Financial Constraints and International Trade with Endogenous Mode of Competition

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Abstract

The goal of this paper is to examine how financial constraint affects firms' decision to export when the mode of intra-sectoral competition is endogenous. We propose an extension of the Neary and Tharakan's (2012) model, in which firms resort to external funders to finance fixed export costs as well as investment in production capacities. We assume that sectors differ in financial health and that the cost of capital increases with the level of financial vulnerability. We show that less financially vulnerable sectors are more likely to export. On the one hand, a high level of financial health allows firms to finance fixed export costs at a lower interest rate. On the other hand, financial health 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. We also exhibit a new transmission channel of financial crisis that affects both the extensive and intensive margin of trade. By increasing the cost of external finance, a financial shock increases the financial cost of exporting and reduces firms' production capacities and export (intensive margin). By making it more difficult to engage in a (more profitable) Cournot pricing behavior, it also reduces firms' duopoly profit and probability to export (extensive margin).

1 Introduction

The great trade collapse experienced in 2009 is one of the most striking phenomenon observed in recent years. According to the Word Trade Organization (WTO), the volume of world trade fell by 12% in 2009. More interestingly, the slump in world trade appears much stronger than the contraction in Gross Domestic Product (GDP), which amounted to -2.6% in 2009 (source: WTO). The recent drop in export volumes was also more severe than the fall in word trade observed during the Great Depression of the 1930s. While the decline in trade experienced during the Great Depression is largely due to the implementation of trade barriers, the 2009 trade collapse cannot be attributed to increased protectionism.

One of the main explanations for the magnitude of the trade collapse, heavily emphasized by the WTO (Auboin, 2009; Auboin, 2011), relates to the key role of the recent crisis that affected financial systems worldwide. A first series of papers examine the links between financial constraint and international trade by introducing the notion of financial dependence in the two-country two-sector Heckscher-Ohlin-Samuelson's model. They assume that, in each country, the two sectors differ in financial needs and degrees of financial dependence. Their main conclusion is that differences in financial development give rise to comparative advantages and mutual gains from specialization and trade, even when countries have identical endowments, consumer preference and technologies (Bardhan and Kletzer, 1987, Baldwin, 1989, Beck, 2002).

In the line of the international trade Melitz's (2003) model, another series of contributions investigate how the notion of external financial dependence can be introduced into trade models with firm-level heterogenous productivity. In this approach, exporters face upfront costs, due to advertising, gathering information on foreign customers, administrative procedures, translation, organizing foreign distribution networks etc. As these specific costs must be financed, intensive and extensive margins crucially depend on the strength of firms' financial constraints. In Chaney (2005), productivity affects not only 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, as they are competitive and generate large profits from their domestic activities, high-productivity firms export. 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. As Chaney (2005), Manova (2013) assumes that high productivity implies large profits and allows firms to offer high returns to external funders. For this reason, they can 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 while high-productivity firms (which face no financial constraint) can export. Finally, these theoretical findings have been widely confirmed by the empirical literature (Berman and Héricourt, 2010, Bellone et al., 2010, Muûls, 2012, Askénazy et al., 2011).

However, these models do not account for the fact that another striking consequence of the recent financial crisis was also a severe drop in firms' investment. For example, during the first quarter of 2009, the growth rate of investment reached about -6.5% in the United States and the Euro area (source: OECD). Investment expenditures were significantly af-

fected by the decline in bank lending, especially after the bankruptcy of Lehman Brothers. But the shock also affected financial markets: due to a crisis of confidence, investors fled stock markets for less risky markets (notably sovereign bond markets), such that firms' investment also suffered from a global slop in credit supply. A large literature has explored this phenomena, showing that the decline in investment was stronger for financially dependent firms (Almeida et al., 2012, Duchin et al, 2010, Campello et al., 2010, 2011, 2012).

Because the financial crisis affected both investment expenditures and exports, its appears particularly interesting to explore more deeply the relationship that exists between financial factors, trade patterns and firms' investment behavior. First, dealing simultaneously with both (i.e. investment and export) aspects should provide a more comprehensive description of financial crisis. Above all, it could allow to explore whether there exist interactions between firms' investment and export behavior and in what extend these interactions can give birth to an original transmission channel of financial shocks.

