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Financial constraints and international trade with endogenous mode of competition

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ABSTRACT

The paper examines how financial constraints affect firms' decisions to export when the mode of intra-sectoral competition is endogenous. We propose an extension of Neary and Tharakan's (2012) model, in which firms resort to external funders to finance investments in production capacities. Sectors differ in financial constraint and the cost of capital increases with the level of financial constraint. We first show that a weaker financial constraint allows firms to adopt a Cournot (rather than a Bertrand) pricing scheme and generate a high duopoly profit. Consequently, less financially constrained sectors are more likely to export. We also exhibit a new transmission channel of financial crisis. By increasing the financial cost of exporting and making it more difficult to engage in a Cournot behavior, a financial shock reduces both the intensive and extensive margins of trade.

1. Introduction

A recent and large literature, empirical and theoretical, has documented the implications of the 2007–2008 global financial crisis. Some of this literature has focused on the impact on firms' investment, while the rest has investigated the effect on international trade. In this paper, we offer a theoretical explanation of how financial constraints simultaneously affect trade and investment, and show that interactions between both variables give birth to an additional channel of transmission for the financial crisis to impact the real economy. We build a general equilibrium model with oligopolistic firms facing a sequential decision with three stages (trade-investment-price) and sectors differentiated by financial conditions. This model, where the mode of competition is endogenous, points out a new channel of transmission of a financial shock to both trade and investment: sector-level financial constraints reduce firms' ability to engage in capitalistic and profitable Cournot competition. This new channel, combined with the previously documented effect of an upfront trade cost, explains why the impact of the financial crisis on trade and investment has been so large.

The global financial crisis implied, on the one hand, a severe drop in firms' investment. For example, during the first quarter of 2009, the growth rate of investment reached approximately −6.5 percent in the United States and Europe.[1] Investment expenditures were significantly affected by the decline in bank lending, particularly after the bankruptcy of Lehman Brothers. However, the shock also affected financial markets. Due to a crisis of confidence, investors fled stock markets for less risky markets (notably, sovereign bond markets); firms' investment also suffered from a global collapse in credit supply. A large body of literature has explored this credit rationing phenomenon, showing that the decline in investment was stronger for financially dependent firms (Krosner et al., 2007; Duchin et al., 2010; Almeida et al., 2012; Campello et al., 2010, 2011, 2012).

On the other hand, the financial crisis is considered one of the major causes of the great trade collapse observed in 2009 (Auboin, 2009, 2011). According to the World Trade Organization (WTO), the volume of world trade fell by 12 percent in 2009. More

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[1] Source: OECD.

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notably, the slump in world trade appeared to be much stronger than the contraction in Gross Domestic Product (GDP), which amounted to −2.6 percent in 2009.[2] The recent drop in export volumes was also more severe than the fall in world trade observed during the Great Depression of the 1930s. In line with Melitz's model (2003), some researchers investigated how financial conditions affect international trade. Using a monopolistic competition framework, they introduced the notion of financial constraint with firm-level heterogeneous productivity. Through this approach, exporters face upfront costs, related to things such as advertising, gathering information on foreign customers, administrative procedures, translation, and organizing foreign distribution networks. Since these specific costs must be externally financed, intensive and extensive margins crucially depend on the strength of firms' financial constraints. In Chaney (2005), productivity not only affects firms' competitiveness on foreign markets but also determines the amount of profit earned from domestic activities and firms' ability to cover upfront export costs. Hence, firms with a very low productivity level do not export because they are not competitive enough to sell abroad. Conversely, high-productivity firms export because they are competitive and generate large profits from their domestic activities. Finally, firms with an intermediate level of productivity are financially constrained; despite their potential viability on foreign markets, they do not generate enough profit to cover upfront costs and trade. Similarly to Chaney (2005), Manova (2013) assumes that high productivity implies large profits and allows firms to offer high returns to external funders, enabling them to more easily borrow and finance upfront export costs. Hence, there exists a productivity threshold such that low-productivity firms (which cannot obtain external funds to cover fixed costs) are excluded from international trade, whereas high-productivity firms (which face no financial constraint) can export. These theoretical findings have been widely confirmed by the empirical literature (Bellone et al., 2010; Berman and Héricourt, 2010; Bricongne et al., 2010; Engel et al., 2013; Askenazy et al., 2015; Muûls, 2015).

In both bodies of literature presented above, the implications of a financial shock on investment and exports are examined independently. In fact, interaction between firms' investment and export behavior can give birth to an additional channel of transmission of the financial crisis to the real economy: firms' investment crucially determines the level of their production capacities. For this reason, a drop in investment expenses does not only represent a reduction in final demand; it also has large implications on firms' supply. This supply effect is particularly interesting in an oligopolistic set-up, where firms make their decision in two stages, first choosing investment capacity and then determining prices. In such a framework, as shown by Kreps and Scheinkman (1983), Maggi (1996) and Neary and Tharakan (2012), the level of production capacities influences the degree of competitive behavior as well as prices and profit. For example, Neary and Tharakan (2012) design a capacity-price competition model in a general equilibrium in which sectors are heterogeneous in terms of skilled/unskilled-labor intensity. Focusing on the duopoly case, the authors show that in each sector, the mode of competition is endogenously determined. Since their marginal cost to produce above capacity is lower than the marginal cost to invest and produce at capacity, very unskilled-labor intensive sectors do not install a production capacity. Firms in these sectors set their price as in a Bertrand equilibrium. In contrast, very skilled-labor intensive sectors install a production capacity, which implicitly commits firms in these sectors in the second stage to set a price such that the demand addressed to them will equal the level of production capacity. For these sectors, production capacity acts as a commitment device, with everything happens as if they behaved in a one-stage Cournot game. The price they set corresponds to the Cournot-game price and their profit is higher than in a Bertrand equilibrium.

This literature thus concludes that the mode of competition (Bertrand or Cournot) crucially determines prices and firms' profit in international trade. Consequently, through their effects on production capacity, the mode of intra-sectoral competition and firms' duopoly profit, investment expenses should finally affect export behavior. This effect may explain why capital-intensive firms export more than others (Bellone et al., 2006; Bernard et al., 2007). Furthermore, this idea can be transposed in a framework where, in line with Rajan and Zingales (1998), sectors differ in their financial constraint rather than in skilled/unskilled-labor intensity. In this case, most financially dependent sectors are particularly affected by a financial crisis, which increases their cost of capital and reduces their level of investment and production capacity.

Taken together, these arguments suggest that a financial shock does not only affect international trade through the need to financing fixed exporting costs, as described in the existing literature. It should also decrease exports by reducing financially dependent firms' investment in production capacity and their ability to engage in a more profitable mode of international competition.

The goal of our paper is to account for this new transmission channel of financial shocks. To do so, we introduce financial constraints in the theoretical set-up proposed by Neary and Tharakan (2012) to investigate the extent to which financial factors affect firms' competitive behavior, capacity production decisions and, ultimately, export behavior. Based on the notion that sectors differ in their financial constraint, one important contribution of our paper is to show that less financially constrained sectors are more likely to export. On the one hand, a high level of financial constraint allows firms to finance fixed export costs at a lower interest rate. On the other hand, a weaker financial constrained reduces the cost of investing in capacities, allowing firms to adopt a Cournot (rather than a Bertrand) pricing scheme and generate a high duopoly profit. Another innovation of the paper is the exhibiting of a new transmission channel of financial crisis, which passes through firms' investment in production capacities and affects both the extensive and intensive margins of trade. A rise in the cost of capital increases the cost of investment in production capacities, thus reducing firms' ability to engage in Cournot pricing schemes. Combined with the (more standard) argument that a financial shock increases the financial cost of exports, this finally reduces firms' probability to export. Moreover, by reducing firms' levels capacity, the transmission channel described in our model also decreases firms' production and exports.

The paper is organized as follows: the second section presents the basic assumptions of the model; the third section considers the case of autarky; the fourth section introduces the case of free trade; in the fifth section, we discuss our results; and in the sixth section we present our conclusions.

2. Assumptions

2.1. The supply side

2.1.1. Financial constraint across sectors

We consider two identical economies, domestic and foreign, with a continuum of sectors indexed by $z \in [0;1]$ in each country. There is one domestic firm and one foreign firm in each sector; these firms supply different products. The first crucial assumption of our model refers to financial constraint across sectors:

[2] Source: WTO.

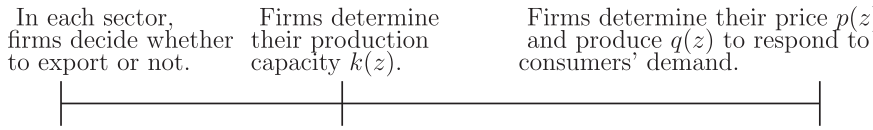

Fig. 1. Timing of actions.

Assumption 1. In each country, sectors differ in their financial constraint, from the less constrained ($z = 0$) to the most constrained ($z = 1$). The sector-level ranking is the same in both countries.

In their seminal paper, Rajan and Zingales (1998) propose measuring sector-level financial constraint through external finance dependence. Their idea is that technological specificity induces significant differences among sectors, such that external finance dependence has a sector-specific dimension. Calculated from a data set that contains all publicly listed US based companies from 1980 to 1989, the indicator proposed by Rajan and Zingales (1998), below denoted by "RZ indicator", is calculated as the median level of capital expenditures not financed with cash-flows from operations for 23 ISIC industries with a mix of 4-digit and 3-digit ISIC levels. A higher RZ indicator indicates a more financially dependent sector, and vice versa. The literature, which has widely used the RZ indicator (Braun, 2003; Claessens and Laeven, 2003; Krosner et al., 2007; Manova, 2008, 2013), provides strong support for Assumption 1. First of all, empirical evidence indicates that sectors clearly differ in financial constraint. For example, in Braun (2003), Manova (2008, 2013) and Manova et al. (2014), the most financially constrained sectors are the tobacco, pottery, china and earthenware, leather, footwear and clothing apparel sectors, whereas the less constrained ones are the machinery, professional and scientific equipment and iron and steel sectors. Second, Rajan and Zingales (1998) and Braun (2003) show that the ranking of industries seems to be stable across periods. Third, because external finance dependence has a large sector-specific component, it seems plausible that the financial constraint rank is similar across countries. This idea is confirmed by Braun (2003), who shows that financial constraint ranks in the US, Japan, Germany and the UK are highly correlated. Therefore, the RZ indicator has been widely exploited in the literature to rank sectors not only in the US but also sectors in other countries for which financial constraint indicators are not easily computable. Taken together, these arguments provide convincing rationale for our assumption that sectors are heterogeneous in terms of financial constraint and that the ranking of sector-level financial constraint is invariant across countries and time.

Another important assumption of our model is that sector-level financial constraint determines the cost of external finance for sectors:

Assumption 2.

$r(z) = R(1 + \gamma z), \text{ with } \gamma > 0.$

R is the remuneration of capital for the less constrained sector ($z = 0$). Knowledge of the value of R implies knowledge of capital cost $r(z)$ for all sectors. Assumption 2 states that a shift in R has a stronger effect on more constrained sectors than on less constrained ones. Parameter γ measures the size of this amplification effect and can be considered as accounting for the level of financial development: as the financial system becomes more developed, the effect of sector-level financial constraints on the cost of capital $r(z)$ decreases. This assumption is consistent with Rajan and Zingales (1998), who show that external financially dependent sectors benefit more strongly from an increase in the level of financial development. Finally, it is noteworthy that Assumption 2 prevails for both countries. Our model thus describes a "North–North" world, in which, due to perfect mobility of capital flows, both countries exhibit similar financial conditions and financial development. Hence our model seems particularly relevant to account for the consequences of an international financial crisis, i.e., a crisis that affects both economies similarly.

2.1.2. Timing of actions

Within each sector, firms have to make three decisions:

– Stage 1. Firms have to make the decision to export or not to the other country. In line with the theoretical literature on finance and trade (Chaney, 2005; Manova, 2013), we consider that there is a fixed cost of exporting (per period of time). This cost refers to, e.g., marketing, document translation and network creation, which are required to sell abroad:

Assumption 3. Exporting requires the payment of Φ units of capital regardless of the level of exports. Firms resort to external funders to finance this fixed exporting cost and are charged a per unit capital cost of $r(z)$ in sector z.

Consequently, the financial cost of exportation is $\Phi r(z)$.

– Stage 2. Firms have to determine the level of their production capacities $k(z)$. Each unit of installed production capacity requires δ units of capital, regardless of what the sector is. Moreover, we consider that sectors' financial constraint is also crucial for determining the cost of investing in capacities:

Assumption 4. Each unit of installed production capacity requires δ units of capital. Firms resort to external funders to finance this investment and are charged a per unit capital cost of $r(z)$ in sector z.

Therefore, if $k(z)$ is installed, the cost of capital is $r(z)\delta k(z)$.

– Stage 3. Firms select their output prices. When output prices have been chosen, each firm produces $q(z)$ to respond to consumer's demand at the fixed prices.[3] Each unit of output is normalized such that it requires one unit of labor to produce it. The total labor supply in each economy is $\bar{L}$ and labor is perfectly mobile between sectors. The remuneration of labor is w. Therefore, if the production is not greater than the production capacity, the labor cost is $wq(z)$. If the production is above capacity, the production requires θ additional units of labor (i.e., units of output) for each unit above the supply capacity. In this case, the labor cost is $wq(z) + w\theta(q(z) - k(z))$. In contrast to Neary and Tharakan (2012) we suppose that θ is independent of z and depends on labor market institutions such as the national regulation of overtime work or union density.

