Home Market Effects with Endogenous Costs of Production

Armando J. Garcia Pires *
Institute for Research in Economics and Business Administration (SNF)

July 5, 2012

Abstract

Home Market Effects (HMEs) are a central mechanism in the theoretical models of the "new" trade theory and of the "new" economic geography. A key assumption in these models is the exogeneity of the costs of production. In this paper, we endogenize the costs of production and test the implications for HMEs. In particular, we consider process R&D that reduces marginal costs but increases fixed costs. In this set-up, we find that outputs and prices are a function not only of the spatial distribution of firms (as when the costs of production are exogenous), but also of the spatial distribution of demand, given that R&D efforts depend on market size. In fact, firms in the larger market tend to invest more in R&D than firms in the smaller market. As a result, the larger market does not necessarily host a disproportionately higher share of the world's industry than of demand or employ more labor (HMEs in the number of firms and employment). However, the larger country can nevertheless run trade surplus in the increasing returns sector, since it hosts firms that have higher competitiveness and larger size (HMEs in trade patterns).

Keywords: Home Market Effects, Oligopoly, R&D Investment, Endogenous Asymmetric Firms.

JEL Classification: F12, L13, O31, R3.

*Address for correspondence: Institute for Research in Economics and Business Administration (SNF), Norwegian School of Economics (NHH), Breiviksveien 40, 5045 Bergen, Norway. Tel: +(47)55959622, Fax: +(47)55959439; E-mail: armando.pires@snf.no.

1 Introduction

In 2008, Paul Krugman won the Nobel Memorial Prize in Economics for his contributions to "New" Trade Theory and "New" Economic Geography[1]. Central to both of these theories are the so-called "Home Market Effects" (HMEs). The HMEs predict that in increasing return sectors the larger countries, relatively to smaller countries, tend to: (*i*) host a disproportionately higher share of the world's industry than of the world's demand; (*ii*) run trade surplus; and (*iii*) use more factors of production (Krugman, 1980; Helpman and Krugman, 1985). For the sake of space, in the rest of the paper we will refer to these three different types of HMEs as HMEs in the number of firms, trade patterns and factor employment, respectively. Given the importance of the HMEs, a body of research has emerged to test the robustness of the previous predictions. In this paper, we propose to follow the same line of inquiry.

The literature on HMEs has in particular focused on the main assumptions behind the theoretical models of the "new" trade theory and of the "new" economic geography. To be more precise, the basic structure of a model with HMEs is the following (e.g.: Krugman, 1980; Helpman and Krugman, 1985). There are two countries (home and foreign) and two sectors (increasing returns and constant returns to scale) and one factor of production (labor). The constant returns sector produces a homogeneous good under perfect competition. The increasing returns sector produces a horizontal differentiated good under monopolistic competition. The increasing returns good is subject to iceberg trade costs, while the constant returns good can be freely traded across countries. As a result, labor earns the same wages everywhere[2]. Preferences are Cobb-Douglas across the two goods. In the increasing returns horizontally differentiated good, preferences are of CES type and each variety enters symmetrically in the utility function of a representative consumer. Lastly, firms in the increasing returns sector incur

[1]The "new" trade theory analyzes the role of increasing returns to scale on international trade (see Krugman, 1980). The "new" economic geography, in turn, looks at how increasing returns in production affect the location of industry (Krugman, 1991).

[2]Trade costs in the homogeneous goods also absorb all trade imbalances in the increasing returns sector, allowing for international specialization. If instead of just one factor of production, the model considers two factors of production and each factor is sector specific (as in Krugman, 1991), returns are not equalized across countries. Furthermore, if the factor used in the increasing returns sector is internationally mobile, we will have HMEs in the returns to this factor of production.

marginal and fixed costs of production, which are constant, exogenous and equal across countries.

Of the assumptions above, special attention has be given to market structure (Feenstra et al., 2001; Head et al., 2002), preferences (Helpman, 1990; Head et al., 2002; Yu, 2005), trade costs (Davis, 1998; Crozet and Trionfetti, 2008), number of countries (Behrens et al., 2009) and traded *versus* non-traded goods (Behrens, 2005). In this paper, instead, we look at the exogeneity of the fixed and the marginal costs of production.

Before turning to the analysis carried out in our paper, we discuss first in more detail the papers that have tested the main assumptions behind the models that lead to HMEs. We start with the assumptions that proved to be robust to alternative formulations and then turn to those that failed the test. It results that market structure is not very central to HMEs. In fact, as shown by Feenstra et al. (2001) and Head et al. (2002), HMEs also arise in a model with oligopolistic competition and homogeneous goods, such as Brander (1981). The same occurs if instead of a CES demand for the differentiated goods, we consider, like in Ottaviano et al. (2002), linear preferences (Head et al., 2002). Given, then, that the models of Krugman (1980), Brander (1981) and Ottaviano et al. (2002) share the same properties in terms of HMEs, in the rest of the paper we label them as standard "new" trade theory models.

We now analyze the assumptions that proved to be not so strong. While, as mentioned above, it is not important whether we assume CES or linear demands, preferences can become central if, as in Armington (1969), goods are differentiated according to their country of origin (Head et al., 2002). In turn, Helpman (1990) demonstrates that the relation between the cross-elasticity of varieties of the differentiated good and the price elasticity of demand for the differentiated good can matter for HMEs. Yu (2005) also finds that if the upper-tier preferences for the differentiated and the homogenous goods are of the CES type (instead of Cobb-Douglas), the existence of HMEs depends on the relation between the elasticity of substitution between the two goods.

The assumption of no trade costs in the homogeneous good can also be problematic for HMEs. For instance, Davis (1998), by introducing trade costs of the iceberg type in the homogenous good, shows that when the trade costs for the homogenous and the differentiated goods are equal, HMEs disappear. HMEs are only restored if the trade costs in the increasing returns sector are substantially larger than in the constant returns sector, although Davis

(1998) contends that there is no compelling evidence to support this claim. In turn, Crozet and Trionfetti (2008) also demonstrate that with costly trade in the homogenous good, HMEs are weakened. However, HMEs can still survive for very large and very small countries, but not necessarily for medium size countries (in terms of demand). They argue that although the assumption of no trade costs in the homogenous good is not realistic, it does not affect qualitatively the results in terms of the direction of trade and international specialization.

In what concerns the number of countries, Behrens et al. (2009) extend the basic model of Helpman and Krugman (1985) to many countries and show that HMEs can be eliminated due to third-country effects. However, if the model takes into account cross-country technological differences and there is no factor price equalization, HMEs can be restored. In a similarly way, Behrens (2005) demonstrates that if the increasing returns sector produces non-traded gods (instead of traded goods), then, HMEs only emerge if these goods are sufficiently differentiated.

In this sense, most of the central assumptions of a basic model with HMEs have been scrutinized. As we have mentioned above, the only exception has been the assumption of constant and symmetric marginal and fixed costs of production across countries. This assumption is made mostly for analytical convenience, given that empirical evidence demonstrates that the costs of production are endogenous (see for instance Roberts and Tybout, 1997). However, the literature on international trade and economic geography only recently started to pay due attention to this issue. Some examples can be found in the heterogeneous firms' literature (Melitz, 2003) and oligopoly trade theory (Neary, 2010; Garcia Pires, 2009).

We start with the heterogeneous firms' literature. In Melitz (2003), in order to enter the market and export, firms need to incur a fixed cost of production and a fixed cost of export, respectively. It is further assumed that firms draw productivity levels from a statistical distribution[3]. Together these two assumptions imply that only the firms with a productivity level above the fixed costs of production enter the market. Similarly, of the firms that enter the market, only a subset exports, in particular those with productivity levels superior to the fixed costs of exporting. The empirical tests of Melitz's model with firm level data shows that it fits well the observed market dynamics at the national level (see Bernard et al., 2003). However, the same does not

[3]In this sense, in Melitz (2003) productivity asymmetries across firms are exogenous.

occur at the international level (see Feenstra and Kee, 2008). The reason for this is that in the Melitz's framework, firms in different countries draw their productivity levels from the same statistical distribution and therefore the distribution of productivity is the same across countries. In other words, although both in the US and in Chile only the more productive firms exports, US exporting firms might on average be more productive than Chilean ones. The Melitz model cannot capture scenarios like the previous one. However, the empirical research presents clear evidence that productivity levels differ a across countries (see Trefler, 1993, 1995; Davis and Weinstein, 2001; Feenstra and Kee, 2008). In addition, given that firms in Melitz draw productivity from a statistical distribution, we cannot explain the asymmetries between firms. Therefore, we do not know whether the asymmetries between firms arise only due to randomness or to something else. These question have started to become tackled in some recent oligopoly trade models.

For instance, Neary (2010) shows that natural oligopolies and superstar firms can arise when firms invest in firm-specific assets, like investment on R&D or capacity, which make the costs of production endogenous[4]. This cannot occur in a standard oligopoly trade model, when free-entry and exit are introduced. Similarly, Garcia Pires (2009) demonstrates that if a firm is a Stackelberg R&D leader, it will achieve higher competitiveness and larger size than a Stackelberg R&D follower. Such is not possible in a standard Stackelberg model (von Stackelberg, 1934), where firms independently of being leaders or followers, although they have different output levels (i.e.: the leader produces more than the follower), always have the same costs of production.

Following some of the insights in Neary (2010) and Garcia Pires (2009), in this paper, we endogenize the costs of production and test whether HMEs survive. In particular, we start with a very general model that can encompass different types of market structures, preferences and costs of production. We consider both the cases with exogenous and with endogenous costs of production. With endogenous costs of production, firms can invest in process R&D, which reduces marginal costs but increases fixed costs. We then illustrate the general model with the special example of oligopolistic competition and linear demands, similar to Brander (1981). The reason for choosing this

[4]According to Shaked and Sutton (1983) a natural oligopoly arises when the equilibrium number of firms does not increase as market size rises. In turn, Rosen (1981) defines superstar firms as the cases where a "relatively small numbers of people earn enormous amounts of money and dominate the activities in which they engage".

particular market structure is that process R&D has been mostly applied in oligopolistic models (see Leahy and Neary, 1997)[5]. Furthermore, and as we have referred to above, Head et al. (2002) showed that the Brander (1981) model shares the same properties in terms of HMEs as Krugman (1980). With this set-up, we analyze the effects of market size on production, R&D, spatial distribution of firms, trade and employment patterns[6].

With exogenous costs of production, we demonstrate that sales per consumer and prices depend only on the spatial distribution of firms, but not on the spatial distribution of demand. This means that standard "new" trade theory models consider spatial price discrimination in relation to local competition levels, however they ignore spatial price discrimination in relation to local demand levels. It turns out that due to this, demand effects are positive (i.e.: profits of local firms increase when domestic demand rises) and the competition effects are negative (i.e.: profits of local firms decrease when domestic competition increases). Furthermore, the demand effects tend to dominate the competition effects, and, as a consequence, in the end HMEs in the number of firms, trade patterns and employment always emerge.

The same is not necessarily the case when the costs of production are endogenous, given that R&D has a spatial dimension. As a result of this, with endogenous costs of production, sales per consumer and prices depend both on the spatial distribution of firms and of demand[7]. Then, with endogenous costs of production, firms price discriminate not only in relation to local competition levels but also to local demand levels. The main consequence is that the demand effect does not always need to be positive. The rationale for this is that since R&D reduces marginal costs but increases fixed costs, and a larger market size tends to promote local firms' R&D, then firms located in larger markets tend to achieve higher competitiveness and larger size than firms located in smaller markets. Therefore, on the one hand a country with a large market size brings benefits for the local firms, because of higher local

[5]In addition, Tybout (2003) defends that the empirical evidence gives support to the oligopolist market structure in international trade. In fact, not only are very few firms involved in the export markets, but exporters also tend to be larger and more productive than domestic firms, i.e.: exporters enjoy some form of market power.

[6]In turn, Gerlach et al. (2009) and Combes and Duranton (2006) focus on the role of labor markets on innovation and the location of industry.

[7]Empirical evidence shows in fact that price competition depends both on the spatial distribution of firms and on demand (see Konishi, 2005; Syverson, 2007). Local demand levels can affect sales and prices since it influences firm specific assets such as distribution channels or investment in innovation.

demand. However, on the other hand it can also carry negative effects by increasing local competition, since domestic firms' competitiveness and size can increase to a level that fewer firms can survive in equilibrium relatively to the case with symmetric firms across countries.

When this occurs, HMEs will tend to be canceled, given that the larger market, in spite of hosting firms that have higher competitiveness and larger size, does not necessarily need to host a disproportionately higher share of the world's industry than of the world's demand. In addition, since firms in the larger market are more efficient, given that they invest more in R&D, then factor demand might not be higher there than in the smaller market. Therefore HMEs in factor employment may also be canceled. However, the same does not occur with the HMEs in trade patterns, which in our framework continue to hold. The reason for this is that even if the larger market does not host a disproportionately higher share of the world's industry in relation to the world's demand, the firms located there can overcome foreign competition, because they have higher competitiveness and larger size than firms in the smaller market. As a result, HMEs in trade patterns still emerge in our set-up. In this sense, our model can conciliate with the evidence on productivity differences across countries (Trefler, 1993, 1995; Davis and Weinstein, 2001; Feenstra and Kee, 2008), which, as we have discussed above, has been difficult to incorporate in the heterogeneous firms' literature.

