Wang et al. (2017) show that although increased Chinese imports have negative employment effects for regions that produce the same goods that China exports, they have positive effects for regions that use those goods as inputs. We show that productivity improvements in a region may lead not only to increased import competition, but also to new offshoring opportunities. As a result, studies that exploit industry variation in import penetration changes may confound the effects of import competition with those of offshoring. This general finding is consistent with Kovak et al. (2017) who study US multinationals and find employment gains for those multinationals that offshore vertical tasks, but negative employment effects for domestic firms that compete with offshorers.[3] Our results suggest that offshoring and import competition may have different effects, particularly for new product introductions, so an analysis examining the net effects of these two forces may miss longer-term gains that accrue as firms specialize in innovation.

This paper contributes to two distinct literatures. An extensive body of work documents a role for offshoring in increased inequality (Feenstra and Hanson, 1996, 1999; Harrigan et al., 2016) and in employment and wage changes (Ebenstein et al., 2014; Oldenski, 2014). The most closely related paper is by Hummels et al. (2014), who show that increased firm-level imports increase demand and wages for high-skill workers and decrease wages for low-skill workers. We find similar results in terms of increased shares of high skill labor and decreased shares of low skill labor in response to offshoring. We build on their work by highlighting the fact that the effects of offshoring are distinct from those of increased import competition. We

[2]Other firm-level measures of offshoring include using information on multinational firms' foreign affiliate activities (e.g. Harrison and McMillan, 2009; Becker and Muendler, 2010) or Trade Adjustment Assistance applications (Monarch et al., 2017).

[3]Antràs et al. (2017) provide a theoretical framework that captures these effects. Offshoring firms lower prices and expand, but the lower price index leads non-offshorers to shrink.

also show that offshoring leads firms to shift their workforce composition into technology-related occupations, and that this change in worker occupations is associated with increased product development and R&D expenditures.

The paper also contributes to work that studies a firm's joint decision to engage in international trade and invest in new technology. Several papers analyze firms' joint decisions to exploit new export markets and invest in new technology (Melitz and Constantini, 2008; Lileeva and Trefler, 2010; Bustos, 2011). This paper is more closely related to Bøler et al. (2015), who document increased foreign sourcing by Norwegian firms that had increased their R&D activities due to an exogenous policy shock. The key theoretical channel in all these papers is a firm scale effect, in which technology and trade both require fixed cost payments and also increase profitability. We provide evidence that offshoring to EU12 countries induces a firm to reallocate workers to technology-related activities, and that this occurs even when controlling for changes in firm sales over the offshoring period.

In related work, Bloom et al. (2015) show that increased import competition from China led European firms to upgrade their technology and innovate. We show that increased import competition increases the probability that Danish firms will offshore to EU12, and this offshoring is an important channel leading towards new product introductions. One potential explanation for the reallocation of workers to technology occupations is that offshoring may have lowered the returns to production work, and therefore the opportunity cost to innovate. This theoretical mechanism was first highlighted by Rodríguez-Clare (2010), who shows that worker reallocation can lead to higher aggregate productivity and growth in a dynamic setting. Our results suggest that firms may play an important role in mediating this type of worker reallocation as they take advantage of low-cost production opportunities in other countries.

The rest of the paper proceeds as follows. In section 2 we describe the new offshoring data and the other linked data. Section 3 documents the differences between offshoring and non-shoring firms. Section 4 discusses how we exploit the productivity changes within EU12

countries to identify the effects of offshoring. We present results from this analysis in section 5, and in section 6 show that offshoring is also associated with increased R&D spending. The last section concludes.

2 Data

In this section, we describe our novel measure of offshoring. We combine this measure with information from several other sources to construct a rich dataset of firm and employee characteristics.

2.1 Offshoring survey

We use a 2007 offshoring survey run by Statistics Denmark that asked firms about their offshoring decisions between 2001 and 2006. The survey was part of a larger effort designed by Eurostat to assess European firms' global production decisions. While the original Eurostat survey was aimed at all private sector firms with at least 100 employees, Statistics Denmark surveyed all firms with more than 50 employees that existed in 2005, and firms with 20-50 employees in selected industries.[4] The Danish survey achieved a response rate of approximately 98 percent, which translates to 4,161 firms.

The survey asked firms about their decisions to relocate, either in part or entirely, nine different business functions: core activity; distribution and logistics; marketing; sales and after sales services (including help desk and call center); ICT services; administrative and management functions; engineering work and other technical services; R&D; facility management (cleaning, security, food, etc...); other functions. We focus on a firm's decision to offshore its core business activity to a foreign location.[5]

The specific language in the survey asked firms whether they moved a particular activity

[4]Certain industries, such as government services were deemed less relevant for measuring offshoring.

[5]The survey instructions specify that a firm's core activity corresponds to its primary industry classification.

to one or more of seven distinct regions.[6] We emphasize that this offshoring definition includes only those functions that were previously performed domestically, either by the firm itself or by another domestic firm. It does not include foreign locations of activities which are new to the firm, which are covered in a separate part of the questionnaire.

The survey also asked firms to identify the country or regions to which they offshored. The survey used the following breakdown of sourcing by location: "Old" EU countries (EU15); "New" EU countries (EU12)[7]; other European countries; China; India; other Asian countries and Oceania; US and Canada; Central America; and Africa. Firms were also asked to identify whether they offshored their core activity to new and/or existing firms within the same business group, or to separate firms.

The survey therefore provides a direct measure of a firm's decision *to begin* offshoring in the period from 2001 to 2006. We focus solely on the relocation of the firm's activity to a foreign country, regardless of whether this relocation occurred within or outside the boundary of the firm. In practice, the survey suggests that both integrated and outsourced offshoring are important. Approximately 44 percent of firms that offshored their core activity did so to other foreign companies (with no ownership or less than 50 percent ownership). The remaining offshored to a partner with an ownership relationship.

2.2 Additional data sources

We combine the offshoring survey data with a number of different data sources on Danish firms. We use the Firm Statistics Register (FirmStat), which is based on Value-Added Tax (VAT) administrative data, to gather information on firm sales, value added, material expenditures, capital, total employees, and industry (six-digit NACE). We use these data, which are available for the population of Danish firms, to construct a firm-level panel from

[6]The actual Danish language is "...udflytning...", which literally translates to "move out." The precise question is presented in the online appendix.

[7]EU12 countries are Poland, Hungary, Bulgaria, Romania, Slovakia, Czech Republic, Cyprus, Slovenia, Estonia, Latvia, Lithuania, and Malta.

1996 to 2008.[8] This time frame and coverage allow us to analyze potential selection into the offshoring survey, as well as any differential trends for offshoring versus non-offshoring firms.

We augment the VAT data with product-level information about the values and quantities of firm production from manufacturing production surveys (ProdCom). These surveys are available beginning in 1995 and cover all manufacturing firms with at least ten employees. They provide information on the value of production by ten-digit product codes, the first eight digits of which map to Combined Nomenclature (CN) product codes. The CN classification system maps to the Harmonized System (HS) at the six-digit level.

We also exploit a survey conducted by Statistics Denmark that collects manufacturing firms' purchases of intermediate inputs. These data are available for manufacturing firms with at least 50 employees. In principle these data are also available at the same HS6 level of aggregation as the production data, though in practice firms often report at the more aggregated HS4 level.

We also link our data set to the Danish Foreign Trade Statistics Register. The trade data are based on Customs declarations and cover all international trade transactions of Danish firms by product and destination/origin. A benefit of the Danish data is that products in the trade data are classified using the same HS codes as the production and input use data. This facilitates comparisons of Danish firms' production, input purchase, and trade decisions.

A critical element in our analysis is to exploit detailed information about the population of Danish individuals over the period 1991 to 2008. To do so, we use data extracted from Integrated Database for Labor Market Research (IDA). These data cover the universe of the Danish population aged 15-74, including the unemployed and those outside of the labor force. They provide information on workers' gender, age, experience, tenure, wage, education level, and occupation. Workers are linked to the plant and firm where they are employed. The dataset also provides a six-digit NACE industry code for the economic activity of each worker's plant.

[8]Some of the firm-level data continues past 2008 but we have chosen to end the sample to avoid the great recession.

We use the Integrated Database for Labor Market Research (IDA) data to define worker occupation groups. Following Bernard et al. (2017), we determine the number of workers for five different occupational categories: managers; technology workers (R&D workers and technicians); support activities; sales activities; and line workers. We further decompose line workers into two separate categories: those involved in transport and warehousing (line 1) and the others, mostly involved in the production process (line 2).[9]

We also add data from R&D surveys that span the period from 2000 to 2010. These surveys are only available for between 3,500 and 4,500 firms depending on the year. Firms surveyed are supposed to represent the universe of potential innovators, which means in practice that specific innovative sectors and firms above a certain size threshold are targeted. While the full set of questions in each survey varies by year, we construct a panel of the share of R&D expenditure in total revenue, as well as the share of R&D workers in total employment.

3 Offshorers versus Non-Offshorers

The availability of a new, direct measure of offshoring provides a unique opportunity to consider the differences between offshoring and non-offshoring firms both before and after the core activity is moved abroad. In particular, this section provides summary statistics of the new offshoring data and descriptive evidence on how offshoring relates to changes in firms over time. A particular focus is on the interaction between offshoring and importing with a goal of better understanding the nature of imports by offshoring firms.

3.1 Summary statistics about offshoring

We first describe the distribution of offshoring activities across sectors. Figure 1 shows two views of the distribution of offshoring across broad sectors. The industries are sorted by

[9]See the online data appendix for the definition of these groups based on the ISCO code.

the share of firms that offshore in the sector between 2001 and 2006 - the solid (darker) blue columns. Textile and Apparel has the greatest share of offshoring firms, more than 30 percent, while almost 20 percent of firms in the Machinery and Furniture sectors report offshoring their main activity between 2001 and 2006. At the other extreme are Business Services and Transport where fewer than 5 percent of firms offshore.