One fruitful avenue to investigate this issue is the literature that consists in examining how exogenous shocks can trigger changes in the mode of competition and firms' competitive behavior. In line of Kreps and Scheinkman (1983), Maggi (1996) and Neary (2003), Neary and Tharakan (2012) propose a very innovative contribution to this approach. The authors conceive a trade model in general equilibrium in which sectors are heterogenous in terms of skilled-labour/unskilled-labour intensity. In each sector, the mode of competition is endogenous and firms take their decision in two stages: they first choose investment capacity and then determine prices. The authors show that skilled-labour intensive sectors invest in capacities while unskilled-labour intensive sectors do not. Finally, capacity decision is shown to crucially determines firms' competitive behavior: while the formers behave as in a (more profitable) Cournot equilibrium, the latter adopt a Bertrand pricing policy.

The goal of our paper is to introduce financial constraints in this theoretical framework to investigate in what extent financial factors affect firms' competitive behavior, capacity production decision and, ultimately, exporting behavior. Our model thus interestingly provides a comprehensive analysis of financial crisis by dealing with their impact on both investment and exports. Based on the notion that sectors differ in financial vulnerability, one important contribution of our paper is to show that less financially vulnerable sectors are more likely to export. On the one hand, a high level of financial health allows firms to finance fixed export costs at a lower interest rate. On the other hand, financial health 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 to exhibit a new transmission channel of financial crisis, that passes through firms' investment in production capacities and affects both the extensive and intensive margin of trade. Concerning the impact of a financial shock on the extensive margin, an increase in the cost of capital due to a global crisis increases the cost of investment in production capacities, thus reducing firms' ability to engage in a Cournot pricing schemes. Combined with the (more standard) increase in the financial cost of export, this reduces firms' probability to export. But the transmission channel described in our model also affects the intensive margin of trade by reducing the level of firms' capacity, thus decreasing their production and export.

The paper is organized as follows. Section 2 presents the basic assumptions of the model. Section 3 considers the case of monopoly. Section 4 introduces the case of duopoly.

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2 Assumptions

2.1 The supply side

2.1.1 Financial vulnerability 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 supplying a differentiated product. The first crucial assumption of our model refers to financial vulnerability across sectors:

Assumption 1

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

In their seminal paper, Rajan and Zingales (1998) propose to measure sector-level financial vulnerability through external finance dependence. Their idea is that technological specificity induces significant differences among sectors in terms of cash-flow and payment schedule, such that external finance dependence has a sector-specific dimension. Calculated from data about all publicly listed US based companies from 1980 to 1989 the indicator proposed by Rajan and Zingales (1998) (below denoted "RZ indicator") is calculated as the median level of capital expenditures not financed with cash-flows from operations for 23 ISIC industries on a mix of 4-digit and 3-digit ISIC level. The higher it is, the more external financially dependent the sector. The elements provided in the papers that exploit the RZ indicator are globally consistent with Assumption 1 (Classen and Laeven, 2003, Braun, 2003, Krosner, Laeven and Klingebiel, 2007, Manova, 2008, 2014). First of all, this literature indicates that sectors significantly differ in financial vulnerability. For example, in Braun (2003), Manova (2008, 2014) and Manova et al. (2012), the most financially vulnerable sectors are tobacco, pottery, china & earthenware, leather, footwear and wearing apparel sectors while the less vulnerable are machinery, professional & scientific equipment and iron & steel sectors. Second, Rajan and Zingales (1996) and Braun (2003) show that the ranking of industries seems to be quite stable across periods. Third, the RZ indicator is widely exploited in the literature to rank not only US sectors but also sectors in other countries for which financial vulnerability indicators are not easily computable. As emphasized by Braun (2003), Rajan and Zingales (1998), Manova (2008, 2014) and Manova et al. (2012), insofar as external finance dependence has a large sector-specific component, it seems plausible that financial vulnerability rank is similar across countries. This idea is confirmed by Braun (2003) who shows that financial vulnerability sectors' ranks in US, Japan, Germany and UK are highly correlated. Taken together, these arguments provide convincing rationale for our assumption that sectors are heteregenous in terms of financial vulnerability and that the

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ranking of sector-level financial vulnerability is invariant across countries and time.