The timing of actions is summarized in Fig. 1.

2.1.3. Output and capacity decisions

Let us first consider output decisions. Firms may produce below the supply capacity. However, it is easy to understand that this is not optimal: a better strategy would be to set a lower capacity such

[3] We do not consider the case of consumers' rationing.

that profit would be higher. Therefore, two options have to be considered:

- production is either equal to capacity, which is greater or equal to 0 ($q(z) = k(z) \geqslant 0$). In this case, the total cost is

  $$C(z) = r(z)\delta k(z) + wq(z) = (r(z)\delta + w)q(z),$$

- or production is above capacity ($q(z) > k(z)$). In this case, the total cost is

  $$C(z) = r(z)\delta k(z) + wq(z) + \theta w(q(z) - k(z)) \\ = (r(z)\delta - \theta w)k(z) + w(1+\theta)q(z).$$

Turning to capacity decisions, we see two options for a firm:

- either installing a production capacity and producing at capacity, with the marginal cost c^K defined as

  $$c^K = c^K(z) = \delta r(z) + w, \tag{1}$$

- or producing above capacity, with marginal cost c^L defined as

  $$c^L = w(1+\theta). \tag{2}$$

Capacity decisions are based on the comparison between $c^K(z)$ and c^L. Three cases are possible, and only one is worth studying: $c^K(z) < c^L, \forall z \in [0;1]$, and all sectors install a sufficient productive capacity to respond to all demands; $c^L < c^K(z), \forall z \in [0;1]$, and all sectors produce above capacity; or $c^K(z) < c^L$ for some sectors whereas $c^K(z) > c^L$ for others. In the latter case, let us call $\tilde{z}$ the marginal sector for which $c^K(\tilde{z}) = c^L$. We have

$$r(\tilde{z})\delta + w = w(1+\theta) \Longleftrightarrow \tilde{z} \equiv \frac{w\theta - \delta R}{R\gamma\delta}. \tag{3}$$

Hence, sectors for which $z < \tilde{z}$ invest in capacity (we will call these sectors "capacity-user sectors") whereas sectors for which $z > \tilde{z}$ do not. The extensive margin $\tilde{z}$ increases with w (when the remuneration of labor increases, there are more sectors that are capacity-users). It also increases with θ (when the cost increases, more sectors are capacity-users), decreases with δ (when the number of capital units required to produce one unit of output increases, fewer sectors are capacity-users) and decreases with γ (when the effect of R on $r(z)$ is more strongly amplified, fewer sectors are capacity-users). Because w and R are endogenously determined, every shock in the economy affects w and R, and indirectly, the extensive margin $\tilde{z}$.

2.2. The demand side

We now turn to the demand side. There are $\bar{L}$ identical households with additively separable preferences over all goods. Denoting $x(z)$ as the consumption of the good(s) produced in sector z, we have

$$U(\{x(z)\}) = \int_0^1 u\{x(z)\}dz. \tag{4}$$

Consumers' preferences are of a continuum quadratic form, depending on the market structure, either a monopoly or a duopoly.

2.2.1. The monopoly case

If the market structure is a monopoly (autarky), the local producer is the only supplier of a unique good. In this case, we have

$$u\{x(z)\} = ax(z) - \frac{b}{2}x(z)^2 \tag{5}$$

with $a > 0$ and $b > 0$.

Hence, denoting $p(z)$ as the price of the unique good produced in sector z, the consumers' inverse demand function is

$$p(z) = \hat{a} - \hat{b}q(z) \tag{6}$$

with $\hat{a} > 0$ and $\hat{b} > 0$. The proof of (6) is provided in the Appendix A.

2.2.2. The duopoly case

If the market structure is a duopoly, the local producer is in competition with the foreign producer to supply this market. We suppose that there are two goods 1 and 2, more or less differentiated, and consumption of good i is called $x_i(z)$. We have

$$u\{x(z)\} = a(x_1(z) + x_2(z)) - \frac{b}{2}\left(x_1(z)^2 + x_2(z)^2 + 2ex_1(z)x_2(z)\right) \tag{7}$$

with $a > 0, b > 0$ and $0 < e < 1$. e is a measure of product differentiation: if $e = 0$, the products are unrelated whereas if $e = 1$, the products are identical.

Denoting $p_i(z)$ as the price of good i produced in sector z, the consumers' inverse demand function is now

$$p_i(z) = \hat{a} - \hat{b}\big(q_i(z) + eq_j(z)\big) \tag{8}$$

with $\hat{a} > 0$ and $\hat{b} > 0$. The proof of (8) is provided in the Appendix A.

2.3. Factor markets and national income

In this economy we suppose that the $\bar{L}$ households get the same endowment in primary factors, that is to say 1 unit of labor and χ units of capital. All units of capital owned by the $\bar{L}$ households bring the same remuneration which is an average remuneration of capital. In fact there is a costless market intermediate (for example a mutual fund) that receives χ from each household, and invests this money in the same portfolio spread on all sectors such that each household receives $\chi\bar{r}$ as capital income, with

$$\bar{r} = \frac{\int_0^1 r(z)k(z)dz}{\chi\bar{L}}.$$

Because sectors are in a monopoly or a duopoly there are excess profits in each sector and these excess profits are fairly redistributed to households. We call $\pi(z)$ the excess profit in sector z and Π the total excess profit in the economy. We have $\Pi = \int_0^1 \pi(z)dz$. Consumer income I thus includes wage, capital income and excess profit:

$$I = w + \chi\bar{r} + \frac{\Pi}{\bar{L}}. \tag{9}$$

3. Autarky equilibrium

We now solve the model in autarky. We consider only one economy, and in each sector, the firm is in a monopoly. We examine successively the capital market equilibrium and the labor market equilibrium.

3.1. Capital market equilibrium

Denoting K^A as firms' demand for capital, we first investigate the equilibrium in the capital market.

In autarky, profit maximization in each sector implies that the equilibrium level of output is defined by

$$q^A(c) = \frac{\hat{a} - c}{2\hat{b}} \tag{10}$$

with $c = c^L$ for $\tilde{z} < z < 1$ and $c = c^K(z)$ for $0 < z < \tilde{z}$.

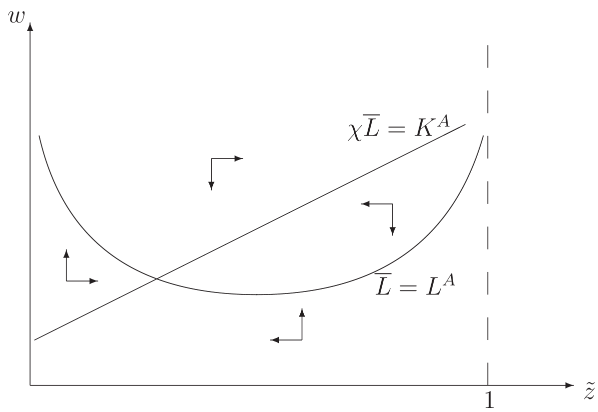

Fig. 2. Simultaneous determination of the salary rate and the extensive margin.

Credit-constrained sectors $(z > \tilde{z})$ do not demand capital because the capital cost is too high. Hence, on the capital market the equilibrium condition is

$$\chi\overline{L} = \int_0^{\tilde{z}} \delta q^A[c^K(z)]dz = K^A. \tag{11}$$

From (1), (10) and Assumption 2, we thus have

$$K^A = \frac{\delta}{2\hat{b}}\left(\hat{a}\tilde{z} - w\tilde{z} - \delta R\tilde{z} - \frac{1}{2}\delta R\gamma\tilde{z}^2\right). \tag{12}$$

Let us now represent the capital market equilibrium in the $(\tilde{z};w)$ plan. Using (12), we can calculate the total differential of K^A with respect to w and show that

$$\frac{dK^A}{dw} = \frac{\partial K^A}{\partial w} + \frac{\partial K^A}{\partial R}\frac{dR}{dw} < 0. \tag{13}$$

The proof of (13) is given in the Appendix A. As in Neary and Tharakan (2012), an increase in the wage rate w results in a decrease in K^A for two reasons. First, a rise in w implies a decline in the demand for labor. Because labor and capital are technically complementary, the demand for capital also decreases. Second, according to (3), a rise in w implies an increase in the cost of capital R to maintain the value of $\tilde{z}$ and also leads to a fall in the demand for capital.

Calculating the total differential of K^A with respect to $\tilde{z}$, we obtain

$$\frac{dK^A}{d\tilde{z}} = \frac{\partial K^A}{\partial \tilde{z}} + \frac{\partial K^A}{\partial R}\frac{dR}{d\tilde{z}} > 0. \tag{14}$$

The proof of (14) is given in the Appendix A. The expression (14) indicates that when $\tilde{z}$ increases, K^A also increases. The rationale for this result is as follows. On the one hand, a rise in the threshold $\tilde{z}$ indicates that more sectors invest in capital in the extensive margin. On the other hand, according to (3), an increase in $\tilde{z}$ results in a reduction in R at a given wage w, which induces an increase in the demand for capital from capacity-user sectors.

3.2. Labor market equilibrium

Denoting L^A as firms' demand for labor, we now concentrate on the labor market equilibrium. The demand for labor now comes from both types of sectors. The equilibrium condition is given by

$$\overline{L} = \int_0^{\tilde{z}} q^A(c^K(z))dz + \int_{\tilde{z}}^1 (1+\theta)q^A(c^L)dz = L^A. \tag{15}$$

From (1), (2), (10) and Assumption 2, this yields

$$L^A = \frac{1}{2\hat{b}}\Big(\hat{a}\tilde{z} - w\tilde{z} - \delta R\tilde{z} - \frac{1}{2}\delta R\gamma\tilde{z}^2 + (1+\theta)\hat{a} - w(1+\theta)^2 - (1+\theta)\hat{a}\tilde{z} + w(1+\theta)^2\tilde{z}\Big). \tag{16}$$

Using (16), we can calculate the total differential of L^A with respect to w

$$\frac{dL^A}{dw} = \frac{\partial L^A}{\partial w} + \frac{\partial L^A}{\partial R}\frac{dR}{dw} < 0. \tag{17}$$

The proof of (17) is given in the Appendix A. An increase in the wage rate w results in a decrease in L^A for two reasons. First, a rise in w obviously implies a reduction in the demand for labor. Second, according to (3), a rise in w implies an increase in R to maintain the value of $\tilde{z}$. This leads to a fall in the demand for capital and, because both factors are technically complementary, in the demand for labor.

Calculating the total differential of L^A with respect to $\tilde{z}$ yields

$$\frac{dL^A}{d\tilde{z}} = \frac{\partial L^A}{\partial \tilde{z}} + \frac{\partial L^A}{\partial R}\frac{dR}{d\tilde{z}}. \tag{18}$$

The sign of $\frac{dL^A}{d\tilde{z}}$ is ambiguous (the proof is given in the Appendix A). When $\tilde{z}$ increases, two effects are in play. First, a rise in $\tilde{z}$ indicates that more sectors invest in capacities. This extensive-margin effect implies a decline in the demand for labor. According to the second effect, an increase in $\tilde{z}$ results in a fall in R at a given wage w (see (3)), which reduces the production cost of capacity-user sectors and, consequently, increases their demand for labor. When $\tilde{z}$ is close to 0, very few sectors invest in capacities and the second effect is small. The first effect thus prevails such that $\frac{dL^A}{d\tilde{z}} < 0$. When $\tilde{z}$ is close to 1, nearly all sectors are already capacity-users. For this reason, the first effect vanishes and the second one prevails such that $\frac{dL^A}{d\tilde{z}} > 0$.

From this calculus, we finally derive Fig. 2. The equilibrium on the capital market can be represented by an increasing curve, whereas the equilibrium on the labor market is represented by a convex curve. As explained above, when $\tilde{z}$ is close to 0, one has $\frac{dL^A}{d\tilde{z}} < 0$ such the labor market equilibrium curve is decreasing. When $\tilde{z}$ is close to 1, one has $\frac{dL^A}{d\tilde{z}} > 0$ and the curve is increasing. The intersection of both curves provides the autarky equilibrium.

4. Free trade

We now consider the case of free trade. We first solve the duopoly equilibrium. We then successively study firms' decision to export and the capital market and labor market equilibria. Finally, we present comparative statics results.

4.1. Duopoly equilibrium

We now present the duopoly equilibrium. Let us suppose that in each sector z a domestic firm is in competition with a foreign one.

Following Neary and Tharakan (2012), we consider three subsets of sectors. We first focus on the sectors for which $z > \tilde{z}$. We know from Section 3 that these sectors do not invest in capacities. At the final stage, the firms compete in price with a marginal cost consisting only in labor. Domestic and foreign sectors thus directly choose prices and engage in a Bertrand game. Incurring a cost c^L, they charge a price denoted by $p^B(c^L)$ which corresponds to the price that maximizes profits under Bertrand competition when the marginal cost is c^L. We call these sectors Bertrand sectors. Note that they are the most financially constrained.