The (lighter) red columns show the share of that industry in total offshoring, again using firm counts. Machinery is the largest broad manufacturing sector in Denmark and accounts for more than half of all offshoring firms.[10] While a small share of Business Services firm offshore, the large size of the sector in the overall economy mean that it accounts for more that 10 percent of all offshoring firms.

Panel (b) of Figure 1 takes a more disaggregated look at the Machinery sector itself. Offshoring firms comprise about 30 to 12 percent of firms in each industry. Machinery and equipment hosts the largest share of offshorers, with over 20 percent of all offshoring firms classified in that industry.[11]

The data show that just over nine percent of firms in the survey relocate their core activity to a foreign region/country between 2001 and 2006. Table 1 presents the count of firms that offshore to the two main low wage destinations, recent EU members (EU12) and China and other destinations along with the fraction of total offshoring firms that they represent.[12] EU12 is the most popular offshoring location. More than one third of Danish offshorers choose EU12 (but not China) as an offshore destination, while another 17 percent offshore to both EU12 and China. China, but not EU12, is a destination for just over 15 percent of Danish offshoring firms.

[10] In later sections of the paper, we are forced to restrict our sample to firm with production, thereby increasing the importance of the Machinery sector in our results.

[11] Similar patterns hold at the worker level, see the Appendix. The main difference for workers is that the share of workers at offshoring firms within industries in the Machinery sector ranges from 20 to over 60 percent.

[12] See the Appendix for a breakdown of the other regions.

3.2 Importing and offshoring

We also examine the relationship between offshoring and importing. Offshoring is often equated with imported intermediates, but it can take place in a variety of forms. It is not evident that a firm that relocates its main activity to a foreign country will necessarily import intermediates. In fact, offshoring need not entail any importing by the firm back to the home country. Many firms offshore assembly of the final product, and others offshore the entire production activity of a product.[13]

For the top two sourcing locations, EU12 and China, we analyze how offshoring relates to firm import behavior. Figure 2 shows that firms re-orient their imports from the regions to which they offshore. The left panel shows that firms that offshore to EU12 but not China more than double their share of imports from EU12 over the offshoring period. The right panel presents similar results for firms that offshore to China but not EU12.[14] For firms that offshore to both EU12 and China, their share of imports from each of these regions grows, though not as dramatically (as expected, since import shares must sum to one). These results provide reassuring evidence that the offshoring survey is capturing real changes in firm behavior, and support prior work that has argued for using imports as a measure for offshoring.

A common preconception about offshoring is that firms' foreign activities substitute for domestic production. From this perspective, an increase in imports should lead to a reduction in production in Denmark. While prior work has found that access to foreign imports increases domestic productivity (Amiti and Konings, 2007) and that cost reductions in foreign affiliate locations can increase domestic employment (Kovak et al., 2017), the displacement effects of offshoring could be particularly strong for imports of goods the firm produces domestically. We use data on produced goods from the Prodcom production survey described above to identify whether a firm's imports constitute domestically produced goods. We

[13]For example, firms may engage in platform FDI, as modeled in Tintelnot (2017).

[14]In the Appendix, we perform a similar analysis for firm exports. While firms' exports to their offshore locations grow, they do so much less than for their imports.

identify a firm's production by HS6 product and label all imports that the firm also produces in Denmark as imports of produced goods.

Table 2 shows the share of production and import value by product status for offshorers and non-offshorers in 2000 and 2008. Surprisingly firms frequently import and produce domestically the same narrow HS6 variety. More than half the value is in goods that are both produced and imported. For offshorers, the value share is more than two thirds. The big change over the offshoring period is the rise in importance of imports relative to production in these products from 11 percent to 19 percent of their domestic production value.

Figure 3a plots the evolution of produced good imports over total domestic production from 2000 to 2008, by firms' offshoring status. To rule out any role from changing product composition, we limit the goods to those produced by the firm in 2000 and/or 2001, prior to offshoring. We use two years of production data to ensure that we capture goods produced frequently, as well as lumpier products. In section 4, we will use these pre-offshoring initial production shares to assess how firms with different product mixes are differentially affected by cost-saving opportunities in the EU12.

Figure 3a shows that offshoring firms' share of these produced good imports over their current year production of these goods grows over the offshoring period from less than 10 percent to over 15 percent. In contrast, non-offshorers do not significantly change their share of produced good imports over production. Panel (b) shows that this change is not driven by declining domestic production at offshoring firms as offshoring firms' domestic production stays relatively constant. The rise in the produced good imports to production for offshorers is driven by rising imports.

A natural question is why do firms produce and import the same products? One possibility is that firms maintain domestic production of a higher quality variety, while they offshore production of lower quality varieties. Table 3 provides evidence consistent with this story. For the sample of firm-products (CN8) from 2000-2008 with both production in Denmark and imports from abroad in the same year, we regress unit values on a dummy for domes-

tic production while controlling for firm-product and year fixed effects.[15] The coefficient on domestically produced varieties is large, positive and significant. On average, domestic varieties have unit values 60 percent higher than their imported counterparts within the same firm. The second column includes an interaction with an offshoring dummy and shows that the price gap is even larger for offshoring firms. The final column adds country/region specific interactions for the imported varieties and confirms that imports from the EU12 and especially China are lower priced while imports from the EU15 have significantly higher prices than domestic varieties.

In the Appendix, we also present results analyzing firms' imports of inputs, as reported in the material purchase survey. This survey generally only provides detail at the HS4 product level, so we compare imports of inputs and produced goods with each defined at the HS4 level. The input and produced good classifications need not be mutually exclusive since a firm could both produce a particular product and also purchase it as an input. While offshoring firms increase their share of produced good imports and of imports that are classified as both produced goods and inputs, they do not seem to increase imports of goods classified solely as inputs.

The richness of these data provides novel evidence on the relationship between offshoring and importing. While it has become common to equate a firm's decision to relocate production to a foreign country with a decision to import intermediates, we show that offshorers tend to import the same goods that they produce domestically. Perhaps most surprisingly, firms' imports of goods that they produce do not seem to decrease domestic production. The unit values of domestically-produced goods are systematically higher, however, suggesting a role for quality differentiation within the same detailed product category.

[15]The unit value for the domestic variety comes from the Prodcom survey and represents the domestic factory gate price while the unit value for the imported variety comes from the Danish customs data and represents the imported price.

3.3 Offshorer premia

Firms that engage in international activities such as exporting, importing and foreign direct investment are well know to be significantly different from purely domestic firms (Bernard et al. (2018)). They are usually larger, more skill- and capital intensive, and more productive. Given the different definition of offshoring used in this paper, we compare offshoring Danish firms to their non-offshoring counterparts in the year before offshoring activity begins.

Column 1 of Table 4 reports premia from a simple regression of the (log) characteristic in 2000 on a future offshoring dummy including industry fixed effects. Offshorers are substantially larger in terms of sales and employment than non-offshoring firms in the same industry. They also are more likely to either export or import. Surprisingly, labor productivity, measured as sales per worker and value added per worker, is not different at offshoring firms compared to non-offshorers.[16] These results are broadly consistent with the characteristics of firms that engage in foreign markets more generally, with the exception of the lower labor productivity.

Column 2 of Table 4 shows the changes in these same firm characteristics from 2001 to 2006, the period when the offshoring is undertaken. While both employment and sales growth are significantly lower at offshorers, the relative changes lead to a significant increase in sales per worker. The measure of labor productivity, value-added per worker, grows at the same rate for both groups of firms over the interval while import shares rise at offshoring firms.

3.4 Offshoring and employment composition

There has been considerable attention paid to the employment effects of offshoring. Table 5 presents summary statistics of the labor composition at offshoring and non-offshoring firms in 2001 and 2008. The top Panel A shows that offshoring firms have seen a large decline

[16]The difference between value-added and total sales comes from the resales of goods without transformation, materials ,and the cost of subcontractors. More work is needed to see which of the last three adjustments explain the difference between the sales per worker and value-added per worker premia.

in their share of less-educated workers, those with less than a high school degree. These workers fell from 37 percent of the workforce at offshoring firms in 2001, to 30 percent in 2008. In contrast, the share of these workers at non-offshorers stayed constant at 38 percent over the same period. The decline in low-education worker shares at offshorers shows up in large increase in the high education worker share, which almost doubles, and a more modest rise in middle education worker shares. Non-offshorers have a small decrease in the middle category and a small rise in the most educated group.

Panel B of Table 5 presents similar information on labor composition by occupations. The most notable difference between offshoring and non-offshoring firms is in their shares of technology workers. Offshorers start with technology workers comprising 17 percent of their workforce in 2001, but the share climbs about more than 40 percent to 24 percent of the workforce by 2008. In contrast, technology workers increase slightly from 12 to 14 percent of the workforce for non-offshorers over the same interval. Both types of firms see their production worker shares decline, with larger declines for offshorers. While offshorers increase their technology worker shares relatively more, non-offshorers see bigger increases in their share of sales workers. Sales worker shares increase by 3 percentage points at offshorers, compared to 11 points at non-offshorers.[17]

Figure 4 plots the average number of workers at offshoring and non-offshoring firms for a balanced panel of firms from 1998 to 2008. First, it is clear that firms in the offshoring survey are significantly larger than the average firm in Denmark. The average non-offshorer has about 125 employees in 1999. Offshoring firms are almost twice this size, with about 250 employees in 1999. Although offshoring firms start larger, their trends in average firm size are similar from 1998 to 2001. Starting in 2001, however, the offshoring and non-offshoring firms' behavior diverges significantly. The average offshoring firm size drops sharply from 2001 to 2005 and then flattens out. In contrast, non-offshorers display a slight upward trend

[17]We present the level of employment shares by category, but the patterns depicted here are similar when calculating averages relative to a firm's industry average. The empirical analysis will be based only on manufacturing firms and include industry fixed effects to control for compositional differences by offshore status.

in their average firm size.