In addition, our results can also be an important finding for the empirical exercises that evaluate the existence of HMEs (see Davis and Weinstein 1996, 2003). These studies have focused solely on the HMEs in the number of firms. This has been so for two reasons. First, it is difficult to establish causation from market size to factor employment and trade patterns. Second, in the standard set-up with exogenous costs of production, the existence of HMEs in the number of firms always implies the existence of HME is trade patterns and employment. This line of research, however, has not provided very robust results. In fact, while Lundbäck and Torstensson (1998), Torstensson (1998), Davis and Weinstein (1999, 2003) find support for the hypothesis that in increasing returns sectors large markets have a disproportionately higher share of the world's industry than of the world's demand, the contrary occurs in Davis and Weinstein (1996) and Head and Ries (2001).

Our paper might contribute to understand this contradictory evidence. In fact, we show that HMEs in the number of firms might not hold when firms located in different countries are asymmetric, due to the endogeneity of the costs of production. Nevertheless, HMEs in trade patterns can still arise.

What this means is that the tests of HMEs based solely on the number of firms an economy hosts need to take into account international asymmetries between firms that result from having endogenous costs of production. In fact, without controlling for competitiveness and size asymmetries between firms across countries, HMEs might erroneously not be observed in the data. This can be so because for HMEs, firms' size and competitiveness can be more relevant than the number of firms established in a country.

The remainder of the paper is organized as follows. In section 2, we introduce a very general imperfect competition trade model (in terms of preferences, demand and costs of production). With this general model, in section 3, we look at the HMEs in the number of firms and in section 4, we turn to the HMEs in trade patterns and employment. In sections 5 and 6, we analyze the existence of HMEs by considering the special case of oligopolistic competition. However, while in section 5 the costs of production are exogenous, in section 6 the costs of production are endogenized via R&D investment. In section 7, we conclude.

2 The general model

We adopt the framework in Krugman (1980), which is considered to be the standard set-up for having "home-market effects" (HMEs). The objective is to make our model as similar as possible to those of the literature on the HMEs (see Head et al., 2002). We then have only one factor of production, two regions, and two sectors. The sectors are the constant returns perfect competition sector (CRS), and the increasing returns sector (IRS)[8]. The two regions are home (H) and foreign (F). Preferences and underlying technologies are the same in both regions[9]. In turn, the only factor of production is labor, where M is the world endowment of labor and w_i is the labor wages, with $i = H, F$. We denote r as the share of world endowment of M located at home (with $r \in (0, 1)$). Then, r is the home share of world expenditure and rM is the number of consumers at home.

The CRS-sector produces the CRS-good that can be freely traded between regions. The output of the CRS-sector at home and foreign is q_{0H}

[8] The general model in this section can encompass both monopolistic competition and oligopolistic competition. In a subsequent section we focus in the oligopoly case.

[9] Since the model is then symmetric, in most of the following, we concentrate our attention in the home region. Equations for foreign apply by symmetry.

and q_{0F}, respectively. This sector is kept in the background and its role is to represent the "rest of the economy" and to correct for trade imbalances that can occur in the IRS-sector.

Firms in the IRS-sector compete in an imperfect competitive setting to produce the IRS-good, which is subject to trade costs (t) when exchanged between countries. Resources of the sending region are used to pay for the trade costs of the IRS-good. In this sense, due to trade costs in the IRS-sector, markets for the IRS-good are segmented. The main implication is that we have a representative firm in each market. The number of firms in the world economy is represented by $N = n_H + n_F$. Where $1_H, 2_H, ...n_H$ is the number of firms located at home, and $1_F, 2_F, ...n_F$ is the number of firms located at foreign. We can then say that $s \in (0, 1)$ is the share of firms at home, i.e.: home hosts $sN = n_H$ IRS-firms, while foreign $(1 - s)N = n_F$. There is free entry and exit and in the long run equilibrium the number of firms in each region is determined by the zero profit condition.

Firms incur marginal and fixed costs of production, C_i and Γ_i, respectively. In addition, we denote by q_{ij} the quantity that an individual firm from country i (origin) sells to each individual consumer in country j (destination) and P_i the price of the IRS-good in country i (with $i, j = H, F$).

Both the CRS- and the IRS-sectors use labor as only input. This implies that due to perfect competition in the CRS-sector, and since the CRS-good is freely traded, this good is the *numéraire*. Furthermore, since labor is used in both sectors, then as long as the CRS-sector produces positive output, the economy wide wages are fixed relatively to the price of the CRS-good. Thus, nominal wages in both countries and sectors can be normalized to one: $w_H = w_F = 1$.

The larger country in our model is the one that hosts more demand (r). In other words, the firms located in the larger country have more consumers served with zero transport costs than the firms located in the smaller country. As such, we interpret country size as a metaphor for the level of preferential market access that firms in a given location have.

The above basic structure is also the one adopted not only in Krugman (1980), but also in other imperfect competition trade models like Brander (1981) and Ottaviano et al. (2002)[10]. As argued by Head et al. (2002), these

[10] Krugman (1980) is a monopolistic competition model with CES demand, Ottaviano et al. (2002) is a monopolistic competition model with linear demand and Brander (1981) is an oligopolistic competition model.

three papers are the main representatives of the increasing returns revolution in trade theory and economic geography, also known as the "new" trade theory and the "new" economic geography, respectively. These models have many similarities both in terms of assumptions and results. First, in all of them, marginal and fixed costs of production are exogenous and equal across countries. Second, they share the same properties in what concerns HMEs (see Head et al., 2002). In particular, in Krugman (1980), Brander (1981) and Ottaviano et al. (2002), the larger country tends to host a disproportionately higher share of the world's increasing returns industry (in terms of the number of firms) than of the world's demand (HMEs in the number of firms). Furthermore, the larger country tends to employ more labor and to run trade surplus in the IRS-sector (HMEs in employment and in trade patterns, respectively). Given these similarities, in this paper we label these three models as standard imperfect competition trade models.

The purpose of the set-up above is to evaluate the influence of international market size differences on HMEs when marginal and fixed costs of production are not exogenous[11]. To be more precise, we endogenize marginal and fixed costs of production via R&D investment. We then define k_i as the R&D investment from an individual firm located in country i (in the exogenous marginal and fixed costs case $k_i = 0$)[12]. We start with HMEs in the number of firms and then move to HMEs in employment and trade patterns.

Summing up, the main variables in our model are:

Two countries: home (H) and foreign (F),

One factor of production: labor (M),

Two sectors: IRS-sector and CRS-sector,

q_{0i}: production in the CRS-sector in country i,

M: total number of identical consumers in the world economy,

r: share of world's consumers residing at H,

N: number of firms in the IRS-sector in the world economy,

s: share of firms from the IRS-sector located at H,

t: trade costs,

C_i: marginal costs of production in country i,

[11] The importance of the endogeneity of costs for trade, innovation and entrepreneurship is for instance documented in Roberts and Tybout (1997), Gustavsson et al. (1999), Aw et al. (2008) and Glaeser et al. (2010).

[12] As discussed by Neary (2010), k_i does not need to be interpreted only as R&D investment. It can be thought of as any other strategic variable that firms use to affect their costs of production (such as capital stock, quality or distribution channels).

Γ_i: fixed costs of production in country i,

q_{ij}: quantity that an individual firm from country i (origin) sells to each individual consumer in country j (destination),

k_i: R&D from an individual firm located in country i,

P_i: prices in country i.

In the next two sections, we turn to HMEs. We start with the HMEs in the number of firms and then turn to the HMEs in employment and trade patterns. We follow mostly Head et al. (2002), since they compare the existence of HMEs in the three standard imperfect competition trade models referred to above (Krugman, 1980; Brander, 1981; Ottaviano et al., 2002). This allows us to be as close as possible to the "textbook" case of HMEs, and to show that our results are not the outcome of other assumptions rather than the endogeneity of the costs of production.

3 HMEs in the number of firms

We define profits by a representative home and foreign firm as:

$$\begin{aligned} \Pi_H &= (P_H - C_H)\, q_{HH} r M + (P_F - C_H - t)\, q_{HF} (1-r) M - \Gamma_H \\ \Pi_F &= (P_F - C_F)\, q_{FF} (1-r) M + (P_H - C_F - t)\, q_{FH} r M - \Gamma_F. \end{aligned} \tag{1}$$

In order to simplify the notation, we write $\pi_{ij} = (P_i - C_i - t_{i,j})\, q_{ij}$ as the sales of a representative firm from country i to an individual consumer in country j, where $t_{i,j} = t$ if $i \neq j$ and $t_{i,j} = 0$ if $i = j$ (with $i, j = H, F$). Profits then equal:

$$\begin{aligned} \Pi_H &= \pi_{HH} r M + \pi_{HF} (1-r) M - \Gamma_H \\ \Pi_F &= \pi_{FF} (1-r) M + \pi_{FH} r M - \Gamma_F. \end{aligned} \tag{2}$$

We assume that firms enter the industry until all profits opportunities are exhausted. The free entry conditions then imply that $\Pi_H = 0$ and $\Pi_F = 0$:

$$\Pi_H = \Pi_F = 0 \Rightarrow \Delta\Pi = \Pi_H - \Pi_F = 0, \tag{3}$$

where $\Delta\Pi$ is the profit differential between locating at home or at foreign. Solving explicitly for Π_H and Π_F, we obtain:

$$\Delta\Pi = 0 \Rightarrow M\left(r\left(\pi_{HH} - \pi_{FH}\right) + (1-r)\left(\pi_{HF} - \pi_{FF}\right)\right) - \left(\Gamma_H - \Gamma_F\right) = 0. \tag{4}$$

Totally differentiating $\Delta\Pi$ with respect to s and r:

$$d\Delta\Pi = \frac{\partial\Delta\Pi}{\partial s}ds + \frac{\partial\Delta\Pi}{\partial r}dr. \tag{5}$$

From equation 5, we have:

$$\frac{ds}{dr} = \frac{\frac{\partial\Delta\Pi}{\partial r}}{-\frac{\partial\Delta\Pi}{\partial s}}. \tag{6}$$

where $c = \frac{\partial\Delta\Pi}{\partial s}$ is in the literature on HMEs usually denoted the "competition effect" and $d \equiv \frac{\partial\Delta\Pi}{\partial r}$ the "demand effect". The competition effect looks at the change in profits of domestic firms as a consequence of changes in the level of local competition. The demand effect measures the change in profits of domestic firms as a result of changes in local market size.

As shown by Head et al. (2002), HMEs in the number of firms arise if:

$$\frac{ds}{dr} > 1 \Rightarrow d + c > 0. \tag{7}$$

In the next two sub-sections, we analyze when HMEs in the number of firms emerge (equation 7 is satisfied). We look first at the case with exogenous costs of production (i.e.: with no R&D investment) and then at the case with endogenous costs of production (i.e.: with R&D investment). In what follows, we work with general functional forms for demand and costs. As expected with general functional forms, we will not be able to derive closed form solutions for all the cases analyzed. For this reason, in subsequent sections, we will turn to special cases with specific functional forms.

3.1 Exogenous costs of production

In standard "new" trade theory models (Krugman 1980; Brander 1981; Ottaviano et al., 2002) marginal and fixed costs of production are exogenous and symmetric across countries: $C_H = C_F = \omega$ and $\Gamma_H = \Gamma_F = f$. The main implication is that, as shown by Head et al. (2002), prices and sales per consumer do not depend on the spatial distribution of demand (r), they just depend on the spatial distribution of firms (s). This can be seen from the FOCs for sales per consumer. In particular, taking the example of the sales per consumer of a representative home firm in the home market, we have:

$$\frac{d\Pi_H}{dq_{HH}} = 0 \Rightarrow (P_H - \omega) + \frac{\partial P_H}{\partial q_{HH}} = 0. \tag{8}$$

The above result follows, since P_H and q_{HH} are only a function of s. In other words, in a standard "new" trade theory model (with exogenous costs of production) there is no spatial price discrimination in relation to demand patterns. There is only spatial price discrimination with respect to industrial location patterns. This has implications for the competition and the demand effects. Start with the competition effect. Since prices and outputs per consumer are a function of s, the competition effect is:

$$c = \frac{\partial \Delta \Pi}{\partial s} = \frac{r\left(\pi'_{HH} - \pi'_{FH}\right) + (1-r)\left(\pi'_{HF} - \pi'_{FF}\right)}{M^{-1}}, \tag{9}$$

where π'_{ij} represents the derivatives of the maximized profit functions, $\pi_{ij}(s)$, with respect to s. Our presumption is that $\pi'_{HH} < 0$, $\pi'_{FH} < 0$, $\pi'_{HF} > 0$ and $\pi'_{FF} > 0$. Accordingly, an increase in competition in a market leads to a decrease in the sales per consumer and in the profits made in this market (and *vice-versa*). Also, we expect that $\left(\pi'_{HH} - \pi'_{FH}\right) < 0$ and $\left(\pi'_{HF} - \pi'_{FF}\right) < 0$. This is so, since due to trade costs firms rely more on the profits made in their domestic market than from exports (see Head et al., 2002). As such, an increase in local competition affects the profits of domestic firms more than those of foreign firms (i.e.: $\left(\pi'_{HH} - \pi'_{FH}\right) < 0$). Similarly, a decrease in the intensity of local competition benefits the local sales of domestic firms more than the exports of foreign firms (i.e.: $\left(\pi'_{HF} - \pi'_{FF}\right) < 0$). As a result, we have that $c < 0$, i.e.: the competition effects are negative.