Another important assumption of our model is that sector-level financial vulnerability determines the cost of external finance for sectors. We have

Assumption 2
$$r(z) = R(1 + \gamma z), with$$

$\gamma > 0$.

R is the remuneration of capital for the less vulnerable 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 vulnerable sectors than on less vulnerable ones. Parameter γ measures the size of this amplification effect and can be considered as accounting for the level of financial development: the more developed the financial system, the less sector-level financial constraints affects the cost of capital $r(z)$. 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 take three decisions:

- First, firms have to take the decision to export to the other country. In line with the theoretical literature on finance and trade (Chaney, 2005; Manova, 2014), we consider that there is a fixed cost of exporting (per period of time). This cost refers to marketing, documents' translation, network creation etc., required to sell abroad:

Assumption 3
Exporting requires to pay Φ units of capital whatever the level of exports. Firms resort to external funders to finance these costs.

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

- Second, firms have to determine the level of their production capacities $k(z)$. Each unit of installed production capacity requires δ units of capital, whatever the sector is. Moreover, we consider that sectors' financial health is also crucial for determining the cost of investing in capacities:

Assumption 4

Investing in production capacities requires δ units of capital by unit of production capacity and capital remuneration is $r(z)$ in sector z.

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

- Third, 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[1]. Each unit of output is normalized such that it requires one unit of labour to produce it. Total labour supply in each economy is $\overline{L}$ and labour is perfectly mobile between sectors. The remuneration of labour is w. Therefore, if production is not greater than production capacity, labour cost is $wq(z)$. If production is above capacity, production requires θ units of labour (i.e., units of output) for each unit above the supply capacity. In this case, labour cost is $wq(z) + w\theta\big(k(z) - q(z)\big)$ Contrarily to Neary and Tharakan (2012) we suppose that θ is independent of z and depends on labour market institutions such as the national regulation of overtime work, union density etc.

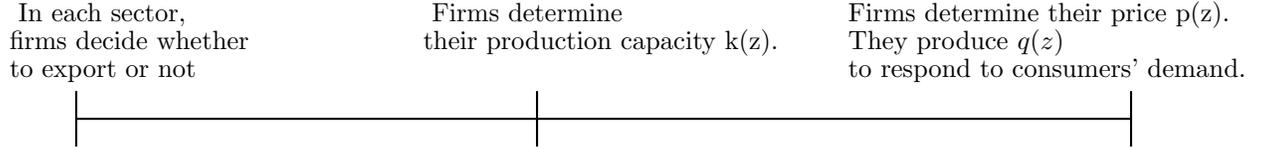Finally, the timing of actions is summarized by Figure 1.

| In each sector, firms decide whether to export or not | Firms determine their production capacity k(z). | Firms determine their price p(z). They produce $q(z)$ to respond to consumers' demand. |

Figure 1: Timing of actions

2.1.3 Output and capacity decisions

Let us first consider capacity decision. Firms may produce below the supply capacity. But it is easy to understand that this is not an option: a better strategy would be to install less capacity such that profit will be higher. Therefore two options have to be considered:

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

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

- Or production is above capacity $\Big(q(z) > k(z)\Big)$. In this case, total cost is

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

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

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

- either a capital-intensive production process - installing a high enough production capacity to make all production "on site" - with marginal cost c^K defined as:

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

- Or a labour-intensive production process with part of (or all) production outsourced, with marginal cost c^L defined as:

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

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

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

Hence, sectors for which $z < \tilde{z}$ invest in capacity while sectors for which $z > \tilde{z}$ do not. The extensive margin is increasing with w (when the remuneration of labour increases, there are less sectors which are labour-intensive). Because w is endogenously determined by the general equilibrium, every shock in the economy affects w and, indirectly, the extensive margin $\tilde{z}$. The extensive margin is also increasing with θ (when the cost of outsourcing increases, there are less sectors which produce above capacity), decreasing with δ (when the number of capital unit required to produce one unit of output increases, there are less sectors which are capital-intensive), decreasing with R (when the equilibrium cost of capital increases, there are less capital-intensive sectors) and decreasing with γ (when the impact of R on $r(z)$ is more strongly amplified, less sectors are capital-intensive).