An important contribution of this paper is to show how offshoring relates to a firm's allocation of resources – and in particular employees – towards innovative activities. Figure 5 plots the share of technology workers in total employment for offshoring and non-offshoring firms. Offshoring firms start with slightly higher shares of technology workers, but their share diverges from non-offshoring firms' technology worker share over the offshoring period. While offshoring firms' tech worker growth rate increases in 2002, non-offshorers' growth rate flattens out in about 2003.

One possible concern is that the rising share of tech workers is due to a decrease in offshoring firms' average size. Figure 6 shows that this is not the case. Even as total employment at offshoring firms falls, their level of technology workers rises. In contrast, non-offshorers tech workers grow at about the same rate as their total employment.

3.5 Offshoring and product development

To assess outcomes related to this increase in technology workers and the declining share of production workers at offshoring firms, we compare changes in their product-level margins. This exercise is limited to firms with manufacturing production, since production data are only available for this sector. Table 6 shows that in 2000, offshorers produce an average of 4.85 distinct products, compared to only 2.89 by non-offshorers. The difference is even larger by 2007, with offshoring firms producing 6.26 products relative to only 3.05 for non-offshorers. The right panel shows that this disproportionate increase in products by offshorers is driven by the fact that almost half of their products in 2007 are new, while less than one third of the products sold by non-offshorers are new introductions after 2000.

The evidence in table 6 suggests that product development may be an important new activity for offshorers. Since offshorers are more concentrated in certain industries, we also calculate within-industry statistics for product counts. The bottom panel of table 6 presents average product counts by offshore status, normalized by each firm's industry average. In

both 2000 and 2007, non-offshorers produced fewer products than the average firm in their industry. Offshorers produced 28 percent more products than their industry average in 2000, and almost 50 percent more by 2007. As in the raw count data, new products represent the most important margin of adjustment for these differences. While non-offshorers introduced only 0.81 percent of their industry average, offshoring firms introduced almost twice as many new products over the period.

The descriptive evidence here is suggestive of a casual relationship between offshoring and a firm's allocation of resources towards innovative activities. In the next section, we discuss potential theoretical channels that might drive this evidence and outline an empirical strategy to analyze the relationship more rigorously.

4 Theoretical motivation and empirical approach

In this section, we first describe potential theoretical channels through which offshoring and innovation may be related. We then discuss several challenges to documenting a causal relationship between a firm's decision to relocate its core activity to a foreign country and its decision to reorganize domestic production towards R&D. Finally, we present an identification strategy to address these issues and to provide information on the various potential channels.

4.1 Theoretical channels for offshoring and innovation

One way in which offshoring may affect innovation is to allow for increased gains from specialization. A number of early papers focus on the possible efficiency gains from this type of fragmentation of production (e.g., Deardorff, 2001; Jones and Kierzkowski, 2001; Kohler, 2004). More recent work conceptualizes production as a combination of different tasks that can be performed in distinct geographic locations (Grossman and Rossi-Hansberg, 2008, 2012). In these papers, decreases in the costs to offshore certain tasks lead to productiv-

ity gains that imply offshoring sectors may expand their remaining domestic activities. A distinct but related link between offshoring and innovation can be found in the work of Rodríguez-Clare (2010). In that paper, increased offshoring lowers the production worker wage in high wage countries, thereby decreasing the opportunity cost for workers in those countries to engage in innovation-related activities. In our context, when Danish firms relocate activities in which they are relatively less productive (e.g., production work) to a foreign country, they may enjoy gains to specialization as they re-focus domestic resources on R&D-related activities.

Another channel linking offshoring and innovation is through the firm's decisions to trade with other countries and to invest in new research and technology. Melitz and Constantini (2008), Lileeva and Trefler (2010), and Bustos (2011) present endogenous technology adoption models in which a trade shock may induce some firms to upgrade their technology so that they grow enough to pay the fixed cost to trade. In a related paper, Bøler et al. (2015) develop a model in which there are strong complementarities between firms' sourcing decisions and their R&D investment. In their model, trade and technology are complementary activities because they both lead firms to become more profitable and thus cover associated fixed costs. Analogously in our work, if firms find offshoring more profitable, this may facilitate an increase in their innovative activities. One way to assess the importance of this channel is to control for changes in firm sales over the offshoring period. If the impact of offshoring on innovation is due to a firm scale effect, controlling for growth in firm output should eliminate the offshoring effect on innovation.

Offshoring and innovation may also be related if both are optimal responses to increased competitive pressure from abroad. Bloom et al. (2014) present a framework in which firms that face increased import competition reallocate "trapped" resources within the firm towards R&D activities. In that model, increased competition lowers the opportunity cost to innovate so that firms decrease production and shift workers into innovative activities. A key feature of their theoretical channel is the presence of labor market frictions that make it in-

feasible (or suboptimal) for the firm to fire workers in response to the increased competition. Denmark has a particularly flexible labor market and it seems unlikely that Danish firms face these types of firing frictions reducing the likelihood of a trapped factors explanation.[18]

Import competition may also lead firms to innovate by reducing x-inefficiencies (Schmitz, 2005), by changing managerial incentives (Schmidt, 1997; Aghion et al., 2005), or by incentiving firms to invest in new product varieties that do not compete with foreign imports (Impullitti and Licandro, 2017; Fieler and Harrison, 2018). We therefore focus on empirical specifications in which we control for industry-level import penetration separately from a firm's decision to offshore.

Offshoring and innovation may also be related if firms' decisions to relocate overseas increase their access to new ideas or inputs. A number of papers document an important role for imported intermediates in improving firm productivity (Amiti and Konings, 2007; Goldberg et al., 2010; Halpern et al., 2011), and for imports in spreading ideas across countries (Coe and Helpman, 1995; Acharya and Keller, 2009). These channels may be quite important for offshoring by developing countries to more developed countries, but are likely to be less important when considering Danish firms' offshoring decisions to low wage countries, such as China and EU12 countries. In addition, we focus on Danish firms' decision to offshore their main activity, which is potentially distinct from the decision to offshore IT and R&D activities.

4.2 Empirical approach

An important contribution of this paper is to show that offshoring leads firms to reallocate their domestic workers towards innovative activities. A primary concern with estimating this relationship is that firms may offshore production in response to other shocks. One might expect a downward bias on the estimated coefficient of the effect of offshoring on innovation if firms start offshoring in response to negative demand or productivity shocks,

[18] Andersen and Svarer (2007) document the flexibility of the Danish labor market.

for example as in Monarch et al. (2017). In this scenario, firms may seek to lower costs not just by relocating production offshore, but also by reducing domestic expenditure on higher wage occupations. Alternatively, one might expect an upward bias on the OLS estimates if firms offshore their main activities so that they can re-orient domestic resources towards innovation.

Perhaps one of the most obvious challenges to estimating the effect of offshoring to EU12 or China is that production cost saving opportunities in these locations may also entail increased import competition. We assess this potential concern by estimating the probability of offshoring to China or EU12 as a function of increased import penetration from those regions. Table 7 shows that this concern is empirically relevant for China. Increased import penetration from China in a firm's sector is associated not only with an increased likelihood that a firm will offshore to China, but also that it will offshore to EU12. In contrast, increased import penetration from EU12 does not seem to influence firm's offshoring decisions.

The inter-relatedness between import competition and offshoring opportunities is thus an added challenge to distinguishing the effects of a negative demand shock that differs across industries (increased import competition in a firm's industries) from a positive offshoring shock (increased production cost savings opportunities). The results presented in Table 7 also highlight a potential omitted variable concern in prior work. For instance, Bloom et al. (2015) find that European firms that faced increased Chinese import competition increased their domestic innovation. One possibility is that those firms offshored production to EU12, and that offshoring was actually the channel through which they increased innovation.

To address these issues, we implement an instrumental variables (IV) strategy in which we identify changes in a firm's offshoring decisions due to factors external to both the firm and Denmark. Given the strong correlation between Chinese import competition and offshoring, we focus on firms' offshoring to EU12. We focus on EU12 both because it is the main offshoring destination for Danish firms, and because we are better able to distinguish between import competition and offshoring opportunities.

In order to exploit the most detailed product-level data available, and to control for broad industry changes, we do not use the offshoring dummy in this section. Instead we rely on the evidence of the strong relationship between changes in a firm's import share of domestically produced goods and its offshoring decision. The change in the import share of produced goods from the EU12 is used as a proxy for firm offshoring to the EU12. The benefit of using changes in firm's produced good import shares is that these can be measured at the detailed six-digit product level and this measure can be employed by researchers without access to comparable direct surveys on offshoring. Figure 7 shows that this measure is indeed a good predictor of offshoring to EU12, while increased shares of non-produced goods are not.

With this detailed product-level measure of offshoring in hand, we can exploit the fact that the 12 new EU member states underwent significant productivity growth and changes in comparative advantage across products during the offshoring period due to internal changes required for accession to the EU. We measure variation in their comparative advantage changes across detailed product categories using changes in six-digit HS product export shares by the EU12 countries to the rest of the world (ROW), excluding Denmark. This approach is similar to Hummels et al. (2014), although we use changes in EU12's export *shares* rather than changes in levels to rule out growth driven by aggregate demand or technology shocks that increase demand for particular products across all countries.