In turn, since prices and outputs per consumer do not depend on r, the demand effect is just:

$$d = \frac{\partial \Delta \Pi}{\partial r} = \frac{(\pi_{HH} - \pi_{HF}) + (\pi_{FF} - \pi_{FH})}{M^{-1}}. \tag{10}$$

As discussed above, due to trade costs, firms have higher profits from local sales than from exports, and as such $\pi_{HH} > \pi_{HF}$ and $\pi_{FF} > \pi_{FH}$. Then it must follow that $d > 0$, i.e.: the demand effects are positive.

We can now also understand better why changes in market size do not trigger a response by firms on sales per consumer and prices. Take the example of the home firms. The derivative of profits in relation market size equals: $\frac{\partial\Pi}{\partial r} = \pi_{HH} - \pi_{HF}$. Since we expect that $\pi_{HH} > \pi_{HF}$, then with free entry and exit, the adjustment to an increase in r comes via an increase in the number of firms located in this market until profits go down to zero.

Summing up, since $d > 0$ and $c < 0$, we do not know for certain whether HMEs in the number of firms arise or not. However, as shown by Head et al. (2001), in standard "new" trade theory models (with exogenous costs of production) the demand effect always dominates the competition effect, and therefore HMEs in the number of firms always emerge. Below, we reproduce this result for an oligopolistic competition trade model similar to Brander (1981).

3.2 Endogenous costs of production

Consider now that marginal and fixed costs depend on investment in R&D (k_i): $C_i(k_i)$ and $\Gamma_i(k_i)$. In particular, we assume process R&D investment that reduces marginal costs but increases fixed costs[13]:

$$\begin{aligned} \frac{\partial C_H}{\partial k_H} &< 0 \\ \frac{\partial \Gamma_H}{\partial k_H} &> 0. \end{aligned} \tag{11}$$

For simplification, we do not consider strategic R&D investment. The objective of this assumption is to demonstrate clearly that our results are not driven by strategic behavior on R&D, but are only due to the endogeneity of the costs of production[14].

We now have that the FOC for outputs per consumer continue to be the same as in standard "new" trade theory models (Krugman 1980; Brander 1981; Ottaviano et al., 2002), with the only difference that marginal costs can be different for home and foreign firms:

$$\frac{d\Pi_H}{dq_{HH}} = 0 \Rightarrow (P_H - C_H) + \frac{\partial P_H}{\partial q_{HH}} = 0. \tag{12}$$

The FOC for R&D, however, equals:

$$\frac{d\Pi_H}{dk_H} = 0 \Rightarrow \frac{\partial \Gamma_H}{\partial k_H} = -M\frac{\partial C_H}{\partial k_H}\left(rq_{HH} + (1-r)\,q_{HF}\right). \tag{13}$$

[13] The alternative to process R&D is product innovation R&D. For the relation between the two, see Callois (2008).

[14] Note that the strategic behavior can only arise in an oligopolist model, and not in a monopolistic competition model.

Since the demand parameter (r) cannot be canceled from the FOC for R&D, R&D is going to depend on r, i.e.: $k_i(r)$. As a consequence, the same is going to be the case with prices and outputs per consumer (given that they are a function of R&D), i.e.: $q_{ij}(r)$ and $P_i(r)$. Furthermore, since the costs of production now depend on R&D, they will also be a function of the spatial distribution of industry (s) and demand (r). This implies that the competition and the demand effects in the model with endogenous costs of production are different from those obtained in the model with exogenous costs of production.

Start again with the competition effect. For the reason that $q_{ij}(s)$, $P_i(s)$, $\Gamma_i(s)$ and $k_i(s)$, we have that the competition effect is now:

$$c = \frac{\partial \Delta \Pi}{\partial s} = \frac{r\left(\pi^{'}_{HH} - \pi^{'}_{FH}\right) + (1-r)\left(\pi^{'}_{HF} - \pi^{'}_{FF}\right)}{M^{-1}} - \left(\Gamma^{'}_{H} - \Gamma^{'}_{F}\right), \tag{14}$$

where $\pi^{'}_{ij}$ represents the derivatives of the maximized profit functions, $\pi_{ij}(s)$, with respect to s. Similarly, $\Gamma^{'}_{i}$ stands for the derivatives of the fixed costs of production, $\Gamma_i(s)$, with respect to s. Relatively to the case with exogenous costs of production, we have a new term affecting the competition effects: $\left(\Gamma^{'}_{H} - \Gamma^{'}_{F}\right)$, i.e.: the effects of competition on fixed costs.

In equation 14, the derivative of k_i in relation to s is central, because it can determine the signs of $\pi^{'}_{ij}$ and $\Gamma^{'}_{i}$. We can either have: $\frac{dk_H}{ds} > 0$ (i.e.: R&D of the home firms increases with the level of competition at home) or $\frac{dk_H}{ds} < 0$ (i.e.: R&D of the home firms decreases with the level of competition at home). We can say that if k_H increases with s, R&D competition is "tough" (i.e.: an increase in local competition promotes an increase in the R&D of local firms, making competition even more fierce); while if k_H decreases with s, R&D competition is "soft" (i.e.: an increase in local competition promotes a decrease in the R&D of local firms, making competition less fierce).

R&D competition can be "tough" given that when the fixed costs of production are endogenous, the behavior of R&D is determined not only by the spatial distribution of industry (s), but also by the spatial distribution of demand (r), i.e.: local R&D competition has to be balanced by the level of domestic demand. In fact, we know from standard "new" trade theory models that the spatial distribution of demand (r) affects the spatial distribution of firms (s). For instance, if a region is smaller it will tend to host fewer firms (Krugman, 1991). As such, an increase in local competition in the smaller region might promote local firms to respond more toughly on R&D, since they already face lower demand than firms in the other region. The contrary can occur in the larger region, since firms have more room to accommodate an increase in local competition by a reduction in the investment on R&D (i.e.: R&D competition is "soft")[15].

In this sense, the signs of π'_{ij} and Γ'_i will depend on the "toughness" of R&D competition. Start first with π'_{ij}. If $\frac{dk_H}{ds} < 0$, we should expect that $\frac{dq_{HH}}{ds} < 0$, because domestic firms not only invest less in R&D, but also face fiercer competition from other domestic firms. However $\frac{dq_{HF}}{ds} \lesseqgtr 0$, given that home firms invest less in R&D, but at the same time they can sell more at foreign due to lower competition there. Similarly, $\frac{dk_F}{ds} > 0 \Rightarrow \frac{dq_{FF}}{ds} > 0$ and $\frac{dq_{FH}}{ds} \lesseqgtr 0$. Then we have that $\pi'_{HH} < 0$ and $\pi'_{FF} > 0$, while $\pi'_{HF} \lesseqgtr 0$ and $\pi'_{FH} \lesseqgtr 0$. In any case, and since due to trade costs, firms' profits depend more on local sales than on exports, we can expect that, as for the exogenous costs of production case, $\left(\pi'_{HH} - \pi'_{FH}\right) < 0$ and $\left(\pi'_{HF} - \pi'_{FF}\right) < 0$.

If, in contrast, $\frac{dk_H}{ds} > 0$, we should anticipate that $\frac{dq_{HH}}{ds} \lesseqgtr 0$, because home firms invest more in R&D, but at the same time they can sell less in the home market due to higher competition there. In turn, $\frac{dq_{HF}}{ds} > 0$, given that domestic firms benefit from higher investment in R&D and softer competition in the foreign market. Similarly, $\frac{dk_F}{ds} < 0 \Rightarrow \frac{dq_{FF}}{ds} \lesseqgtr 0$ and $\frac{dq_{FH}}{ds} < 0$. Then we have that $\pi'_{HF} > 0$ and $\pi'_{FH} < 0$, while $\pi'_{HH} \lesseqgtr 0$ and $\pi'_{FF} \lesseqgtr 0$. As a result, $\left(\pi'_{HH} - \pi'_{FH}\right) \gtreqless 0$ and $\left(\pi'_{HF} - \pi'_{FF}\right) \gtreqless 0$.

Turn now to Γ'_i. If R&D competition is "soft", as s increases k_H decreases, k_F increases and therefore $\Gamma'_H < 0$ and $\Gamma'_F > 0$, which makes $-\left(\Gamma'_H - \Gamma'_F\right) > 0$. If this occurs, higher local competition can be beneficial for local firms because it leads them to optimize the fixed costs of production in a cost-saving way. If, in turn, R&D competition is "tough", as s increases k_H increases, k_F decreases and therefore $\Gamma'_H > 0$ and $\Gamma'_F < 0$, which makes $-\left(\Gamma'_H - \Gamma'_F\right) < 0$.

We then see that the sign of the competition effect will depend both on the signs of π'_{ij} and Γ'_i and the relation between the first and second terms in equation 14. If $\frac{dk_H}{ds} > 0$, on the one hand, higher competition is positive since it increases the competitiveness and the size of local firms via higher investment in R&D, but on the other hand, local competition becomes

[15] Another explanation for "tough" R&D competition can be R&D spillovers. In this paper, however, we ignore them. Note that in spite of this, the functional form adopted for R&D below can still encompass "tough" R&D competition.

tougher, since local rivals are stronger. If $\frac{dk_H}{ds} < 0$, the contrary occurs. From one side higher competition is negative since it decreases the competitiveness and the size of local firms via lower investment in R&D, but from the other side local competition becomes softer, given that local rivals are weaker.

In the subsequent sections we will adopt a functional form for the costs of production that is standard in the literature on R&D investment. It turns out that this functional form can encompass the two cases of the "toughness" of R&D competition ("tough" and "soft" R&D competition). As we shall see, however, in the end the negative effects of competition still dominate the positive effects of competition identified above. This might be due to the functional form that we adopt and therefore future work should try to check the robustness of this result. In any case, note that when the positive effects of competition dominate the negative ones (i.e.: the competition effect is positive), this will contribute to the existence of HMEs in the number of firms. Remember that if $d + c > 0$, HMEs in the number of firms arise, and in standard "new" trade theory models $c < 0$. Then with $c > 0$, HMEs in the number of firms can more easily emerge. In this paper, though, our focus is not on what can strengthen the HMEs in the number of firms, but on what can weaken them. In other words, for our argument it is not central that the competition effect stops being negative, since this promotes HMEs in the number of firms. What is interesting for us is what can reduce the possibility of obtaining HMEs.

In this respect, the demand effect is of particular significance. In fact, contrary to the exogenous costs of production model where, as already mentioned, prices and outputs per consumer do not depend on the spatial distribution of demand (r), the contrary is the case when the costs of production are endogenous, since r determines R&D investment across countries. Furthermore, since this also implies that costs of production are a function of r, we have that the demand effect now becomes:

$$d = \frac{\partial \Delta \Pi}{\partial r} = \frac{(\pi_{HH} - \pi_{FH}) + (\pi_{FF} - \pi_{HF}) + r\left(\pi'_{HH} - \pi'_{FH}\right) + (1-r)\left(\pi'_{HF} - \pi'_{FF}\right)}{M^{-1}} - \left(\Gamma'_H - \Gamma'_F\right), \qquad (15)$$

where π'_{ij} represents the derivatives of the maximized profit functions, $\pi_{ij}(r)$, with respect to r. Similarly, Γ'_i stands for the derivatives of the fixed costs of production, $\Gamma_i(r)$, with respect to r. Relatively to the case with exogenous costs of production, we have three new terms affecting the demand effects: $\left(\pi'_{HH} - \pi'_{FH}\right)$, $\left(\pi'_{HF} - \pi'_{FF}\right)$ and $\left(\Gamma'_H - \Gamma'_F\right)$, i.e.: the effects of market size on sales per consumer and on fixed costs.

In equation 15, the derivative of k_i in relation to r is central, because it can determine the signs of π'_{ij} and Γ'_i. We can either have: $\frac{dk_H}{dr} > 0$ (i.e.: R&D of the home firms increases with the size of the home market) or $\frac{dk_H}{dr} < 0$ (i.e.: R&D of the home firms decreases with the size of the home market). In either case, the implication is that if countries differ in market size, firms in different countries will be asymmetric in outputs per consumer, R&D and marginal and fixed costs of production. In other words, while with exogenous costs of production the adjustment to an increase in market size comes only via the number of firms, with endogenous costs of production there are also responses by firms on sales per consumer, prices and R&D (with consequent effects on marginal and fixed costs of production). If $\frac{dk_H}{dr} > 0$, as the home market size increases, home firms will tend to have higher competitiveness and larger size than foreign firms. If $\frac{dk_H}{dr} < 0$, as the home market size increases, home firms will tend to have lower competitiveness and size than foreign firms. Note that given the symmetry in our model, if $\frac{dk_H}{dr} > 0$, $\frac{dk_F}{dr} < 0$, and *vice-versa*.

Neary (2010) argues that we have a clear presumption to believe that $\frac{dk_H}{dr} > 0$. Empirical evidence also seems to suggest the positive effects of market size on a firm's R&D behavior (see Eaton et al., 1998; Eaton and Kortum, 2002; Campbell and Hopenhayn, 2005; Syverson, 2007). Furthermore, the case of $\frac{dk_H}{dr} < 0$ is just symmetric to $\frac{dk_H}{dr} > 0$. For this reason, we focus our attention on the case where $\frac{dk_H}{dr} > 0$.