2.2 The demand side

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

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

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, the local producer is the only supplier of a unique good. The consumer's subutility derived from consumption of good z is in this case:

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

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

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

$$\int_0^1 p(z)x(z)dz = I \tag{6}$$

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Maximizing (4) under (6) yields

$$x(z) = \frac{a}{b} - \frac{\lambda}{b}p(z) \tag{7}$$

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

$$\lambda = \frac{\alpha\mu_1^p - I}{\beta\mu_2^p} \tag{8}$$

with $\alpha = \frac{a}{b}$ and $\beta = \frac{1}{b}$. Summing on all households we get the consumers' inverse demand function:

$$p(z) = \hat{a} - \hat{b}q(z) \tag{9}$$

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

For convenience, in the rest of the paper, we choose the households' marginal utility of income as a numeraire, such that $\lambda = 1$.

2.2.2 The duopoly case

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

The consumer's subutility derived from consumption of good z is in this case:

$$u\{x(z)\} = a\Big(x_1(z) + x_2(z)\Big) - \frac{b}{2}\Big(x_1(z)^2 + x_2(z)^2 + 2ex_1(z)x_2(z)\Big) \tag{10}$$

with $a > 0$, $b > 0$ and $0 < e < 1$. e is a measure of product differentiation: if $e = 0$ products are unrelated while if $e = 1$, products are identical. The consumer's budget constraint is now:

$$\int_0^1 \Big(p_1(z)x_1(z) + p_2(z)x_2(z)\Big)dz = I \tag{11}$$

Maximizing (4) under (11) yields

$$x_i(z) = \frac{a}{b(1+e)} - \frac{\lambda}{b(1-e^2)}\Big(p_i(z) - p_j(z)e\Big) \tag{12}$$

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

$$\lambda = \frac{\alpha\mu_1^p - I}{\beta(\mu_2^p - e\nu^p)} \tag{13}$$

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

$$p_i(z) = \hat{a} - \hat{b}\Big(q_i(z) + eq_j(z)\Big) \tag{14}$$

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

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2.3 Factor markets and national income

In this economy we suppose that the $\overline{L}$ households get the same endowment in primary factors, that is to say 1 unit of labour and d units of capital. All units of capital owned by the $\overline{L}$ 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) receiving d from each household, and investing this money in the same portfolio spread on all sectors such that each household receives $\overline{r}d$ as capital income, with:

$$\overline{r} = \frac{\int_0^1 r(z)k(z)dz}{d\overline{L}}$$

Since sectors are in monopoly or 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 thus includes wage, capital income and excess profit:

$$I = w + \overline{r}d + \frac{\Pi}{\overline{L}} \tag{15}$$

3 Autarky equilibrium

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

3.1 Capital market equilibrium

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

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

$$q^A(z) = \frac{\hat{a} - c}{2\hat{b}} \tag{16}$$

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

Credit-constrained sectors ($z \in [\tilde{z}; 1]$) do not demand capital and externalize fully production since capital cost is too high. Hence, on the capital market the equilibrium condition is

$$d\overline{L} = \int_0^{\tilde{z}} \delta q^A[c^K(z)]dz = K^A \tag{17}$$

It means that

From (1), (16) and (28), we have

$$K^A = \frac{\delta}{2\hat{b}} \int_0^{\tilde{z}} \hat{a} - w - \delta r(z)dz.$$

Using Assumption 2, we have

$$K^A = \frac{\delta}{2\hat{b}}(\hat{a}\tilde{z} - w\tilde{z} - \delta R\tilde{z} - \frac{1}{2}\delta R\gamma\tilde{z}^2). \tag{18}$$

Let us now represent the capital market equilibrium in the $(\tilde{z}; w)$ plan. Using (18), we can calculate the total differential of K^A with respect to w and show that

$$\frac{dK^a}{dw} = \frac{\partial K^a}{\partial w} + \frac{\partial K^a}{\partial R}\frac{dR}{dw} < 0 \tag{19}$$

The proof of (19) is given in Appendix. 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 labour. As labour 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 $\tilde{z}$. This also leads to a fall in the demand for capital.