The export share growth rates are a product-level measure, but we require a firm-level instrument to predict changes in offshoring. Since offshoring involves imports of goods also produced domestically by the firm, we use each firm's production across six-digit HS products in 2000 and 2001 to assign the product-level shocks to the firm. Specifically, we aggregate the change in the export share in product k, $\Delta ExpShare_k^{2001-2006}$, to the firm level according to:

$$\Delta ExportSh_{iEU12} = \sum_k sh_{ik} \Delta ExpShare_k^{2001-2006}, \tag{1}$$

where sh_{ik} is firm i's share of production of product k in 2000 and 2001.[19] Single product firms will therefore be assigned the change in the EU12 export share for their single product, while multi-product firms, which comprise the majority of the sample, will have a firm-specific shock based on the distribution of their pre-offshoring production.

One concern is that firms within industries may not be different according to their product mix. We find substantially product-share variation across firms within industries. The average EU12 offshoring firm produces 5.3 unique products, while the average non-EU12 offshorer produces 3.4 products. For all firms, the average of the firm-level median product share is 0.48 for EU12 offshorers and 0.57 for non-EU12 offshorers.[20]

Our IV strategy identifies firms that began offshoring to the EU12 as a result of improved EU12 exports in products relevant to the firm. The key identifying assumption is that the common within-product component of the relative increase in regional exports is due to relative increases in EU12 productivity. The exclusion restriction requires that the foreign region's increased productivity only affects a firm's innovative activities through its impact on the offshoring decision. This restriction would be violated if improvements in EU12 comparative advantage also led to increased competition from the EU12, and that increased competition directly affected firms' innovative activities (e.g., as in Bloom et al., 2015). We therefore construct a comparable measure of import competition from the EU12 into Denmark in the firm's pre-period products. We measure import penetration at the HS6 level as imports from EU12 over total imports and domestic production, but excluding each firm's own imports and production. We calculate changes from 2001 to 2006 and construct a weighted average based on the firm's pre-period production shares. Our identification strategy thus precisely exploits important distinctions between offshoring and import com-

[19] We use production data in two years to ensure that we do not miss pre-offshoring production of lumpy goods.

[20] As an example of the variation we exploit, consider a hypothetical firm in the two-digit NACE industry "Manufacture of electrical equipment (27)." Potential HS6 products that firm could produce include: 850110 (Electric motors; of an output not exceeding 37.5W), 850151 (Electric motors; AC motors, multi-phase, of an output not exceeding 750W), and 850161 (Generators; AC generators (alternators), of an output not exceeding 75kVA).

petition. In our first stage, we estimate how 2001 to 2006 changes in a firm's produced good imports from EU12 over total imports are predicted by EU12 export share growth in the firm's pre-offshoring product mix:

$$\Delta PP\,ImpSh_{i,EU12} = \alpha + \beta_{Sh}\Delta ExportSh_{i,EU12} + \beta_{Imp}\Delta ImpPen_{i,EU12} + \varepsilon_i, \qquad (2)$$

where $PP\,ImpSh_{i,EU12}$ is the change firm import share of produced products from the EU12, $\Delta ExportSh_{iEU12}$ is the firm-specific change in EU12 export shares in markets outside Denmark, and $\Delta ImpPen_{iEU12}$ is a firm-specific measure of the change in the import penetration to Denmark from EU12 in a firm's pre-period product mix. All variables are changes from 2001 to 2006. Note that estimation of equation (2) is thus similar to a first differences approach since we exploit changes in foreign comparative advantage to identify changes in a firm's offshoring status. All specifications also include two-digit NACE industry fixed effects. Since the regressions are in differences, these fixed effects capture broad industry-level changes in import competition. We weight the regressions by firm employment and winsorize the top and bottom one percent of outliers.

In the second stage regressions, we estimate how firm-level outcomes such as employment and workforce composition change in response to a firm's offshoring decisions according to:

$$\Delta y_i^{2001-2008} = \alpha + \beta_{PP}\Delta PP\,ImpSh_{i,EU12} + \beta_{Imp}\Delta ImpPen_{iEU12} + \varepsilon_i^{2001-2008} \qquad (3)$$

where $\Delta y_i^{2001-2008}$ is the change in the firm-level outcome variable from 2001 to 2008 and the other variables are as described in equation (2). These specifications again include two-digit NACE industry fixed-effects to control for broad sectoral changes over time. We weight the regressions by firm employment and winsorize the top and bottom one percent of outliers.

5 Offshoring and Firm Outcomes

In this section, we present results from estimating Equation (3) via OLS and when instrumenting for offshoring decisions using the instrument described in section 4.2. We also present the reduced-form results from regressing the firm-level employment outcome variables directly on the instrument described in equation (1).

5.1 OLS and Reduced form results

Table 8 presents OLS results for the IV sample for offshoring to the EU12. The sample size drops substantially to 1,149 firms due to the need for product-level data to construct the measure of firm produced product imports and the instrument itself.

Column 1 reports the results for log firm employment. The coefficient on the offshoring variable is negative and significant at the 10 percent level and the magnitude is comparable to that for the firm-level import penetration measure. Columns (2)-(4) report results for measures of labor force composition within the firm. Offshoring is positively and significantly correlated with the firm's share of technology workers in total employment and the share of workers with a college degree or higher. The share of workers with less than a high school degree is negatively and significantly correlated with offshoring.

The final two columns examine a firm-level measure of innovative activity through the introduction of new products. The dependent variable is the number of new products and the share of new products in the firm product portfolio in columns (5) and (6) respectively. The number of new products is positively related to offshoring, although weakly significant, while the new product share is also positive and significant at the one percent level. While the relationship between offshoring and innovation is positive in these specifications, import competition is associated with relatively fewer new product introductions and shares. These OLS regressions largely conform to the stylized facts presented previously and suggest an important distinction between import competition and offshoring.

Table 9 presents the reduced-form results for the same sample of firms. The main variable of interest is now the change in export share by EU12 countries weighted by the firm's pre-period production shares, $\Delta ExportSh_{i,EU12}$. The biggest change occurs in the employment regression where the instrument is essentially zero, in contrast to the negative and significant coefficient in the OLS regression. This result is consistent with the premise that firms offshore in response to a negative shock. The coefficient on import penetration remains negative and essentially unchanged, although still not significant.

For the labor force variables, the results are consistent with the OLS findings with smaller coefficients. Offshoring has a positive effect on tech worker and high education workers shares and a negative effect on the share of the lowest education group. The proxies for innovative activity, new product introductions and new product shares, both have positive and significant coefficients on the offshoring variable.

5.2 IV results

The first stage results are given in Table 10. The instrument is significant with the expected sign for both samples. The first-stage F-statistic on the excluded instruments is 87.7 and 110.7, respectively.

Table 11 presents the results from estimating equation (3), while instrumenting for changes in the firm's share of produced good imports using growth in the EU12's export shares in the firms' pre-offshoring product mix. As in the reduced form results, the effect of offshoring on firm employment is not significantly different from zero. The IV estimates again confirm a positive impact of offshoring on firms' share of technology workers. They suggest that a ten percentage point increase in the share of EU12 imports of goods initially produced domestically leads to a 6.5 point increase in the firm's share of technology workers.[21] This represents an almost 40 percent increase relative to the average offshoring firm's pre-offshoring technology worker share. The IV results also show that offshoring firms

[21]The mean (standard deviation) of the change in the produced good import share at non-offshorers is 0.006 (0.065) versus 0.05 (0.136) at offshorers.

increase their share high skilled workers and reduce their low skilled worker share.

Offshoring also increases the number of new domestically-produced goods relative to non-offshorers. A ten percentage point increase in the firm's produced good import share leads to a 1.4 new product introductions. In contrast, increased import penetration from EU12 is associated with fewer new products at the firm. As is typical, the IV coefficients are substantially larger than the OLS estimates which in turn are larger than the reduced form coefficients.

5.3 Robustness

We report a wide variety of robustness checks on our main specification.[22] First we check for the possibility that omitted firm characteristics are driving the results. We include initial firm size to check if the findings are driven by differential changes at large (small) firms which are more likely to offshore. The results are all quite similar when we control for initial firm size in the regressions. To account for the possibility that offshorers are inherently more likely to use technology, we include a proxy for IT use by the firm and find that the results are also robust. The results are also robust to controlling for pre-trends in the dependent variable, which we do using changes in the dependent variable from 1996 to 2001. Finally, although the two-digit NACE fixed effects capture broad industry trends, we also control for firm-specific changes in Chinese import competition and find that our estimates are robust to this control.

To assess whether the effects we estimate are likely driven by changes in scale at offshorers, we run a specification with growth in firm sales as an additional control. Our results are generally robust to adding this variable, which suggests that the channel driving our findings is not simply a scale effect.

[22]These results are not yet disclosed, but will be added to the Appendix.

6 Innovation

In this section, we consider the nature of the increases in technology worker shares and ask whether these increase are driven by external hiring or reallocation of workers within the firm. We also provide additional evidence on innovative activity by offshoring firms by exploiting R&D survey data, available for a subset of firms, to show that offshoring firms increase their R&D expenditures.

6.1 Margins of worker adjustment

The results in Sections 3 and 5 show that offshoring firms are reallocating their activities away from those performed by production workers towards those performed by technology workers. Here we provide descriptive evidence on the nature of those occupation shifts. These changes may mask a large amount of churning of workers inside the firm. Figure 8 shows that the shares of technology workers in firm hires and separations are both higher and increasing from 1998 to 2008 for offshoring firms. In Figure 8a, we show that offshoring firms are increasing their hiring of technology workers relative to overall hires during the period, while non-offshoring firms have relatively constant hiring shares of technology workers. Similarly, Figure 8b shows that separations at offshorers are disproportionately in technology workers, and that prevalence is rising during the period. For non-offshorers, the share of tech workers in separations is lower and constant.