Start by noticing that if $\frac{dk_H}{dr} > 0$, most likely also $\frac{dq_{HH}}{dr} > 0$. More interestingly, it can also occur that $\frac{dq_{HF}}{dr} > 0$, since higher competitiveness can promote home firms' exports. Similarly $\frac{dk_F}{dr} < 0 \Rightarrow \frac{dq_{FF}}{dr} < 0$ and $\frac{dq_{FH}}{dr} \lesseqgtr 0$. In this sense, we expect that $(\pi_{HH} - \pi_{FH}) > 0$, given that as discussed above, due to trade costs, local sales tend to be more important for profits than sales abroad. In the same token, we might be lead to believe that $(\pi_{FF} - \pi_{HF}) > 0$. However, with endogenous marginal and fixed costs of production, this does not always necessarily need to be the case. If home firms achieve endogenously higher competitiveness and larger size than foreign firms, then it might occur that home firms can sell more in the foreign market than even the foreign firms themselves, i.e.: $(\pi_{FF} - \pi_{HF}) < 0$.

In what relates to π'_{ij}, we have the following. First, $\pi'_{HH} > 0$, given that we presume that a larger home market leads to higher investment in R&D,

which in turn leads to higher sales per consumer for the home firms in the home market. Second, π'_{FH} can either be positive or negative. It can be positive, since the home market is increasing, which benefits the exports of the foreign firms to the home market. It can be negative, because if the home firms have higher competitiveness as a result of R&D investment, they can predate the foreign firms' sales in the home market. In any case, we expect that $\left(\pi'_{HH} - \pi'_{FH}\right) > 0$, since even when $\pi'_{FH} < 0$, $\pi'_{HH} > 0$ is more likely to dominate π'_{FH}. This is so, because, as mentioned above, due to trade costs, local sales are more important than exports.

Third, π'_{HF} can either be negative or positive. It can be negative because the foreign market is shrinking as r increases, reducing the exports of home firms in the foreign market. However, since home firms' R&D increases with r, this higher competitiveness can translate into higher sales per consumer in the foreign market. In turn, π'_{FF} is expected to be unambiguously negative, since local sales are shrinking (due to a decrease in market size) and R&D investment by foreign firms is also diminishing. As a result, we can have that $\left(\pi'_{HF} - \pi'_{FF}\right) \gtreqless 0$, depending on the relation between π'_{HF} and π'_{FF}.

In what concerns the derivatives of fixed costs in relation to r, we have the following. Since $\frac{dk_H}{dr} > 0$ and $\frac{dk_F}{dr} < 0$, then most likely $\Gamma'_H > 0$ and $\Gamma'_F < 0$. In this sense, $-\left(\Gamma'_H - \Gamma'_F\right) < 0$. Therefore, this term contributes negatively to the demand effects.

Summing up, from the above we have that the demand effects are not necessarily unambiguously positive as in standard "new" trade theory models with exogenous costs of production. In particular, the terms $(\pi_{FF} - \pi_{HF})$, $\left(\pi'_{HF} - \pi'_{FF}\right)$ and $\left(\Gamma'_H - \Gamma'_F\right)$ can add negatively to the demand effects. In addition, if these negative demand effects dominate the positive ones, HMEs in the number of firms will be weakened[16].

Below we will look at a particular functional form for the costs of production, which is standard in the R&D literature. In this framework, we will show that, in fact, $\frac{dk_H}{dr} > 0$ and that under some conditions the demand effect is negative and HMEs in the number of firms do not emerge.

Summing up, relatively to models with exogenous costs of production, with endogenous costs of production two effects arise. First, the spatial dis-

[16] Note that the same can occur when $\frac{dk_H}{dr} < 0$. This is so since when $\frac{dk_H}{dr} < 0$ the following terms affect negatively the demand effect: $(\pi_{HH} - \pi_{FH})$, $\left(\pi'_{HH} - \pi'_{FH}\right)$ and $\left(\pi'_{HF} - \pi'_{FF}\right)$.

tribution of industry (s) affects not only outputs per consumer and prices (as in models where the costs of production are exogenous), but also the costs of production. Second, contrary to models with exogenous costs of production, the spatial distribution of demand (r) determines outputs per consumer, prices and the costs of production, since R&D depends on r. As a result, the competition effect is not necessarily always unambiguously negative. The idea is that fiercer competitive environments can either increase or decrease R&D efforts of local firms, depending on "toughness" of R&D competition. More interestingly, the demand effect can be negative. The rationale is the following. If for instance higher local demand promotes investment in R&D of local firms relatively to foreign ones, the former will achieve higher competitiveness and larger size than the latter. With firms that have higher competitiveness and larger size, local competition can become much fiercer, and fewer firms will be sustainable in equilibrium, relatively to a case where firms are symmetric but smaller and with lower competitiveness. In the end, if the demand effect is negative, it can offset HMEs in the number of firms.

4 HMEs in trade patterns and employment

The literature on HMEs has mostly focused on HMEs that arise via the number of firms an economy hosts. However, the first paper on HMEs by Krugman (1980) only showed the existence of HMEs in what concerns trade patterns and employment. In fact, HMEs in the number of firms were first presented by Helpman and Krugman (1985)[17]. HMEs in trade patterns state that the larger country tends to run trade surplus. In turn, HMEs in employment imply that the larger country uses more labor in the IRS-sector. In this section, we will look at HMEs in trade patterns and employment.

Start with HMEs in employment. The full employment condition implies:

$$rM = sN\left(C_H q_H + \Gamma_H\right) + q_{0H}, \tag{16}$$

where $q_H = q_{HH} + q_{HF}$ (and $q_F = q_{FF} + q_{FH}$). Rearranging, we obtain:

[17] Krugman (1991), in turn also demonstrates the existence of HMEs in the wages of the mobile factor. In our model, however, we cannot analyze HMEs in wages, since we only consider one factor of production. In order to look at HMEs in wages, we would need to assume two factors of production as in Krugman (1991). For empirical evidence on the spatial behavior of wages see Combes et al. (2008).

$$\frac{sN(C_H q_H + \Gamma_H)}{rM} = 1 - \frac{q_{0H}}{rM}. \tag{17}$$

And a similar expression for the foreign country. If home is the larger country, HMEs in employment then arise if and only if:

$$\frac{sN(C_H q_H + \Gamma_H)}{rM} > \frac{(1-s)N(C_F q_F + \Gamma_F)}{(1-r)M}. \tag{18}$$

Or:

$$\frac{s}{r}\frac{(1-r)}{(1-s)} > \frac{C_F q_F + \Gamma_F}{C_H q_H + \Gamma_H}. \tag{19}$$

In what concerns HMEs in trade patterns, we have that the trade balance for the home country equals:

$$B = MN\left((1-r)\, s q_{HF} - r\,(1-s)\, q_{FH}\right). \tag{20}$$

As such, for having $B > 0$, we need that:

$$\frac{s}{r}\frac{1-r}{1-s} > \frac{q_{FH}}{q_{HF}}. \tag{21}$$

The expressions for HMEs in employment and trade patterns (equations 19 and 21, respectively) are then similar, since they both depend on the relation $\frac{s}{r}\frac{(1-r)}{(1-s)}$. Without loss of generality, we assume that home is the larger country, i.e.: $r > (1-r) > \frac{1}{2}$. If HMEs in the number of firms arise (as is always the case in standard imperfect competition trade models with exogenous costs of production), it follows that $s > r$ and $(1-r) > (1-s)$, and therefore $\frac{s}{r}\frac{(1-r)}{(1-s)} > 1$. Then, what we need to have HMEs in employment and trade patterns is that $\frac{C_F q_F + \Gamma_F}{C_H q_H + \Gamma_H} < 1$ and $\frac{q_{FH}}{q_{HF}} < 1$, respectively.

If on the contrary, HMEs in the number of firms do not arise (as can occur in a model with endogenous marginal and fixed costs of production), it can result that $s < r$ and $(1-r) < (1-s)$, and therefore $\frac{s}{r}\frac{(1-r)}{(1-s)} < 1$. As a consequence, when this is the case, HMEs in employment and trade patterns only emerge if $\frac{C_F q_F + \Gamma_F}{C_H q_H + \Gamma_H} < \frac{s}{r}\frac{(1-r)}{(1-s)} < 1$ and $\frac{q_{FH}}{q_{HF}} < \frac{s}{r}\frac{(1-r)}{(1-s)} < 1$.

In the next two sub-sections, we look at the two cases analyzed in the previous section: exogenous and endogenous costs of production.

4.1 Exogenous costs of production

As we have seen above, when marginal and fixed costs of production are exogenous and equal across firms in different countries, the following occurs. First, we have that $C_H = C_F = \omega$ and that $\Gamma_H = \Gamma_F = f$. Second, since firms are symmetric, we obtain that $q_H = q_F$. In order to apply this to the HMEs in employment and in trade patterns, without loss of generality, we continue to look at the case where $r > (1-r) > \frac{1}{2}$.

Start with HMEs in employment (equation 19). Given that $C_H = C_F$, $\Gamma_H = \Gamma_F$ and $q_H = q_F$, then $\frac{C_F q_F + \Gamma_F}{C_H q_H + \Gamma_H} = 1$, and therefore $\frac{s}{r}\frac{(1-r)}{(1-s)} > \frac{C_F q_F + \Gamma_F}{C_H q_H + \Gamma_H}$ is satisfied. This is so since in standard imperfect competition trade models (i.e.: with exogenous costs of production), HMEs in the number of firms always arise and as such $\frac{s}{r}\frac{(1-r)}{(1-s)} > 1$.

Turning now to HMEs in trade patterns (equation 21), the first thing to note is that, as mentioned before, in standard imperfect competition trade models the larger country tends to host in equilibrium a disproportionately higher share of the world's industry than of the world's demand (i.e.: if $r > \frac{1}{2} \Rightarrow s > \frac{1}{2}$). This implies that firms selling in the larger market face fiercer competition, which reduces the exports to the larger country. As a consequence, since $r > \frac{1}{2} \Rightarrow s > \frac{1}{2}$, we have that $\frac{q_{FH}}{q_{HF}} < 1$. In this sense, $\frac{s}{r}\frac{1-r}{1-s} > \frac{q_{FH}}{q_{HF}}$ is satisfied. In other words, in standard imperfect competition trade models, we also always have HMEs in trade patterns.

4.2 Endogenous costs of production

Contrary to standard imperfect competition trade models with exogenous costs of production, when the costs of production are endogenous, firms in different countries are not necessarily symmetric. In particular, with endogenous marginal and fixed costs we have that $C_H \neq C_F$ and $\Gamma_H \neq \Gamma_F$. As a result, also $q_H \neq q_F$.

Without loss of generality, look again at the case where home is the larger country (i.e.: $r > \frac{1}{2}$). If in addition $\frac{dk_H}{dr} > 0$, we then might expect that $k_H > k_F$ and also that $q_H > q_F$, $C_H < C_F$ and $\Gamma_H > \Gamma_F$ (i.e.: firms are asymmetric across countries)[18]. Then, the right-hand side of equation 19 can either be smaller or bigger than one. Furthermore, as we have seen

[18]If $\frac{dk_H}{dr} < 0$, by symmetry, the essence of the results below also follows. However, the calculations and interpretation of results are different.

above, with endogenous costs of production, HMEs in the number of firms do not necessarily arise, i.e.: we can either have $s > r$ or $s < r$. If $s > r$ (HMEs in the number of firms arise), the expression on the left hand side of equation 19 is bigger than one; if $s < r$ (HMEs in the number of firms do not arise), the expression on the left hand side of equation 19 is smaller than one. In either case, we can see that when the marginal and the fixed costs of production are endogenous, HMEs in employment in the IRS-sector do not necessarily emerge.

In what relates to HMEs in trade patterns, the left-hand side of equation 21 has the same behavior as the left-hand side of equation 19. This means that the left-hand side of equation 21 can either be bigger or smaller than one, depending on whether HMEs in the number of firms are present or not. We might then be lead to conclude that with endogenous marginal and fixed costs, HMEs in trade patterns might not arise either, since most likely $\frac{q_{FH}}{q_{HF}} < 1$. We might anticipate that $\frac{q_{FH}}{q_{HF}} < 1$, because like in standard imperfect competition models, for $r > \frac{1}{2} \Rightarrow s > \frac{1}{2}$. Therefore, as a result of higher local competition in the home country, exports from foreign firms to the home market become more difficult than exports of home firms to the foreign market (i.e.: $q_{FH} < q_{HF}$). However, one important piece is missing from the picture. Given that firms now invest in R&D (and that $\frac{dk_H}{dr} > 0$) the advantage of the home exports to the foreign country relatively to the foreign exports to the home country can be so large that q_{FH} is much smaller than q_{HF}. If this difference is significant, it can occur that even when the right-hand side of equation 21 is smaller than one, we still have that $\frac{s}{r}\frac{1-r}{1-s} > \frac{q_{FH}}{q_{HF}}$.

