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MULTI-PRODUCT OFFSHORING†

Abstract

We show that the labor market effects of product line relocations within multi-product firms differ significantly from the relocation of production tasks within single-product firms. By incorporating offshoring of labor-intensive goods in a model with multi-product firms, and exploring its implications in partial and general equilibrium, we identify the cannibalization effect of offshoring as an important transmission mechanism within multi-product firms and show that this effect hits domestic labor demand in addition to the well-known relocation effect. Furthermore, we contribute to the growing literature on multi-product firms and trade by showing that lower offshoring costs tend to increase the range of products produced.

JEL Classification: F12, F23 and L23
Keywords: cannibalization effect, efficiency-seeking offshoring, general oligopolistic equilibrium and product range

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1 Introduction

Over the past decades, progress in communication and information technologies has changed the international organization of production. Markets are dominated by large multinational firms that control and manage production lines on a global scale. Within these global production networks, many firms relocate labor-intensive production processes to low-wage countries in an effort to save on production costs. These strategies, typically referred to as offshoring, have started a fierce debate in particular in industrialized countries about potential negative effects of globalization: If manufacturing jobs are relocated to low-wage countries on a grand scale, high-wage industrialized countries fear a rise in unemployment and pressure on wages.

Fueled by the public debate, there is now a large academic literature on the labor market effects of cost-based offshoring to low-wage countries (See McMillan, 2010, and Hummels et al., 2014, for recent overviews). This literature has identified two main channels by which offshoring affects domestic labor demand. Firstly, there is a direct relocation or displacement effect. Jobs that were previously performed at home are now carried out in a foreign low-wage location. This can be interpreted as a substitution of domestic workers by foreign workers, and clearly lowers labor demand at home. But this is not the full story: The relocation effect is (partly or fully) offset by an efficiency (or productivity) effect that tends to raise labor demand at home. Since cost-based offshoring lowers labor costs for the firms performing the production relocation, the products of these firms become more competitive. As a consequence, these firms are able to either defend or even increase their market shares on global markets, which tends to increase demand for labor. With the relocation effect and the efficiency effect working in opposite directions, the net effect of offshoring on domestic labor demand is - at least according to conventional wisdom - ambiguous.

Naturally, the cost savings associated with the lower labor costs abroad have a positive effect on domestic labor demand only if production at home and abroad are in a vertical relationship, i.e. if production in one location uses the production in the other location as an input. For firms that produce a single (aggregated) output, this is not a very restrictive assumption: Any two production fragments are automatically vertically connected, and as long as some production remains in the home country, workers at home will benefit from cost reductions in other locations through lower product prices.

The main message of this paper is that the situation is very different if the firm performing offshoring is a multi-product firm (MPF) and the production relocated is a (complete) production line within the range of products produced by this firm. In this case, offshoring looks very similar: Labor-intensive parts of a firm's production are relocated to low-wage countries. But the labor market effects are strikingly different: The relocation effect remains, but the efficiency effect vanishes. If the products produced by an MPF are varieties of a horizontally differentiated good, production at home and abroad are essentially substitutes, and workers at home no longer benefit from lower production costs in other locations.

In fact, the relocation of a complete production line not only prevents the positive efficiency effect but causes a cannibalization effect that tends to aggravate the negative effect on labor demand. If - due to offshoring - one product within a firm's product range becomes more competitive, the expansion of this product will create a negative demand externality on all other products of this firm. This is referred to as the cannibalization effect and is one of the key characteristics of MPFs (Feenstra and Ma, 2008, Eckel and Neary, 2010, and Dhingra, 2013). However, the role of the cannibalization effect in the context of offshoring has not been addressed by the literature. We show that if an MPF decides to offshore a labor-intensive production line to a low-wage country, labor demand at home is hit twice: First by the relocation effect, and then again by the cannibalization effect. Therefore, in the context of MPFs, the labor market effects of (cost-based) offshoring need to be reevaluated. This is the purpose of this paper.

Our analysis of offshoring within a firm's product range builds on recent advances in the modeling of MPFs.[1] In particular, we use the MPF framework by Eckel and Neary (2010) and combine it with the Feenstra and Hanson (1996, 1997) model of offshoring. In Feenstra and Hanson (1996, 1997), intermediate inputs differ in their factor intensities, and the production of (low-skilled) labor-intensive inputs are relocated to a low-wage location according to comparative advantages. In Eckel and Neary (2010), MPFs use a flexible manufacturing technology where products within a firm's product range differ in their unit labor requirements. We will show that in this framework individual firms have a very similar incentive to relocate labor-intensive product lines to the low-wage location. We call this phenomenon "multi-product offshoring".

What we call "multi-product offshoring" - the international relocation of a firm's entire production line - is a common phenomenon in many industries. Take for example the European automotive industry: Between 1992 and 2010, German car manufacturers increased their foreign production by 4.9 million cars while domestic production stayed almost constant (VDA, 2011). A large share of this increase was due to a relocation of entire production plants for specific models: Audi opened a new plant for its Q7 model in Bratislava (Slovakia), Mercedes-Benz now produces its CLA-class at the Kecskemét plant (Hungary), and Opel is

[1] Feenstra and Ma (2008), Bernard et al. (2010, 2011), Eckel and Neary (2010), Dhingra (2013), Qiu and Zhou (2013), Mayer et al. (2014), Nocke and Yeaple (2014), and Arkolakis et al. (2014) have introduced new models of MPFs in order to study the effects of international trade on the range of products produced by MPFs.

currently relocating the production of the Opel Astra from the German city Ruesselsheim to Gliwice (Poland). Similar evidence can be found for other countries: French PSA Peugot Citroen manufactures the model C3 Picasso solely in its newest production plant in Trnava (Slovakia), and Ford of Europe began with the exclusive production of the Ford B-Max in Craiova (Romania). Further evidence for the relocation of entire production lines in the light truck industry following NAFTA is provided by McCalman and Spearot (2013). More generally, Yeaple (2013) shows that relocations of entire product lines are a common expansion strategy of US multi-product multinationals.

Our slightly different definition of offshoring - focusing on final goods instead of inputs - is actually very much in the spirit of many empirical contributions on this topic. Feenstra and Hanson (1996, p.92) argue that in order to capture the full magnitude of the labor market effects of offshoring, they "adopt a more general definition of outsourcing, which in addition to imports by U.S. multinationals, includes all imported intermediate or *final goods* that are used in production of, *or sold under the brandname of*, an American firm. This definition of outsourcing corresponds to common usage and would include a very wide range of textiles and apparel, footwear, consumer electronics, and many other imports" (our highlights). Berman et al. (1994) and Lawrence (1994) make similar points. More recently, Biscourp and Kramarz (2007) use the same specification as Feenstra and Hanson (1996) to quantify job losses due to outsourcing. And our concept of "multi-product offshoring" is also consistent with any measure of offshoring based on foreign affiliate activity (e.g., Becker et al., 2013; Ottaviano et al., 2013; Ebenstein et al., 2014).

In our framework, the extent of multi-product offshoring is endogenously determined by trading-off the higher costs of operating foreign production facilities (offshoring costs) against the benefits of lower labor costs in low-wage countries. When offshoring costs fall (due to globalization), firms expand their foreign operations and relocate marginal product lines to low-wage locations. As a result, labor demand at home clearly falls. In addition, we can show that the entire range of products produced by an individual firm (at home and abroad) expands. This latter result contributes to our understanding of how globalization affects MPFs. Eckel and Neary (2010) emphasize that an increase in the global market leads to a "leaner and meaner" profile, inducing MPFs to expand their core products and to prune their product ranges. We show that offshoring has the exact opposite effect: Firms expand their product ranges at the expense of their core products.

However, this latter result changes when we extend our analysis to general equilibrium. In general equilibrium, the fall in demand for domestic labor lowers wages at home, and this wage effect reduces the relative benefit of offshoring. As a result, the incentive to offshore product lines is reduced, and the partial equilibrium effects are dampened. In fact, it is even possible that the partial equilibrium results are reversed if the wage effects are large, which in turn depends on the degree of heterogeneity within the firm's product range. Our general equilibrium results suggests that offshoring rates can overshoot if wages are inflexible in the short run.

The remainder of the article is structured as follows. Section 2 recaps the basic model of Eckel and Neary (2010) and incorporates offshoring into this framework. Subsequently, we provide comparative static results of falling offshoring costs. Section 3 shows how these results transform when wages are endogenized in general equilibrium. Section 4 concludes and summarizes results. Mathematical derivations and a numerical simulation of our model are presented in the Appendix.

2 The Model

For our analysis we combine the multi-product framework by Eckel and Neary (2010) with the offshoring framework by Feenstra and Hanson (1996, 1997). Firms can produce either at home, using domestic labor, or in a foreign low-wage location, using foreign labor. Final products are sold on the world market. We make two important simplifying assumptions: First, we assume that the home country is a small country on the world market. This implies that (i) the wage rate in the foreign location is independent of the level of offshoring from our home country (w^* is exogenous), and (ii) the income of the representative consumer on the world market is independent of the wage rate in the home country. This assumption allows us to focus on the (labor market) effects of offshoring on the source country of the relocation. Second, we assume that each industry is serviced by a single multi-product monopolist. This will be explained in more detail in section 2.2.