We also examine the composition of workers employed at the same firm from year t to $t+1$. Figure 9 shows that for workers that remain at the firm, the share of technology workers is higher and steadily rising at offshorers. This stands in sharp contrast to the pattern in non-offshorers, where the share of retained workers in technology occupations remains relatively constant over the period. Approximately one third of the tech stayers within the firm over this period switch into technology occupations from non-technology occupations within the firm. Traiberman (2018) documents high switching costs for workers switching occupations

in response to import competition. The results here highlight the possibility that within-firm switching may mitigate some of these costs.

6.2 R&D Expenditure

We conclude this section with simple descriptive evidence on firms' R&D activities. Figure 10 shows (average) total R&D expenditures and R&D worker shares for offshoring and non-offshoring firms from 2001 to 2008. Figure 10a plots average R&D expenditure in thousands of Danish Kroner by firms' offshore status. Beginning in 2004, there is a clear divergence in R&D spending trajectories, as offshoring firms significantly increase their expenditures, both in level terms and relative to non-offshorers.[23] A similar stark shift is seen in the share of R&D workers at offshoring firms in Figure 10b. These results provide additional evidence that firms' shift in their workforce composition towards technology workers is indeed related to changes in their innovative efforts.

We further exploit the richness of the R&D survey information to shed light on which types of expenditures drive these changes. The survey records process and product R&D expenditures separately every other year. Figure 11 plots firms' average R&D expenditures broken apart by product versus process R&D from 2001 to 2007. The left panel, Figure 11a shows that offshoring firms sharply increase their process innovation spending after 2005. Non-offshoring firms show little or no process innovation spending throughout the period. This suggests that offshoring entails changes in firms' physical production process which require additional research to implement.

In contrast, Figure 11b shows that expenditure on product innovation by offshoring firms rises towards the end of the offshoring period and stays up in 2007. Non-offshoring firms have much lower levels of product R&D spending and it trends up steadily over the entire period.

This evidence supports the premise that offshoring allows firms to reallocate both workers

[23]The share of expenditures shows a comparable divergence starting in 2004, rising from just under 3 to over 4 percent of total expenditures at offshorers.

and financial resources towards innovation, and highlights its potential to increase future growth with the advent of potentially more and better varieties of goods.

7 Conclusion

This paper exploits new information on Danish firms' offshoring to construct a rich dataset on firms' global production decisions. We use these data to analyze how firms' decisions to relocate their primary activities to foreign countries affect not only their aggregate employment, but also their employment across activities. We find that over time, offshoring firms change their employment composition significantly so that they ultimately employ a much higher share of technology and research-related workers.

The results in this paper point to important long-term implications of offshoring. We show that firms that relocate their main activities to a foreign country are more likely to shift their domestic resources into innovative activities. Since innovation is a major determinant of future performance, this shift has important potential implications for the long-term effects of offshoring on productivity and growth.

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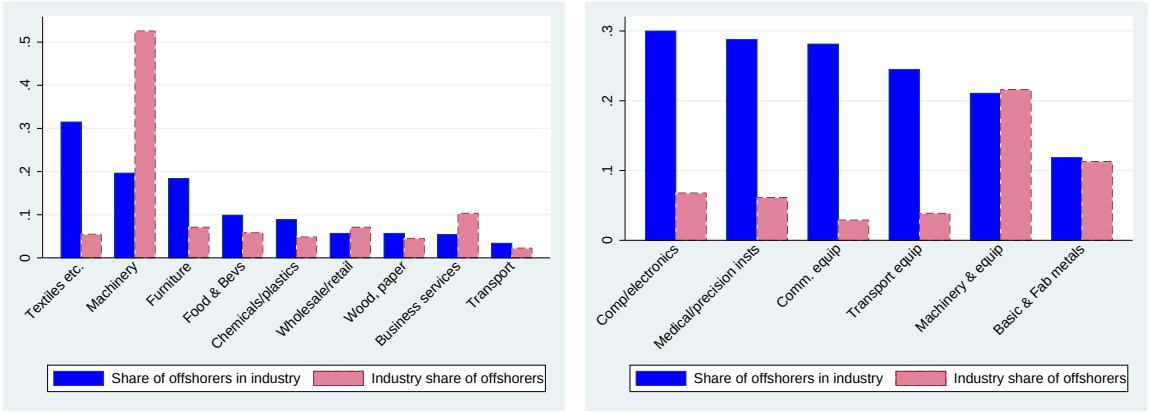
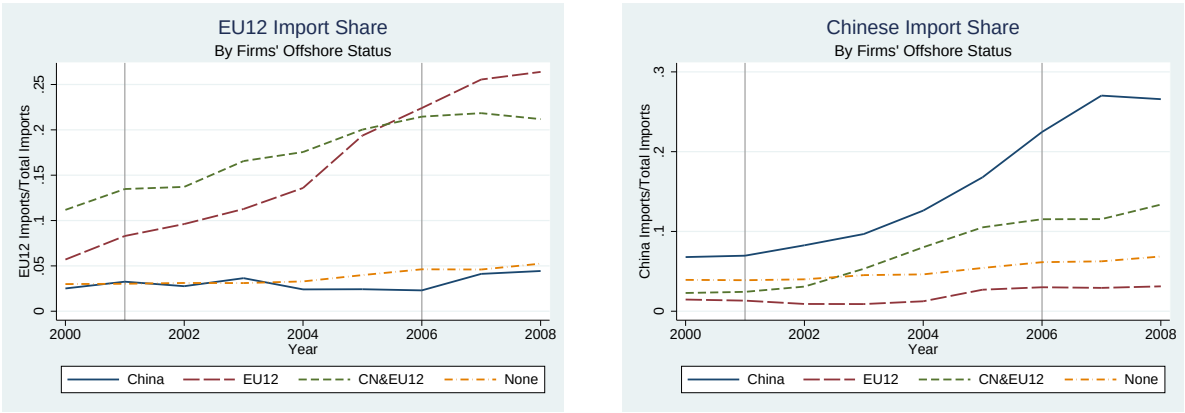
Figure 1: Industry distribution of offshoring firms



(a) Across Broad Sectors (b) Within Machinery

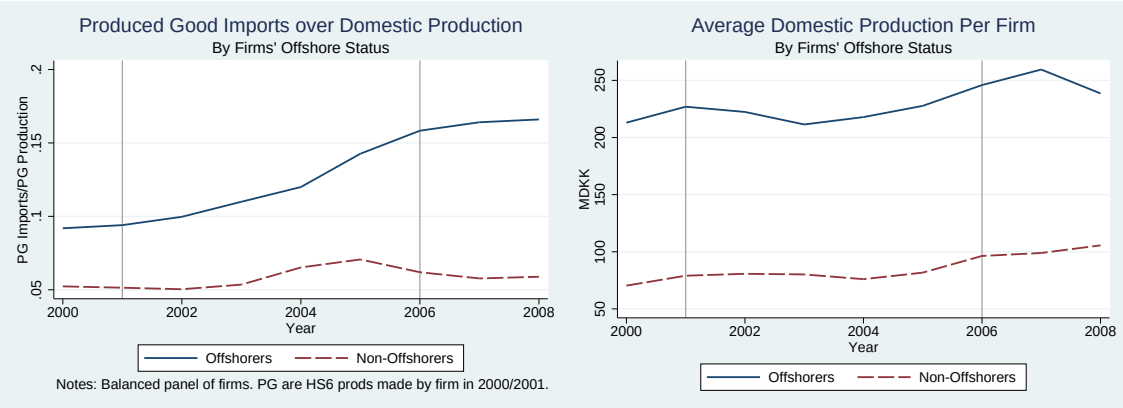
Notes: Figure plots the share of offshoring firms within each industry (first/blue bars) and the share of offshoring firms across industries (second/red bars). Note that the red bars do not sum to 1 since only the top industries are presented to minimize disclosure concerns.

Figure 2: Imports from offshoring region over total imports



(a) EU12 (b) China

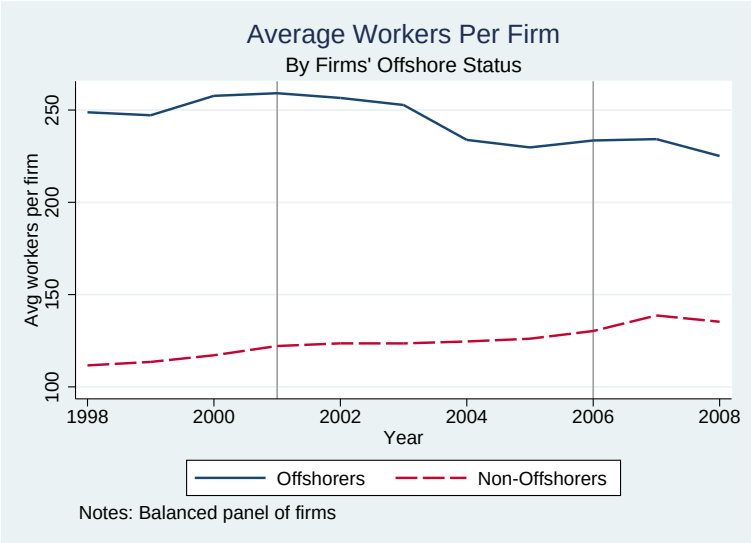
Figure 3: Produced good imports and domestic production



(a) Produced good import share (b) Average domestic production

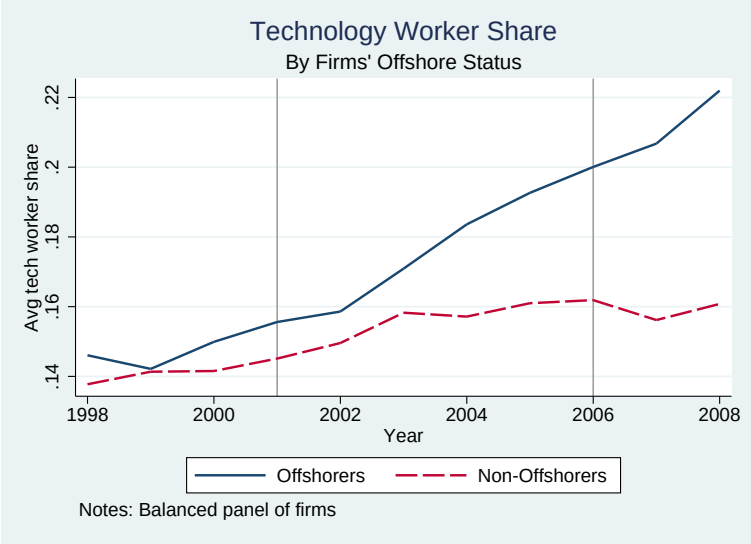
Notes: Panel (a) plots imports of goods that the firm produced domestically in 2000 and 2001 over domestic production of those same goods. Panel (b) plots average domestic production by firms.