With the functional forms that we assume below for the costs of production when these are endogenous, we are going to see that the previous case always arises, i.e.: HMEs in trade patterns are robust to the introduction of endogenous costs of production. In this sense, endogenous costs of production can only offset HMEs in what relates to the number of firms and employment, but not trade patterns. The rationale is the following. Due to the R&D advantage of firms in the larger market, they have higher competitiveness and larger size than firms in the smaller market. The consequence of this is first that firms in the larger market need less labor to produce the same amount of output as firms in the smaller market, because the former are more efficient (i.e.: no HMEs in employment). Second, fewer firms can survive in equilibrium in the larger market relatively to the symmetric case with exogenous costs of production, since local competition becomes extremely tough and the larger firms crowd-out the smaller ones (i.e.: no HMEs in the number of firms). Third, however, firms in the larger market can export more than firms in the smaller market, since the former have higher competitiveness than the latter (HME in trade patterns). In the next sections, we explore these mechanisms.

5 Example: Exogenous costs of production

In this section, we adopt a standard oligopolistic trade model similar to Brander (1981)[19]. As mentioned above, this model shares many similarities in terms of assumptions and results with Krugman (1980) and also with Ottaviano et al. (2002). In particular, they all assume exogenous costs of production and, as shown by Head et al. (2002), predict HMEs in the number of firms, employment and trade patterns. The base structure of the model in this section is the same as for the general model above, but in order to facilitate the reading, we repeat some of the assumptions here.

Preferences and demand. We assume that preferences for a representative consumer are quasi-linear in the CRS-good and in the IRS-good, with a quadratic sub-utility in the latter[20]:

$$\max_{q_{0H}>0, q_{i_iH}>0} U(q_{0H}, q_{i_iH}) = q_{0H} + a \sum_{i=1_H}^{n_F} q_{i_iH} - \tfrac{b}{2} \left(\sum_{i=1_H}^{n_F} q_{i_iH} \right)^2, \tag{22}$$

where q_{0H} is the quantity of the CRS-good produced at home and q_{i_iH} is the sales of the firm i_i to each consumer in the home market (with $i_i = 1_H, 2_H, ...n_H, 1_F, 2_F, ...n_F$). Accordingly, q_{i_HH} is the domestic sales of the home firm i_H to each consumer in the home country (with $i_H = 1_H, 2_H, ...n_H$) and q_{i_FH} is the exports of the foreign firm i_F to each consumer in the home country (with $i_F = 1_F, 2_F, ...n_F$). Also, $n_H + n_F = N$ (number of firms in the IRS-sector in the world economy). We assume that the CRS-good is the

[19]For a more recent exposition and interpretation of trade models under oligopoly see Neary (2003).

[20]In this paper, for convenience, we ignore the integer problem. However, to justify our choice, we can invoke proposition 1 in Neary (2010) which states that: "The number of firms in any heterogeneous-firm free-entry equilibrium of an aggregative game is the same as the integer number of firms in the corresponding lean symmetric equilibrium".

numéraire, and therefore its price can be normalized to $P_0 = 1$. To simplify notation, we can define Q_H as:

$$Q_H = \sum_{i=1_H}^{n_F} q_{i_i H}. \tag{23}$$

Similar interpretation holds for Q_F, which depends on $q_{i_i F}$. Utility is maximized subject to the budget constraint:

$$\sum_{i=1_H}^{n_F} P_{i_i H} q_{i_i H} + q_{0H} \leq I, \tag{24}$$

where $P_{i_i H}$ is the price charged by firm i_i for the IRS-good at home (with $i_i = 1_H, 2_H, ...n_H, 1_F, 2_F, ...n_F$). In turn, I is the income of a representative consumer. Income equals labor returns (w_H and w_F) which, as we have seen in the general model, can be normalized to one.

Maximizing in relation to the CRS-good, we have: $\frac{\partial U}{\partial q_{0H}} - \lambda P_0 = 0 \Leftrightarrow 1 = \lambda P_0$. Where λ is the budget constraint multiplier. Since we have $P_0 = 1$, then $\lambda = 1$. In turn, maximizing in relation to the quantity of the IRS-good sold by firm i_i at home, we obtain: $\frac{\partial U}{\partial q_{i_i H}} - \lambda P_{i_i H} = 0 \Leftrightarrow a - bQ_H = \lambda P_{i_i H}$. Given that the conditions for home and foreign products at home are the same, they face the same price, so $P_{i_i H} = P_H$. In addition, for the reason that $\lambda = 1$, the indirect demand function for the IRS-good equals:

$$P_H = a - bQ_H. \tag{25}$$

From the indirect demand function (equation 25), we can solve for the direct demand function:

$$Q_H = \tfrac{1}{b}\left(a - P_H\right). \tag{26}$$

Equation 26 shows that the demand for the IRS-good is independent of income. In this formulation all income effects are captured by the *numéraire* good. This is so because we use a quasi-linear utility function that abstracts from general equilibrium income effects. Although, like in the monopolistic competition models of Ottaviano et al. (2002) and Melitz and Ottaviano (2008), this modeling strategy gives our framework a partial equilibrium flavor, it does not remove the interaction between product and labor markets.

This allows us to develop a full-fledged model of international trade, which is independent of the relative size of the manufacturing sector[21].

By substituting in the budget constraint (equation 24) for equation 25, it is also possible to derive the conditions that guarantee $q_{0H} > 0$. In particular, $q_{0H} > 0$ for $I > (a - bQ_H) Q_H = Q_H P_H$. In other words, $q_{0H} > 0$ when the representative consumer's income is larger than the amount he/she consumes of the IRS-good. In this sense, the previous equation shows that our model does not imply that the share of the manufacturing sector must be small[22].

Firms and technology. The CRS-sector operates under perfect competition and produces a homogeneous good under constant returns to scale using M as the only input. In turn, the IRS-sector works under oligopolistic competition. Furthermore, the IRS-sector produces a homogeneous good under increasing returns to scale also using only labor (M) as input. We assume a linear cost function for the IRS-sector. Very importantly, all firms at home and foreign face the same exogenous fixed and marginal costs of production: $\Gamma_{i_H} = \Gamma_{i_F} = f$ and $C_{i_H} = C_{i_F} = \omega$, respectively. For the home firm i_H (with $i_H = 1_H, 2_H, ...n_H$), the total cost of producing $q_{i_H H} + q_{i_H F}$ units is then: $TC_{i_H H} = f + \omega (q_{i_H H} + q_{i_H F})$. The firm problem can then be stated as:

$$\max_{q_{i_H H} \geq 0, q_{i_H F} \geq 0} \Pi_i (q_{i_H H}, q_{i_H F}) = (P_H - \omega) rMq_{i_H H} + (P_F - \omega - t)(1 - r) Mq_{i_H F} - f. \tag{27}$$

Following Brander (1981), firms set outputs taking as given the outputs of the rivals in all markets. Furthermore, due to trade costs, markets are segmented. In the Brander's (1981) setting, the segmented market hypothesis implies that firms can price discriminate between locations. In particular, firms choose the quantities to ship to each market independently, and there-

[21] The assumption of no income effects in the IRS-good, however, is only realistic if the share of consumers' expenditure devoted to this good does not vary significantly with changes in income. In this way, our model seems more appropriate for explaining international trade between developed countries. Accordingly, while in developed countries changes in income do not significantly alter the share of different goods in consumption, the opposite tends to be the case in developing countries. This remark also applies to other standard "new" trade theory models.

[22] Antweiler and Trefler (2002) present evidence that increasing returns production accounts for one third of the world trade. From the relation above, we can thus see that our model encompasses this case.

fore the export price (net of transport costs) needs not be equal to the price charged to domestic consumers[23]. We then have that as in Brander (1981) that: $q_{i_H H} = q_{HH}$ and $q_{i_H F} = q_{HF}$ for $i_H = 1_H, 2_H, ...n_H$; $q_{i_F F} = q_{FF}$ and $q_{i_F H} = q_{FH}$ for $i_F = 1_F, 2_F, ...n_F$.

5.1 Production equilibrium

From the maximization problem in equation 27, we obtain:

$$\begin{aligned} q_{HH} &= \tfrac{(D+(1-s)Nt)}{b(N+1)} \\ q_{HF} &= \tfrac{(D-t((1-s)N+1))}{b(N+1)} \\ q_{FF} &= \tfrac{(D+sNt)}{b(N+1)} \\ q_{FH} &= \tfrac{(D-t(sN+1))}{b(N+1)}, \end{aligned} \tag{28}$$

where $D = (a - \omega) > 0$ is a measure of the firms' cost competitiveness. A high D means that firms have high cost competitiveness, since marginal costs (ω) are low relative to the intercept of demand (a). Like in Brander (1981), we assume that $0 < t < D$, so that firms can cover trade costs[24].

Solving for prices from equation 25, we arrive at:

$$\begin{aligned} P_H &= \omega + \tfrac{D+(1-s)Nt}{N+1} \\ P_F &= \omega + \tfrac{D+sNt}{N+1}. \end{aligned} \tag{29}$$

In the remainder of the section, we follow the "new" trade theory literature by assuming that trade can arise in equilibrium. To know this, we have to derive the trade condition (see Ottaviano et al., 2002 and Head et al., 2002). The trade condition is obtained by making $q_{HF} = 0$ and $q_{FH} = 0$ and solve for t. We have that for the home firms trade is possible if $t < \bar{t}_H \equiv \frac{D}{(1-s)N+1}$ and for the foreign firms if $t < \bar{t}_F \equiv \frac{D}{sN+1}$. It can be easily seen that the most restricted trade condition for both the home and the foreign firms is when $s = 0$ and $s = 1$, respectively. Then:

[23] As shown by Brander and Krugman (1983) this occurs because Cournot rivalry leads to reciprocal dumping.

[24] Note, however, that the previous assumption is not sufficient to assure that all firms will always be able to export. Below, we derive the conditions for trade to be possible.

$$t < \bar{t}_H = \bar{t}_F \equiv \tfrac{D}{N+1}. \tag{30}$$

In other words, in a standard "new" trade theory model, the trade condition is the same for the home and the foreign firms and does not depend on the international distribution of demand (r) or industry (s).

With outputs per consumer and prices, we are ready to focus on the HMEs. In the next subsection, we look at HMEs in the number of firms. We then turn to HMEs in the number of firms and trade patterns.

5.2 HMEs in the number of firms

As we have seen above, in order to calculate the HMEs in the number of firms, we have to analyze the free entry-exit condition, equation 3. In the model in this section, $\Delta\Pi$ simplifies to:

$$\Delta\Pi = 2\left((2D-t)\left(r-\tfrac{1}{2}\right) - Nt\left(s-\tfrac{1}{2}\right)\right)\left(\tfrac{Mt}{(N+1)b}\right). \tag{31}$$

From equation 31, we can investigate two important relations in the model. First, the existence of competition and demand effects. Second, the equilibrium number of firms in each location. We start with the competition and demand effects, which equal, respectively:

$$\begin{aligned} c &= \tfrac{\partial\Delta\Pi}{\partial s} = -\tfrac{2t^2NM}{(N+1)b} < 0 \\ d &= \tfrac{\partial\Delta\Pi}{\partial r} = \tfrac{2Mt(2D-t)}{(N+1)b} > 0. \end{aligned} \tag{32}$$

In a standard imperfect competition trade model with exogenous costs of production, then, the demand effect is positive (profits of local firms increase with the size of the domestic market) and the competition effect is negative (profits of local firms decrease with the level of domestic competition).

In turn, the equilibrium number of firms in each location, $\hat{s}$, can be found by solving $\Delta\Pi = 0$ for s:

$$\hat{s} = \tfrac{1}{2} + \tfrac{2\left(D-\frac{t}{2}\right)}{Nt}\left(r-\tfrac{1}{2}\right). \tag{33}$$

Equation 33 shows that for $r = \frac{1}{2} \Rightarrow \hat{s} = \frac{1}{2}$, for $r > \frac{1}{2} \Rightarrow \frac{1}{2} < \hat{s} \leq 1$ and for $r < \frac{1}{2} \Rightarrow 0 \leq \hat{s} < \frac{1}{2}$. In this sense, the larger country always hosts more firms than the smaller country.

We can now study if the larger market not only hosts more firms (as shown in equation 33) but also hosts a disproportionately higher share of the world's firms than of the world's demand (i.e.: HMEs in the number of firms). We have seen above that HMEs in the number of firms arise if $d+c>0$ (see equation 7)[25]. Computing $d+c$ from equation 32, it results:

$$d+c=\frac{2(2D-t(N+1))Mt}{(N+1)b}>0. \tag{34}$$

In this sense, HMEs in the number of firms emerge if $t<\frac{2D}{N+1}$. Then, as long as trade is possible (i.e.: $t<\frac{D}{N+1}$, equation 30 is satisfied), the larger country hosts a disproportionately higher share of the world's industry than of the world's demand. In other words, in a standard "new" trade theory model, HMEs in the number of firms always arise.

5.3 HMEs in trade patterns and employment

In what relates to HMEs in employment and trade patterns it is straightforward to show that both also emerge in a standard imperfect competition trade model. In fact, from equation 19, we have that HMEs in employment arise if $\frac{s}{r}\frac{(1-r)}{(1-s)}>\frac{\omega q_F+f}{\omega q_H+f}$ (since $C_H=C_F=\omega$ and $\Gamma_H=\Gamma_F=f$). It can be easily noted from equation 28 that $q_H=q_F$. Then $\frac{\omega q_F+f}{\omega q_H+f}=1$. Given that $\frac{s}{r}\frac{(1-r)}{(1-s)}>1$, the existence of HMEs in employment clearly follow.