To conduct our analysis, we rely on the multi-product framework with flexible manufacturing proposed by Eckel and Neary (2010). Our setup consists of two countries, Home and Foreign, and a large world market. There is a continuum of identical industries in Home, whereby the output produced in each of these industries is sold on the world market. Foreign is a low wage emerging country and acts as a potential location for an affiliate. We begin this section with the analysis of one single sector by considering the behavior of the consumers in the world market and the optimal firm behavior in this industry.

2.1 Consumer Behavior: Preferences and Consumer Demand

We assume that L^W consumers in the world market maximize their utility defined over the consumption of differentiated products. Referring to the model of Eckel and Neary (2010), we maintain the specification of preferences in the form a two-tier utility function.[2] The upper tier is an additive function of a continuum of sub-utility functions over industries z, where z varies over the interval $[0, 1]$, given by

$$U\left[u\left(z\right)\right]=\int_{0}^{1}u\left(z\right)dz. \tag{1}$$

The representative consumer's sub-utility is defined over per variety consumption $q(i, z)$ with $i \in \Omega$ and total consumption $Q \equiv \int_{i\in\Omega} q(i, z)di$, where Ω is a set of differentiated goods potentially offered in industry z. To be more specific, we assume

$$u\left(z\right)=aQ-\frac{1}{2}b\left[\left(1-e\right)\int_{i\in\Omega}q(i,z)^{2}di+eQ^{2}\right]. \tag{2}$$

Eq. (2) has a standard quadratic form, where a, b denote non-negative preference parameters and e is an inverse measure of product differentiation which lies between 0 and 1. Lower values of e imply that products are more differentiated and hence less substitutable. In the event of $e = 1$, consumers have no taste for diversity in products and demand depends on aggregate output only. Consumers maximize utility in Eqs. (1) and (2) subject to the budget constraint $\int_0^1 \int_{i\in\Omega} p(i, z)q(i, z)didz \leq I$, where $p(i, z)$ denotes the price for variety i in industry z and I is individual income. This yields the following linear inverse individual demand function:

$$\lambda p(i,z)=a-b\left[(1-e)q(i,z)+eQ\right], \tag{3}$$

where λ is the marginal utility of income, the Lagrange multiplier attached to the budget constraint. Market-clearing imposes that each firm faces a market demand $x(i, z)$ that consists of the aggregated demand of all consumers in the world market $L^W q(i, z)$. For the inverse world market demand, we get

$$p(i,z)=a'-b'\left[(1-e)x(i,z)+eX\right], \tag{4}$$

where $a' \equiv \frac{a}{\lambda}$ is the consumers' maximum willingness to pay and $b' \equiv \frac{b}{\lambda L^W}$ is an inverse measure for the market size. Finally, $X \equiv \int_0^\delta x(i, z)\, di$ represents the total volume of varieties produced and consumed in industry z. Note that X is defined over the goods actually consumed with $i \in [0, \delta]$, which is a subset of the potential products Ω. With no quasi-linear term in Eq. (2), the value of λ is not constant, which implies that a' and b' are endogenously determined in general equilibrium. However, with a continuum of industries, we may assume

[2] These preferences combine the continuum quadratic approach to symmetric horizontal product differentiation of Ottaviano et al. (2002) with the preferences in Neary (2009).

that each firm takes these parameters as given. Hence, each firm has market power in its own market but it is small in the economy as a whole. This assumption permits a consistent analysis of oligopoly in general equilibrium. As it has become standard in the literature, we choose the marginal utility of income as the numeraire and set λ equal to one (see Neary (2009) for further discussion).

2.2 Firm Behavior: Costs and Technology of MPFs

This section considers technology and optimal firm behavior in industry z.[3] We focus on intra-firm adjustments, so competition between firms plays only a second-order role. To keep the analysis as simple as possible, we focus on the monopoly case. Extending the analysis to oligopoly is straightforward.[4] According to that, each industry z is characterized by exactly one firm whose objective it is to maximize profits by choosing both the scale and scope of production, as well as choosing the optimal location for producing each specific variety. When choosing the optimal location for production, firms seek to reduce costs by producing labor-intensive goods offshore where a comparative advantage exists due to lower wages. For simplicity, we assume no fixed costs for both domestic and foreign production.

Following Eckel and Neary (2010) and Mayer et al. (2014), the technology of an MPF can be characterized by a core competency product and flexible manufacturing. The core competency product is the product with the lowest marginal production costs. As the firm adds product to its product range, it becomes less efficient in the production of these added products, and marginal production costs of new products are increasing in the product range. As in Grossman and Rossi-Hansberg (2008), technology is transferable as a home firm will use its own technology when performing a task abroad. Thus, technology is firm-specific and can be applied in all locations.

Production costs in our model comprise both a product-specific and a monitoring component (managerial effort) which we assume to be zero for production at home. This assumption implies that the ability to monitor varies with distance. Managerial effort is needed to supervise production and to provide the firm's technology abroad.[5] By incorporating these costs, we try to capture the more general idea that aggravated monitoring through managers, less skilled workers, worse infrastructure, or inferior contractual enforcement, affect

[3] We concentrate on symmetric industries and drop the industry index z in the following analysis. We consider this index again when we aggregate over all industries and turn to the level of the economy as a whole in general equilibrium.

[4] See the Appendix in Eckel et al. (2015).

[5] See for example Grossman and Helpman (2004). They assume that a principal is able to observe the manager's efforts at a lower cost when the manager's division is located near to the firm's headquarters as compared with when it is located across national borders.

production in emerging countries. In the following analysis, we refer to this cost component as offshoring costs. To put it formally, we assume a Ricardian technology where domestic (foreign) production costs $c(i)$ ($c^*(i)$) are given by

$$c(i) = w\gamma(i) \text{ and} \tag{5}$$

$$c^*(i) = w^*(\gamma(i) + t), \tag{6}$$

with $\gamma(i)$ denoting the labor input coefficient for variety i, w (w^*) being the wage level in Home (Foreign) and finally t representing the offshoring costs.[6] Latter is measured in labor costs and is the same for all products assembled abroad. This way of modelling offshoring costs does not challenge the assumptions made in the recent literature where tasks within the production process of one variety differ in their offshorability. However, as we are analyzing the relocation of the total range of tasks involved in the production of one variety, the assumption that t is identical across offshored varieties seems fair. Technology is firm- and not country-specific, therefore $\gamma(i)$ is the same in both countries. The idea of core competence and flexible manufacturing are formally introduced throughthe following properties: $\gamma(0) = \gamma^0$ and $\frac{\partial c}{\partial i} = \frac{\partial \gamma}{\partial i} w > 0$.

Closed Economy: Without offshoring, optimal firm behavior is composed of maximizing total firm profits both with regard to scale and to scope. Considering the technology assumptions above and denoting the scope of the product portfolio by δ, profits are given by

$$\Pi = \int_0^\delta [p(i) - c(i)]\, x(i) di. \tag{7}$$

Firms simultaneously choose the quantity produced of each good and the mass of products produced. Maximizing profits in Eq. (7) with respect to scale $x(i)$ implies the first-order condition for scale:

$$\frac{\partial \Pi}{\partial x(i)} = p(i) - c(i) - b' [(1-e)x(i) + eX] = 0 \tag{8}$$

that leads to the optimal output of a single variety

$$x(i) = \frac{a' - w\gamma(i) - 2b'eX}{2b'(1-e)}, \tag{9}$$

[6]Foreign variables are denoted by an asterisk throughout.

with $X \equiv \int_0^\delta x(i)di$ denoting total firm scale.[7] The negative impact of total firm scale X on the output of a single variety displays the cannibalization effect: $\frac{\partial x(i)}{\partial X} = -\frac{e}{(1-e)} < 0$. An MPF internalizes the effect that increasing output of a certain variety lowers prices for this, as well as, for all other varieties in the firm's product range. This effect only exists if $e > 0$, i.e. if products are not perfectly differentiated. Furthermore, Eq. (9) shows that, given its total output, a firm produces less of each variety the further away it is from its core competence. Given the symmetric structure of demand, this means that a firm charges higher prices for products that are further away from its core competence (see Eckel and Neary (2010), p.193 for a detailed analysis).

In the next step, we consider the firm's optimal choice of product line. MPF's add new products as long as marginal profits are positive. Maximizing Eq. (7) with respect to scope implies the respective first-order condition[8]

$$\frac{\partial \Pi}{\partial \delta} = [p(\delta) - c(\delta)]x(\delta) = 0. \tag{10}$$

From Eq. (8), we know that the profit on the marginal variety $[p(\delta) - c(\delta)]$ cannot be zero. The firm adds new varieties up to the point where the marginal cost of producing the marginal variety equals the marginal revenue at zero output. The profit maximizing product range implies that the output of the marginal variety $x(\delta)$ is zero. Using Eq. (9) and setting $x(\delta)$ equal to zero yields

$$c(\delta) = a' - 2b'eX. \tag{11}$$

Comparing Eqs. (9) and (11), we see that firms add new varieties to their product portfolio until optimal output of the marginal variety falls to zero. Inspecting Eq. (11) reveals the cannibalization effect which influences the scope of production: $\frac{\partial \delta}{\partial X} = -\frac{b'e}{\partial c(\delta)/\partial \delta} < 0$. Figure 1 illustrates the first-order condition for scope and determines the profit-maximizing product range.