Figure 4: Average firm employment by firm's offshoring status



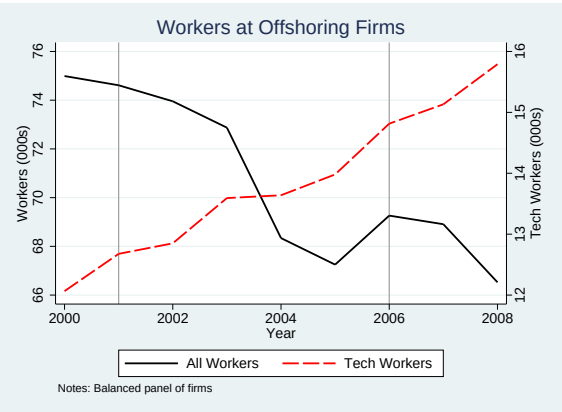
Notes: Figure plots average firm employment for firms in the offshoring survey. Offshoring firms are those that relocated their core activity to a foreign country between 2001 and 2006.

Figure 5: Share of technology workers by firm's offshoring status

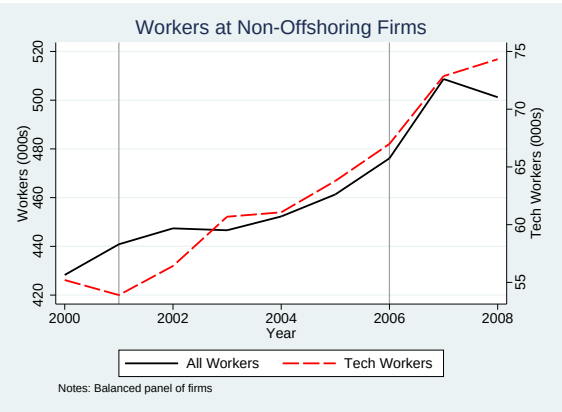


Notes: Figure plots the share of technology workers over total employment for firms in the offshoring survey. Offshoring firms are those that relocated their core activity to a foreign country between 2001 and 2006.

Figure 6: Level of technology worker employment by offshoring status

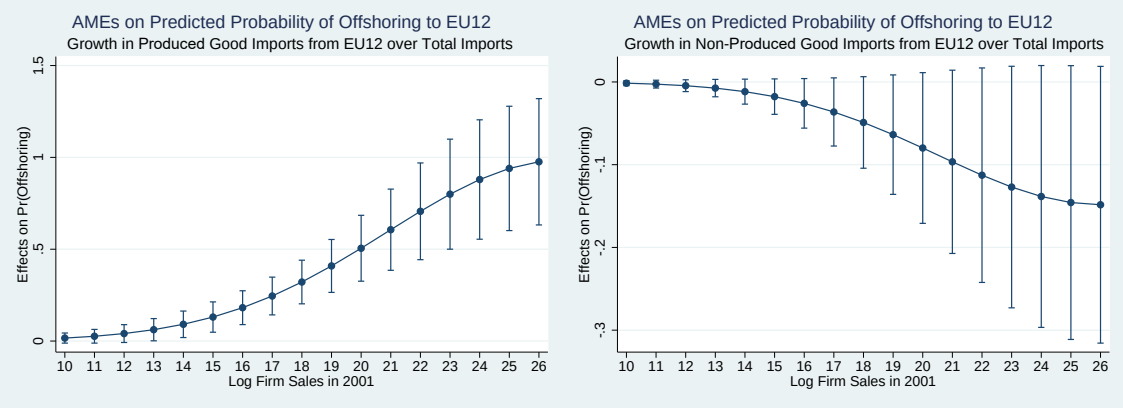


(a) Offshorers



(b) Non-Offshorers

Figure 7: Average marginal effects of import shares on predicted offshoring to EU12



(a) Produced good import share (b) Non-produced good import share

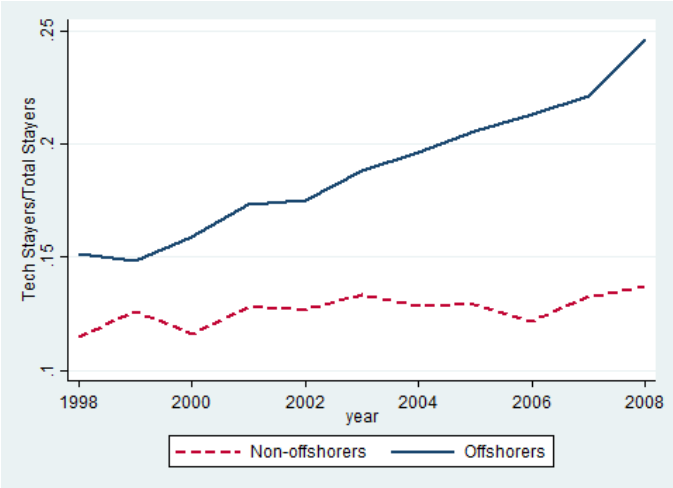
Notes: Panel (a) plots the average marginal effects of growth in a firm's produced good imports over total imports share from 2001 - 2006 on its predicted probability of offshoring. Panel (b) plots a comparable figure for non-produced good import share growth. Produced goods are defined as goods produced domestically by the firm in 2000 or 2001.

Figure 8: Tech worker shares of hires and separations by offshore status

(a) Share of tech worker hires (b) Share of tech worker separations

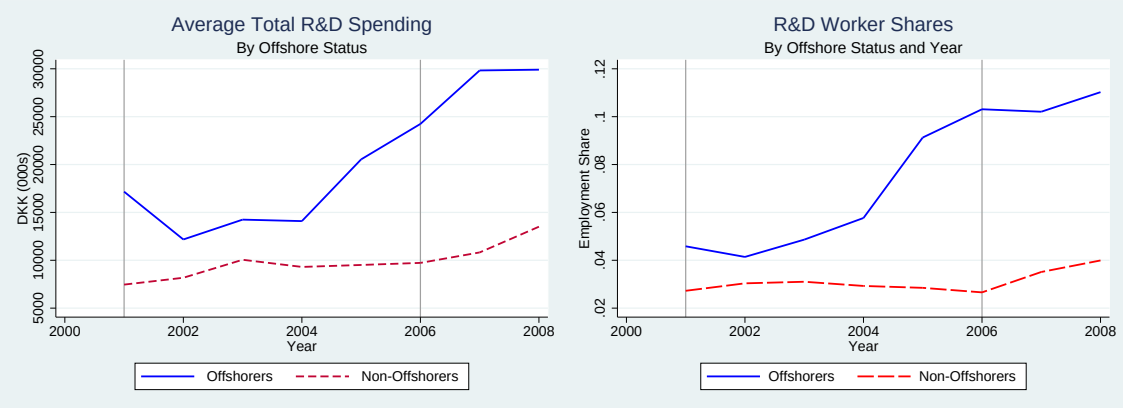
Notes: Figure plots the share of technology worker hires over total hires and share of technology worker separations over total separations for firms in the offshoring survey. Offshoring firms are those that relocated their core activity to a foreign country between 2001 and 2006.

Figure 9: Share of tech worker stayers by offshore status



Notes: Figure plots the share of continuing technology worker over all continuing workers for firms in the offshoring survey. Offshoring firms are those that relocated their core activity to a foreign country between 2001 and 2006.

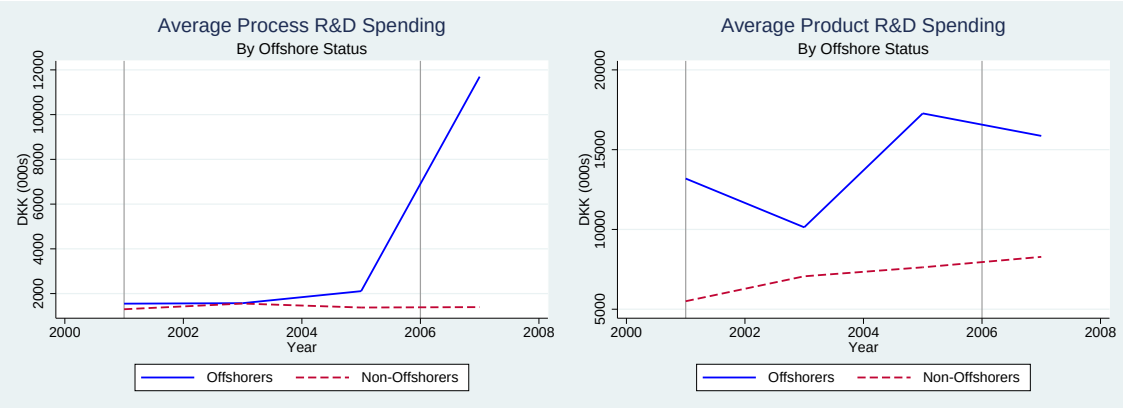
Figure 10: Total R&D spending and R&D workers



(a) Total R&D spending (b) R&D worker share

Notes: Figure plots average product and process R&D expenditure for firms in the offshoring and R&D surveys. Offshoring firms are those that relocated their core activity to a foreign country between 2001 and 2006.