Let us now turn to sectors for which $z < \tilde{z}$. As explained in Section 3, all these sectors invest in capacities at the second stage. Let us first define the Cournot benchmark. This is an equilibrium with prices and quantities exactly equal to those in a virtual game in which firms would play Cournot, i.e., select the quantities to maximize profits. This is the best situation for a firm. In a perfect Nash equilibrium where duopolistic profits are maximized, firms choose their production capacities at the second stage such that all demand expressed by consumers at the third stage is exactly equal to the production capacity installed earlier. If not, profit is not maximized. Therefore, we can simplify this two-stage game (second and third stages) into a one-shot game where firms choose the production capacity that maximizes profit, i.e., play Cournot. In this game, the choice of production capacities can be interpreted as a commitment device: everything happens as if the level of production capacities installed in the second stage committed firms to set a price in the third stage such that the demand equals capacity.

Following Maggi (1996) and Neary and Tharakan (2012), we demonstrate that there are potentially two types of sectors in the subset of sectors for which $z < \tilde{z}$: a first subset of sectors with high profitability, called Cournot sectors (whose equilibrium prices and quantities are expressed with a C exponent, p^C and q^C) and a second subset with profitability lower than in Cournot sectors, but higher than in Bertrand sectors, called Quasi-Bertrand sectors (whose equilibrium prices and quantities are expressed with a QB exponent, p^{QB} and q^{QB}). There exists a threshold z_c defined by

$$p^B(c^L) = p^C(c^K(z_c)). \tag{19}$$

This threshold is such that sectors for which $z < z_C$ exhibit Cournot behavior whereas sectors for which $\tilde{z} > z > z_C$ exhibit Quasi-Bertrand behavior. The mechanism at play behind this result is presented in Appendix A.

This allows us to obtain the following proposition:

Proposition 1.

(a) The threshold z_c is strictly lower than $\tilde{z}$,
(b) The threshold z_c increases with the wage w and the extensive margin $\tilde{z}$ and decreases with δ.

Proof. See Appendix A. □

Part (b) of Proposition 1 states that when w increases, more sectors adopt Cournot behavior. This pattern can be explained as follows. When the labor cost increases, investing in capacities is relatively less costly than not investing in capacities. Therefore, the commitment to charge a higher price becomes stronger, and more sectors charge a price equal to the Cournot price. The same reasoning is at play when $\tilde{z}$ increases, i.e., when more sectors are capacity-users. Finally, when there is a rise in δ, investing in capacities becomes relatively more costly than not investing in capacities, and the commitment to charge a higher price becomes weaker. Hence, fewer sectors choose a Cournot pricing scheme.

Finally, we can easily calculate firms' equilibrium profits in each (Bertrand, Quasi-Bertrand and Cournot) configuration. Using the consumers' inverse demand function given by (8), Bertrand and Cournot equilibrium prices and quantities are given by

$$p^B(c) = \frac{(1-e)\hat{a} + c}{2-e}, \quad p^C(c) = \frac{\hat{a} + (1+e)c}{2+e},$$
$$q^B(c) = \frac{\hat{a} - c}{\hat{b}(1+e)(2-e)}, \quad q^C(c) = \frac{\hat{a} - c}{\hat{b}(2+e)}, \tag{20}$$

where c is $c^K(z) = \delta r(z) + w$ or $c^L = w(1+\theta)$. Note that, in line with standard results about Bertrand and Cournot equilibria, we have

$$p^B(c) < p^C(c), \quad q^B(c) > q^C(c). \tag{21}$$

We sum up the sectors' behavior in the following proposition:

Proposition 2.

(a) In sectors in a duopoly for which $z < z_c$ (Cournot sectors), firms' equilibrium profit, marginal cost, unit cost, equilibrium price, equilibrium quantity and Lerner index denoted as, respectively, $\Pi^C, mc^C, uc^C, p^C, q^C$ and LI^C are defined as follows:

$$\Pi^C = \frac{(\hat{a} - (\delta R(1+\gamma z) + w))^2}{\hat{b}(2+e)^2},$$

$$mc^C = w(1+\theta),$$

$$uc^C = \delta R(1+\gamma z) + w,$$

$$p^C = \frac{\hat{a} + (1+e)(\delta R(1+\gamma z) + w)}{(2+e)},$$

$$q^C = \frac{\hat{a} - (\delta R(1+\gamma z) + w)}{\hat{b}(2+e)},$$

$$LI^C = \frac{\hat{a} - (\delta R(1+\gamma z) + w)}{\hat{a} + (1+e)(\delta R(1+\gamma z) + w)}.$$

(b) In sectors in a duopoly for which $\tilde{z} < z < z_c$ (Quasi-Bertrand sectors), firms' equilibrium profit, marginal cost, unit cost, equilibrium price, equilibrium quantity and Lerner index denoted as, respectively, $\Pi^{QB}, mc^{QB}, uc^{QB}, p^{QB}, q^{QB}$ and LI^{QB} are defined as follows:

$$\Pi^{QB} = \frac{(\hat{a} - w(1+\theta))(\hat{a}(1-e) + w(1+\theta) - (2-e)(\delta R(1+\gamma z^*) + w))}{\hat{b}(1+e)(2-e)^2},$$

$$mc^{QB} = w(1+\theta),$$

$$uc^{QB} = \delta R(1+\gamma z) + w,$$

$$p^{QB} = \frac{\hat{a}(1-e) + w(1+\theta)}{(2-e)},$$

$$q^{QB} = \frac{\hat{a} - w(1+\theta)}{\hat{b}(1+e)(2-e)},$$

$$LI^{QB} = 1 - \frac{(2-e)(\delta R(1+\gamma z) + w)}{\hat{a}(1-e) + w(1+\theta)}.$$

(c) In sectors in a duopoly for which $z > \tilde{z}$ (Bertrand sectors), firms' equilibrium profit, marginal cost, unit cost, equilibrium price, equilibrium quantity and Lerner index denoted as, respectively, $\Pi^B, mc^B, uc^B, p^B, q^B$ and LI^B are defined as follows:

$$\Pi^B = \frac{(1-e)(\hat{a} - w(1+\theta))^2}{\hat{b}(1+e)(2-e)^2},$$

$$mc^B = w(1+\theta),$$

$$uc^B = w(1+\theta),$$

$$p^B = \frac{\hat{a}(1-e) + w(1+\theta)}{(2-e)},$$

Table 1
Profits and firms' decisions to export.

domestic \ foreign	*E*	*NE*
E	$2\Pi_D - \Phi r(z)$; $2\Pi_D - \Phi r(z)$	$\Pi_M + \Pi_D - \Phi r(z)$; Π_D
NE	Π_D; $\Pi_M + \Pi_D - \Phi r(z)$	Π_M; Π_M

$$q^B = \frac{\hat{a} - w(1+\theta)}{\hat{b}(1+e)(2-e)},$$

$$LI^B = \frac{(1-e)(\hat{a} - w(1+\theta))}{\hat{a}(1-e) + w(1+\theta)}.$$

These calculations allow us to characterize the three modes of competition, illustrated in Fig. 3.

Proposition 2 and Fig. 3 clearly show that sector-level financial constraint crucially affects the competitive behavior of firms, which in turn determines their profitability:

- on the left, sectors that have access to relatively good credit conditions, bear a reduced unit cost. Because they adopt a Cournot behavior, their profitability measured by the Lerner Index is relatively high. Let us mention that the price of the firms that benefit from the best access to credit is lower than other firms'. In fact, they have an even lower unit cost (on the left side of the graph, the slope of the unit cost line is steeper than the slope of the price cost), indicating that their margin is higher,
- on the right, Bertrand firms are more financially constrained such that they adopt process of production that only requires labor. Consequently their unit cost is relatively high and their profitability is relatively low,
- for firms in sectors z such that $z_c < z < \tilde{z}$ (Quasi-Bertrand sectors), because capacity choices are observed before prices are charged, the investment in capacities can have two beneficial effects. First, it decreases the unit cost of production. Second, production capacities operate as a commitment device. By limiting their capacity of production which is an irreversible decision, they support a unit cost of $c^K = \delta r(z) + w$ and charge a Bertrand price that corresponds to $c^L = w(1+\theta) > c^K$, that is to say $p^B(c^L)$. This leads to a higher profit over Bertrand sectors.

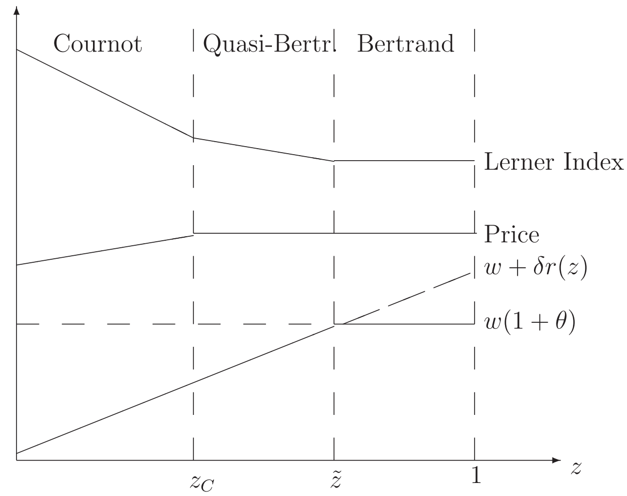

Fig. 3. Unit cost, marginal cost, price and Lerner index.

This finding can be summarized in Table 1. The first entry in each cell corresponds to the domestic firm's gain, whereas the second entry corresponds to the foreign firm's gain.

From Table 1, deriving the following proposition is straighforward:

Proposition 3. *Within a given sector,*

(a) *The situation in which both the domestic and the foreign firm export is a Nash equilibrium if the duopoly profit is larger than the financial costs of export,*
(b) *The situation in which neither the domestic nor the foreign firm export is a Nash equilibrium if the duopoly profit is weaker than the financial costs of export.*[5]

Proposition 3 states that the decision to export depends only on export costs and the duopoly profits of firms but not on their monopoly profits. This proposition is based on the fact that, *given the choice of the other firm*, a firm makes its decision to export by comparing either $2\Pi_D - \Phi r(z)$ and Π_D (if the other firm chooses "E") or $\Pi_M + \Pi_D - \Phi r(z)$ and Π_M (if the other firm chooses "NE"). In each case, the marginal cost attached to the decision to export is $\Phi r(z)$, and the marginal profit is Π_D.

Using profit expressions given in Proposition 2, we can summarize this comparison between firms duopoly profit and export costs in Fig. 4.

The comparison between the financial export cost curve $\Phi r(z)$ and the profit curve allows us to determine which sectors export. Sectors for which the cost curve is above the profit curve do not export whereas those for which the cost curve is below the profit curve export. Hence, we can define the threshold z^* such that

$$\Phi r(z^*) = \Pi_D. \quad (22)$$

We have to consider three cases according to whether the threshold sector z^* may belong to the Cournot ($z^* < z_c$), Quasi-Bertrand ($z_c < z^* < \tilde{z}$), or Bertrand ($z^* > \tilde{z}$) sectors, which define different expressions Π^C, Π^{QB} or Π^B for Π_D (see Proposition 2).

4.2. Firms' export decision

In this section, we investigate firms' decision to export. In each sector of each country, the firm has the choice between exporting (E) and not exporting (NE). Because the model is symmetric, there exist three different situations:

- if both firms export, they both earn the duopoly profit on their domestic market and the duopoly profit on the foreign market ($2\Pi_D$). However, they have to pay the financial costs of exports ($\Phi r(z)$).
- if no firm exports, they both earn the monopoly profit on their domestic market (Π_M).
- if one firm exports and the other one does not, the exporting firm earns the monopoly profit on its domestic market and the duopoly profit on the foreign market ($\Pi_M + \Pi_D$) minus the financial costs of export ($\Phi r(z)$). The non-exporting firm earns the duopoly profit on its domestic market (Π_D).[4]

[4] Because this reasoning is made at each (infinitesimal-sized) sector-level, its effect on the general equilibrium can be considered negligible.

[5] It could be argued that the financial cost of export varies according to whether both firms export (E/E) or only one firm exports (E/NE or NE/E). Indeed, when both firms export, they both resort to external funders to finance export costs, thus increasing the demand for external funds and the interest rate, compared to the case where only one firm exports. However, the individual effect of each sector on the general equilibrium is negligible. For this reason, one can consider that the financial cost of exports is the same in all cells of Table 1 and that the determination of the Nash equilibrium is not affected.

This allows us to obtain the following proposition:

Proposition 4. *If Φ is too large, there is no trade.*

If Φ is low enough, there exists a unique threshold denoted by z^* such that sectors with $z < z^*$ export whereas those with $z > z^*$ do not export.

Proposition 4 states that financial constraints prevent some sectors from exporting: more financially constrained sectors (those with a high z) do not export whereas those that are less constrained (i.e., have a low z) export.

This finding is globally in line with the theoretical findings of Chaney (2005) and Manova (2013). It is also consistent with the empirical literature, which documents that financially constrained sectors are less likely to export (Bellone et al., 2010; Berman and Héricourt, 2010; Bricongne et al., 2010; Engel et al., 2013; Askenazy et al., 2015; Muûls, 2015).

A major contribution of our paper is the new rationale for the link between financial constraint and the decision to export. The effect of firms' financial constraint on their export behavior is twofold. First, a low level of financial constraint allows firms to finance fixed export costs at a lower interest rate. This effect is similar to the one described in Chaney (2005) and Manova (2013). The second effect, however, is innovative: because a low level of financial constraint reduces the cost of investing in capacities, it allows firms to adopt a Cournot (rather than a Bertrand) pricing scheme and to yield a high duopoly profit. Taken together, both effects increase firms' incentive to export. Hence, the export decision is narrowly linked not only to the existence of upfront export costs but also to the mode of competition in which the sectors are engaged.