Open Economy: So far, we have implicitly assumed that the offshoring costs t were prohibitively high, so that all production was located in the home country. As globalization leads to improvements in information technology and reductions in communication costs, we analyze a decrease in the parameter t, which implies that firms can enjoy benefits of lower factor prices and thus gains from relocating labor-intensive products to a low-wage

[7] The second-order condition of this maximization problem is: $\frac{\partial^2 \Pi}{\partial x(i)^2} = \frac{\partial p(i)}{\partial x(i)} - b'(1-e) - b'e\frac{\partial X}{\partial x(i)} < 0$.

[8] The second-order condition of this maximization problem is: $\frac{\partial^2 \Pi}{\partial \delta^2} = [p(\delta) - c(\delta)]\frac{\partial x(\delta)}{\partial \delta} < 0$, as $\frac{\partial c(\delta)}{\partial \delta} > 0$ and, thus, $\frac{\partial x(\delta)}{\partial \delta} = -\frac{1}{2b'(1-e)}\frac{\partial c(\delta)}{\partial \delta} < 0$.

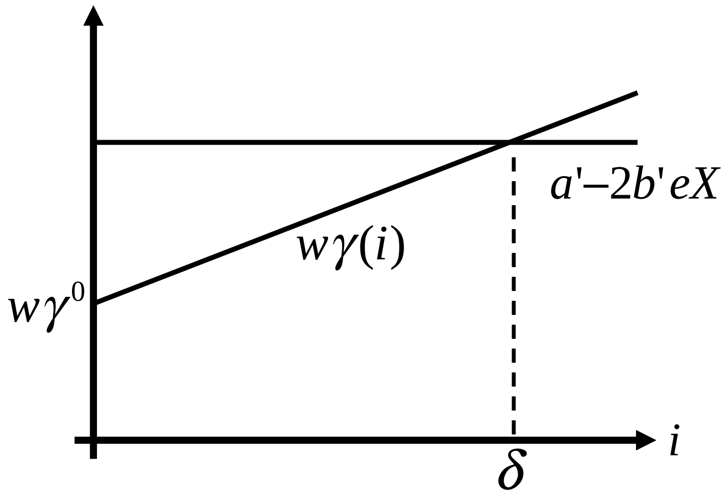

Figure 1: Profit Maximizing Product Range

location. In our model, the motive for offshoring is efficiency-seeking, which means that the necessary condition for offshoring is: $w^* < w$. The sufficient condition for offshoring is that the offshoring costs are below a critical value: $t < t^{crit}$. The critical value of offshoring costs can be calculated as[9]

$$t^{crit} = \frac{(w - w^*)}{w^*} \gamma(\delta). \tag{12}$$

It is straightforward to see that the critical value of offshoring costs is rising in the wage differential between Home and Foreign. This implies that the larger are the savings on wages, the higher can be the additional costs of producing abroad.

In the analysis below, we refer to cases in which offshoring cost are sufficiently low, so there is a fragmentation of production into domestic and foreign-produced varieties. We define $\widetilde{\delta}$ as the cutoff variety. For variety $\widetilde{\delta}$, the firm is indifferent concerning its optimal production location. Varieties with a lower labor input coefficient than $\widetilde{\delta}$ are produced onshore, whereas varieties with a higher labor input coefficient are produced offshore. Combining Eqs. (6) and (9), gives the optimal scale of a foreign-produced variety:

$$x^*(i) = \frac{a' - w^*(\gamma(i) + t) - 2b'eX}{2b'(1-e)}. \tag{13}$$

Given that the marginal variety is produced in Foreign, the profit maximizing product range is defined by

$$w^*(\gamma(\delta) + t) = a' - 2b'eX. \tag{14}$$

[9] To calculate the critical value of offshoring costs t^{crit}, we equate domestic and foreign production costs in Eqs. (5) and (6) at $i = \delta$.

In the open economy, an MPF faces a third maximization problem, next to optimal scale and scope of production. Now, the firm has also to determine the profit maximizing geographic location of production. Analogous to Eq. (7), total profits in the open economy are given by

$$\Pi = \int_{0}^{\widetilde{\delta}} (p(i) - c(i))\, x(i)di + \int_{\widetilde{\delta}}^{\delta} (p^*(i) - c^*(i))\, x^*(i)di, \tag{15}$$

with the first integral being total profits from domestic production and the second integral being the equivalent for foreign production. With Eq. (8) and total firm output X being composed of domestically and foreign-produced goods as

$$X = \int_{0}^{\widetilde{\delta}} x(i)di + \int_{\widetilde{\delta}}^{\delta} x^*(i)di, \tag{16}$$

we can rearrange Eq. (15):

$$\Pi = (1-e)b' \left[\int_{0}^{\widetilde{\delta}} x(i)^2 di + \int_{\widetilde{\delta}}^{\delta} x^*(i)^2 di \right] + b'eX^2. \tag{17}$$

Maximizing Eq. (17) with respect to the optimal cutoff of production $\widetilde{\delta}$ leads to

$$x(\widetilde{\delta}) = x^*(\widetilde{\delta}). \tag{18}$$

Formal details of the derivation can be found in the Appendix.

Lemma 1 *An MPF chooses the optimal cutoff level of production $\widetilde{\delta}$ exactly at that product where optimal scale in Home and in Foreign are the same. Combining Eqs. (9) and (13), this means that for variety $\widetilde{\delta}$ the firm is just indifferent concerning the location of production because costs are identical, i.e.*

$$w\gamma(\widetilde{\delta}) = w^*(\gamma(\widetilde{\delta}) + t). \tag{19}$$

To visualize our analysis, we illustrate the effects of falling offshoring costs in Figure 2. In Figure 2a), production of the whole portfolio is accomplished in Home as offshoring costs are prohibitively high. In Figure 2b), offshoring cost are below the critical value in Eq. (12). We observe that varieties $i \in [0; \widetilde{\delta}]$ are still produced in Home, as their production is efficient enough, so the benefits of lower foreign wages do not prevail the offshoring costs. Production

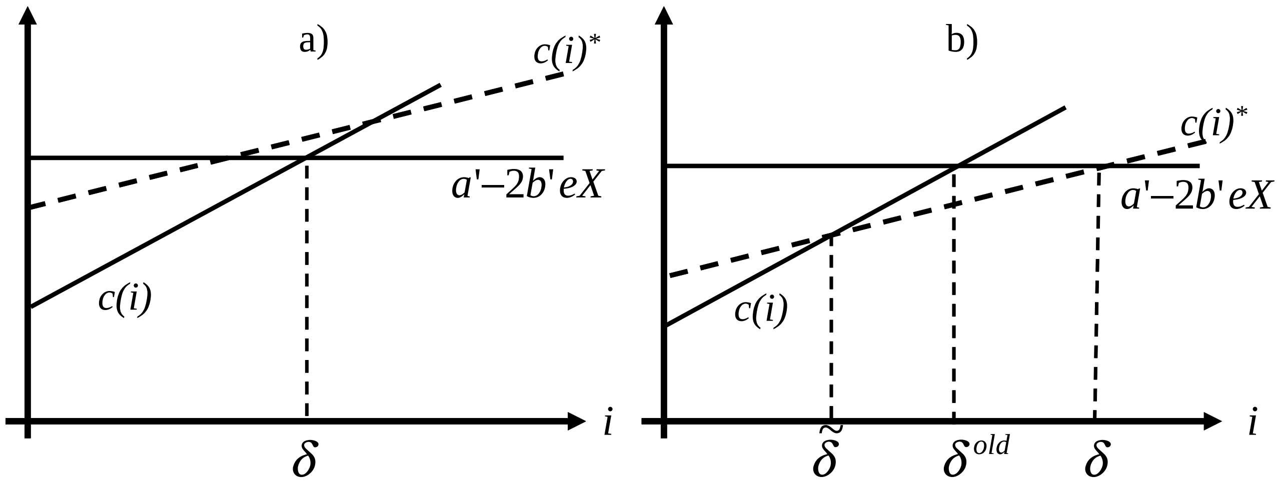

Figure 2: Effects of Falling Offshoring Costs

of varieties $i \in]\widetilde{\delta}; \delta^{old}[$ is relocated, as these goods can be produced at a lower cost in Foreign. Products $i \in]\delta^{old}; \delta[$ constitute an extension of the firm's product range. The MPF adds these varieties at the intra-firm extensive margin, whereby these goods would not be offered in case of producing exclusively in Home. The specification of our model suggests that an MPF produces exactly those varieties offshore, where its efficiency is relatively low.

We conclude this section with a graphical illustration of the main properties of our model in Figure 3. The graph portrays optimal scale of production for the entire portfolio across the two production locations. We will use this graph in the next section as a useful tool in the comparative statics analysis. Figure 3 shows that due to the underlying flexible manufacturing technology, output of the core competence is the highest. At the cutoff $\widetilde{\delta}$ $\left(x\left(\widetilde{\delta}\right) = x^*\left(\widetilde{\delta}\right)\right)$ the firm switches to foreign production. Therefore, the slope of the curve changes at this point. Finally, the profit maximizing product range is pinned down at $x^*(\delta) = 0$.