Also from equation 21, we have that HMEs in trade patterns are present if $\frac{s}{r}\frac{1-r}{1-s}>\frac{q_{FH}}{q_{HF}}$. From equation 28, it results that if home is the larger country, then $q_{FH}<q_{HF}$. This shows that in a standard "new" trade theory model HMEs in trade patterns also always emerge.

6 Example: Endogenous costs of production

The model in this section takes as its starting point the model in the preceding section. In particular, preferences and demand are as in equations 22 to 26. The two models differ only in that the costs of production are no

[25] We obtain the same results if instead we calculate $\frac{ds}{dr}>1$ from equation 33 or $\frac{\frac{\partial\Delta\Pi}{\partial r}}{-\frac{\partial\Delta\Pi}{\partial s}}>1$ from equation 32.

longer exogenous, but are instead endogenous. In particular, the costs of production are endogenized via investment in R&D.

In this sense, the IRS-sector now works under oligopolistic competition not only on outputs but also on R&D. As in Krugman (1984), firms choose outputs and R&D levels simultaneously[26]. As discussed before, with this assumption, we can clearly show that our results do not follow from strategic oligopolistic behavior, but from the endogeneity of the costs of production.

The IRS-sector continues to have a linear cost function with fixed costs, Γ_{i_i}, and marginal costs, C_{i_i} (where $i_i = 1_H, 2_H, ...n_H, 1_F, 2_F, ...n_F$). However, these costs now depend on R&D investment k_{i_i}. For the home firm i_H (with $i_H = 1_H, 2_H, ..., n_H$), the total cost of producing $q_{i_H H} + q_{i_H F}$ units is then $TC_{i_H} = \Gamma_{i_H}(k_{i_H}) + C_{i_H}(k_{i_H})$. We choose a standard functional form for the marginal and fixed costs of production. To be more precise, we follow Leahy and Neary (1997) in assuming process R&D investment of the type:

$$\begin{aligned} C_{i_H} &= \omega - \theta k_{i_H} \\ \Gamma_{i_H} &= f + \gamma \frac{k_{i_H}^2}{2}, \end{aligned} \tag{35}$$

where $\omega > 0$ and $f > 0$, relatively to the model with exogenous cost of production, can now be interpreted as the marginal and the fixed costs without R&D[27]. In this sense, $D = (a - \omega) > 0$ also becomes a measure of the firms' cost competitiveness without R&D investment. Accordingly, a high D means that firms have high cost competitiveness prior to investing in R&D. In

[26] According to Fudenberg and Tirole (1991), the simultaneous choice of R&D and outputs implies that firms have open loop strategies. In turn, the case with sequential choices on R&D and outputs is labeled by Fudenberg and Tirole (1991) as closed loop strategies. Fudenberg and Tirole (1984) show that with process R&D and closed loop strategies, Cournot firms over-invest above the profit maximizing level in order to promote rivals to exit, while Bertrand firms under-invest in order to soften price competition. In this sense, the open loop game of this section can be seen as a benchmark case where firms invest at the optimum level without any waste of resources, i.e.: with no under- or over-investment (for this terminology see Leahy and Neary 1997). In addition, as argued by Fudenberg and Tirole (1991), when the number of players (i.e.: firms in our model) is relatively large, the open loop equilibrium is a good approximation for the closed loop equilibrium.

[27] We have decided to keep an exogenous part on the fixed and the marginal costs of production (f and ω, respectively) for two reasons. First, without the exogenous part of C_{i_i}, investment in R&D would lead to negative marginal costs. Second, by maintaining f and c, the model of the previous section with exogenous costs of production is a special case of the model in this section with endogenous costs of production, where $k_{i_i} = 0$.

turn, $\theta > 0$ is the cost-reducing effect of R&D and $\gamma > 0$ is the cost of R&D. Note that not only do all firms in a location have the same cost parameters (i.e.: $\theta_{i_H} = \theta_H$, $\gamma_{i_H} = \gamma_H$, $f_{i_H} = f_H$ and $\omega_{i_H} = \omega_H$ for $i_H = 1_H, 2_H, ...n_H$; $\theta_{i_F} = \theta_F$, $\gamma_{i_F} = \gamma_F$, $f_{i_F} = f_F$ and $\omega_{i_F} = \omega_F$ for $i_F = 1_F, 2_F, ...n_F$), but the same also occurs for firms located in different countries (i.e.: $\theta_H = \theta_F = \theta$, $\gamma_H = \gamma_F = \gamma$, $f_H = f_F = f$ and $\omega_H = \omega_F = \omega$). This is assumed in order to make sure that asymmetries between firms only arise endogenously.

Equation 35 shows that process R&D reduces marginal costs, but increases fixed costs. In this way, when firms choose R&D they face a trade-off between investing more in R&D and achieving lower marginal costs at the expense of higher fixed costs (and *vice-versa*). Furthermore, equation 35 satisfies the properties defined in the general model, see equation 11 (i.e.: $\frac{\partial \Gamma_H}{\partial k_H} > 0$ and $\frac{\partial C_H}{\partial k_H} > 0$). Note also, that the assumption of quadratic fixed costs of R&D, $\frac{\gamma(k_{i_H})^2}{2}$, implies diminishing returns to scale in innovation[28]. However, as will be demonstrated below, firms with privileged access to larger markets can more easily cover the fixed costs of innovation due to increasing returns in production[29].

At this stage, it is important to follow the process R&D literature (see Leahy and Neary, 1997) and construct a composite parameter made up of the R&D parameters θ and γ, since this not only simplifies equations but also allows us to give a more straightforward interpretation of the dynamics of R&D investment. In this sense, like in Leahy and Neary (1997), we label $\eta = \frac{\theta^2 M}{b\gamma}$ as the "relative return on R&D". A high η represents a large relative return on innovative activities, since the cost-reducing effect of R&D (θ) is high relatively to the cost of R&D (γ). In other words, for high η, firms reap larger benefits from investment in R&D in terms of cost reduction. The reverse interpretation holds for low η. As will be seen in the rest of this section, the parameter η plays a central role in the model with endogenous costs of production.

[28] There is no consensus in the empirical literature of whether R&D exhibits constant, increasing or diminishing returns to scale. Although it seems that there is more support for the diminishing returns hypothesis (see Fung, 2002).

[29] The importance of fixed costs and scale for R&D efforts is for instance confirmed by the empirical studies of Gustavsson et al. (1999) and Aw et al. (2008). In turn, as discussed in the introduction, increasing returns are the hallmark of the "new" trade theory (Krugman, 1980) and the empirical evidence shows its centrality in international trade (see Antweiler and Trefler, 2002).

Before turning to analyzing the properties of the model just described, we need first to write down the profit maximization problem for the home firm i_H:

$$\begin{aligned} \max_{q_{i_H H}\geq 0, q_{i_H F}\geq 0, k_{i_H}\geq 0} \Pi_{i_H} \left(q_{i_H H}, q_{i_H F}, k_{i_H} \right) = \\ \left(P_H - C_{i_H} \right) r M q_{i_H H} + \left(P_F - C_{i_H} - t \right) (1-r) M q_{i_H F} - \Gamma_{i_H}. \end{aligned} \quad (36)$$

As for the standard "new" trade theory model presented above, firms set outputs taking as given the outputs of the rivals in all markets. Consequently, and since markets are segmented, in equilibrium we have that: $q_{i_H H} = q_{HH}$, $q_{i_H F} = q_{HF}$, $k_{i_H} = k_H$, $C_{i_H} = C_H$ and $\Gamma_{i_H} = \Gamma_H$ for $i_H = 1_H, 2_H, ..., n_H$; similarly $q_{i_F F} = q_{FF}$, $q_{i_F H} = q_{FH}$, $k_{i_F} = k_F$, $C_{i_F} = C_F$ and $\Gamma_{i_F} = \Gamma_F$ for $i_F = 1_F, 2_F, ..., n_F$. However, and very importantly, due to trade costs, market size differences, increasing returns and R&D investment, it is possible to have $k_H \neq k_F$ and therefore, differently from standard "new" trade theory models with exogenous costs, $C_H \neq C_F$ and $\Gamma_H \neq \Gamma_F$. Below, we will prove this endogenous asymmetry property.

6.1 Production equilibrium

In order to find outputs per consumer and R&D levels, we need to compute the respective FOCs. From the FOCs for outputs per consumer, we obtain:

$$\begin{aligned} q_{HH} &= \tfrac{(a - C_H(1+(1-s)N) + C_F(1-s)N + t(1-s)N)}{b(N+1)} \\ q_{HF} &= \tfrac{(a - C_H((1-s)N+1) + C_F(1-s)N - t((1-s)N+1))}{b(N+1)} \\ q_{FF} &= \tfrac{(a - C_F(1+sN) + C_H sN + tsN)}{b(N+1)} \\ q_{FH} &= \tfrac{(a - C_F(sN+1) + C_H sN - t(sN+1))}{b(N+1)}. \end{aligned} \quad (37)$$

In turn, from the FOCs for R&D, it results that:

$$\begin{aligned} k_H &= \tfrac{\theta M}{\gamma} \left(r q_{HH} + (1-r) q_{HF} \right) \\ k_F &= \tfrac{\theta M}{\gamma} \left((1-r) q_{FF} + r q_{FH} \right). \end{aligned} \quad (38)$$

As discussed above for the general model, we then have that when the costs of production are endogenous, demand spatial patterns (r) affect investment in R&D across countries. The consequence of this is that, differently from standard "new" trade theory models, prices and outputs per consumer are also going to depend on market size. In fact, solving simultaneously for outputs per consumer and R&D from equations 37 and 38, we arrive at:

$$\begin{aligned}
q_{HH} &= \frac{(N+1)((1-\eta)D+(1-s)Nt)-(1-r)\eta t(2(1-s)N(N+2-\eta)+(1-\eta))}{b((N+1)-\eta)(1-\eta)(N+1)} \\
q_{HF} &= \frac{(N+1)((1-\eta)(D-t)-(1-s)Nt)+r\eta t(2(1-s)N(N+2-\eta)+(1-\eta))}{b((N+1)-\eta)(1-\eta)(N+1)} \\
k_H &= \theta M\frac{(1-\eta)(D-t(1-r))+2(1-s)Nt\left(r-\frac{1}{2}\right)}{\gamma b((N+1)-\eta)(1-\eta)} \\
q_{FF} &= \frac{(N+1)((1-\eta)D+sNt)-r\eta t(2sN(N+2-\eta)+(1-\eta))}{b((N+1)-\eta)(1-\eta)(N+1)} \\
q_{FH} &= \frac{(N+1)((1-\eta)(D-t)-sNt)+(1-r)\eta t(2sN(N+2-\eta)+(1-\eta))}{b((N+1)-\eta)(1-\eta)(N+1)} \\
k_F &= \theta M\frac{(1-\eta)(D-rt)-2sNt\left(r-\frac{1}{2}\right)}{\gamma b((N+1)-\eta)(1-\eta)},
\end{aligned} \tag{39}$$

In turn, from outputs per consumer and R&D levels, we can derive prices in each country. Substituting equation 39 in the indirect demand, we obtain:

$$\begin{aligned}
P_H &= \omega + \frac{D+(1-s)t-\eta\left(D-(1-r)t\left(s-\frac{1}{2}\right)\right)}{2-\eta} \\
P_F &= \omega + \frac{D+st-\eta\left(D+rt\left(s-\frac{1}{2}\right)\right)}{2-\eta}.
\end{aligned} \tag{40}$$

We can now clearly see that while in standard "new" trade theory models with exogenous costs of production (Krugman 1980; Brander 1981; Ottaviano et al., 2002) outputs per consumer and prices are not affected by market size, r (see Head et al. 2002, and equations 28 and 29), the contrary occurs in the model of this section, due to the fact that the costs of production are endogenous (see equations 39 and 40). The other difference, relatively to standard "new" trade theory models, is that as a result of introducing R&D investment, a new parameter shows up in the outputs per consumer and price equations: the relative return on R&D (η)[30]. In this sense, R&D investment

[30] Obviously η is absent from the output and price equations of standard "new" trade theory models, because these models do not include R&D investment. This differs from the parameter r, which in spite of being present in these standard models, still does not affect production and price patterns across countries. As we have mentioned above, this is due to the exogeneity of the costs of production.

not only affects prices and outputs per consumer indirectly via r, but also directly via η. In the rest of this section, we will demonstrate that these differences have important implications for HMEs.

Similar to what occurs in other process R&D models (like Leahy and Neary 1997), η is then central to the model with endogenous costs of production. Furthermore, the second order conditions (SOCs) for R&D demands a restriction on η. We can check that the SOCs for R&D, for both the home and the foreign firms, demands that[31]:

$$0 < \eta < 1. \tag{41}$$

Equation 41 says that the relative return on R&D (η) cannot be extremely high, otherwise the trade-off that a firm faces when investing in R&D (lower marginal costs *versus* higher fixed costs) is not binding[32].