Figure 11: Average product and process R&D expenditure



(a) Process R&D (b) Product R&D

Notes: Figure plots average product and process R&D expenditure for firms in the offshoring and R&D surveys. Offshoring firms are those that relocated their core activity to a foreign country between 2001 and 2006.

Table 1: Offshoring of core activity by region

Offshoring of core activity by detailed region

Region	Firm count	Share
EU12	139	0.37
EU12 & China	66	0.17
China	60	0.16
Other	115	0.30
Total Offshorers	380	1.00

Notes: Locations to which firms relocated their core activity.

Table 2: Shares of total production and import value by product status

	Non-Offshorers		Offshorers	
Product Status	2001	2008	2001	2008
Produced only	0.19	0.16	0.15	0.16
Imported only	0.30	0.33	0.18	0.20
Produced and imported	**0.51**	**0.51**	**0.67**	**0.65**
P&I Imports'/Production	0.07	0.10	0.11	0.19

Notes: Table reports value shares by offshore and product status and year. "Produced only" are HS6 products produced in Denmark but not imported by the same firm. "Imports only" are HS6 products imported by the firm but not produced in Denmark. "Produced and imported" are HS6 products that are both produced and imported by the same firm in that year.

Table 3: Unit value differences for domestically-produced varieties of the same product

Dependent variable - the log unit value of a CN8 product

	(1)	(2)	(3)
Domestic variety	0.596***	0.520***	0.566***
	(0.096)	(0.093)	(0.117)
Domestic × Offshorers		0.268**	0.205*
		(0.113)	(0.112)
China			-0.423***
			(0.066)
EU12			-0.200***
			(0.058)
EU15			0.123**
			(0.060)
Constant	3.966***	3.966***	3.946***
	(0.039)	(0.039)	(0.067)
R2	0.70	0.70	0.70
Year Fixed Effects	Yes	Yes	Yes
Firm-by-Product Fixed Effects	Yes	Yes	Yes
Observations	37,450	37,450	37,450

Notes: The sample includes all firm-product-year combinations from 2001-2008 where there is both domestic production and importing of the same CN8 product by the firm in the same year. The dependent variable is the log unit value. "Domestic" is a dummy for whether the variety is produced domestically; "Offshorer" is a dummy for whether the firm offshored its core activity during 2001-2006; "China", "EU12" and 'EU15" are dummies for whether the imported variety comes from China, the EU12, or the EU15 respectively. Standard errors clustered by CN8 product.

Table 4: Offshorer versus Non-Offshorers

	Level (2001)	Change (2001-2006)
log FTE	0.57***	-0.17***
log Sales	0.62***	-0.08*
log Sales/Worker	0.06	0.08**
log VA/Worker	-0.03	0.00
Importer	0.18***	-0.02
Exporter	0.19***	-0.01
Imports/Sales	0.05***	0.02***
Exports/Sales	0.16***	0.00

Notes: Each entry is the estimated coefficient from regressing the variable in column 1 on an indicator for whether the firm offshored its primary activity between 2001 to 2006. For the column titled "Level" the dependent variables is the (log) level of the variable in 2001 and the controls include NACE4 industry fixed effects. For the column "Change", the dependent variable is the change from 2001-2006 and the controls include NACE4 industry fixed effects.

Table 5: Labor force characteristics by offshoring status

	2001	2008
Panel A: Education		
Offshoring firms		
Education - low	0.37	0.30
Education - middle	0.57	0.59
Education - high	0.06	0.11
Non-offshoring firms		
Education - low	0.38	0.38
Education - middle	0.55	0.52
Education - high	0.07	0.09
Panel B: Occupations		
Offshoring firms		
Managers	0.03	0.04
Production workers	0.54	0.38
Blue non-production workers	0.07	0.06
Tech workers	0.17	0.24
Support workers	0.13	0.18
Sales workers	0.05	0.08
NEC	0.01	0.01
Non-offshoring firms		
Managers	0.04	0.04
Production workers	0.32	0.22
Blue non-production workers	0.09	0.10
Tech workers	0.13	0.14
Support workers	0.27	0.28
Sales workers	0.13	0.21
NEC	0.02	0.01

Notes: Offshoring firms are defined as those that relocated their core activity to a foreign region between 2001 and 2006. Low education workers have less than a high school degree, middle education workers have a high school degree but less than a bachelors degree, and high education workers have a bachelor's degree or above. See the online Appendix for the ISCO codes corresponding to the occupation categories.

Table 6: Product switching by offshore status

	No. of Products		Product changes from 2000-2007		
	2000	2007	Continued	Dropped	Introduced
Non-offshorers	2.89	3.05	2.15	0.74	0.90
percent			*74.4%*	*25.6%*	*29.5%*
Offshorers	4.85	6.26	3.41	1.44	2.85
percent			*70.3%*	*29.7%*	*45.5%*
Total	3.22	3.60	2.36	0.86	1.24
percent			*73.3%*	*26.7%*	*34.4%*
Relative to firm's industry average					
Non-offshorers	0.94	0.90	0.95	0.91	0.81
Offshorers	1.28	1.46	1.22	1.46	1.94

Notes: There are 1,220 firms (207 offshorers) with production data.

Table 7: Probability of Offshoring to China or EU12

Dep var is indicator equal to one if firm i offshores from 2001-2006 to:

	China		EU12	
$\Delta ChImpPen_j^{2001-2006}$	1.111**	1.225*		2.543***
	(0.537)	(0.594)		(0.613)
$\Delta EU12ImpPen_j^{2001-2006}$		0.393	-0.006	0.329
		(0.266)	(0.652)	(0.430)
$logSales_i^{2001}$	0.029**	0.029**	0.035**	0.038***
	(0.011)	(0.011)	(0.013)	(0.012)
Constant	-0.487**	-0.503**	-0.540**	-0.644***
	(0.186)	(0.184)	(0.227)	(0.212)
R2	0.03	0.03	0.02	0.04
Observations	1,679	1,679	1,682	1,679

Notes: Import penetration measured at 2-digit NACE industry. Standard errors clustered by industry.

Table 8: OLS results for offshoring to EU12 and workforce changes

Dependent variable is 2001-2008 change in :						
	(1) log empl	(2) Tech Share	(3) Edu Hi Share	(4) Edu Low Share	(5) New Prods	(6) New Prod Sh
$\Delta PGimpSh_{i,EU12}^{2001-2006}$	-0.398*	0.081***	0.066***	-0.127***	3.776*	0.338***
	(0.204)	(0.026)	(0.015)	(0.025)	(1.984)	(0.109)
$\Delta ImpPen_{i,EU12}^{2001-2006}$	-0.320	0.044	-0.044	-0.033	-10.319**	-0.495*
	(0.537)	(0.068)	(0.041)	(0.065)	(5.088)	(0.279)
Constant	-0.229***	0.030***	0.027***	-0.048***	2.752***	0.131***
	(0.018)	(0.002)	(0.001)	(0.002)	(0.172)	(0.009)
R2	0.09	0.14	0.22	0.12	0.12	0.12
Observations	1,149	1,149	1,149	1,149	1,026	1,026

Notes: $\Delta PGimpSh_{i,EU12}^{2001-2006}$ is the share of produced goods in total EU12 imports for the firm from 2001-2006. $\Delta ImpPen_{i,EU12}^{2001-2006}$ is a firm-specific measure of product import penetration with firm production shares as weights. Regressions are weighted by employment and include 2-digit NACE industry fixed effects. * p<0.10, ** p<0.05, *** p<0.01

Table 9: Reduced-form results for offshoring to EU12 and workforce changes

Dependent variable is 2001-2008 change in :						
	(1) log empl	(2) Tech Share	(3) Edu Hi Share	(4) Edu Low Share	(5) New Prods	(6) New Prod Sh
$\Delta ExportSh_{i,EU12}^{2001-2006}$	-0.006	0.038***	0.026***	-0.017***	0.969**	0.093***
	(0.045)	(0.006)	(0.003)	(0.005)	(0.434)	(0.024)
$\Delta ImpPen_{i,EU12}^{2001-2006}$	-0.318	0.024	-0.058	-0.024	-11.751**	-0.629**
	(0.538)	(0.067)	(0.040)	(0.066)	(5.089)	(0.279)
Constant	-0.236***	0.017***	0.018***	-0.044***	2.504***	0.106***
	(0.024)	(0.003)	(0.002)	(0.003)	(0.230)	(0.013)
R2	0.09	0.17	0.25	0.1	0.12	0.12
Observations	1,149	1,149	1,149	1,149	1,026	1,026

Notes: $\Delta ExportSh_{i,EU12}^{2001-2006}$ is a firm-specific measure of the change in product export shares from the EU12 excluding exports to Denmark from 2001-2006 with firm production shares as weights. $\Delta ImpPen_{i,EU12}^{2001-2006}$ is a firm-specific measure of product import penetration with firm production shares as weights. Regressions are weighted by employment and include 2-digit NACE industry fixed effects. * p<0.10, ** p<0.05, *** p<0.01