Proposition 4 also notably suggests that sectors that invest in capacities are more likely to export. This result renews the approach taken by Melitz (2003), Chaney (2005) and Manova (2013) in which the investing behavior of firms is not addressed. From an empirical point of view, the idea that investment and exports are positively correlated is in line with Bellone et al. (2006) and Bernard et al. (2007). Indeed, by allowing a firm to diversify its activity and to provide a positive signal to external funders about its quality, exporting activities may mitigate financial constraint, thus enhancing investment (Campa and Shaver, 2002). However, the positive correlation between investment and exports may also account for a causality that goes from investment to exports. This is precisely the case in our model, where investment is crucial for exporting decisions. Because investing in production capacities allows firms to commit to sustaining a higher price than in a Bertrand pricing policy, firms earn a larger duopoly profit, and exporting activities become more profitable for them. Kimura and Kiyuta (2006) provide empirical support for this result. They find that, over the period 1994–2000, Japanese firms' probability of exporting increases by 2 percent in the capital-labor ratio.

Finally, our model provides a comprehensive theoretical set-up that accounts for the idea that *both* financial constraints and investment behavior crucially drive export decisions and that this effect passes through the mode of competition within sectors.

4.3. Capital market equilibrium

We start with the capital market equilibrium. We denote K^T as the demand for capital. A sector's demand for capital crucially depends on whether the sector exports. Consequently, three cases have to be considered according to the locus of z^*.

Let us first consider the case where $z^* < z_c$. Considering (1), (10), (20) and Assumptions 2 and 3, the equilibrium on the capital market can be written as follows

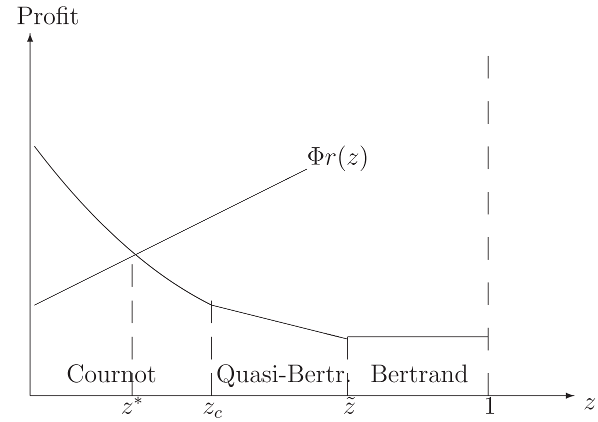

Fig. 4. Firms' decision to export: comparison between firms' duopoly profit and export cost.

$$K^T = \int_0^{z^*} \delta \frac{\hat{a} - \delta R - \delta R\gamma z - w}{\hat{b}(2+e)} dz + \int_{z^*}^{\tilde{z}} \delta \frac{\hat{a} - \delta R - \delta R\gamma z - w}{2\hat{b}} dz + \int_0^{z^*} \Phi R(1+\gamma z) dz. \tag{23}$$

Let us now turn to the case where $z_c < z^* < \tilde{z}$. From (1), (2), (10), (20) and Assumptions 2 and 3, the equilibrium on the capital market becomes

$$K^T = \int_0^{z_c} \delta \frac{\hat{a} - \delta R - \delta R\gamma z - w}{\hat{b}(2+e)} dz + \int_{z_c}^{z^*} \delta \frac{\hat{a} - w(1+\theta)}{\hat{b}(1+e)(2-e)} dz + \int_{z^*}^{\tilde{z}} \frac{\hat{a} - \delta R - \delta R\gamma z - w}{2\hat{b}} dz + \int_0^{z^*} \Phi R(1+\gamma z) dz. \tag{24}$$

We finally consider the case where $z^* > \tilde{z}$. The equilibrium on the capital market is

$$K^T = \int_0^{z_c} \delta \frac{\hat{a} - \delta R - \delta R\gamma z - w}{\hat{b}(2+e)} dz + \int_{z_c}^{\tilde{z}} \delta \frac{\hat{a} - w(1+\theta)}{\hat{b}(1+e)(2-e)} dz + \int_0^{z^*} \Phi R(1+\gamma z) dz. \tag{25}$$

In each of the three cases defined above, we can show that, for sufficiently low values of Φ,

$$\frac{dK^T}{dw} = \frac{\partial K^T}{\partial w} + \frac{\partial K^T}{\partial R} \frac{dR}{dw} < 0. \tag{26}$$

The proof of (26) is given in the Appendix A. As in the monopoly case, an increase in the wage rate w induces a decrease in K^T for two reasons. First, a rise in w implies a reduction in the demand for labor. Because labor and capital are technically complementary, the demand for capital also decreases. Second, (3) indicates that an increase in w implies a rise in R to maintain the value of $\tilde{z}$. This also results in a fall in the capital demand.

Similarly, calculating the total differential of K^T with respect to $\tilde{z}$ in each cases, we obtain

$$\frac{dK^T}{d\tilde{z}} = \frac{\partial K^T}{\partial \tilde{z}} + \frac{\partial K^T}{\partial R} \frac{dR}{d\tilde{z}} > 0. \tag{27}$$

The proof of (27) is given in the Appendix A. As in the monopoly case, (27) indicates that when $\tilde{z}$ increases, K^T also increases. The rationale for this result is as follows. First, a rise in the threshold $\tilde{z}$ indicates that more sectors invest in capital. Second, according to (3), an increase in $\tilde{z}$ results in a reduction in R at a given wage w, thus raising the demand for capital from capacity-user sectors.

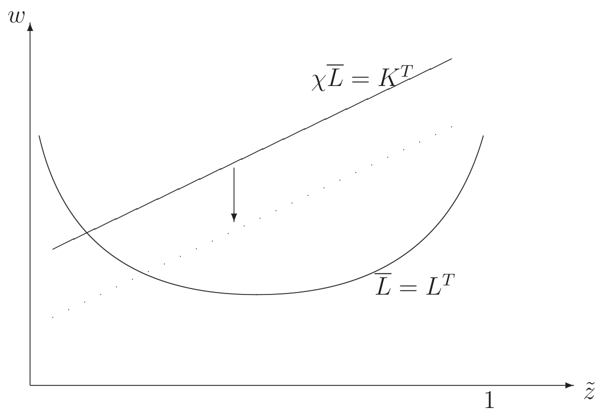

Fig. 5. Effects of an increase in household capital endowment.

4.4. Labor market equilibrium

We now turn to the labor market equilibrium. We denote L^T the labor demand. As in the previous section, we consider the three following cases.

When $z^* < z_c$, based on (1), (2), (10), (20) and Assumption 2, the equilibrium on the labor market is as follows

$$L^T = \int_0^{z^*} \frac{\hat{a} - \delta R - \delta R\gamma z - w}{\hat{b}(2+e)} dz + \int_{z^*}^{\tilde{z}} \frac{\hat{a} - \delta R - \delta R\gamma z - w}{2\hat{b}} dz + \int_{\tilde{z}}^{1} (1+\theta)\frac{\hat{a} - w(1+\theta)}{2\hat{b}} dz. \tag{28}$$

In the case where $z_c < z^* < \tilde{z}$, the equilibrium on the labor market becomes

$$L^T = \int_0^{z_c} \frac{\hat{a} - \delta R - \delta R\gamma z - w}{\hat{b}(2+e)} dz + \int_{z_c}^{z^*} \frac{\hat{a} - w(1+\theta)}{\hat{b}(1+e)(2-e)} dz + \int_{z^*}^{\tilde{z}} \frac{\hat{a} - \delta R - \delta R\gamma z - w}{2\hat{b}} dz + \int_{\tilde{z}}^{1} (1+\theta)\frac{\hat{a} - w(1+\theta)}{2\hat{b}} dz. \tag{29}$$

When $z^* > \tilde{z}$, the equilibrium on the labor market is

$$L^T = \int_0^{z_c} \frac{\hat{a} - \delta R - \delta R\gamma z - w}{\hat{b}(2+e)} dz + \int_{z_c}^{\tilde{z}} \frac{\hat{a} - w(1+\theta)}{2(1+e)(2-e)} dz + \int_0^{z^*} (1+\theta)\frac{(\hat{a} - w(1+\theta))}{\hat{b}(1+e)(2-e)} + \int_{z^*}^{1} (1+\theta)\frac{(\hat{a} - w(1+\theta))}{2\hat{b}} dz. \tag{30}$$

In each of the three cases defined above, calculating the total differential of L^T with respect to w, we obtain

$$\frac{dL^T}{dw} = \frac{\partial L^T}{\partial w} + \frac{\partial L^T}{\partial R}\frac{dR}{dw} < 0. \tag{31}$$

The proof of (31) is given in the Appendix A. The sign of $\frac{dL^T}{dw}$ is the same as in the monopoly case. First, a rise in w obviously implies a reduction in the demand for labor. Second, according to (3) a rise in w implies an increase in R to maintain the value of $\tilde{z}$. This induces a fall in the demand for capital and, because both factors are technically complementary, in the demand for labor.

Calculating the total differential of L^T with respect to $\tilde{z}$ in each case, we obtain

$$\frac{dL^T}{d\tilde{z}} = \frac{\partial L^T}{\partial \tilde{z}} + \frac{\partial L^T}{\partial R}\frac{dR}{d\tilde{z}}. \tag{32}$$

The sign of (32), studied in the Appendix A, is ambiguous. First, when $\tilde{z}$ increases, more sectors invest in capacities, which induces a decline in the demand for labor. According to the second effect, an increase in $\tilde{z}$ results in a fall in R at a given wage w (see (3)). This decreases investing sectors' production cost and increases their demand for labor. When $\tilde{z}$ is close to 0, few sectors have invested in capacities and the second effect is weak. The first effect thus dominates and $\frac{dL^T}{d\tilde{z}} < 0$. When $\tilde{z}$ is close to 1, nearly all sectors are already capacity-users. Consequently, the first effect vanishes and the second one prevails such that $\frac{dL^T}{d\tilde{z}} > 0$.

Finally, the equilibrium in the monopoly case can be summarized in the same way as in Fig. 2. The equilibrium on the capital market is represented by an increasing curve, whereas the equilibrium on the labor market is represented by a convex curve.

4.5. Comparative statics

We now conduct some comparative statics investigations. We first examine the effect of a decrease in the household capital endowment on the number of capacity-user sectors and Cournot sectors. We then study the effect of the capital cost and the labor cost on the extensive and intensive margins of trade.

4.5.1. Effects of the household capital endowment on the number of capacity-user sectors and the number of Cournot sectors

We first investigate the impact of an increase in the household capital endowment χ on $\tilde{z}$. As depicted in Fig. (5), an increase in χ shifts the capital market equilibrium locus downwards. If the intersection of the capital market equilibrium and the labor market equilibrium loci is on the downward-slope of the labor market equilibrium locus, this implies a decrease in w and an increase in $\tilde{z}$. Using (3), this pattern unambiguously leads to a fall in R. Because the factor remunerations move in the same direction, labor and capital can be considered as general-equilibrium complement. However, if the intersection of the capital market equilibrium and the labor market equilibrium loci is on the upward-slope of the labor market equilibrium locus, this induces a decrease in w and $\tilde{z}$. Using (3), the effect on R is ambiguous.

This yields the following proposition:

Proposition 5.

(a) The threshold $\tilde{z}$ is increasing in χ if and only if labor and capital are general-equilibrium complement.
(b) The labor cost w is decreasing in χ.

Turning to the effect of the household capital endowment χ on z_c, the result is less clear-cut. Indeed, we have

$$\frac{dz_c}{d\chi} = \frac{\partial z_c}{\partial w}\frac{dw}{d\chi} + \frac{\partial z_c}{\partial \tilde{z}}\frac{d\tilde{z}}{d\chi}. \tag{33}$$

As indicated in Proposition 1, $\frac{\partial z_c}{\partial w} > 0$ and $\frac{\partial z_c}{\partial \tilde{z}} > 0$. From Proposition 5, we also have $\frac{d\tilde{z}}{d\chi} > 0$. Moreover, if labor and capital are general-equilibrium complement, $\frac{dw}{d\chi} < 0$. As a consequence, the sign of $\frac{dz_c}{d\chi}$ is ambiguous. The second term of (33) indicates that when the household capital endowment increases, more sectors invest in production capacities. For this reason, they can more easily behave as in a Cournot equilibrium. However, the first term of (33) indicates that this effect is undermined by a decrease in the labor cost, which reduces sectors' investment in production capacities and their ability to engage in Cournot behavior.

4.5.2. Effects of the capital cost and the labor cost on the extensive margin of trade

Investigating the effect of w and R on the extensive margin, we obtain the following proposition:

Proposition 6.

(a) The extensive margin of trade z^* is decreasing in w.
(b) The extensive margin of trade z^* is decreasing in R. A larger γ indicates a lower (in absolute value) effect on z^*. A higher initial number of trading sectors indicates a greater (in absolute value) effect on z^*.

The proof of Proposition 6 is given in the Appendix A.

According to Part (a) of Proposition 6, firms' export decision depends on the cost of labor. When w increases, one observes a decrease in the demand for labor and capital, such that there are fewer capacity-user sectors. Consequently, fewer sectors export.