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

$$\frac{dK^a}{d\tilde{z}} = \frac{\partial K^a}{\partial \tilde{z}} + \frac{\partial K^a}{\partial R}\frac{dR}{d\tilde{z}} > 0. \tag{20}$$

The proof of (20) is given in Appendix. Expression (20) 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 $\tilde{z}$ means that more sectors invest in capital at 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-users sectors.

3.2 Labour market equilibrium

Denoting L^A firms' demand for capital, we now concentrate on the labour market equilibrium. The equilibrium condition is given by

$$\overline{L} = \int_0^{\tilde{z}} q^A\Big(c^K(z)\Big)dz + \int_{\tilde{z}}^1 (1+\theta)q^A\Big(c^L\Big)dz = L^A \tag{21}$$

From (1), (2), (16) and (32), we have

$$L^A = \frac{1}{2\hat{b}}\int_0^{\tilde{z}}\hat{a} - w - \delta r(z)dz + \frac{1}{2\hat{b}}\int_{\tilde{z}}^1 (1+\theta)(\hat{a} - w(1+\theta))dz.$$

We then have:

$$L^A = \frac{1}{2\hat{b}}\Big(\hat{a}\tilde{z} - w\tilde{z} - \delta R\tilde{z} - \frac{1}{2}\delta R\gamma\tilde{z}^2 + (1+\theta)\hat{a} - w(1+\theta)^2 - (1+\theta)\hat{a}\tilde{z} + w(1+\theta)^2\tilde{z}\Big) \tag{22}$$

Using (22), we can calculate the total differential of L^A with respect to w:

$$\frac{dL^A}{dw} = \frac{\partial L^A}{\partial w} + \frac{\partial L^A}{\partial R}\frac{dR}{dw} \leq 0 \tag{23}$$

The proof of (23) is given in Appendix. 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 labour demand. 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, as both factors are technically complementary, in the demand for labour.
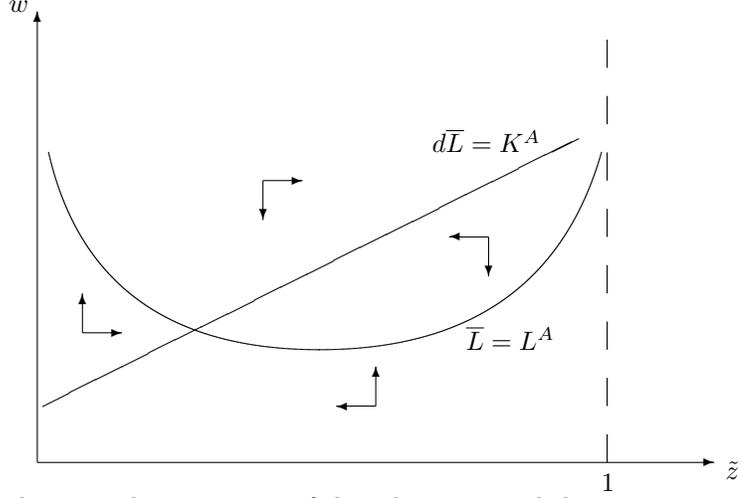
Figure 2: Simultaneous determination of the salary rate and the extensive margin

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

$$\frac{dL^a}{d\tilde{z}} = \frac{\partial L^a}{\partial \tilde{z}} + \frac{\partial L^a}{\partial R}\frac{dR}{d\tilde{z}} = -\theta q^A(c_L) + \frac{w\theta\gamma\tilde{z}}{2\hat{b}}\frac{(1 + \frac{\gamma\tilde{z}}{2})}{(1 + \gamma\tilde{z})^2} \tag{24}$$

The proof of (24) is given in Appendix. The sign of $\frac{dL^a}{d\tilde{z}}$ is ambiguous. When $\tilde{z}$ increases, two effects are at play. First, a rise in $\tilde{z}$ means that more sectors invest in capacities. This extensive-margin effect implies a decline in the demand for labour. The second effect is the intensive-margin 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-users sectors and, consequently, increases their demand for labour. 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 these calculus, we finally derive Figure 2. The equilibrium on the capital market can be represented by an increasing curve while the equilibrium on the labour market is represented by a concave curve. As explained above, when $\tilde{z}$ is close to 0, one has $\frac{dL^A}{d\tilde{z}} < 0$ such the labour 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 provide the autarky equilibrium.