2.3 Comparative Statics

We still assume that t is below its critical value determined in Eq. (12), so the firm engages in foreign production. In the comparative statics, we analyze the effect of better prospects for offshoring on the geographic organization (optimal cutoff) and on the profit-maximizing product range. Furthermore, we investigate the impact of reduced costs of offshoring on the output of domestic and foreign-produced varieties, as well as on total firm output. These endogenous variables of our model $x(i)$, $x^*(i)$, δ, X, and, $\widetilde{\delta}$ are determined in Eqs. (9), (13), (14), (16), and, (19) respectively. Totally differentiating this system of equations generates

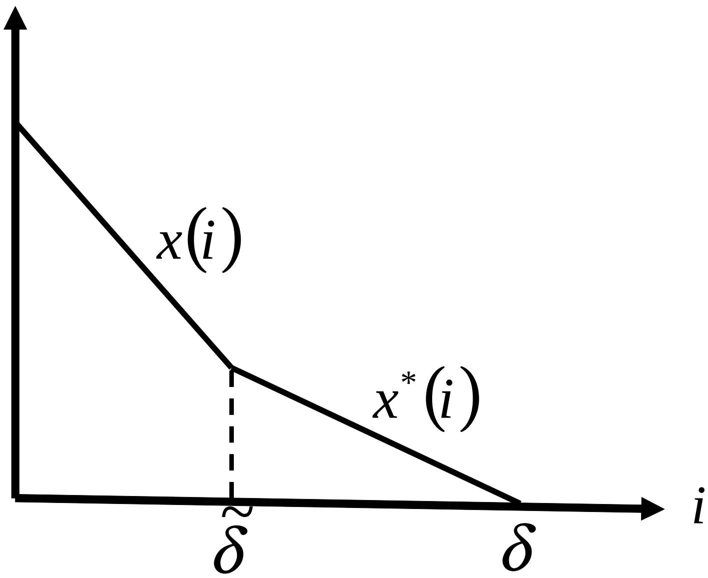

Figure 3: Output Schedule

the comparative-static effects of decreasing offshoring costs t.

Recent academic research on MPFs brings forth varying results on the effects of globalization on the product range of a firm. A set of papers, including Eckel and Neary (2010), Bernard et al. (2011), and Mayer et al. (2014) show that MPFs will reduce their product ranges in response to trade liberalization. Increased competition forces firms to drop their worst performing products. In Feenstra and Ma (2008), increasing the market size leads to an expansion of the product range. Very recently, Qiu and Zhou (2013) show that the most productive firms in an economy may expand their product scope after globalization. In this paper, we do not focus on the competition and market size effects of globalization. Globalization does also mean that access to foreign production locations is facilitated. Having the latter interpretation in mind, we can clearly show that the product scope increases in response to globalization.

Proposition 1 *If t is below the critical value determined in Eq. (12), falling offshoring costs induce an MPF to add new products at the intra-firm extensive margin, i.e.*

$$\frac{d\ln\delta}{d\ln t} = -\frac{\Delta_2 t}{\Delta_1 \gamma'(\delta)\,\delta} < 0, \tag{20}$$

where: $\Delta_1 = (1 - e + e\delta) > 0$ *and* $\Delta_2 = \left(1 - e + e\tilde{\delta}\right) > 0.$

This result can be visualized in Figure 2b). A decrease in t corresponds to a downward shift of the c^*-curve which indicates an extension of the product range.

In a next step, we want to discuss the effects of globalization on the domestic product range $\tilde{\delta}$. With respect to the large literature on international production, this aspect has been neglected so far in theoretical models. We find that better prospects for offshoring reduce the domestic product range and incentivize a firm to relocate marginal varieties.

Proposition 2 *Falling offshoring costs make foreign production more attractive and thus lead to an efficiency-seeking relocation of production from the high-wage country to the low-wage country, i.e.*

$$\frac{d\ln\tilde{\delta}}{d\ln t} = \frac{w^* t}{(w - w^*)\,\gamma'\left(\tilde{\delta}\right)\tilde{\delta}} > 0. \tag{21}$$

As the wage rate in the home country w is higher than abroad w^*, the expression is strictly positive. The magnitude of this effect can be shown to depend on the point elasticity of the cost curve at the marginal variety: $\epsilon_{\gamma(\tilde{\delta})} \equiv \gamma'\left(\tilde{\delta}\right)\tilde{\delta}/\gamma\left(\tilde{\delta}\right)$. The latter stands for an inverse measure of flexibility of an MPF. High values of $\epsilon_{\gamma(\tilde{\delta})}$ imply that a change in $\tilde{\delta}$ will cause a large change in marginal costs. Hence, the change in the domestic product range following globalization will be smaller, the stronger domestic production costs react to a marginal decrease in $\tilde{\delta}$. To see this, we can rewrite Eq. (21) in $d\ln\tilde{\delta}/d\ln t = 1/\epsilon_{\gamma(\tilde{\delta})}$ using the indifference condition in Eq. (19). In Figure 2b), a decrease in t corresponds to a downward shift of the $c\,(i)^*$-curve which is equivalent to shifting production abroad ($\widetilde{\delta}$ falls). Former domestically produced goods are now produced abroad. Referring to previous discussion, the effect is less pronounced in the case of steep cost curves.

So far, we have analyzed within-firm adjustments at the intra-firm extensive margin. In the next step, we focus on the output profiles (intensive margin) of domestically and foreign-produced varieties. Following a fall in t, offshore production gets cheaper and, therefore, foreign varieties are produced at a larger scale.

Proposition 3 *If t is below the critical value determined in Eq. (12), falling offshoring costs induce the firm to increase outputs of all foreign-produced varieties, i.e.*

$$\frac{d\ln x^*(i)}{d\ln t} = -\frac{w^* t}{2b'(1-e)\,x^*(i)}\frac{\Delta_2}{\Delta_1} < 0. \tag{22}$$

As an important feature in our model, we emphasize demand linkages between varieties in the product portfolio of a firm. Falling offshoring costs do not reduce domestic production costs but indirectly affect domestic output through the cannibalization effect. Rising output of foreign production crowds out domestic production as domestic varieties internalize the cannibalization effect.

Proposition 4 *The cannibalization effect induces an MPF to reduce outputs of all domestically produced varieties in consequence of falling offshoring costs, i.e.*

$$\frac{d\ln x(i)}{d\ln t} = \frac{e\left(\delta - \tilde{\delta}\right)}{\Delta_1} \frac{w^* t}{2b'(1-e)\,x(i)} > 0. \tag{23}$$

In the case of perfectly differentiated varieties, i.e. $e = 0$, domestic output is independent of foreign production and hence, the derivative in Eq. (23) is zero. With e being positive, varieties become substitutable and domestic output is crowded out by foreign production. However, it is straightforward to show that despite lower domestic output, total firm output X is increasing with falling offshoring cost. The positive impact of rising foreign output combined with the extension of the product range outweighs the negative impact of falling domestic output on total firm scale.

Proposition 5 *With falling offshoring costs, an MPF increases total firm output because of the higher scale of foreign-produced varieties and the extension of the product portfolio, i.e.*

$$\frac{d\ln X}{d\ln t} = -\frac{w^*\left(\delta - \tilde{\delta}\right)t}{2b'\Delta_1 X} < 0. \tag{24}$$

Formal details of all the derivations can be found in the Appendix. To illustrate the effects of falling offshoring costs, we draw on the graphical tool developed in Figure 3. In Figure 4, the dotted line represents the situation after the reduction in t. Inspecting this graph reveals two negative effects on domestic production: A relocation effect from shifting production abroad and a cannibalization effect from rising foreign output. The latter effect is a new transmission channel specific to MPFs that we want to highlight. It results from the fact that with lower production costs abroad, output of foreign varieties and the foreign product range will increase. These intra-firm adjustments crowd out the production of domestic varieties which does not benefit from lower production costs abroad. The main comparative static results are indicated by the arrows in *Figure 4*.

2.4 Implications for the Measurement of Offshoring

From a theoretical point of view, the way we are thinking about offshoring as a relocation of production lines within MPFs is novel. However, the manner how offshoring is measured in the broad empirical literature on international production is similar to our definition. The measure of outsourcing which is used in Feenstra and Hanson (1996) is directly related to our definition, as it includes also final goods next to imported intermediates. The authors

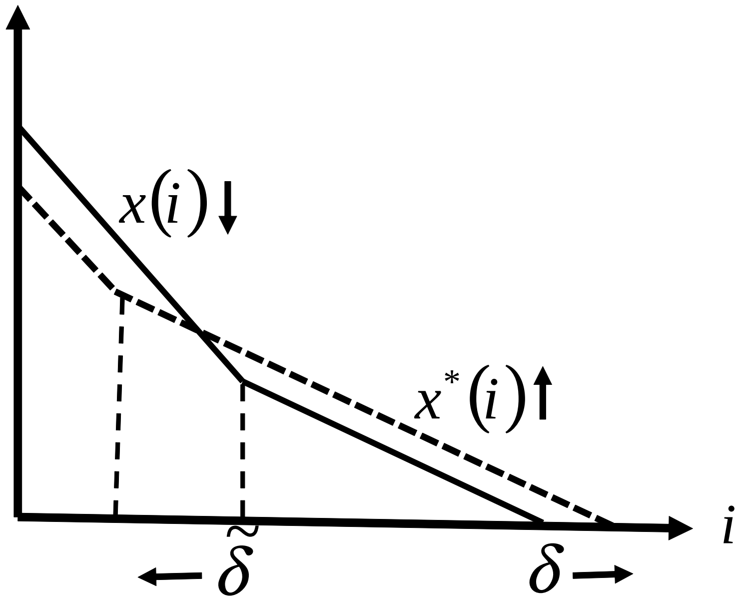

Figure 4: Output Schedule and Comparative Statics

argue that this "must be included in any valid measure of outsourcing" (Feenstra and Hanson (1996), p.107). We argue that using imported intermediates as a proxy for offshoring may lead to potential measurement errors as relocation entire production lines will be not recorded even though offshoring is taking place.