More notably, Part (b) states that an increase in the cost of external finance also affects export decisions. In our model, the consequences of a raise in R on export decision are twofold. First, in accordance with the standard argument developed in the literature on finance and trade, it raises the financial cost of export because it becomes more expensive to finance fixed export costs. Second, it also increases the cost of investment in production capacities, thus reducing firms' ability to engage in a more profitable duopoly (Cournot or Quasi-Bertrand) pricing schemes (decrease in z_c and $\tilde{z}$). Finally, its becomes less profitable to export.

When γ is large, i.e., when the financial system becomes less developed, the negative effect of R on the extensive margin becomes weaker in absolute value. The rationale for this somewhat counter-intuitive effect is as follows. Consequently to an increase in R, the sectors that still export are, on average, less financially constrained and have, on average, better financial conditions than the sectors that exported before the shock. This undermines the initial rise in R. Because a weaker financial constraint reduces the cost of capital more strongly when the financial system is weakly developed, this countervailing effect is stronger when γ is high.

Moreover, a rise in the cost of capital reduces the extensive margin of trade more when the initial number of trading sectors is large. As explained above, when firms make their decision to export, two effects are in play. On the one hand, a financial shock raises the financial cost of exporting. On the other hand, due to a rise in the cost of external finance, firms have a weaker incentive to invest in production capacities. This makes it more difficult for them to engage in a highly profitable pricing scheme. Taken together, these effects reduce firms' probability to export.

Let us now explain why the strength of this effect depends on the number of exporting sectors. Three cases can be considered. Let us first consider the case where few sectors export, i.e., where the marginal sector, z^*, is a Cournot sector. When a financial shock is observed, a certain reduction in z^* is necessary to balance the increase in R and maintain the equality between the financial cost of exporting and the duopoly profit (see (22)). Because this balancing effect goes through both a reduction in the cost of capital and an increase in the duopoly profit, the decline in financial constraint that is necessary to maintain (22) does not need to be very large.

Let us now consider the Quasi-Bertrand sectors. They incur a marginal cost $c^K(z)$ but set the price and quantity according to the marginal cost c^L such that their profit is less sensitive to financial constraint than in the Cournot case. Hence, when an intermediate number of sectors export, i.e. when the marginal sector is a Quasi-Bertrand sector, the reduction in z^* that allows them to maintain equality (22) has to be larger than when only Cournot sectors export. Let us finally turn to the Bertrand sectors. Because their profit does not depend on the cost of capital, the entire balancing effect mentioned above goes through the export cost channel. Consequently, when a large number of sectors export, i.e. when the marginal sector is a Bertrand sector, the reduction in financial constraint that is necessary to maintain equality (22) is larger than when z^* is a Cournot or a Quasi-Bertrand sector. Overall, this result notably suggests that the effect of a financial crisis on a country's exports crucially depends on its trading pattern before the crisis. Having a large number of exporting sectors makes a country more sensitive in terms of the extensive margin.

4.5.3. Effects of the capital cost and the labor cost on the intensive margin of trade

We now turn to the effect of the capital cost and the labor cost on the intensive margin of trade. Studying the effect of w and R on q^C, q^{QB} and q^B respectively, we obtain the following proposition:

Proposition 7.

(a) The intensive margin of trade is decreasing in w.
(b) The intensive margin of trade is decreasing in R. As γ becomes larger, so does the average effect on the intensive margin (in absolute value). As the initial number of trading sectors becomes greater, the average effect on the intensive margin becomes smaller (in absolute value).

The proof of Proposition 7 is given in the Appendix A. Proposition 7 states that exported quantities decrease when the cost of labor and the cost of capital increase. If we consider that an increase in the cost of capital can be triggered by a financial crisis, Part (b) of Proposition 6 is consistent with the empirical literature on the harmful effects of financial crisis on the intensive margin of trade. Relying on monthly US import data over the period 2006–2008, Chor and Manova (2012) show that countries that are effected by global credit tightening measured by high interbank rates export less to the US, particularly in sectors that are highly reliant on external financing. This effect was amplified during the 2008 financial crisis. This result is corroborated by Bricongne et al. (2010) regarding France over the period 2000–2009. They demonstrate that financially dependent firms exhibit a lower export growth rate, particularly during a banking crisis. It is also corroborated by Berman et al. (2012), who rely on a sample of French exporting firms over the period 1995–2005. They establish that firms reduce their exports when the destination country is affected by a financial crisis, and this effect is more pronounced when the time-to-ship is long. Finally, as underlined by Iacovone and Zavacka (2009), these patterns are not specific to the recent financial crisis. Based on a data set of developing and developed countries covering a total of 23 banking crises between 1980 and 2006, they conclude that banking crises amplify the adverse effect of external financial dependence on sectors' export growth rates.

Proposition 7 also indicates that the sensitivity of export quantities to a rise in R is amplified when γ is high. The intuition for this result is straightforward: when the financial system is weakly developed, the increase in R more strongly affects the cost of capital. This means that a country is better hedged against a reduction in export quantities due to a financial shock if its financial system is highly developed.

Another innovating result of Proposition 7 is that the harmful effect of a financial shock on the intensive margin of trade is, on average, weaker when the initial number of trading sectors is high. This result is based on the fact that the three types of sectors are not affected similarly by a financial shock. Because Bertrand sectors do not invest in capacity, their production and export are not affected by an increase in the cost of capital. Similarly, although they invest in capacity, Quasi-Bertrand firms behave as if they had incurred a marginal cost of c^L rather than $c^K(z)$. For this reason, their production and export are also unchanged when the cost of capital is increased. Finally, because they invest in capacity and set their price according to the marginal cost $c^K(z)$, Cournot firms' production and export are highly sensitive to a financial shock. Hence, when trading sectors include Bertrand and/or Quasi-Bertrand firms, the average effect of a financial shock on exports is lower than when only Cournot firms export.

5. Discussion

In this section, we discuss our results. We first consider the implications of assuming that the cost of producing above capacity depends on the level of financial constraint. We then consider what would happen if we relaxed the assumption of perfect labor mobility across sectors. Finally, we examine the implications of differences in labor supply across countries.

5.1. The cost of producing above capacity as a function of z

The key assumption of the model is that the cost of external capital depends on z. Let us now examine what happens if θ also depends on z. For example, let us assume that more financially constrained sectors face a higher penalty of producing above capacity: $\theta = \theta(z)$ with $\theta\prime(z) > 0$. This assumption is consistent with the literature on the financial determinants of the labor demand, which considers that financial constraints induced by information asymmetries make firms' labor demand dependent on their balance-sheet position (Greenwald and Stiglitz, 1993; Sharpe, 1994; Arnold, 2002).

We can show that this assumption introduces useless heaviness in the model without significantly affecting our main findings. If, for example, $\theta = \theta_0 + \theta_1 z$ with $\theta_1 > 0$, (3) becomes

$$\tilde{z} \equiv \frac{\theta_0 w - \delta R}{R\gamma\delta - \theta_1 w}.$$

Because we still have $\frac{dR}{dw} > 0$ and $\frac{dR}{d\tilde{z}} < 0$, the determination of capital and labor market equilibria is not qualitatively affected. Hence, Proposition 1 is unchanged.

Let us now consider the implications for firms' profit and the extensive and intensive margins of trade (Propositions 2 and 4). On the one hand, because they do not depend on θ, exported quantities and profit in Cournot sectors are unchanged. Hence, if the marginal sector $z*$ is a Cournot sector, the expressions for the extensive and intensive margins of trade are not affected. On the other hand, in Bertrand and Quasi-Bertrand sectors, exported quantities and the difference between the price and the marginal cost decrease with z. As a consequence, on Fig. 4, the slope of the Quasi-Bertrand profit curve is steeper than when θ does not depend on z. For the same reason, the profit of Bertrand sectors is decreasing with z (rather than constant). Hence, if z^* is a Quasi-Bertrand or a Bertrand sector, the extensive margin of trade is weaker than when θ does not depend on z. Moreover, as mentioned above, the intensive margin of trade is decreasing with z. Finally, these results indicate that when the cost of producing above capacity is an increasing function of z, the expressions for the extensive and intensive margins of trade are partially modified. However, these changes do not qualitatively affect our key results regarding the role of firms' competitive behavior in the transmission channel of financial shocks.

5.2. Relaxing the assumption of perfect labor mobility across sectors

Let us now turn to the assumption of perfect labor mobility across sectors. Relaxing this assumption induces differences in wage rate across sectors, thus making the model more complex. To understand why, let us assume that there exists a linear relationship between w and $z : w = w_0 + w_1 z$. Solving the model based on this assumption, we can show that capital and labor market equilibria (which crucially depend on the fact that $\frac{dR}{d\tilde{z}} < 0$) are not affected only if $w_1 < 0$. However, it is not straightforward to make the assumption that the wage rate is decreasing with z. Alternatively, this relationship could be endogenously generated by the model; however, this would require a different (and more involved) theoretical framework. Hence, the assumption that labor is perfectly mobile across sectors obviously simplifies calculations.

5.3. Differences in labor endowment across countries

Let us now assume that there exist differences in labor supply across countries, the economy with a low labor endowment being denoted as "the small economy" and the economy with a large labor endowment "the large economy". The key question is to determine which one of these economies is the most strongly affected by a financial shock. However, this issue is not straightforward.

From Proposition 6, we know that z^* is decreasing with w and that a large z^* indicates a greater (in absolute value) effect of a financial shock on the extensive margin. However, Fig. 2 indicates that, by shifting the labor market equilibrium and the capital market equilibrium loci downwards, a larger $\bar{L}$ would induce *either* a rise *or* a decrease in w.[6] Hence, the final impact of the labor endowment on w is ambiguous.

Moreover, allowing for differences in labor endowment would imply different z^* in both economies, thus yielding asymmetric duopoly configurations in which, for example, Cournot sectors (in one economy) would compete with Cournot and Quasi-Bertrand sectors (in the other one), or Cournot and Quasi-Bertrand sectors (in one economy) would compete with Cournot, Quasi-Bertrand and Bertrand sectors (in the other one). Hence the number of cases to be considered to solve the model would be significantly increased.

Taken together, these arguments suggest that allowing for differences in labor supply across countries would make the model much more complex without crucially enriching our key results.

6. Conclusion

The goal of this paper was to introduce the notion of financial constraint in a trade model with an endogenous mode of competition to explore the relationship between finance, investment and trade. Our main result is that firms' competitive behavior is crucial to analyzing the effect of financial factors on firms' production capacity decision and export behavior. We find that sector-level financial constraint not only increases firms' financial cost of export but also increases the cost of investing in capacities, thus reducing firms' ability to engage in a (highly profitable) Cournot pricing scheme. This finally decreases firms' incentive to export. This effect is stronger when the level of financial development is weak. We also emphasize a new transmission channel of financial

[6] Fig. 2, however, suggests that the case where a larger $\bar{L}$ implies a *decrease* in w is the most likely.

shocks that is crucially tied to firms' decision process to invest in production capacity and ultimately affects firms' export performance. By increasing the cost of external finance, a financial shock reduces firms' production capacities and exports (intensive margin). By making it more difficult to engage in Cournot pricing behavior, it also reduces firms' duopoly profit and probability of exporting (extensive margin). Finally, although the literature usually addresses the effect of financial factors on investment and trade separately, our model provides a comprehensive set-up that accounts for the reduction in firms' investment and exports due to an international financial crisis.

Our article undoubtedly calls for further investigations. First, in line with Besedes and Lugovskyy (2014) and Kohn et al. (2015), it would be interesting to extend our model in a dynamic framework with an endogenous financial constraint. We could explore how the strength of financial constraints is affected by past exporting experience and determines the extent to which firms' investment and export behavior are subject to some type of hysteresis. Our approach could also be fruitfully enriched by examining the effect of trade and financial reforms on firms' export performance. We could notably investigate how both types of reforms interact and whether they are complementary (i.e., the implementation of one increases the effectiveness of the other) or substitute (i.e., the implementation of one decreases the effectiveness of the other). Such a development could allow us to formulate useful policy recommendations concerning the bundling of both (trade and financial) reforms.

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Appendix A

A.1. Proof of (6)

Let us issue a reminder from (5) that the consumer's subutility derived from consumption of the good produced by sector z is

$$u\{x(z)\} = ax(z) - \frac{b}{2}x(z)^2$$

with $a > 0$ and $b > 0$.

Let I be a consumer's income. His budget constraint is

$$\int_0^1 p(z)x(z)dz = I. \tag{34}$$

Introducing (5) in (4) and maximizing the resulting expression under (34) yields

$$x(z) = \frac{a}{b} - \frac{\lambda}{b}p(z)$$

with λ being a Lagrange multiplier. Denoting μ_1^p and μ_2^p the first and second moments of the distribution of prices respectively, we see that λ, the household's marginal utility of income, is defined by

$$\lambda = \frac{\alpha\mu_1^p - I}{\beta\mu_2^p}$$

with $\alpha = \frac{a}{b}$ and $\beta = \frac{1}{b}$. Summing all households, we find

$$p(z) = \hat{a} - \hat{b}q(z)$$

with $\hat{a} = \frac{a}{\lambda}$ and $\hat{b} = \frac{b}{\lambda L}$.