4 Duopoly

4.1 Firm behaviour

We now turn to the duopoly equilibrium. We have two symmetric countries. In each sector z a domestic firm is in competition with a foreign one.

Following Neary and Tharakan (2012), we consider three cases.

We first focus on sectors for which $z > \tilde{z}$. We know from Section 3 that these sectors do not invest in capacities. At the final stage both firms compete in price with a marginal cost consisting only in labour: domestic and foreign sectors thus directly choose prices and engage in a Bertrand game. Incurring a cost c^L, they charge a price denoted $p^B(c^L)$ which corresponds to prices maximizing profits when marginal cost is c^L. We called these sectors Bertrand sectors and we note that these are the sectors which are the most financially vulnerable.

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.

Following Maggi (1996) and Neary and Tharakan (2012), we demonstrate that there are potentially two types of sectors in this subset. First a subset of sectors with high profitability called Cournot sectors (equilibrium prices and quantities are expressed with a C exponent, p^C and q^C) and a second one with profitability lower than in Cournot sectors, but higher than in Bertrand sectors: we call these sectors Quasi-Bertrand sectors (equilibrium prices and quantities are expressed with a QB exponent, p^{QB} and q^{QB}).

There exists a threshold defined by:

$$p^B(c^L) = p^C\Big(c^K(z_c)\Big), \tag{25}$$

This threshold is such that sectors for which $z < z_C$ exhibit a Cournot behavior while sectors for which $\tilde{z} > z > z_C$ exhibit a Quasi-Bertrand behavior.

Let us explain the mechanisms at play. For all firms $z < \tilde{z}$, let us remind that unit cost is $c^K(z)$ and marginal cost is c^L, with $c^K < c^L$.

Let us first define a Cournot benchmark. This is an equilibrium with prices and quantities exactly equal to those played in a virtual game where firms would play Cournot, that is to say select the quantities to maximize profits. This is the best situation for a firm: indeed let us remind that at the second stage firms select production capacities, then at the third stage firms select prices. In a perfect Nash equilibrium where duopolistic profits are maximized, firms choose production capacities such that all demand expressed by consumers at the final stage is just equal to the production capacity installed at the second stage. If not, either production is less than capacity and there are wasted capacities or production is more than capacity and the cost of production is not minimized since $c^K < c^L$. So a perfect Nash equilibrium where profits are maximized, is such that the production capacity installed at the second stage is such that demand addressed to a firm is just equal to this capacity. Therefore we can simplify this two-stage game (second and third stages) by a one-shot game where firms choose the production capacity that maximizes profit, *i.e.* play Cournot.

Is Cournot always implementable? The answer is no. The intuition behind this is relatively simple. Whether firms can play Cournot depends on the comparison between the marginal cost of production and the price that can be implemented under Cournot which will lead to a certain level of marginal revenue. So it depends on a comparison between marginal revenue and marginal cost at Cournot benchmark. Let us focus on θ for simplicity. If θ is very small (tends to 0), Cournot may not be implementable: if the other firm charges the Cournot price $p^C\Big(c^K(z)\Big)$, a firm benefits from charging a slightly smaller price. This attracts more demand: it increases revenues. However, it also increases cost but as θ is very

small, revenues may increase more than total cost and profit augments. This explains why the Cournot price may not be implementable. On the contrary when θ is very high (tends to infinity), a Cournot price is implementable since when the other firm applies such a price, a small reduction of price under this level is not beneficial since it increases the cost too much: profit decreases and Cournot prices are implementable[2]

So the first set of sectors are Cournot firms which are successful in installing relatively small production capacities at the first stage such that price and quantities are equivalent to a Cournot game: profits are maximized. For the second set of sectors, the Cournot equilibrium is not implementable since the marginal cost of expanding production above capacity is not high enough as compared to the unit cost of capital actually incurred.

We thus obtain the following proposition:

Proposition 1

(a) The thresold z_c is strictly lower than $\tilde{z}$,

(b) The threshold z_c is increasing with the wage w and the extensive margin $\tilde{z}$ and decreasing with δ.

Proof: see Appendix.