Many other papers that discuss offshoring from an empirical perspective use measurements of offshoring that respond not only to a relocation of vertically related processes, but also respond to what we call multi-product offshoring. Papers such as Head and Ries (2002), Becker et al. (2013), and Ebenstein et al. (2014) measure offshoring activity in an industry by the total employment of foreign affiliates. Using employment in foreign affiliates as a measure for offshoring is perfectly in line with our model. To underline that measuring offshoring like this could also mean the type of offshoring that we have in mind, we calculate the total employment in foreign affiliates and show how it responds to better offshoring opportunities. In industry z, labor demand l^* for foreign-produced varieties is given by

$$l^*(z) = \int_{\widetilde{\delta}(z)}^{\delta(z)} \gamma(i) x^*(i) di. \tag{25}$$

It is determined by the scale and scope of foreign-produced varieties $i \in [\widetilde{\delta}; \delta]$. We derive total labor demand in the offshore destination L^* by integrating over all industries $z \in (0,1)$

$$L^* = \int_0^1 l^*(z)\,dz = \int_0^1 \int_{\tilde{\delta}(z)}^{\delta(z)} \gamma(i,z) x^*(i,z) di dz. \tag{26}$$

By substituting for $x(i)^*$ and evaluating the integral, we come up with the following equation

$$L^* = \frac{\left(\delta - \tilde{\delta}\right)\left[\left(a' - 2b'eX - w^*t\right)\mu_\gamma'^* - w^*\mu_\gamma''^*\right]}{2b'(1-e)}, \tag{27}$$

where $\mu_\gamma'^* \equiv \frac{1}{\delta - \tilde{\delta}} \int_{\tilde{\delta}}^{\delta} \gamma(i)\,di$ is the mean labor input of foreign-produced varieties and $\mu_\gamma''^* \equiv \frac{1}{\delta - \tilde{\delta}} \int_{\tilde{\delta}}^{\delta} \gamma(i)^2\,di$ is the second moment around zero of the distribution of labor requirements. We totally differentiate Eq. (27) and analyze again the effects of better prospects for offshoring:

$$\frac{d\ln L^*}{d\ln t} = -\frac{w^*t}{2b'(1-e)L^*}\left\{\frac{\left(\delta - \tilde{\delta}\right)\mu_\gamma'^*\Delta_2}{\Delta_1} + \frac{\tilde{\delta}w^*\left(\gamma(\delta) - \gamma\left(\tilde{\delta}\right)\right)}{(w - w^*)\,\epsilon_{\gamma(\tilde{\delta})}}\right\} < 0. \tag{28}$$

The latter expression clearly indicates that the total employment of foreign affiliates is increasing in falling offshoring costs. Therefore, measuring offshore activity by total employment of foreign affiliates captures the type of offshoring that we have in mind.

Lemma 2 *Falling offshoring costs increase total employment in the offshoring destination.*

3 General Equilibrium

The previous section analyzed the effects of falling offshoring costs on the product range, per variety output, total firm output and the optimal location of production. Up to this point, the approach was partial, since we did not consider endogenous changes in wages. Our analysis in partial equilibrium clearly yields a fall in domestic production, because, on the one hand, per variety output of domestic varieties gets crowded out and, on the other hand, varieties close to the cutoff are relocated with falling offshoring costs. In the next steps, we focus on new insights into the labor market effects of offshoring arising in our framework. For this purpose, we introduce a simple labor market and show how domestic labor demand is affected by multi-product offshoring. Subsequently, we analyze again the comparative statics exercise of falling offshoring costs under consideration of labor market clearing.

3.1 Labor Market Clearing

In this section, we turn to the level of the economy as a whole and explore the general equilibrium effects of falling offshoring costs. To simplify the analysis, we assume that all industries are identical. In a first step, we need to specify how wages are determined. We assume a total labor supply L^S, that is supplied inelastically by the households in Home. Domestic labor demand in industry z is given by

$$l(z) = \int_0^{\widetilde{\delta}(z)} \gamma(i)\, x(i)\, di. \tag{29}$$

It is determined by the scale and scope of domestically produced varieties $i \in [0; \widetilde{\delta}]$. We derive total labor demand L in our economy by integrating over all industries $z \in (0, 1)$:

$$L = \int_0^1 l(z)\, dz = \int_0^1 \int_0^{\widetilde{\delta}(z)} \gamma(i, z) x(i, z) di dz. \tag{30}$$

Our main interest in this section is to determine the labor market effects of offshoring. In the previous section we have identified two effects of falling offshoring costs: A relocation effect and a cannibalization effect. The relocation effect affects the marginal variety $\widetilde{\delta}$ whereas the cannibalization effect reduces the scale of domestic production $x(i)$. Totally differentiating domestic labor demand in Eq. (30) with respect to t yields:[10]

$$\frac{dL}{dt} = \underbrace{\gamma\left(\widetilde{\delta}\right) x\left(\widetilde{\delta}\right) \frac{d\widetilde{\delta}}{dt}}_{\text{Relocation effect}} + \underbrace{\int_0^{\widetilde{\delta}} \gamma(i) \frac{dx(i)}{dt} di}_{\text{Cannibalization effect}} > 0. \tag{31}$$

The first part of Eq. (31) describes the relocation effect and the second part stands for the cannibalization effect. Latter effect is new and is specific to MPFs. Following a decrease in offshoring costs, scale and scope of foreign production rise because of lower production costs abroad. As foreign production becomes more competitive, domestic varieties internalize a negative demand externality: The cannibalization effect of offshoring. The latter effect is specific to MPFs and reduces domestic demand for labor in addition to the well-known relocation effect of offshoring.

Proposition 6 *For a given domestic wage, falling offshoring costs reduce domestic demand for labor through two channels: (i) a relocation effect and (ii) a cannibalization effect. The*

[10]From inspection of propositions 2 and 4, we know that: $\frac{d\widetilde{\delta}}{dt} > 0$ and $\frac{dx(i)}{dt} > 0$.

relocation effect leads to a shift of labor-intensive domestic products abroad. Furthermore, domestic production internalizes a cannibalization effect of rising foreign output and is crowded out.

In equilibrium, wages must adjust to ensure that total labor supply L^S equals total labor demand determined by the cutoff of domestic production $\widetilde{\delta}$ in all industries $z \in (0,1)$. This is reflected by the following labor-market equilibrium condition for the home country:

$$L^S = \int_0^1 l(z)\,dz = \int_0^1 \int_0^{\widetilde{\delta}(z)} \gamma(i,z)x(i,z)didz. \tag{32}$$

We can now substitute for $x(i)$ and evaluate the integral to obtain

$$L^S = \frac{\widetilde{\delta}\left[(a' - 2b'eX)\,\mu'_\gamma - w\mu''_\gamma\right]}{2b'(1-e)}, \tag{33}$$

with $\mu'_\gamma \equiv \frac{1}{\widetilde{\delta}}\int_0^{\widetilde{\delta}} \gamma(i)di$ being the mean labor input of domestically produced varieties and $\mu''_\gamma \equiv \frac{1}{\widetilde{\delta}}\int_0^{\widetilde{\delta}} \gamma(i)^2 di$ stands for the second moment around zero of the distribution of labor requirements. Combining Eq. (33) with the system of equations from the analysis in partial equilibrium, we can use the respective equations for investigating how firm-level adjustments respond to declining offshoring costs with endogenous wages. We derive the comparative statics results by totally differentiating all equations of the system. Formal details of all the derivations can be found in the Appendix.

3.2 Comparative Statics in General Equilibrium

One important issue in general equilibrium, which we want to analyze in the first place, is the effect of better prospects for offshoring on domestic factor prices w. In the previous sections, we have identified two negative impacts of offshoring on domestic labor demand: The relocation and the cannibalization effect. However, in equilibrium, total labor supply has to equal total demand for labor. To ensure this equality, domestic wages must fall.

Proposition 7 *Falling offshoring costs, ceteris paribus, make foreign production more attractive. To ensure labor market clearing in general equilibrium, there are adjustments on the labor market in the form of falling domestic wages, i.e.*

$$\frac{\Delta w}{w^* t}\frac{d\ln w}{d\ln t} = e\,(w - w^*)\,\gamma'\left(\tilde{\delta}\right)\left(\delta - \tilde{\delta}\right)\tilde{\delta}\mu'_\gamma + \Delta_1 w^*\left[\gamma(\delta) - \gamma\left(\tilde{\delta}\right)\right]\gamma\left(\tilde{\delta}\right) > 0, \tag{34}$$

where:[11]

$$\Delta = \left\{\Delta_1\sigma_\gamma^2 + \left[1 - e + e\left(\delta - \tilde{\delta}\right)\right]\mu_\gamma'^2\right\}(w - w^*)\,\tilde{\delta}\gamma'\left(\tilde{\delta}\right) + \Delta_1\gamma\left(\tilde{\delta}\right)^2 w^*\left(\gamma(\delta) - \gamma\left(\tilde{\delta}\right)\right) > 0.$$

Considering these labor market adjustments reveals that in general equilibrium falling offshoring costs not only reduce foreign production costs but also decrease production costs in the home country. The latter has important implications on the main variables of interest in our model and it is crucial to understand the driving forces behind the general equilibrium adjustments of domestic wages. Inspecting Eq. (34) shows that the wage effect depends on the distribution of labor requirements across varieties produced in the home country. A mean preserving spread of the distribution (a larger variance σ_γ^2) reduces the magnitude of the effect in Eq. (34). Intuitively, this can be explained as follows: Following a shock in offshoring costs t, wages have to decrease in order to increase domestic labor demand and to ensure an equilibrium at the labor market. A large variance of the domestic technology distribution σ_γ^2 implies that there are some varieties within the domestic product portfolio that have a relatively high labor requirement. Having in mind that those varieties benefit a lot from falling wages and thus strongly expand their outputs, domestic wages have to decrease just a bit to cause a strong increase in labor demand and ensure labor market clearing.