A.2. Proof of (8)

Let us issue a reminder from (7) that in the duopoly case, the consumer's subutility derived from consumption of the goods produced by sector z is

$$u\{x(z)\} = a(x_1(z) + x_2(z)) - \frac{b}{2}\left(x_1(z)^2 + x_2(z)^2 + 2ex_1(z)x_2(z)\right)$$

with $a > 0, b > 0$ and $0 < e < 1$. The consumer's budget constraint is now

$$\int_0^1 (p_1(z)x_1(z) + p_2(z)x_2(z))dz = I. \tag{35}$$

Introducing (7) in (4) and maximizing the resulting expression under (35) yields

$$x_i(z) = \frac{a}{b(1+e)} - \frac{\lambda}{b(1-e^2)}(p_i(z) - p_j(z)e)$$

with $i \neq j$. It is easy to show that

$$\lambda = \frac{\alpha\mu_1^p - I}{\beta(\mu_2^p - e\nu^p)}$$

with $\alpha = \frac{a}{b(1+e)}, \beta = \frac{1}{b(1-e^2)}, \mu_1^p = \int_0^1 (p_1(z) + p_2(z))dz, \mu_2^p = \int_0^1 (p_1(z)^2 + p_2(z)^2)dz$ and $\nu^p = 2\int_0^1 p_1(z)p_2(z)dz$. Summing all households, we obtain the consumers' inverse demand function:

$$p_i(z) = \hat{a} - \hat{b}\left(q_i(z) + eq_j(z)\right)$$

with $\hat{a} = \frac{a}{\lambda}$ and $\hat{b} = \frac{b}{\lambda L}$. For convenience, in the rest of the paper, we choose the households' marginal utility of income as a numeraire, such that $\lambda = 1$.

A.3. Proof of (13)

From (12), it is straightforward that $\frac{\partial K^A}{\partial w} = -\frac{\delta}{2\hat{b}}\tilde{z} < 0$ and $\frac{\partial K^A}{\partial R} = -\frac{\delta^2}{2\hat{b}}(\tilde{z} + \frac{1}{2}\gamma\tilde{z}^2) < 0$. From (3), we have $\frac{dR}{dw} = \frac{\theta}{\delta(1+\gamma\tilde{z})} > 0$. Hence, we obtain $\frac{dK^A}{dw} = \frac{\partial K^A}{\partial w} + \frac{\partial K^A}{\partial R}\frac{dR}{dw} < 0$.

A.4. Proof of (14)

From (12), we have $\frac{\partial K^A}{\partial \tilde{z}} = \frac{\delta}{2\hat{b}}(\hat{a} - w - \delta R - \delta\gamma\tilde{z})$. Using (1), (10) and Assumption 2, this gives $\frac{\partial K^A}{\partial \tilde{z}} = \delta q^A(c^K(\tilde{z})) > 0$ and $\frac{\partial K^A}{\partial R} = -\frac{\delta^2}{2\hat{b}}(\tilde{z} + \frac{1}{2}\gamma\tilde{z}^2) < 0$. From (3), we also have $\frac{dR}{d\tilde{z}} = -\frac{w\theta\gamma}{\delta(1+\gamma\tilde{z})^2} < 0$. Consequently, $\frac{dK^A}{d\tilde{z}} = \frac{\partial K^A}{\partial \tilde{z}} + \frac{\partial K^A}{\partial R}\frac{dR}{d\tilde{z}} > 0$.

A.5. Proof of (17)

From (16), we get $\frac{\partial L^A}{\partial w} = \frac{1}{2\hat{b}}(-\tilde{z} - (1+\theta)^2 + (1+\theta)^2\tilde{z}) < 0$, $\frac{\partial L^A}{\partial R} = -\frac{\delta}{2\hat{b}}(\tilde{z} + \frac{1}{2}\gamma^2\tilde{z}^2) < 0$ and $\frac{dR}{dw} = \frac{\theta}{\delta(1+\gamma\tilde{z})} > 0$. Hence, we obtain $\frac{dL^A}{dw} = \frac{\partial L^A}{\partial w} + \frac{\partial L^A}{\partial R}\frac{dR}{dw} < 0$.

A.6. Proof of (18)

From (16), we have $\frac{\partial L^A}{\partial \tilde{z}} = \frac{1}{2\hat{b}}(\hat{a} - w - \delta R - \delta\gamma R - (1+\theta)\hat{a} + w(1+\theta)^2)$. Using (1), (2), (10) and Assumption 2, this yields $\frac{\partial L^A}{\partial \tilde{z}} = q^A(c_K(\tilde{z})) - (1+\theta)q^A(c_L)$. According to the definition of $\tilde{z}$

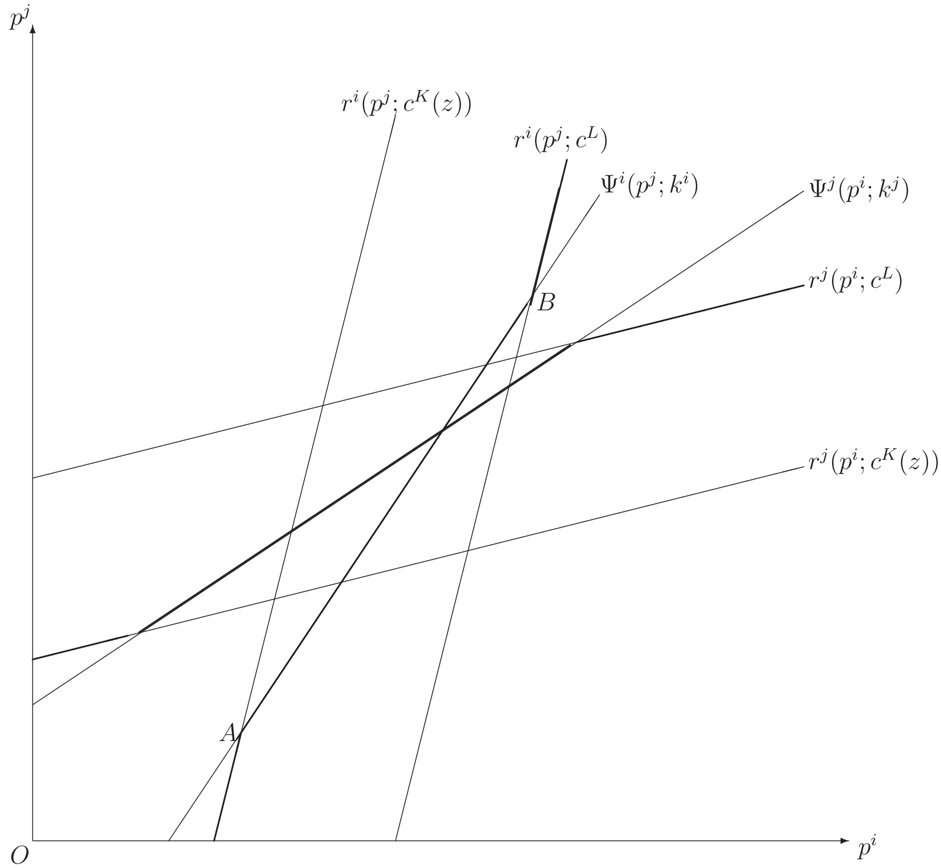

Fig. 6. The price game.

given by (3), this gives $\frac{\partial L^A}{\partial \tilde{z}} = -\theta q^A(c_L) < 0$. From (16), we also have $\frac{\partial L^A}{\partial R} = -\frac{\delta}{2b}(\tilde{z} + \frac{1}{2}\gamma^2\tilde{z}^2) < 0$. Finally, we know that $\frac{dR}{d\tilde{z}} = -\frac{w\theta\gamma}{\delta(1+\gamma\tilde{z})^2} < 0$. Consequently, the sign of $\frac{dL^A}{d\tilde{z}} = \frac{\partial L^A}{\partial \tilde{z}} + \frac{\partial L^A}{\partial R}\frac{dR}{d\tilde{z}}$ is ambiguous.

A.7. Proof of (19)

As a reminder, for all firms $z < \tilde{z}$, the unit cost is $c^K(z)$ and the marginal cost is c^L, with $c^K(z) < c^L$.

Let us first assume that both firms i and j (with $i \neq j$), have installed production capacities equal to k^i and k^j respectively, in the second stage of the game. Fig. 6 describes the price game in sector z. A $r^i(p^j; x)$ function corresponds to the price p^i which maximizes firm i's profit π^i, given its marginal cost x, for all prices p^j that the other firm j can implement: these functions correspond to well-known Bertrand reaction functions. In Fig. 6, they are drawn for two marginal costs c^L and $c^K(z)$. Let us now explain what a $\Psi^i(.)$ function is. Consider that in the second stage of the game, firm i has selected a production capacity k^i. In the third stage, firm j sets a price p^j. The $\Psi^i(.)$ function simply indicates the price p^i which ensures that the demand is just equal to the production capacity installed at the previous stage, given the price set by the other firm. It is easy to show, following Maggi (1999), that in the (p^i, p^j) quadrant, Ψ^i is increasing and less sloping than r^i and that Ψ^j is increasing and more sloping than r^j. It is also noteworthy that on the left side of, for example, Ψ^i, p^i is relatively low such that the demand addressed to firm i is relatively high (above capacity) and the marginal cost of production is c^L. On the right side of Ψ^i, p^i is relatively high such that the demand addressed to firm i is relatively low (under capacity) and the marginal cost of production is $c^K(z)$. With these elements in mind, let us now study price reaction functions. When price p^j is under A, firm i's price reaction is $r^i(p^j; c^K(z))$. When p^j lies between A and B, firm i's price reaction is $\Psi^i(p^j; k^i)$. Finally, when p^j lies above B, firm i's price reaction is $r^i(p^j; c^L)$. The reasoning is symmetrical for firm j. Finally, we obtain the price reaction functions which are drawn with a thick line in Fig. 6. Let us now consider what happens when production capacities vary. In Fig. 7, firm i (respectively firm j) considers three production capacities installed in stage 2: k_1^i (resp. k_1^j), k_C^i (resp. k_C^j), or k_2^i (resp. k_2^j). It is noteworthy that Ψ-functions corresponding to k_1^i (resp. k_1^j) and k_2^i (resp. k_2^j) pass through D, the intersection of $r^i(p^j; c^K(z))$ and $r^j(p^i; c^K(z))$, and E, the intersection of $r^i(p^j; c^L)$ and $r^j(p^i; c^L)$. We may also take notice that $k_1^i > k_C^i > k_2^i$ (resp. $k_1^j > k_C^j > k_2^j$). Indeed, concerning firm i, let us move vertically down the Ψ-functions corresponding to these three production capacities, i.e., $\Psi^i(p^j; k_1^i), \Psi^i(p^j; k_C^i)$ and $\Psi^i(p^j; k_2^i)$. Along this downwards motion, p^i is constant whereas p^j decreases such that the demand addressed to firm j increases, and the demand addressed to firm i decreases. Hence, $k_1^i > k_C^i > k_2^i$. Likewise $k_1^j > k_C^j > k_2^j$. We can show that the production capacities that firm i (respectively firm j) has to consider are those in the interval $[k_2^i; k_1^i]$ (respectively $[k_2^j; k_1^j]$). First it is clear that the game is symmetrical such that the solution is on the bisector. Second, suppose that the firms install a production capacity lower than k_2^i and k_2^j respectively. Hence, according to Fig. 7, the Nash equilibrium of the price game, which lies at the intersection of the firms' reaction functions, is at point E. At this point, there is not enough production capacity

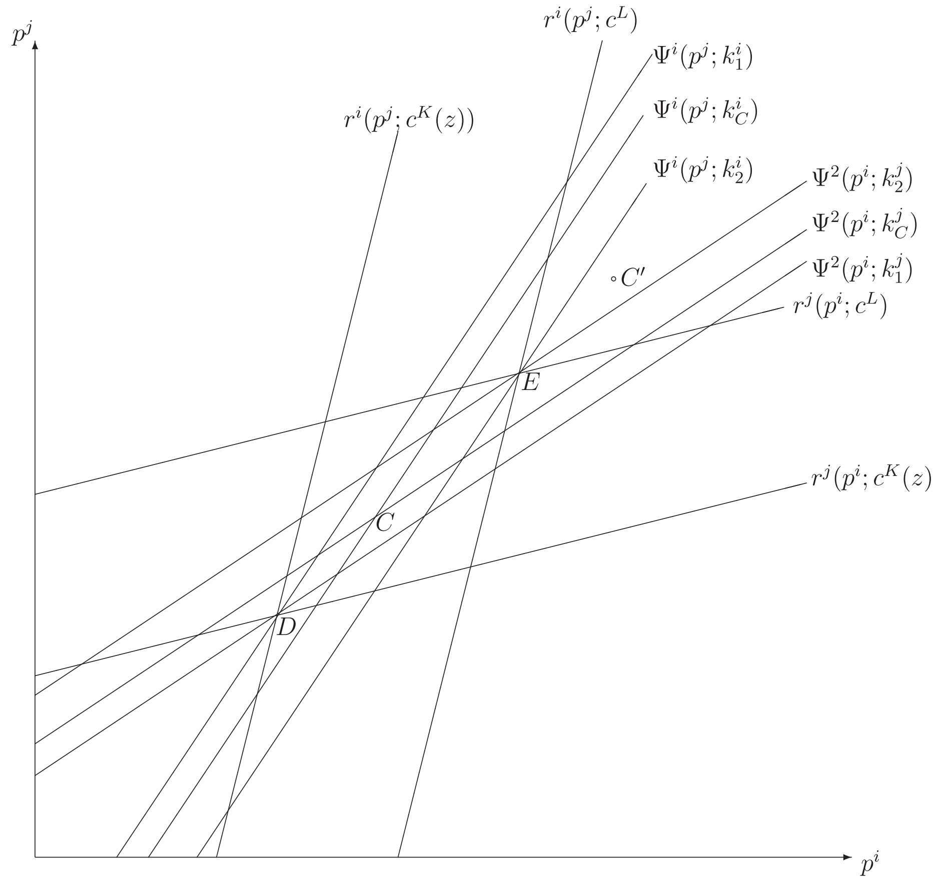

Fig. 7. The full game.

to satisfy the demand and firms are obliged to produce above capacity, at marginal cost c^L, while $c^L > c^K(z)$.[7] The cost is not minimized. Third, suppose that both firms install a production capacity greater than k_1^i and k_1^j respectively. In this case, the Nash equilibrium of the price game is at point D. At this point, the production capacity is too high because the demand addressed to both firms is lower than the production capacity: these are wasted capacities, and profit is not maximized. Taken together, these elements indicate that the full game equilibrium lies somewhere between D and E on the bisector.