Part b) of Proposition 1 states that when w increases, more sectors adopt a Cournot behavior. This can be explained as follows. When the labour cost increases, investing in capacities is relatively less costly than not investing in capacities. For this reason, the commitment to charge a higher price becomes stronger, such that more sectors charge a price equal to the Cournot price. The symmetrical reasoning applies when there is a rise in δ. In this case, investing in capacities becomes relatively more costly than not investing in capacities, such that the commitment to charge a higher price becomes weaker. Hence, less sectors choose a Cournot pricing scheme.

Finally, we can easily calculate firms' equilibrium profits in each (Bertrand, Quasi-Bertrand and Cournot) configuration. To do so, we use the consumers' inverse demand function given by (16) and Bertrand and Cournot equilibrium prices and quantities given by

$$p^B(c) = \frac{(1-e)\hat{a}+c}{2-e}, p^C(c) = \frac{\hat{a}+(1-e)c}{2-e}, q^B(c) = \frac{\hat{a}-c}{\hat{b}(1+e)(2-e)}, q^C(c) = \frac{\hat{a}-c}{\hat{b}(2+e)}. \tag{26}$$

Note that, in line with standard results about Bertrand and Cournot equilibria, we have

$$p^B(c) < p^C(c), \ q^B(c) > q^C(c). \tag{27}$$

We sum up sectors' behavior in the following proposition

Proposition 2

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[2]Let us notice that in our model, θ is constant from one sector to the other while the cost of capital differs from one sector to the other. In Neary and Tharakan (2012), the cost of capital is constant from one sector to the other while θ differs from one sector to the other. Anyway our specification also leads to potential Cournot sectors and Quasi Bertrand sectors since the threshold defined by equation (25) includes $r(z)$.

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

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

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

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

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

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

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

(b) In sectors 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 respectively Π_{QB}, mc^{QB}, uc^{QB} p^{QB} and LI^{QB} are defined as follows:

$$\Pi^{QB} = \frac{\hat{a} - c_L}{\hat{b}(1 + e)(2 - e)} \frac{(1 - e)\hat{a} + c_L - (2 - e)(w + \delta r(z))}{(2 - e)}$$

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

$$uc^{QB} = w + \delta r(z)$$

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

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

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

(c) In sectors for which $z < z_C$ (Cournot sectors), firms' equilibrium profit, marginal cost, unit cost, equilibrium price and Lerner index denoted respectively Π_C, mc^C, uc^C p^C and LI^C are defined as follows:

$$\Pi^C = \frac{\left(\hat{a} - (w + \delta r(z))\right)^2}{\hat{b}(2 + e)^2}$$

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

$$uc^C = w + \delta r(z)$$

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

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

$$LI^C = \frac{(\hat{a} - (w + \delta r(z)))}{\hat{a} + (1 + e)(w + \delta r(z))}$$
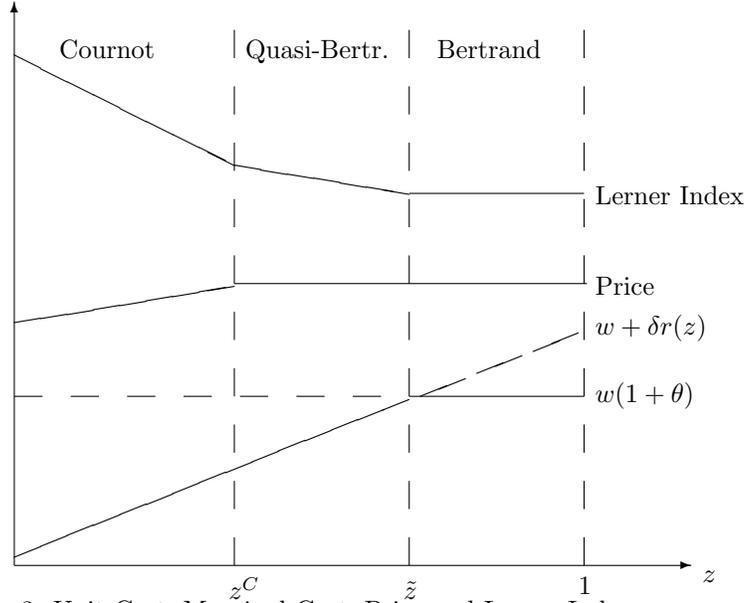
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Figure 3: Unit Cost, Marginal Cost, Price and Lerner Indexes