Another central implication of the model in this section with endogenous costs of production is that, as can be seen from equation 39, the relation of R&D investment with s and r is exactly as we have argued above in the general model (i.e.: $\frac{dk_H}{ds} \lesseqgtr 0$ and $\frac{dk_H}{dr} > 0$). In fact, $\frac{dk_H}{ds}$ equals:

$$\frac{dk_H}{ds} = -\frac{2\left(r-\frac{1}{2}\right)MNt\theta}{(N+1-\eta)(1-\eta)b\gamma} \lesseqgtr 0. \tag{42}$$

Equation 42 is positive for $r < \frac{1}{2}$ and negative for $r > \frac{1}{2}$. Therefore, firms located in the larger country are penalized on R&D investment when local competition increases. The contrary occurs in the smaller country. The reason for this result follows from oligopolistic behavior. Firms in the smaller market suffer more than firms in the larger market by an increase in local competition. As a result, firms in the larger market can try to accommodate an increase in local competition by reducing R&D investment, while the contrary occurs in the smaller market.

In turn, $\frac{dk_H}{dr}$ simplifies to:

[31] The SOCs for R&D for the home and the foreign firms are: $\frac{d^2\Pi_H}{dk_H^2} = \gamma\left(\eta\frac{(1-s)+1}{2} - 1\right) < 0$ and $\frac{d^2\Pi_F}{d(k_F)^2} = \gamma\left(\eta\frac{s+1}{2} - 1\right) < 0$. Solving both expressions for η, we obtain: $\eta < \frac{2}{(1-s)+1}$ and $\eta < \frac{2}{s+1}$. It can be checked that: $1 < \frac{2}{(1-s)+1} < 2$ and $1 < \frac{2}{s+1} < 2$. Since $\eta > 0$, then, the SOCs for R&D are always satisfied if $0 < \eta < 1$.

[32] In fact, for $\eta \geq 1$ counter intuitive results can arise. For example, even when home hosts all world demand ($r = 1$), which due to trade costs should promote local sales, still q can be negative. Equation 41, then, gives an empirical restriction for the R&D parameters.

$$\frac{dk_H}{dr} = \frac{(2N(1-s)+(1-\eta))Mt\theta}{(N+1-\eta)(1-\eta)b\gamma} > 0. \tag{43}$$

Equation 43 is unambiguously positive, since $0 < \eta < 1$. Then, home firms' R&D investment increases with the local share of demand. The rationale for this outcome follows from the R&D trade-off: lower marginal costs *versus* higher fixed costs. In other words, the R&D trade-off is more easily met in larger markets due to economies of scale in production[33].

What equations 43 and 42 tell us is that, given that firms in different countries behave differently in terms of investment in R&D in relation to the spatial demand and competition patterns, firms can become endogenously asymmetric across countries. Note that this is never the case in standard "new" trade theory models (Krugman 1980; Brander 1981; Ottaviano et al., 2002), where firms are always symmetric in costs.

As a result, since firms across countries are asymmetric, they should also have different levels of market access. To show this, we need to derive the trade conditions. As for the model with exogenous costs of production, the trade conditions are obtained by solving q_{HF} and q_{FH} for t. In particular, the trade conditions for home and foreign firms are:

$$\begin{aligned} t &< \bar{t}_H \equiv \frac{(1-\eta)(N+1)D}{(N+1)((1-s)N+1-\eta)-\eta r(2(1-s)N(N+2-\eta)+1-\eta)} \\ t &< \bar{t}_F \equiv \frac{(1-\eta)(N+1)D}{(N+1)(sN+1-\eta)-\eta(1-r)(2sN(N+2-\eta)+1-\eta)}. \end{aligned} \tag{44}$$

We can then see that differently from standard "new" trade theory models, where all firms (either from home or foreign) have the same trade condition (see equation 30), in the model with endogenous costs of production, firms from different countries can have different levels of access to international markets. This is a consequence of R&D investment and market size differences, which trigger endogenous competitiveness asymmetries across firms from different countries.

[33]Syverson (2007) and Campbell and Hopenhayn (2005) give support to the importance of market size (as measured by population) for firms' R&D investment, efficiency and size. Syverson (2007) shows that producers located in more densely populated areas are more efficient. In turn, Campbell and Hopenhayn (2005) observe that firms in larger regions are larger in size. Eaton et al. (1998) and Eaton and Kortum (2002) also establish a link between market size and R&D, however, they use wages (instead of population) as a proxy for market size.

We are now ready to analyze the consequences of the endogenous costs of production (and the endogenous asymmetries between firms that follow) for the HMEs. We first look at the HMEs in the number of firms and then turn to the HMEs in trade patterns and employment.

6.2 HMEs in the number of firms

To derive the HMEs in the number of firms, we follow the same strategy as for the standard "new" trade theory model with exogenous costs of production. We then analyze the free entry-exit condition, $\Pi = \Pi^* = 0 \Rightarrow \Delta\Pi = 0$ (equation 3). For the model in this section, $\Delta\Pi = 0$ simplifies to:

$$\Delta\Pi = \frac{(1-\eta)(2-\eta)\left(D-\frac{t}{2}\right)\left(r-\frac{1}{2}\right)+Nt\left((1-\eta)\left(4\eta r(1-r)\left(1+\frac{1-\eta}{N+1}\right)-1\right)-2\eta\left(r-\frac{1}{2}\right)^2\right)\left(s-\frac{1}{2}\right)}{(2tM)^{-1}b(1-\eta)^2((N+1)-\eta)}. \tag{45}$$

As for the standard "new" trade theory model, from the profit differential expression, we can analyze the existence of competition and demand effects and the equilibrium number of firms at home and at foreign. We start with the competition and the demand effects, which equal, respectively:

$$\begin{aligned} c &= \frac{\partial\Delta\Pi}{\partial s} = -\frac{(1-\eta)\left(1-4\eta r(1-r)\left(1+\frac{1-\eta}{N+1}\right)\right)+2\eta\left(r-\frac{1}{2}\right)^2}{(2MNt^2)^{-1}(N+1-\eta)(1-\eta)^2 b} < 0 \\ d &= \frac{\partial\Delta\Pi}{\partial r} = \frac{(1-\eta)(2-\eta)\left(D-\frac{t}{2}\right)-\frac{4Nt\eta}{(N+1)}\left(s-\frac{1}{2}\right)\left(r-\frac{1}{2}\right)((2(1-\eta)(N+2-\eta)+N+1))}{(2tM)^{-1}(N+1-\eta)(1-\eta)^2 b}. \end{aligned} \tag{46}$$

It can be checked that the competition effect is unambiguously negative[34]. Then, like in standard "new" trade theory models, higher local competition always depresses profits.

In turn, the demand effect can either be positive or negative. In effect, while the first term in the numerator of $\frac{d\Pi}{dr}$ is positive the sign of the second term depends on the sign of $\left(r-\frac{1}{2}\right)\left(s-\frac{1}{2}\right)$. Equation 46 is positive if $r > \frac{1}{2}$ and $s < \frac{1}{2}$ or $r < \frac{1}{2}$ and $s > \frac{1}{2}$, since the second term in the numerator is

[34] To see this, note that the denominator of the fraction is positive, once $0 < \eta < 1$. In turn, the numerator is also positive, given that the second term in the numerator is always positive, while the same is also the case with the first term in the numerator, since even at its local minimum (at $r = \frac{1}{2}$) it is positive.

then also positive. However, if $r > \frac{1}{2}$ and $s > \frac{1}{2}$ or $r < \frac{1}{2}$ and $s < \frac{1}{2}$, equation 46 is not necessarily positive, given that the second term is negative. In particular, when $r > \frac{1}{2}$ and $s > \frac{1}{2}$ or $r < \frac{1}{2}$ and $s < \frac{1}{2}$, equation 46 tends to be negative for high η (and the reverse for low η)[35].

We then have that the demand effect is weaker for high η (and the opposite for low η). The mechanism is the following. When η is high, the importance of the demand effect is reduced, given that firms are less dependent on domestic demand to be efficient on R&D and to sell. As we shall see in what follows, the behavior of the demand effect in relation to η plays an important role in the existence of HMEs.

In turn, in what concerns the equilibrium number of firms in each location, $\hat{s}$ (which is obtained by solving equation 45 for s), we have that:

$$\hat{s} = \frac{1}{2} + \frac{(1-\eta)(2-\eta)\left(D-\frac{t}{2}\right)}{Nt\left(2\eta\left(r-\frac{1}{2}\right)^2-(1-\eta)\left(4\eta r(1-r)\left(1+\frac{1-\eta}{N+1}\right)-1\right)\right)}\left(r-\frac{1}{2}\right). \qquad (47)$$

Start by noticing that the large fraction on the right hand side of equation 47 is always positive[36]. Then, for $r = \frac{1}{2} \Rightarrow \hat{s} = \frac{1}{2}$, for $r > \frac{1}{2} \Rightarrow \frac{1}{2} < \hat{s} \leq 1$ and for $r < \frac{1}{2} \Rightarrow 0 \leq \hat{s} < \frac{1}{2}$. As for the standard "new" trade theory model with exogenous costs of production above, the larger region also hosts more firms in equilibrium.

We can now investigate if the larger country not only hosts more firms (as shown in equation 47) but also hosts a disproportionately higher share of the world's firms than of the world's demand (i.e.: HMEs in the number of firms). As we have seen before, HMEs in the number of firms arise if $d+c > 0$ (see equation 7)[37]. Computing $d + c$ from equation 46, we obtain:

---

[35] In fact this is so, since, as $\eta \to 1$, the first term in the numerator of equation 46 approaches zero. Therefore, and if $r > \frac{1}{2}$ and $s > \frac{1}{2}$ or $r < \frac{1}{2}$ and $s < \frac{1}{2}$, it is more likely that the first (positive) term in the numerator is dominated by the second (negative) one.

[36] The numerator of the large fraction in equation 47 is positive, since $D > t$ and $0 < \eta < 1$. In turn, the denominator is also positive, given that it has a local minimum at $r = \frac{1}{2}$, where it is positive.

[37] As for the standard "new" trade theory model, we obtain the same results if instead we calculate $\frac{ds}{dr} > 1$ from equation 47 or $\frac{\frac{\partial \Delta \Pi}{\partial r}}{-\frac{\partial \Delta \Pi}{\partial s}} > 1$ from equation 46.

$$d+c=\frac{2tM}{(N+1-\eta)(1-\eta)^2 b}$$
$$\left(\begin{array}{c}(1-\eta)\left((2-\eta)\left(D-\frac{t}{2}\right)-Nt\left(1-4\eta r\left(1-r\right)\left(1+\frac{1-\eta}{N+1}\right)\right)\right)\\ -2Nt\eta\left(r-\frac{1}{2}\right)\left(\left(r-\frac{1}{2}\right)+\frac{2\left(s-\frac{1}{2}\right)\left((2(1-\eta)(N+2-\eta)+N+1)\right)}{N+1}\right)\end{array}\right). \quad (48)$$

Note first that the term outside the big parenthesis is always positive, then, to sign equation 48, we just need to look at what is inside the parenthesis. After close inspection, we can conclude that the sign of equation 48 depends on the parameter η (relative efficiency of R&D). In fact, we observe the following patterns. If $\eta \to 0$, the big parenthesis tends to $2D - t(N+1)$. Then, as $\eta \to 0$, $d + c > 0$ for $t < \frac{2D}{N+1}$. In turn, if $\eta \to 1$, the big parenthesis tends to $(3-4s-2r)\left(r-\frac{1}{2}\right)Nt$. It can be checked that the previous expression is negative for $r > \frac{1}{2}$, given that for $r > \frac{1}{2} \Rightarrow \hat{s} > \frac{1}{2}$ (see equation 47)[38]. In this sense, for higher values of η, HMEs in the number of firms tend to not arise (since most likely $d + c < 0$). The contrary occurs for lower values of η (since most likely $d + c > 0$).

The rationale for this result comes from R&D investment. In effect, as we have seen previously, market size differences can trigger endogenous asymmetries between firms in different countries, since firms in larger markets tend to invest more in R&D. Though, by investing more in R&D, firms in the larger market achieve higher competitiveness and larger size than firms in the smaller market. As a result, in equilibrium the larger market does not need to host a disproportionately higher share of the world's industry than of the world's demand. All the previous effects are magnified when the return on R&D is high (i.e.: $\eta \to 1$).

6.3 HMEs in trade patterns and employment

We turn now to HMEs in employment and trade patterns (equations 19 and 21, respectively). For both, we will use the fact that with endogenous costs of production, HMEs in the number of firms will more likely not arise for higher values of η, and the contrary for lower values of η. In other words, we have that right hand side of equation 19 (HMEs in employment) and equation 21

[38] To see this, note that: the expression $(3-4s-2r)\left(r-\frac{1}{2}\right)$ has two solutions $\left(\frac{3}{2}-2s, \frac{1}{2}\right)$; and the second derivative of the expression is negative and therefore it has an inverse U-shape in relation to r. Consequently, for $r > \frac{1}{2}$, the expression is negative.

(HMEs in trade patterns), $\frac{s}{r}\frac{(1-r)}{(1-s)}$, as $\eta \to 1$ tends to be smaller than one. The opposite occurs as $\eta \to 0$, where $\frac{s}{r}\frac{(1-r)}{(1-s)}$ tends to be bigger than one. Having this in mind, we analyzed the right-hand side of equations 19 and 21 ($\frac{C_F q_F+\Gamma_F}{C_H q_H+\Gamma_H}$ and $\frac{q_{FH}}{q_{HF}}$, respectively).