Having understood the labor market implications of multi-product offshoring, we analyze again the comparative statics exercise of falling offshoring costs under consideration of endogenous domestic factor prices. With lower production costs in both countries, it is apparent that an MPF will increase its total scale:

$$\frac{d\ln X}{d\ln t} = -\frac{w^*\left(\delta - \tilde{\delta}\right)t}{2b'\Delta_1 X} - \frac{w\tilde{\delta}\mu_\gamma'}{2b'\Delta_1 X}\frac{d\ln w}{d\ln t} < 0. \tag{35}$$

The mathematical derivation and an expression where the change in wages is substituted can be found in the Appendix. Eq. (35) is the general equilibrium equivalent of Eq. (24). Comparing both equations immediately points out that due to the adjustment of factor prices (represented by the second fraction), the general equilibrium effect will be of greater magnitude than the partial equilibrium effect (represented by the first fraction). Consequently, the larger larger total firm scale X - caused by the additional channel of falling domestic wages - enhances cannibalization between varieties within the firm. Therefore, the latter effect leads to a new channel that we have to consider when analyzing the repercussions of falling offshoring costs on the product range of a firm. We illustrate this channel in the

[11] The term Δ is the determinant of the system of equations. It is positive which ensures that the equilibrium is unique and stable.

following equation:

$$\frac{d\ln\delta}{d\ln t}=-\frac{\Delta_2 t}{\Delta_1\gamma'(\delta)\,\delta}+\frac{ew\tilde{\delta}\mu'_\gamma}{\Delta_1 w^*\gamma'(\delta)\,\delta}\frac{d\ln w}{d\ln t}<0, \tag{36}$$

where the first part of Eq. (36) represents the partial effect which is clearly of a negative sign. The second part of Eq. (36) is the additional channel in general equilibrium arising from the adjustment of wages. This effect is positive and works in the opposite direction as it induces the firm to increase its total output X. Inspecting Eq. (36) reveals that the general equilibrium effect is switched off for $e=0$. With products being perfectly differentiated, there is no cannibalization of the rising total firm output X on the marginal varieties within the product range. However, we can analytically show that the result from partial equilibrium is reconfirmed even for $e>0$. Therefore, the adjustments in general equilibrium only have a dampening effect on the product range which is driven by the intensity of cannibalization determined by the differentiation parameter e. A proof for this result is provided in the Appendix.

Proposition 8 *Falling offshoring costs reduce costs in both production sites and hence enlarge total firm output X to a larger extend compared to partial equilibrium. Latter result dampens but does not reverse the effect of falling offshoring costs on the product range in general equilibrium. The dampening effect depends on the strength of cannibalization.*

In the next step, we focus our attention on the optimal geographic organization of an MPF. Regarding the optimal cutoff of production, we identify two opposing forces in general equilibrium following a fall in the parameter t. On the one hand, there is the direct effect of lower offshoring costs which tends to shift production abroad (observed effect in partial equilibrium, see Eq. (21)). On the other hand, we find decreasing domestic wages which brings forth an incentive to pull back production into the home country. The latter causes an ambiguity on the total effect of falling offshoring costs in general equilibrium which can be seen in the following derivative:

$$\frac{\Delta}{w^*t}\frac{d\ln\tilde{\delta}}{d\ln t}=\Delta_1\mu''_\gamma-e\left[\left(\delta-\tilde{\delta}\right)\gamma\left(\tilde{\delta}\right)+\tilde{\delta}\mu'_\gamma\right]\mu'_\gamma\gtrless 0. \tag{37}$$

We now focus on this ambiguity and investigate the causes that lie behind it. To begin with, Eq. (37) is positive for e being zero. With perfectly differentiated products, domestic varieties do not internalize cannibalization through rising outputs of foreign varieties (compare Eq. (23)). Consequently, there is no reducing force on domestic labor demand via a lower scale of domestically produced varieties through the cannibalization effect of offshoring stressed in Eq. (31). Thereby, to ensure labor market clearing, domestic wages will decline less and the wage-effect will not dominate the better opportunities to offshore. With $0 < e < 1$, there is the possibility that Eq. (37) gets negative, i.e. with falling offshoring costs even more products are produced in Home. This is the case if the general equilibrium adjustment of factor prices prevails the foreign cost reduction via lower offshoring costs.

To get some further intuition for this ambiguity, we investigate the effect of an *exogenous* change in domestic wages on domestic output. Differentiating optimal scale $x(i)$ in Eq. (9) with respect to the wage rate w yields:[12]

$$\frac{d\ln x(i)}{d\ln w} = \frac{w}{2b'(1-e)\,x(i)} \frac{\left[e\widetilde{\delta}\mu'_{\gamma} - \Delta_1 \gamma(i)\right]}{\Delta_1} \lesseqgtr 0. \tag{38}$$

The algebraic sign of Eq. (38) behaves ambiguously. Outputs of varieties with a labor input coefficient $\gamma(i)$ far below the average μ'_{γ} may even fall with falling wages (i.e. for these varieties $\frac{d\ln x(i)}{d\ln w} > 0$). Very efficient varieties require just sparse labor input and hence, benefit slightly from falling wages. However, these varieties fully internalize the cannibalization effect through rising outputs of labor-intensive products which benefit a lot from lower factor prices.[13] Latter results imply that varieties benefit more from falling wages the higher is their respective labor input $\gamma(i)$. This insight can help to explain the ambiguous effects of lower offshoring costs on the cutoff variety $\widetilde{\delta}$. Without inserting the general equilibrium effect on domestic wages, Eq. (37) reads as follows:

$$(w - w^*)\,\gamma'\left(\tilde{\delta}\right)\tilde{\delta}\frac{d\ln\tilde{\delta}}{d\ln t} = \underbrace{w^* t}_{\text{PE effect}} \underbrace{- w\gamma\left(\tilde{\delta}\right)\frac{d\ln w}{d\ln t}}_{\text{GE effect}} \gtreqless 0 \tag{39}$$

Inspecting Eq. (39) reveals that the partial equilibrium effect (first part of the expression) is more likely to be reversed, the stronger is the opposing general equilibrium effect (second part of the expression). In fact, the strength of the general equilibrium effect depends on two components: (i) the labor requirement at the cutoff and (ii) the adjustment of domestic wages. Firstly, from the analysis of Eq. (38), we know that varieties with high labor inputs will benefit more from reductions in factor prices. This insight can be reapplied to Eq. (39), where it is observed that the wage effect is of a greater impact, the higher is the labor input

[12] The interested reader finds the effects of an exogenous change in domestic wages on all endogenous variables in the Appendix.

[13] The condition for the output of the core competence to fall with falling wages is : $\gamma(0) < \frac{e\widetilde{\delta}\mu'_{\gamma}}{\Delta_1}$. The cutoff variety $\widetilde{\delta}$ has the highest labor input coefficient $\gamma(\widetilde{\delta})$ in the domestic product range. The output of this variety $x(\widetilde{\delta})$ rises with falling wages: $\frac{d\ln x(\widetilde{\delta})}{d\ln w} < 0$.

at the marginal variety: $\gamma\left(\tilde{\delta}\right)$. Secondly, Eq. (39) shows that the larger is the response of domestic wages to changes in offshoring costs, the more likely is a result contrary to the partial equilibrium case. The discussion of Eq. (34) revealed that the magnitude of the wage effect depends on the distribution of labor requirements across domestic varieties. It was shown that a mean preserving spread of the distribution dampens the effect. Therefore, we conclude that the partial effect is more likely reversed if the variance σ_γ^2 of the domestic technology distribution is low. These insights are summarized in the following proposition.

Proposition 9 *In partial equilibrium, lower offshoring costs t lead to a distinct fall in $\widetilde{\delta}$ (i.e. $\frac{d\ln\widetilde{\delta}}{d\ln t} > 0$). This result does not necessarily hold in general equilibrium which implies that it is possible that even more products are produced onshore with better opportunities of offshoring (i.e. $\frac{d\ln\widetilde{\delta}}{d\ln t} < 0$). This ambiguity is caused by the general equilibrium adjustments of domestic wages.*

4 Conclusion

This paper has developed a new view on offshoring by multi-product firms where these firms relocate labor-intensive product lines to a low wage country. Although globalization of production has been discussed extensively in the literature, there is not yet a framework to study the relocation of entire product lines within the boundaries of a firm. We call this phenomenon "multi-product offshoring" and show that the relocation of entire production lines leads to new insights into the labor market outcomes of offshoring. While the relocation effect remains, the efficiency effect of offshoring vanishes as we reverse the assumptions that (i) processes within a firm are vertically related and (ii) part of the production of a variety stays in the home country. Within an MPF that produces varieties of a horizontally differentiated good, production at home and abroad are essentially substitutes, and domestic workers no longer benefit from lower production costs in other locations. Importantly, the relocation of a complete production line not only prevents the positive efficiency effect but causes a cannibalization effect of offshoring that tends to aggravate the negative effect on domestic labor demand. We show that better prospects for offshoring increase the competitiveness of foreign-produced varieties and even induce an MPF to extend its product portfolio. Consequently, the expansion of foreign production creates a negative demand externality on all domestically produced varieties and thus hits domestic labor demand. This cannibalization effect of offshoring is specific to MPFs and by now has not been addressed by the extensive literature on international production.