Table 10: First Stage Results

Dependent variable is $\Delta PGimpSh_{i,EU12}^{2001-2006}$:		
	(1)	(2)
$\Delta ExportSh_{i,EU12}^{2001-2006}$	0.059***	0.069***
	-0.006	-0.007
$\Delta ImpPen_{i,EU12}^{2001-2006}$	-0.029	-0.217***
	-0.076	-0.077
Constant	0.001	0.006
	-0.003	-0.003
R2	0.23	0.22
FStat on Excl Ins	87.74	110.70
Observations	1,149	1,026

Notes: $\Delta PGimpSh_{i,EU12}^{2001-2006}$ is the share of produced goods in total imports for the firm from 2001-2006. $\Delta ExportSh_{i,EU12}^{2001-2006}$ is a firm-specific measure of the change in product export shares from the EU12 excluding exports to Denmark from 2001-2006 with firm production shares as weights. $\Delta ImpPen_{i,EU12}^{2001-2006}$ is a firm-specific measure of product import penetration with firm production shares as weights. Regressions are weighted by employment and include 2-digit NACE industry fixed effects. * p<0.10, ** p<0.05, *** p<0.01

Table 11: IV results for offshoring to EU12 and workforce changes

Dependent variable is 2001-2008 change in :						
	(1) log empl	(2) Tech Share	(3) Edu Hi Share	(4) Edu Low Share	(5) New Prods	(6) New Prod Sh
$\Delta PGimpSh_{i,EU12}^{2001-2006}$	-0.101	0.648***	0.436***	-0.284***	13.980**	1.341***
	(0.742)	(0.113)	(0.069)	(0.092)	(6.250)	(0.353)
$\Delta ImpPen_{i,EU12}^{2001-2006}$	-0.321	0.042	-0.045	-0.032	-8.724*	-0.338
	(0.529)	(0.081)	(0.049)	(0.066)	(5.158)	(0.291)
Constant	-0.326	-0.11	-0.066	-0.051	-2.687	-0.213
	(0.817)	(0.124)	(0.076)	(0.101)	(7.175)	(0.405)
Observations	1,149	1,149	1,149	1,149	1,026	1,026

Notes: $\Delta PGimpSh_{i,EU12}^{2001-2006}$ is the share of produced goods in total imports for the firm from 2001-2006 and is instrumented by $\Delta ExportSh_{i,EU12}^{2001-2006}$. $\Delta ImpPen_{i,EU12}^{2001-2006}$ is a firm-specific measure of product import penetration with firm production shares as weights. Regressions are weighted by employment and include 2-digit NACE industry fixed effects. * p<0.10, ** p<0.05, *** p<0.01

A Data appendix

A.1 Offshoring data details

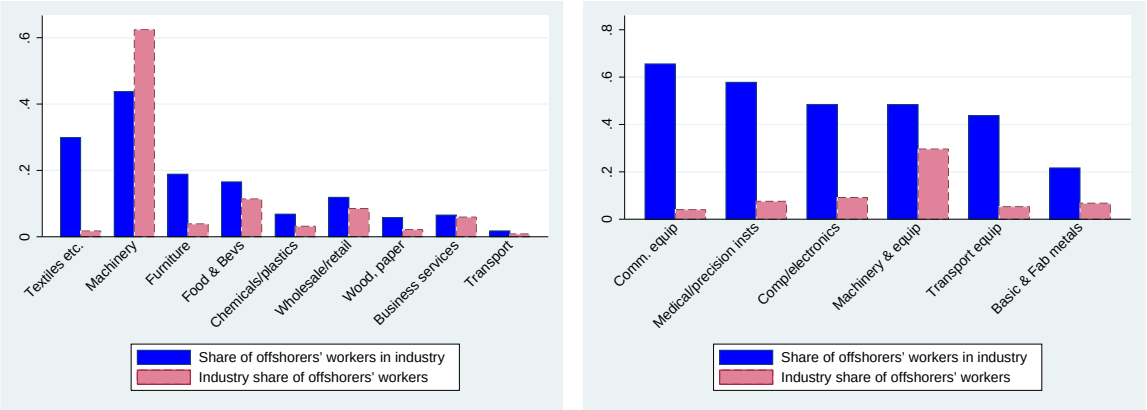
Table A.1 presents all the offshoring location regions to which Danish firms relocate their core activities.

Table A.1: Offshoring of core activity by region

Region	Firm count	Share
EU-12	205	0.54
China	126	0.33
EU-15	109	0.29
Other Asian countries and Oceania	60	0.16
Other European countries	46	0.12
India	30	0.08
US and Canada	25	0.07
Total offshoring firms	380	0.091

Notes: Locations to which firms relocated their core activity.

Figure A.1: Industry distribution of offshoring workers



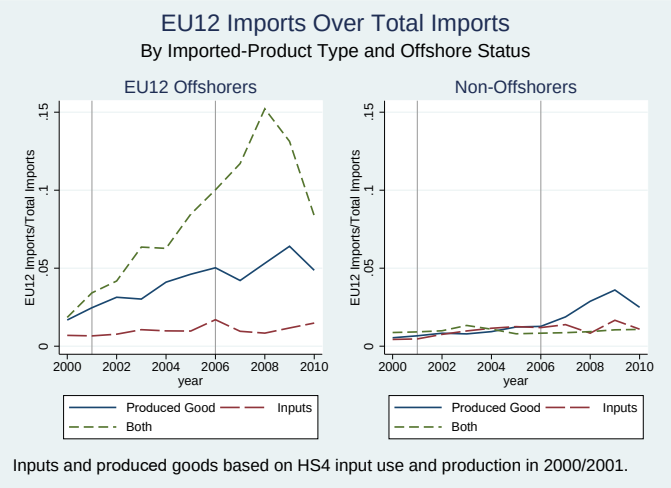
(a) Across Broad Sectors (b) Within Machinery

Notes: Figure plots the share of workers at offshoring firms within each industry (first/blue bars) and the share of workers at offshoring firms across industries (second/red bars). Note that the red bars do not sum to 1 since only the top industries are presented to minimize disclosure concerns.

A.2 Imports of produced goods versus intermediates

In this section, we use the Prodcom data at the HS4 level and the input purchase data, which are generally available at the HS4 level, to assess the extent to which offshoring firms import

Figure A.2: EU12 imports of inputs and produced goods



Notes: Figure plots the share of imports from EU12 of HS4 products that are "Produced goods", "Purchased inputs", or HS4 products classified as "Both" produced goods and purchased inputs over total imports of the firm.

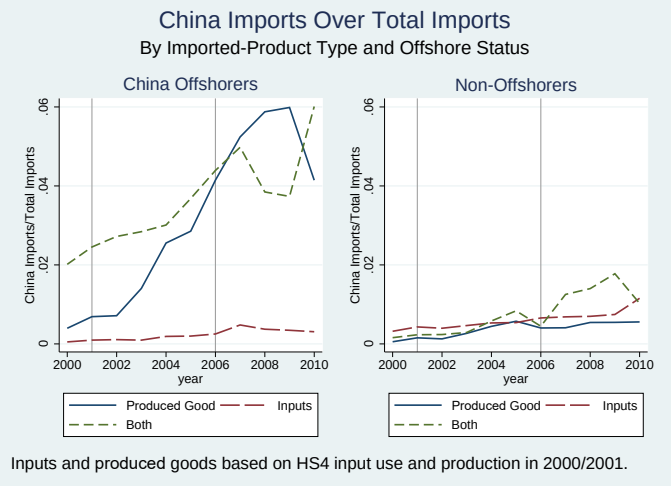
inputs and/or domestically produced goods. Figure A.2 shows that firms that offshore to the EU12 increase their share of produced good imports, as well as their share of imports of products that they both produce and purchase as inputs ("Both"). In contrast, their share of imported inputs of HS4 products that they do not produce domestically is low and fairly stable.

Given the lack of detail for firms' input purchases, we cannot rule out the possibility that they are importing both inputs and produced goods. It is also possible, however, that HS6-level detail on inputs would lead to much smaller shares of imported inputs (whereas the main text shows that firms import the same detailed HS6 products they produce). Given the low share and small changes for imported inputs, it seems that offshoring may be more related to imports of produced goods rather than inputs. Figure A.3 presents similar patterns for firms that offshore to China.

A.3 Offshoring and exporting

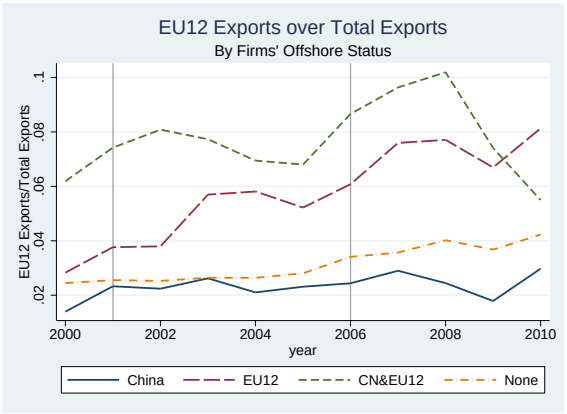
Here we show that offshoring firms shift their exports somewhat towards offshore regions, those these changes and levels are considerably smaller than the comparable changes observed for firm imports. Offshoring thus seems to entail imports from the offshore location back to Denmark, without considerable exporting of inputs from Denmark to the offshore location. Figure A.4 depicts these patterns.

Figure A.3: Chinese imports of inputs and produced goods



Notes: Figure plots the share of imports from EU12 of HS4 products that are "Produced goods", "Purchased inputs", or HS4 products classified as "Both" produced goods and purchased inputs over total imports of the firm.

Figure A.4: Exports to offshoring region over total exports



(a) EU12

(b) China