Finally, let us show that the Nash equilibrium locus crucially depends on whether $p^B(c^L) > p^C(c^K(z))$ or $p^B(c^L) < p^C(c^K(z))$. We know that $p^B(c^K(z)) < p^C(c^K(z))$. Let us first suppose that $p^B(c^L) > p^C(c^K(z))$. It indicates that the Cournot benchmark lies somewhere between D and E on the bisector (illustrated in Fig. 7 by point C). Because it is at the intersection of the firms reaction functions induced by production capacities $\Psi^i(p^j; k_C^i)$ and $\Psi^j(p^i; k_C^j)$, it is also the full game equilibrium. It indicates that at stage 2, firms install production capacities k_C^i and k_C^j. Once these capacities are installed (which is an irreversible decision), both firms propose prices $p^C(c^K(z))$ such that demands are strictly equal to capacities. Profits are maximized and are equivalent to a Cournot benchmark, where firms select quantities to maximize profit. The intuition behind this situation is that it is not profitable for firms to deviate from C by reducing their respective price. If they did, they would trigger an increase in consumers' demand above the level of their production capacities. The extra cost they would incur to produce above capacity would be too large compared to their marginal revenue. Their profit would thus decrease. The commitment device described above is effective: because the cost of producing above capacity is relatively too large, firms have no incentive to charge a price that is lower than the Cournot price.

Then let us suppose that $p^B(c^L) < p^C(c^K(z))$. In this case, the Cournot benchmark lies on the north-east of point E (point $C\prime$ on Fig. 7). The choice of firm i at stage 2 can be described as follows. Whatever firm j's installed capacity is, firm i's best strategy is to install k_2^i, the smallest capacity that can be envisaged. Consequently, firm i installs production capacity k_2^i and similarly firm j installs production capacity k_2^j. The full game equilibrium is in E. The intuition behind this situation is as follows. Cournot capacities cannot be installed because firms know that at the third stage, they can increase their profit by decreasing their price under a Cournot price. Because the price of producing above capacity is relatively low, this deviation increases profit. Consequently, the Cournot benchmark cannot be implemented and the Nash equilibrium is at point E.

A.8. Proof of Proposition 1

(a) Let us assume that $z_c \geqslant \tilde{z}$. It is easy to show that such a situation is not possible. In this case, we would have $r(z_c) \geqslant r(\tilde{z})$, i.e., $\delta r(z_c) + w \geqslant \delta r(\tilde{z}) + w$. According to (3), this gives $\delta r(z_c) + w \geqslant c_L$, i.e., $c_K(z_c) \geqslant c_L$, which yields

[7] To see why the demand addressed in E to firm i is higher than installed capacity, see that E is above the Ψ-function corresponding to the installed capacity. Therefore, for a constant price p^i, the demand addressed in E to firm i corresponds to a higher price p^j and is necessarily greater than installed capacity.

$p^C(c_K(z_c)) \geqslant p^C(c_L)$. Using (21), and by transitivity, this implies $p^C(c_K(z_c)) \geqslant p^B(c_L)$. This contradicts expression (19). Hence $r(z_c) < r(\tilde{z})$.

(b) Introducing (1), (2) and (20) in (19), we obtain

$$\frac{(1-e)\hat{a} + w(1+\theta)}{2-e} = \frac{a + ((1+e)(w + \delta r(z_c)))}{2+e},$$

i.e.,

$$r(z_c) = \frac{(1-e)(2+e)\hat{a} + w(2+e)(1+\theta) - \hat{a}(2-e)}{\delta(1+e)(2-e)} - \frac{w}{\delta}.$$

Let us now denote

$$\Delta^r \equiv \frac{(1-e)(2+e)\hat{a} + w(2+e)(1+\theta) - \hat{a}(2-e)}{\delta(1+e)(2-e)} - \frac{w}{\delta} - r(z_c)$$

with $\Delta^r = 0$. Partial derivatives of Δ^r with respect to $z_c, w, \tilde{z}$ and δ are denoted $\Delta^r_{z_c}$, Δ^r_w, $\Delta^r_{\tilde{z}}$ and Δ^r_δ respectively. Using the implicit function theorem yields $\frac{dz_c}{dw} = -\frac{\Delta^r_w}{\Delta^r_{z_c}}$. We have $\Delta^r_w = \frac{2\theta + \theta e + e^2}{\delta(2-e)(2+e)} > 0$ and $\Delta^r_{z_c} = -\gamma R$. Hence $\frac{dz_c}{dw} > 0$. Using the same approach, we can show that $\frac{dz_c}{d\tilde{z}} > 0$ and $\frac{dz_c}{d\delta} < 0$.

A.9. The sign of (26)

Let us first consider the case where $z^* < z_c$. From (23), we have $\frac{\partial K^T}{\partial w} = -\frac{\delta}{\hat{b}(2+e)} z^* - \frac{\delta}{2\hat{b}} \tilde{z} + \frac{\delta}{2\hat{b}} z^*$. The sign of this expression is negative because $z^* < z_c < \tilde{z}$. Moreover, we have $\frac{\partial K^T}{\partial R} = \frac{\delta}{\hat{b}(2+e)}(-\delta z^* - \frac{1}{2}\delta\gamma z^{*2}) + \frac{\delta}{2\hat{b}}(-\delta\tilde{z} - \frac{1}{2}\delta\gamma\tilde{z}^2 + \delta z^* + \frac{1}{2}\gamma z^{*2}) + \Phi z^* + \frac{1}{2}\Phi\gamma z^{*2}$. Because $z^* < z_c < \tilde{z}$, and for sufficiently low values of Φ, this expression is negative. From (3), we know that $\frac{dR}{dw} > 0$. Finally, we have $\frac{dK^T}{dw} = \frac{\partial K^T}{\partial w} + \frac{\partial K^T}{\partial R}\frac{dR}{dw} < 0$.

We now consider the case where $z_c < z^* < \tilde{z}$. From (24), we have $\frac{\partial K^T}{\partial w} = -\frac{\delta}{\hat{b}(2+e)} z_c - \frac{\delta(1+\theta)}{\hat{b}(1+e)(2-e)} z^* + \frac{\delta(1+\theta)}{\hat{b}(1+e)(2-e)} z_c - \frac{\delta}{2\hat{b}}\tilde{z} + \frac{\delta}{2\hat{b}} z^*$. The sign of this expression is negative because $z_c < z^* < \tilde{z}$. We also have $\frac{\partial K^T}{\partial R} = -\frac{\delta^2}{\hat{b}(2+e)}(z_c + \frac{1}{2}\gamma z_c^2) - \frac{\delta^2}{2\hat{b}}(\tilde{z} + \frac{1}{2}\gamma\tilde{z}^2) + \frac{\delta^2}{2\hat{b}}(z^* + \frac{1}{2}\gamma z^{*2}) + \Phi z^* + \frac{1}{2}\Phi\gamma z^{*2}$. Because $z_c < z^* < \tilde{z}$ and for sufficiently low values of Φ, this expression is negative. Moreover, we know that $\frac{dR}{dw} > 0$. Hence, $\frac{dK^T}{dw} = \frac{\partial K^T}{\partial w} + \frac{\partial K^T}{\partial R}\frac{dR}{dw} < 0$.

Finally, we focus on the case where $z^* > \tilde{z}$. From (25), we have $\frac{\partial K^T}{\partial w} = -\frac{\delta}{\hat{b}(2+e)} z_c - \frac{\delta(1+\theta)}{\hat{b}(1+e)(2-e)}\tilde{z} + \frac{\delta(1+\theta)}{\hat{b}(1+e)(2-e)} z_c$. The sign of this expression is negative because $z_c < \tilde{z}$. Moreover, $\frac{\partial K^T}{\partial R} = -\frac{\delta}{\hat{b}(2+e)}(\delta z_c + \frac{1}{2}\delta\gamma z_c^2) + \Phi z^* + \frac{1}{2}\Phi\gamma z^{*2}$. This expression is negative for sufficient low values of Φ. Since $\frac{dR}{dw} > 0$, we have $\frac{dK^T}{dw} = \frac{\partial K^T}{\partial w} + \frac{\partial K^T}{\partial R}\frac{dR}{dw} < 0$.

A.10. Proof of (27)

In the case where $z^* < z_c$, from (23) we have $\frac{\partial K^T}{\partial \tilde{z}} = \frac{\delta}{2\hat{b}}(\hat{a} - \delta R - \delta\gamma R\tilde{z} - w)$. Using (1), (10) and Assumption 2, we have $\frac{\partial K^T}{\partial \tilde{z}} = \delta q^A(c^K(z)) > 0$. We also know that $\frac{dR}{d\tilde{z}} < 0$ and $\frac{\partial K^T}{\partial R} < 0$. Hence, we have $\frac{dK^T}{d\tilde{z}} = \frac{\partial K^T}{\partial \tilde{z}} + \frac{\partial K^T}{\partial R}\frac{dR}{d\tilde{z}} > 0$.

In the case where $z_c < z^* < \tilde{z}$, from (24) we have $\frac{\partial K^T}{\partial \tilde{z}} = \frac{\delta}{2\hat{b}}(\hat{a} - \delta R - \delta\gamma R\tilde{z} - w)$. Using (1), (20) and Assumption 2, we get $\frac{\partial K^T}{\partial \tilde{z}} = \delta q^C(c^K(z)) > 0$. We also know that $\frac{dR}{d\tilde{z}} < 0$ and $\frac{\partial K^T}{\partial r} < 0$. Hence, $\frac{dK^T}{d\tilde{z}} = \frac{\partial K^T}{\partial \tilde{z}} + \frac{\partial K^T}{\partial R}\frac{dR}{d\tilde{z}} > 0$.

Finally, let us consider the case where $z^* > \tilde{z}$. From (25), we have $\frac{\partial K^T}{\partial \tilde{z}} = \frac{\delta}{\hat{b}(1+e)(2-e)}(\hat{a} - w(1+\theta))$. Using (2), (20) and Assumption 2, we have $\frac{\partial K^T}{\partial \tilde{z}} = \delta q^{QB}(c^L) > 0$. As in both previous cases, we obtain $\frac{dK^T}{d\tilde{z}} = \frac{\partial K^T}{\partial \tilde{z}} + \frac{\partial K^T}{\partial R}\frac{dR}{d\tilde{z}} > 0$.

A.11. Proof of (31)

Let us first consider the case where $z^* < z_c$. From (28), we have $\frac{\partial L^T}{\partial w} = -\frac{1}{\hat{b}(2+e)} z^* - \frac{1}{2\hat{b}}\tilde{z} + \frac{1}{2\hat{b}} z^* - \frac{(1+\theta)^2}{2\hat{b}} + \frac{(1+\theta)^2}{2\hat{b}}\tilde{z}$. The sign of this expression is negative because $z^* < z_c < \tilde{z}$. Moreover, we have $\frac{\partial L^T}{\partial R} = -\frac{\delta}{\hat{b}(2+e)} z^* - \frac{\delta\gamma}{2\hat{b}(2+e)} z^{*2} - \frac{\delta}{2\hat{b}}\tilde{z} - \frac{\delta\gamma R}{4\hat{b}}\tilde{z}^2 + \frac{\delta}{2\hat{b}} z^* + \frac{\delta\gamma R}{4\hat{b}} z^{*2}$. This expression is negative because $z^* < z_c < \tilde{z}$. From (3), we know that $\frac{dR}{dw} > 0$. Finally, we have $\frac{dL^T}{dw} = \frac{\partial L^T}{\partial w} + \frac{\partial L^T}{\partial R}\frac{dR}{dw} < 0$.

We now consider the case where $z_c < z^* < \tilde{z}$. From (29), we have $\frac{\partial L^T}{\partial w} = -\frac{1}{\hat{b}(2+e)} z_c - \frac{(1+\theta)}{\hat{b}(1+e)(2-e)} z^* + \frac{(1+\theta)}{\hat{b}(1+e)(2-e)} z_c - \frac{1}{2\hat{b}}\tilde{z}$ $+ \frac{1}{2\hat{b}} z^* - \frac{(1+\theta)^2}{2\hat{b}} + \frac{(1+\theta)^2}{2\hat{b}}\tilde{z}$. The sign of this expression is negative because $z_c < z^* < \tilde{z}$. We also have $\frac{\partial L^T}{\partial R} = -\frac{\delta}{\hat{b}(2+e)} z_c - \frac{\delta\gamma}{2\hat{b}(2+e)} z_c^2 - \frac{\delta\tilde{z}}{2\hat{b}} - \frac{\delta\gamma}{4\hat{b}}\tilde{z}^2 + \frac{\delta}{2\hat{b}} z^* + \frac{\delta\gamma}{4\hat{b}} z^{*2}$. The sign of this expression is negative because $z_c < z^* < \tilde{z}$. Moreover, we know that $\frac{dR}{dw} > 0$. Hence, $\frac{dL^T}{dw} = \frac{\partial L^T}{\partial w} + \frac{\partial L^T}{\partial R}\frac{dR}{dw} < 0$.