Having identified the labor market effects of multi-product offshoring, we endogenize domestic wages and analyze the repercussions of better prospects for offshoring. As a consequence of the two negative effects on domestic labor demand, we find that domestic wages decrease following a reduction in offshoring costs. Obviously, this adjustment of domestic wages reduces the relative benefits of offshoring in general equilibrium. While in partial equilibrium marginal products were unambiguously relocated abroad following a reduction in offshoring costs, in general equilibrium this result is dampened or even reversed if the wage effect is large. Therefore, our model is able to predict patterns in which firms re-relocate entire product lines following globalization and a decline in offshoring costs.

Our findings also contribute to the understanding how globalization can affect the product portfolio of MPFs. As previous contributions to this literature have pointed out, adjustments in the product ranges contribute significantly to the product diversity in an economy. This indicates that adjustments at the intra-firm extensive margin are an important aspect from a welfare perspective. As a novelty in this paper, we focused on the impact of offshoring on the intra-firm extensive margin and showed that the opportunity to relocate labor-intensive production unambiguously increases the product portfolio of an MPF. This points to a so far unexplored channel through which globalization can increase product variety and thus stimulate welfare.

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5 Appendix

5.1 Proof of Lemma 1

In the open economy scenario, an MPF has to determine the profit maximizing geographic location of production. In the following, we will sketch this maximization problem. From the first-order condition for scale in Eq. (8), we know:

$$p(i) - c(i) = b'(1-e)x(i) + b'eX, \tag{A1}$$

which inserted in the open economy total profits in Eq. (15) leads to

$$\frac{\Pi}{b'} = (1-e)\int_0^{\widetilde{\delta}} x(i)^2 di + eX\int_0^{\widetilde{\delta}} x(i)di + (1-e)\int_{\widetilde{\delta}}^{\delta} x^*(i)^2 di + eX\int_{\widetilde{\delta}}^{\delta} x^*(i)di. \tag{A2}$$

Given that $X = \int_0^{\widetilde{\delta}} x(i)di + \int_{\widetilde{\delta}}^{\delta} x^*(i)di$, we derive Eq. (17). To identify a condition for an optimally chosen cutoff variety $\widetilde{\delta}$, we maximize Eq. (17) with respect to $\widetilde{\delta}$. This implies the following first-order condition:

$$\frac{1}{b'}\frac{d\Pi}{d\widetilde{\delta}} = (1-e)\left[\int_0^{\widetilde{\delta}} 2x(i)\frac{dx(i)}{d\widetilde{\delta}}di + \int_{\widetilde{\delta}}^{\delta} 2x^*(i)\frac{dx^*}{d\widetilde{\delta}}di\right] \tag{A3}$$

$$+(1-e)\left[x(\widetilde{\delta})^2 - x^*(\widetilde{\delta})^2\right] + (1-e)x^*(\delta)\frac{d\delta}{d\widetilde{\delta}} + 2eX\frac{dX}{d\widetilde{\delta}} = 0.$$

With $x^*(\delta) = 0$, $\frac{dx(i)}{d\widetilde{\delta}} = \frac{dx^*(i)}{d\widetilde{\delta}} = -\frac{e}{1-e}\frac{dX}{d\widetilde{\delta}}$, and some mathematical conversion, we derive

$$\frac{1}{b'}\frac{d\Pi}{d\widetilde{\delta}} = (1-e)\left[x(\widetilde{\delta})^2 - x^*(\widetilde{\delta})^2\right] = 0. \tag{A4}$$

5.2 Comparative Statics in Partial Equilibrium

In the following, we show how to derive the comparative static results of the model. In our model, the equilibrium is determined by the following system of equations:

$$w\gamma(\widetilde{\delta}) = w^*(\gamma(\widetilde{\delta}) + t) \tag{A5}$$

$$x(i) = \frac{a' - w\gamma(i) - 2b'eX}{2b'(1-e)} \tag{A6}$$

$$x^*(i) = \frac{a' - w^*(\gamma(i) + t) - 2b'eX}{2b'(1-e)} \tag{A7}$$

$$X = \int_0^{\widetilde{\delta}} x(i)di + \int_{\widetilde{\delta}}^{\delta} x^*(i)di \tag{A8}$$

$$w^*(\gamma(\delta) + t) = a' - 2b'eX \tag{A9}$$

We can reduce this system of equations to two equations in $\widetilde{\delta}$ and δ. In a first step, we substitute Eqs.(A6) and (A7) in Eq.(A8) and derive total output as

$$X = \frac{1}{2b'\Delta_1}\left\{a'\delta - w\int_0^{\widetilde{\delta}} \gamma(i)\, di - w^*\left[\int_{\widetilde{\delta}}^{\delta} \gamma(i)\, di + t\left(\delta - \widetilde{\delta}\right)\right]\right\}. \tag{A10}$$

In a second step, we combine the latter expression with Eq. (A9) which leads to

$$w^*(\gamma(\delta) + t) = a' - \frac{e}{\Delta_1}\left\{a'\delta - w\int_0^{\widetilde{\delta}} \gamma(i)\, di - w^*\left[\int_{\widetilde{\delta}}^{\delta} \gamma(i)\, di + t\left(\delta - \widetilde{\delta}\right)\right]\right\}. \tag{A11}$$

Eqs. (A5) and (A11) constitute two equations in two endogenous variables: $\widetilde{\delta}$ and δ. By totally differentiating this system of equations, we derive our results in partial equilibrium. We show the total derivatives of Eqs. (A5) and (A11) in the next section of this Appendix.

5.3 Comparative Statics in General Equilibrium

In general equilibrium, we add the labor market clearing condition to our system of equations from the previous section. By substituting Eq. (A9) into the labor market clearing condition in Eq. (33), we derive

$$L = \frac{\widetilde{\delta}\left[w^*(\gamma(\delta) + t)\mu'_\gamma - w\mu''_\gamma\right]}{2b'(1-e)}. \tag{A12}$$

The combination of Eqs. (A5), (A11), and (A12) determines the general equilibrium of our model. In the total derivatives, we take into account that domestic wages are endogenously determined in the domestic labor market. For deriving the following results, note that $\frac{d}{d\tilde{\delta}}(\widetilde{\delta}\mu'_\gamma) = \gamma\left(\tilde{\delta}\right)$ and $\frac{d}{d\tilde{\delta}}(\widetilde{\delta}\mu''_\gamma) = \gamma\left(\tilde{\delta}\right)^2$. Totally differentiating the three equilibrium conditions Eqs. (A5), (A11), and (A12), with the results written as a matrix equation, we can analyze a change in the offshoring cost t as follows:

$$\begin{bmatrix} 0 & (w-w^*)\,\gamma'\left(\tilde{\delta}\right) & \gamma\left(\tilde{\delta}\right) \\ \Delta_1 & 0 & -e\tilde{\delta}\mu'_\gamma \\ \tilde{\delta}\mu'_\gamma & w^*\left[\gamma(\delta)-\gamma\left(\tilde{\delta}\right)\right]\gamma\left(\tilde{\delta}\right) & -\tilde{\delta}\mu''_\gamma \end{bmatrix} \begin{pmatrix} \frac{\gamma'(\delta)\delta d\ln\delta}{td\ln t} \\ \frac{\tilde{\delta}d\ln\tilde{\delta}}{w^*td\ln t} \\ \frac{wd\ln w}{w^*td\ln t} \end{pmatrix} = \begin{pmatrix} 1 \\ -\Delta_2 \\ -\tilde{\delta}\mu'_\gamma \end{pmatrix}. \tag{A13}$$

The terms Δ_1 and Δ_2 are defined in Eq. (20) and are strictly positive. Using $\sigma^2_\gamma = \mu''_\gamma - \mu'^2_\gamma$, we can show that the determinant of the coefficient matrix Δ is positive:

$$\Delta = \left\{\Delta_1\sigma^2_\gamma + \left[(1-e)+e\left(\delta-\tilde{\delta}\right)\right]\mu'^2_\gamma\right\}\tilde{\delta}\,(w-w^*)\,\gamma'\left(\tilde{\delta}\right)+\Delta_1\gamma\left(\tilde{\delta}\right)^2 w^*\left[\gamma(\delta)-\gamma\left(\tilde{\delta}\right)\right] > 0. \tag{A14}$$

In the following, we provide the solutions of the comparative statics exercise which we use in the general equilibrium part of our model.