Start with HMEs in employment. We have that as $\eta \to 0 \Rightarrow \frac{C_F q_F+\Gamma_F}{C_H q_H+\Gamma_H} \to 1$. Then, since as $\eta \to 0$, HMEs in the number of firms tend to be present (i.e.: $\frac{s}{r}\frac{(1-r)}{(1-s)} > 1$), we also have that HMEs in employment arise more easily. In turn, as $\eta \to 1 \Rightarrow \frac{C_F q_F+\Gamma_F}{C_H q_H+\Gamma_H} \to \frac{s^2}{(1-s)^2}$, which is bigger than one for $s > \frac{1}{2}$. However, as we have mentioned, for $\eta \to 1$ HMEs in the number of firms tend not to emerge (i.e.: $\frac{s}{r}\frac{(1-r)}{(1-s)} < 1$). Then, if home is the larger country ($r > \frac{1}{2}$), which as shown in equation 47 implies that $\hat{s} > \frac{1}{2}$, it results that it is more difficult to have HMEs in employment.

In what concerns HMEs in trade patterns, we have the following. As $\eta \to 0 \Rightarrow \frac{q_{FH}}{q_{HF}} \to \frac{(D-t(sN+1))}{(D-t((1-s)N+1))}$. It can be checked that the previous equation is smaller than one for $s > \frac{1}{2}$. Then, it follows that if home is the larger country ($r > \frac{1}{2}$), which from equation 47 means that home hosts more firms ($\hat{s} > \frac{1}{2}$), we have that HMEs in trade patterns arise. The question is then if the same occurs when $\eta \to 1$, since then HMEs in the number of firms and employment, as we have seen, tend not to be present. It comes out that for $\eta \to 1 \Rightarrow \frac{q_{FH}}{q_{HF}} \to -\frac{s}{(1-s)}$. Since $-\frac{s}{(1-s)} < 0$ and $\frac{s}{r}\frac{(1-r)}{(1-s)} > 0$, it therefore results that in spite of, as $\eta \to 1$, HMEs in the number of firms and in employment do not arise, still HMEs in trade patterns always emerge.

The rationale for this result follows from market size effects on R&D investment. We have seen that firms in the larger market invest more in R&D than firms in the smaller market. In other words, the former achieve higher competitiveness and larger size than the latter. This implies that firms in the larger country have higher labor productivity and therefore they need less labor to produce the same amount of output (no HMEs in employment). Larger firm size, in turn, causes that fewer firms can arise in equilibrium in the larger market (no HMEs in the number of firms)[39]. However, the higher competitiveness and the larger size of firms from the larger market, also means that these firms can export more than rivals in the smaller market and that their local sales can crowd-out foreign imports. In the end, the larger

[39] There is some evidence that more efficient firms use less labor, which can lead to a reduction in local employment. Also, in a market with more efficient firms, fewer firms survive. See for example Neumark et al. (2008) for Wal-Mart stores.

market, in spite of the non existence of HMEs in the number of firms and employment, can still run a trade surplus in the IRS-sector (i.e.: HMEs in trade patterns). As we have seen, this is more likely to be the case when the relative return on R&D is very high (i.e.: as $\eta \rightarrow 1$), since the competitiveness and the size advantages of firms from the larger market are amplified.

7 Discussion

In this paper, we have analyzed the role of endogenous costs of production on HMEs. In particular, we have considered process R&D that reduces marginal costs but increases fixed costs. We have shown that when the costs of production are endogenous, production, R&D and prices depend not only on the spatial distribution of firms (as in models with exogenous costs of production), but also on the spatial distribution of demand. In particular, R&D will tend to increase with market size, and, consequently, firms in larger markets will achieve higher competitiveness and larger size than firms in smaller markets. This can have important implications in terms of HMEs. First, the larger markets do not necessarily always host a disproportionately higher share of the world's firms than of the world's demand or employ more labor (i.e.: HMEs in the number of firms and employment can be canceled). Second, in spite of this, the larger country can still always run trade surplus in increasing returns sectors, since it hosts firms that have higher international competitiveness and size.

The endogeneity of the costs of production can then give new insights, at both theoretical and empirical levels, to the literatures on the "new" trade theory and "new" economic geography. At the theoretical level, endogenous costs of production allow us to abandon the firm symmetry assumption of standard models, since we can then generate asymmetries between firms across countries. Future work should try to merge our set-up with the Melitz one, which also opens up for asymmetries between firms located in the same country. The two approaches are complementary, since in Melitz, the distribution of productivity across countries is similar.

At the empirical level the endogeneity of the costs of production suggests that the tests of HMEs based solely on the share of firms a country hosts, should control for the endogeneity of costs and international asymmetries in competitiveness and size between firms. Without this correction, HMEs of all types (number of firms, employment and trade patterns) might be misleadingly dismissed, while HMEs in trade patterns may in fact still hold.

References

[1] Antweiler, W. and Trefler, D. (2002), Increasing Returns and All That: A View from Trade, *American Economic Review*, 92, 93-119.

[2] Armington, P. (1969), A Theory of Demand for Products Distinguished by Place of Production, *International Monetary Fund Staff Papers*, 16, 159-176.

[3] Aw, B.; Roberts, M. and Xu, D. (2008), R&D Investments, Exporting, and the Evolution of Firm Productivity, *American Economic Review*, 98, 451-456.

[4] Behrens, K. (2005), Market Size and Industry Location: Traded vs

[5] Non-traded Goods, *Journal of Urban Economics*, 58, 24-44.

[6] Behrens, K.; Lamorgese, A.; Ottaviano, G. and Tabuchi, T. (2009), Beyond the Home Market Effect: Market size and Specialization in a Multi-Country World, *Journal of International Economics*, 79, 259-265.

[7] Bernard, A.; Eaton, J.; Jensen, J. and Kortum, S. (2003), Plants and Productivity in International Trade, *American Economic Review*, 93, 1268-1290.

[8] Brander, J. (1981), Intra Industry Trade in Identical Commodities, *Journal of International Economics*, 11, 1-14.

[9] Brander, J. and Krugman, P. (1983), A 'Reciprocal Dumping' Model of International Trade, *Journal of International Economics*, 15, 313-321.

[10] Callois, J.-M. (2008), The Two Sides of Proximity in Industrial Clusters: The Trade-Off between Process and Product Innovation, *Journal of Urban Economics*, 63, 146-162.

[11] Campbell, J. and Hopenhayn, H. (2005), Market Size Matters, *Journal of Industrial Economics*, 53, 1-25.

[12] Combes, P.-P. and Duranton, G. (2006), Labour Pooling, Labour Poaching, and Spatial Clustering, *Regional Science & Urban Economics*, 36, 1-28.

[13] Combes, P.-P.; Duranton, G. and Gobillon, L. (2008), Spatial Wage Disparities: Sorting Matters, *Journal of Urban Economics*, 63, 723-742.

[14] Crozet, M. and Trionfetti, F. (2008), Trade costs and the Home Market Effect, *Journal of International Economics*, 76, 309-321.

[15] Davis, D. (1998), The Home Market, Trade, and Industrial Structure, *American Economic Review*, 88, 1264-1276.

[16] Davis, D. and Weinstein, D. (1996), Does Economic Geography Matter for International Specialization?, NBER Working Paper 5706.

[17] Davis, D. and Weinstein, D. (1999), Economic Geography and Regional Production Structure: an Empirical Investigation, *European Economic Review*, 43, 379-407.

[18] Davis, D. and Weinstein, D. (2001), An Account of Global Factor Trade, *American Economic Review*, 91, 1423-1453.

[19] Davis, D. and Weinstein, D. (2003), Market Access, Economic Geography and Comparative Advantage: an Empirical Assessment, *Journal of International Economics*, 59, 1-23.

[20] Eaton, J.; Gutierrez, E. and Kortum, S. (1998), European Technology Policy, *Economic Policy*, 13, 405-439.

[21] Eaton, J. and Kortum, S. (2002), Technology, Geography, and Trade, *Econometrica*, 70, 1741-1779.

[22] Feenstra, R. and Kee, H. (2008), Export Variety and Country Productivity: Estimating the Monopolistic Competition Model with Endogenous Productivity, *Journal of International Economics*, 74, 500-518.

[23] Feenstra, R.; Markusen, J. and Rose, A. (2001), Using the Gravity Equation to Differentiate among Alternative Theories of Trade, *Canadian Journal of Economics*, 34, 430-447.

[24] Fudenberg, D. and Tirole, J. (1984), The Fat-Cat Effect, the Puppy-Dog Ploy, and the Lean and Hungry Look, *American Economic Review*, 74, 361-366.

[25] Fudenberg, D. and Tirole, J. (1991), *Game Theory*, Cambridge: MIT Press.

[26] Fung, M. (2002), Technological Opportunity and Economies of Scale in Research Productivity: A Study on Three Global Industries, *Review of Industrial Organization*, 21, 419-436.

[27] Garcia Pires, A. (2009), R&D and Endogenous Asymmetries between Firms, *Economics Letters*, 103, 153-156.

[28] Gerlach, H.; Rønde, T. and Stahl, K. (2009), Labor Pooling in R&D Intensive Industries, *Journal of Urban Economics*, 65, 99-111.

[29] Glaeser, E.; Kerr, W. and Ponzetto, G. (2010), Clusters of Entrepreneurship, *Journal of Urban Economics*, 67, 150-68.

[30] Gustavsson, P.; Hansson, P. and Lundberg, L. (1999), Technology, Resource Endowments and International Competitiveness, *European Economic Review*, 43, 1501-1530.

[31] Head, K.; Mayer, T. and Ries, J. (2002), On the Pervasiveness of Home Market Effects, *Economica*, 69, 371-390.

[32] Head, K. and Ries, J. (2001), Increasing Returns versus National Product Differentiation as an Explanation for the Pattern of U.S.-Canada Trade, *American Economic Review*, 91, 858-876.

[33] Helpman, E. (1990), Monopolistic Competition in Trade Theory, Special Paper in International Economics 16. Princeton University, International Finance Section.

[34] Helpman, E. and Krugman, P. (1985), *Market Structure and Foreign Trade*, Cambridge: MIT Press.

[35] Konishi, H. (2005), Concentration of Competing Retail Stores, *Journal of Urban Economics*, 58, 488-512.

[36] Krugman, P. (1980), Scale Economies, Product Differentiation, and the Pattern of Trade, *American Economic Review*, 70, 950-959.

[37] Krugman, P. (1984), Import Protection as Export Promotion: International Competition in the Presence of Oligopoly and Economics of Scale, in H. Kierzkowski (ed.), *Monopolistic Competition and International Trade*, Oxford: Clarendon Press.

[38] Krugman, P. (1991), Increasing Returns and Economic Geography, *Journal of Political Economy*, 99, 413-499.

[39] Leahy, D. and Neary, P. (1997), Public Policy Towards R&D in Oligopolistic Industries, *American Economic Review*, 87, 642-662.

[40] Lundbäck, E. and Torstensson, J. (1998), Demand, Comparative Advantage and Economic Geography in International Trade: Evidence from the OECD, *Review of World Economics*, 134, 230-249.

[41] Melitz, M. (2003), The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity, *Econometrica*, 71, 1695-1725.

[42] Melitz, M. and Ottaviano, G. (2008), Market Size, Trade, and Productivity, *Review of Economic Studies*, 75, 295-316.

[43] Neary, P. (2003), Globalization and Market Structure, *Journal of the European Economic Association*, 1, pp. 245-271.

[44] Neary, P. (2010), Two and a Half Theories of Trade, *The World Economy*, 33, 1-19.

[45] Neumark, D.; Zhang, J. and Ciccarella, S. (2008), The Effects of Wal-Mart on Local Labor Markets, *Journal of Urban Economics*, 63, 405-430.

[46] Ottaviano, G.; Tabuchi, T. and Thisse, J.-F. (2002), Agglomeration and Trade Revisited, *International Economic Review*, 23, 409-435.

[47] Roberts, M. and Tybout, J. (1997), The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs, *American Economic Review*, 87, 545-564.

[48] Rosen, S. (1981), The Economics of Superstars, *American Economic Review*, 71, 845-858.

[49] Shaked, A. and Sutton, J. (1983), Natural Oligopolies, *Econometrica*, 51, 1469-1483.

[50] Syverson, C. (2007), Prices, Spatial Competition and Heterogeneous Producers: An Empirical Test, *Journal of Industrial Economics*, 55, 197-222.

[51] Torstensson, J. (1998), Country Size and Comparative Advantage: An Empirical Study, *Review of World Economics*, 134, 590-611.

[52] Trefler, D. (1993), International Factor Price Differences: Leontief was Right!, *Journal of Political Economy*, 101, pp. 961-987.

[53] Trefler, D. (1995). The Case of Missing Trade and other Mysteries, *American Economic Review*, 85, pp. 1029-1046.

[54] Tybout, J. (2003), Plant- and Firm-level Evidence on the 'New' Trade Theories, in E. Kwan Choi and J. Harrigan (eds.), *Handbook of International Trade*, Oxford: Basil-Blackwell.

[55] von Stackelberg, H. (1934), *Marktform und Gleichgewicht*, Vienna: Springer.

[56] Yu, Z. (2005), Trade, Market Size, and Industrial Structure: Revisiting the Home Market Effect, *Canadian Journal of Economics*, 38, 255-272.