We finally focus on the case where $z^* > \tilde{z}$. From (30), we have $\frac{\partial L^T}{\partial w} = -\frac{1}{\hat{b}(2+e)} z_c - \frac{(1+\theta)}{\hat{b}(1+e)(2-e)}\tilde{z} + \frac{(1+\theta)}{\hat{b}(1+e)(2-e)} z_c - \frac{(1+\theta)^2}{\hat{b}(1+e)(2-e)} z^* + \frac{(1+\theta)^2}{\hat{b}(1+e)(2-e)}\tilde{z} - \frac{(1+\theta)^2}{2\hat{b}} + \frac{(1+\theta)^2}{2\hat{b}} z^*$. Because $z^* > \tilde{z}$, this expression is negative. Moreover, $\frac{\partial L^T}{\partial R} = -\frac{\delta}{\hat{b}(2+e)} z_c - \frac{\delta\gamma}{2\hat{b}(2+e)} z_c^2 > 0$. Because $\frac{dR}{dw} > 0$, we have $\frac{dL^T}{dw} = \frac{\partial L^T}{\partial w} + \frac{\partial L^T}{\partial R}\frac{dR}{dw} < 0$.

A.12. Proof of (32)

In the case where $z^* < z_c$, from (28) we have $\frac{\partial L^T}{\partial \tilde{z}} = q^A(c^K(\tilde{z})) - (1+\theta)q^A(c^L)$. Using (3), we obtain $\frac{\partial L^T}{\partial \tilde{z}} = -\theta q^A(c^L) < 0$. We also know that $\frac{dR}{d\tilde{z}} < 0$ and $\frac{\partial L^T}{\partial R} < 0$. Hence, the sign of $\frac{dL^T}{d\tilde{z}} = \frac{\partial L^T}{\partial \tilde{z}} + \frac{\partial L^T}{\partial R}\frac{dR}{d\tilde{z}}$ is ambiguous.

In the case where $z_c < z^* < \tilde{z}$, from (29) we have $\frac{\partial L^T}{\partial \tilde{z}} = -\theta q^A(c^L) < 0$. Because $\frac{dR}{d\tilde{z}} < 0$ and $\frac{\partial L^T}{\partial R} < 0$, the sign of $\frac{dL^T}{d\tilde{z}} = \frac{\partial L^T}{\partial \tilde{z}} + \frac{\partial L^T}{\partial R}\frac{dR}{d\tilde{z}}$ is ambiguous.

Finally, let us consider the case where $z^* > \tilde{z}$. From (30), we have $\frac{\partial L^T}{\partial \tilde{z}} = -\theta q^B(c^L) < 0$. As in both previous cases, the sign of $\frac{dL^T}{d\tilde{z}} = \frac{\partial L^T}{\partial \tilde{z}} + \frac{\partial L^T}{\partial R}\frac{dR}{d\tilde{z}}$ is ambiguous.

A.13. Proof of Proposition 6

Let us first consider the Cournot case ($z^* < z_c$). From (22), the threshold z^* is defined such that

$$\hat{b}(2+e)^2\Phi R(1+\gamma z^*) = (\hat{a} - \delta R(1+\gamma z^*) - w)^2.$$

Hence, we define Δ^C by

$$\Delta^C \equiv \hat{b}(2+e)^2\Phi R(1+\gamma z^*) - (\hat{a} - \delta R(1+\gamma z^*) - w)^2$$

with $\Delta^C = 0$. The partial derivatives of Δ^C with respect to z^* and R are denoted by $\Delta^C_{z^*}$ and Δ^C_R respectively. According to the implicit function theorem, we have $\frac{dz^*}{dR} = -\frac{\Delta^C_R}{\Delta^C_{z^*}} = -\frac{(1+\gamma z^*)}{R\gamma} < 0$. The absolute value of this expression decreases with γ and increases with z^*, the initial number of exporting sectors. Using the same approach, we can show that $\frac{dz^*}{dw} < 0$.

In the Quasi-Bertrand case ($z_c < z^* < \tilde{z}$), we define Δ^{QB} by

$$\Delta^{QB} \equiv \hat{b}(1+e)(2-e)^2\Phi R(1+\gamma z^*) - (\hat{a} - w(1+\theta))(\hat{a}(1-e) + w(1+\theta) - (2-e)(\delta R(1+\gamma z^*) + w))$$

with $\Delta^{QB} = 0$. The partial derivatives of Δ^{QB} with respect to z^* and R are denoted by $\Delta^{QB}_{z^*}$ and Δ^{QB}_R respectively. We have $\frac{dz^*}{dR} = -\frac{\Delta^{QB}_R}{\Delta^{QB}_{z^*}} = -\frac{(1+\gamma z^*)}{R\gamma} < 0$. As above, the absolute value of this expression decreases with γ and increases with z^*, the initial number of exporting sectors. Using the same approach, we can show that $\frac{dz^*}{dw} < 0$.

Turning to the Bertrand case ($z^* > \tilde{z}$), we define Δ^B as follows

$$\Delta^B \equiv \hat{b}(1+e)(2-e)^2\Phi R(1+\gamma z^*) - (1-e)(\hat{a} - w(1+\theta))^2$$

with $\Delta^B(z^*, R, w) = 0$. Using the same approach as in the Cournot and Quasi-Bertrand cases, we finally show that $\frac{\partial z^*}{\partial R} = -\frac{(1+\gamma z^*)}{R\gamma} < 0$. The absolute value of this expression decreases with γ and increases with z^*, the initial number of exporting sectors. We also have $\frac{dz^*}{dw} < 0$.

A.14. Proof of Proposition 7

In the Cournot case ($z^* < z_c$), the quantity exported by each firm is $q^C(c^K(z)) = \frac{\hat{a}-\delta R(1+\gamma z)-w}{\hat{b}(2+e)}$. Therefore, $\frac{\partial q^C(c^K(z))}{\partial w} < 0$ and $\frac{\partial q^C(c^K(z))}{\partial R} = \frac{-\delta(1+\gamma z)}{\hat{b}(2+e)} < 0$.

In the Quasi-Bertrand case ($z_c < z^* < \tilde{z}$), the quantity exported by each firm is $q^{QB}(c^L) = \frac{\hat{a}-w(1+\theta)}{\hat{b}(2-e)(1+e)}$. Consequently, $\frac{\partial q^{QB}(c^L)}{\partial w} < 0$. Moreover, an increase in R does not change the intensive margin of trade in the Quasi-Bertrand sectors.

In the Bertrand case ($z^* > \tilde{z}$), the quantity exported by each firm is $q^B(c^L) = \frac{\hat{a}-w(1+\theta)}{\hat{b}(2-e)(1+e)}$. Consequently, $\frac{\partial q^B(c^L)}{\partial w} < 0$. Moreover, a rise in R does not change the intensive margin of trade in the Bertrand sectors.

Finally, it is straightforward that the absolute value of $\frac{\partial q^C(c^K(z))}{\partial R} = \frac{-\delta(1+\gamma z)}{\hat{b}(2+e)}$ increases in γ. Hence, the average (negative) effect of R on exported quantities is amplified when γ is large.

Moreover, these results indicate that when R increases, the quantity exported decreases only in Cournot sectors, whereas it is unchanged in the Bertrand and Quasi-Bertrand sectors. For this reason, the effect of a variation of R on all sectors' intensive margin is smaller, on average, when the initial number of exporting sectors is large.

References

Almeida, H., Campello, M., Laranjeira, B., Weisbenner, S., 2012. Corporate debt maturity and the real effects of the 2007 financial crisis. Critical Finance Review 1, 3–58.

Arnold, L., 2002. Financial market imperfections, labour market imperfections and business cycles. Scandinavian Journal of Economics 104, 105–124.

Askenazy, P., Caldera, A., Gaulier, G., Irac, D., 2015. Financial constraints and foreign markets entry or exit: Firm-level evidence from France. Review of World Economics 151, 231–253.

Auboin, M., 2009. Restoring trade finance during a period of financial crisis: Stock-taking of recent initiatives. Staff Working Paper 2009–16.

Auboin, M., 2011. World Trade Organization response to the crisis: A convening power to boost the availability of trade finance. In: Chauffour, J.P., Malouche, M. (Eds.), Trade Finance During the Great Trade Collapse. World Bank, Washington DC.

Bellone, F., Musso, P., Nesta, L., Queré, M., 2006. Caractéristiques et performances des firmes exportatrices françaises. Revue de l'OFCE 98, 183–212.

Bellone, F., Musso, P., Nesta, L., Schiavo, S., 2010. Financial constraints and firm export behaviour. The World Economy 33, 347–373.

Berman, N., Héricourt, J., 2010. Financial factors and the margins of trade: Evidence from cross-country firm-level data. Journal of Development Economics 93, 206–217.

Berman, N., De Sousa, J., Martin, P., Mayer, T., 2012. Time to ship during financial crisis. International Seminar on Macroeconomics 9, 225–260.

Besedes, T., Kim, B., Lugovskyy, V., 2014. Export growth and credit constraints. European Economic Review 70, 350–370.

Bernard, A., Jensen, J., Redding, S., Schott, P., 2007. Firms in international trade. Journal of Economic Perspectives 21, 105–130.

Braun, M., 2003. Financial contractibility and asset hardness. Working Paper, Harvard University.

Bricongne, J.-C., Fontagné, L., Gaultier, G., Taglioni, D., Vicard, V., 2010. Exports and sectoral financial dependence: Evidence on French firms during the great global crisis. ECB Working Paper Series 1227.

Campa, J., Shaver, J., 2002. Exporting and capital investment: On the strategic behaviour of exporters. CIFF Research Paper 469.

Campello, M., Graham, J., Harvey, C., 2010. The real effects of financial constraints: Evidence from a financial crisis. Journal of Financial Economics 97, 470–487.

Campello, M., Giambona, E., Graham, J., Harvey, C., 2011. Liquidity management and corporate investment during a financial crisis. Review of Financial Studies 26, 1944–1979.

Campello, M., Giambona, E., Graham, J., Harvey, C., 2012. Access to liquidity and corporate investment in Europe during the financial crisis. Review of Finance 16, 323–346.

Chaney, T., 2005. Liquidity constrained exporters. NBER Working Paper 19170.

Chor, D., Manova, K., 2012. Off the cliff and back? Credit conditions and international trade during the global financial crisis. Journal of International Economics 87, 117–133.

Claessens, S., Laeven, L., 2003. Financial development, property rights and growth. Journal of Finance 58, 2401–2437.

Duchin, R., Ozbas, O., Sensoy, B., 2010. Costly external finance, corporate investment, and the subprime mortgage financial crisis. Journal of Financial Economics 97, 418–435.

Engel, D., Procher, V., Schmidt, C., 2013. Does firm heterogeneity affect foreign market entry and exit symmetrically? Empirical evidence from French firms. The World Economy 85, 37–47.

Greenwald, B., Stiglitz, J., 1993. Financial market imperfection and business cycles. Quarterly Journal of Economics 108, 74–114.

Iacovone, L., Zavacka, Z., 2009. Banking crises and exports: Lessons from the past. World Bank Policy Research Working Paper 5016.

Kimura, F., Kiyuta, K., 2006. Exports, FDI and productivity: Dynamic evidence from Japanese firms. Review of World Economics 142, 695–719.

Kohn D., Leibovici F., Szkup M., 2015. Financial frictions and new exporters dynamics. Available at SSRN: <http://ssrn.com/abstract=2462970>

Kreps, D., Scheinkman, J., 1983. Quantity precommitment and Bertrand competition yield Cournot outcomes. Bell Journal of Economics 13, 326–337.

Krosner, L., Laeven, R., Klingebiel, D., 2007. Banking crises, financial dependence and growth. Journal of Financial Economics 84, 187–228.

Maggi, J., 1996. Strategic trade policies with endogenous mode of competition. American Economic Review 86, 237–258.

Manova, K., 2008. Credit constraints, equity market liberalization and international trade. Journal of International Economics 76, 33–47.

Manova, K., 2013. Credit constraints, heterogeneous firms, and international trade. Review of Economic Studies 80, 711–744.

Manova, K., Wei, S.-J., Zhang, Z., 2014. Firm exports and multinational activity under credit constraints. Review of Economics and Statistics 97, 574–588.

Melitz, M., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica 71, 1695–1725.

Muûls, M., 2015. Exporters, importers and credit constraints. Journal of International Economics 95, 333–343.

Neary, P., Tharakan, J., 2012. International trade with endogenous mode of competition in general equilibrium. Journal of International Economics 86, 118–132.

Rajan, R., Zingales, L., 1998. Financial dependence and growth. American Economic Review 88, 559–586.

Sharpe, S., 1994. Financial market imperfections, firm leverage and the cyclicity of employment. American Economic Review 84, 1060–1074.