Effect on Domestic Wages:

$$\frac{wd\ln w}{w^*td\ln t} = \frac{1}{\Delta}\begin{vmatrix} 0 & (w-w^*)\,\gamma'\left(\tilde{\delta}\right) & 1 \\ \Delta_1 & 0 & -\Delta_2 \\ \tilde{\delta}\mu'_\gamma & w^*\left[\gamma(\delta)-\gamma\left(\tilde{\delta}\right)\right]\gamma\left(\tilde{\delta}\right) & -\tilde{\delta}\mu'_\gamma \end{vmatrix} \tag{A15}$$

$$\frac{wd\ln w}{w^*td\ln t} = \frac{1}{\Delta}\left\{(w-w^*)\,\gamma'\left(\tilde{\delta}\right)e\left(\delta-\tilde{\delta}\right)\tilde{\delta}\mu'_\gamma + \Delta_1 w^*\left[\gamma(\delta)-\gamma\left(\tilde{\delta}\right)\right]\gamma\left(\tilde{\delta}\right)\right\} > 0 \tag{A16}$$

Effect on Product Range:

$$\frac{\gamma'(\delta)\,\delta d\ln\delta}{td\ln t} = \frac{1}{\Delta}\begin{vmatrix} 1 & (w-w^*)\,\gamma'\left(\tilde{\delta}\right) & \gamma\left(\tilde{\delta}\right) \\ -\Delta_2 & 0 & -e\tilde{\delta}\mu'_\gamma \\ -\tilde{\delta}\mu'_\gamma & w^*\left[\gamma(\delta)-\gamma\left(\tilde{\delta}\right)\right]\gamma\left(\tilde{\delta}\right) & -\tilde{\delta}\mu''_\gamma \end{vmatrix} \tag{A17}$$

$$\frac{\gamma'(\delta)\,\delta d\ln\delta}{td\ln t} = -\frac{1}{\Delta}\begin{pmatrix} \left\{\left[(1-e)+e\left(\delta-\tilde{\delta}\right)\right]\tilde{\delta}\mu''_\gamma + e\tilde{\delta}^2\sigma^2_\gamma\right\}(w-w^*)\,\gamma'\left(\tilde{\delta}\right) \\ +\left(\Delta_1\gamma\left(\tilde{\delta}\right) - e\tilde{\delta}\mu'_\gamma\right)w^*\left[\gamma(\delta)-\gamma\left(\tilde{\delta}\right)\right]\gamma\left(\tilde{\delta}\right) \end{pmatrix} < 0 \tag{A18}$$

Effect on Total Output: Totally differentiating Eq. (A10) and using information from Eq. (A16) yields

$$\frac{2b'\Delta_1 X}{w^* t}\frac{d\ln X}{d\ln t} = -\left(\delta - \tilde{\delta}\right) - \frac{\tilde{\delta}\mu'_\gamma}{\Delta}\left\{(w - w^*)\,\gamma'\left(\tilde{\delta}\right) e\left(\delta - \tilde{\delta}\right)\tilde{\delta}\mu'_\gamma + \Delta_1 w^*\left[\gamma(\delta) - \gamma\left(\tilde{\delta}\right)\right]\gamma\left(\tilde{\delta}\right)\right\} < 0. \tag{A19}$$

Effect on Cutoff Variety:

$$\frac{\tilde{\delta} d\ln\tilde{\delta}}{w^* t d\ln t} = \frac{1}{\Delta}\begin{vmatrix} 0 & 1 & \gamma\left(\tilde{\delta}\right) \\ \Delta_1 & -\Delta_2 & -e\tilde{\delta}\mu'_\gamma \\ \tilde{\delta}\mu'_\gamma & -\tilde{\delta}\mu'_\gamma & -\tilde{\delta}\mu''_\gamma \end{vmatrix} \tag{A20}$$

Using again $\sigma^2_\gamma = \mu''_\gamma - \mu'^2_\gamma$, we derive the following result:

$$\frac{d\ln\tilde{\delta}}{w^* t d\ln t} = \frac{1}{\Delta}\left(\Delta_1\mu''_\gamma - e\left[\left(\delta - \tilde{\delta}\right)\gamma\left(\tilde{\delta}\right) + \tilde{\delta}\mu'_\gamma\right]\mu'_\gamma\right) \gtrless 0. \tag{A21}$$

5.4 Effects of an Exogenous Change in Domestic Wages

This section keeps offshoring costs t constant and considers responses of the system of endogenously determined variables in Eqs. (9), (13), (14), (16), and (19) to changes in the domestic wage rate. Totally differentiating this system of equations generates the following comparative statics results. It is apparent that with falling domestic wages total firm output will increase, i.e.

$$\frac{d\ln X}{d\ln w} = -\frac{w\widetilde{\delta}\mu'_\gamma}{2b'\Delta_1 X} < 0. \tag{A22}$$

This effect gets larger the more domestic varieties benefit from falling wages, i.e. the higher is μ'_γ, and the more domestic varieties are produced onshore, i.e. the higher is $\widetilde{\delta}$.

Changes in domestic factor prices clearly affect the cutoff variety $\widetilde{\delta}$ as it is determined by the equality of production costs on- and offshore. With Home becoming a more attractive production site, more varieties will be manufactured domestically, i.e.

$$\frac{d\ln\widetilde{\delta}}{d\ln w} = -\frac{w}{(w - w^*)}\frac{\gamma(\widetilde{\delta})}{\gamma'\left(\widetilde{\delta}\right)\widetilde{\delta}} < 0. \tag{A23}$$

Akin to the previous result, we find that this effect gets stronger the more the cutoff variety benefits from falling wages in terms of a higher marginal labor requirement $\gamma(\widetilde{\delta})$. With varieties not being perfectly differentiated (i.e. $e > 0$), foreign scale gets crowded out

$$\frac{d\ln x^*(i)}{d\ln w} = \frac{w}{2b'(1-e)\,x^*(i)}\frac{e\widetilde{\delta}\mu'_\gamma}{\Delta_1} > 0, \tag{A24}$$

and the product range decreases as marginal varieties undergo cannibalization

$$\frac{d\ln \delta}{d\ln w} = \frac{e\widetilde{\delta} w\mu'_\gamma}{\Delta_1 w^* \gamma'(\delta)\delta} > 0. \tag{A25}$$

The cannibalization effect becomes stronger the more domestic production benefits from falling wages (i.e. the higher $\widetilde{\delta}$ and μ'_γ). Figure 5 illustrates all effects.

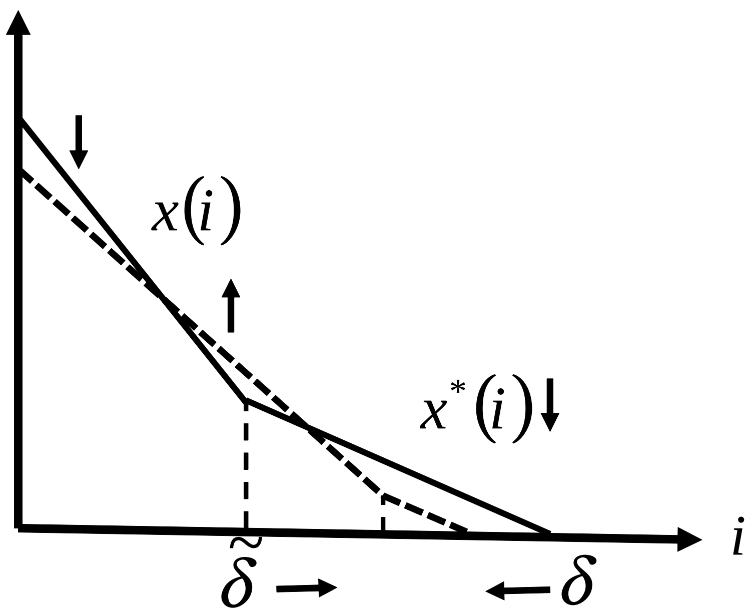

Figure 5: Exogenous Decrease in Domestic Wages

5.5 Numerical Example with a Linear Cost Function

In this section, we round down our analysis in general equilibrium with a numerical simulation, where we focus on the ambiguity of the effect of falling offshoring costs t on the cutoff variety $\tilde{\delta}$. For specific parameter values and a linear cost function, Table 1 summarizes results for different degrees of product differentiation. Results once again underline the issue of cannibalization in this framework. We observe a falling total firm output X and a falling product range δ with rising substitutability between varieties (higher values of

e). Referring to proposition 8 in the main body, it is important to mention that Table 1 shows a specific case where partial equilibrium results with respect to the cutoff variety $\widetilde{\delta}$ get reversed in general equilibrium, i.e. $\frac{d\widetilde{\delta}}{dt} < 0$. In this parameterization with an underlying linear cost function, we find more varieties being produced onshore with falling offshoring costs. As explained before, this result is due to the prevailing effect of falling domestic wages in comparison to the better prospects for offshoring.

Table 1: Numerical Example with a Linear Cost Function

Product differentiation e	w	X	$\widetilde{\delta}$	δ	$\frac{d\widetilde{\delta}}{dt}$	$\frac{d\delta}{dt}$
0.1	8.70	121.73	1.36	22.13	−0.688	−0.495
0.5	8.14	36.13	1.77	8.86	−1.081	−0.003
0.9	9.01	22.96	1.14	2.91	−0.370	−0.143

Notes: Parameter values are: $a' = 100$, $b' = 2$, $L^W = 20$, $w^* = 3.5$, and $t = 2.5$.
For this calculation, we assume a linear cost function: $\gamma(i) = \gamma_0 + \gamma_1 i = 1 + 0.5i$.

Lemma 3 *By assuming a linear cost function within this framework, we can show that there is the possibility that an MPF produces even more varieties domestically when it faces better prospects for offshoring.*