These calculations allow us to characterize the three modes of competition, illustrated on figure 3. Figure 3 clears shows sector-level financial vulnerability crucially affects the competitive behavior of firms, which in turn determines their profitability:

- On the left, sectors which have access to relatively good credit conditions, bear a reduced unit cost. Since they adopt a Cournot behavior, their profitability measured by the Lerner Index is relatively high: let us mention that the price of the firms benefiting from the best access to credit is lower than other firms'. In fact they get an even lower unit cost (on the left of the graph the slope of the unit cost line is steeper than the slope of the price cost), meaning that their margin is higher.

- On the right, Bertrand firms do not get relatively good conditions of access to credit such that they adopt process of production that only require labour. Consequently their unit cost is relatively high and their profitability is relatively low.

- For firms in sectors z such that $\tilde{z} < z < z_C$ (Quasi-Bertrand sectors), because capacity choices are observed before prices are charged, investment in capacities can lead to two beneficial effects. First, capital decreases unit cost of production. Second production capacities play as a commitment device: their unit cost is $c^K = w + \delta r(z)$, while their marginal cost is $c^L = w(1 + \theta) > c^K$. By limiting their capacity of production which is an irreversible decision, they support a unit cost of c^K and charge a Bertrand price corresponding to c^L, that is to say $p^B(c^L)$ which leads to higher profit as compared to Bertrand sectors.

4.2   Capital market equilibrium

Let us consider that all sectors are in duopoly. We denote K^T the demand for capital. On the capital market, the equilibrium is now

$$d\overline{L} = \int_0^{z_c} \delta q^C\left(c^K(z)\right)dz + \int_{z_c}^{\tilde{z}} \delta q^B[c^L]dz + \int_0^1 = K^T \qquad (28)$$

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From (1), (2), (26) and (28), we have

$$K^T = \frac{\delta}{\hat{b}(2+e)}(\hat{a}z_c - \delta Rz_c - \frac{1}{2}R\delta\gamma z_c^2 - wz_c) + \frac{\delta}{\hat{b}(2+e)(2-e)}(\hat{a} - w(1+\theta))(\tilde{z} - z_c) + \Phi R(1+\frac{\gamma}{2}) = d\overline{L}. \quad (29)$$

We can calculate the total differential of K^T with respect to w and show that:

$$\frac{dK^T}{dw} = \frac{\partial K^T}{\partial w} + \frac{\partial K^T}{\partial R}\frac{dR}{dw} < 0 \quad (30)$$

The proof of (30) is given in Appendix. As in the monopoly case, an increase in the wage rate w induces a decrease in K^T for two reasons. On the one hand, a rise in w implies a reduction in the demand for labour. As labour and capital are technically complementary, the demand for capital also decreases. On the other hand, according to (3) a rise in w implies an increase in R to maintain the value of $\tilde{z}$. This also leads to a fall in the demand for capital.

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

$$\frac{dK^T}{d\tilde{z}} = \frac{\partial K^T}{\partial \tilde{z}} + \frac{\partial K^T}{\partial R}\frac{dR}{d\tilde{z}} > 0. \quad (31)$$

The proof of (31) is given in Appendix. As in the monopoly case, (31) indicates that when $\tilde{z}$ increases, K^T also increases. The rationale for this result is as follows. First, a rise in the threshold $\tilde{z}$ means that more sectors invest in capital at the extensive margin. Second, according to (3), an increase in $\tilde{z}$ results in a reduction in R at a given wage w, which raises the demand for capital from capacity-user sectors.

4.3   Labour market equilibrium

We now denote L^T the labour demand. On the labour market, when all sectors are in duopoly, the new equilibrium condition is

$$\overline{L} = \int_0^{z^c} q^C\left(c^K(z)\right)dz + \int_{z^C}^{\tilde{z}} q^B\left(c^L\right)dz + \int_{\tilde{z}}^1 (1+\theta)q^B\left(c^L\right)dz = L^T \quad (32)$$

From (1), (2.1.3), (26) and (32), we have

$$L^T = \frac{1}{\hat{b}(2+e)}(\hat{a} - \delta Rz_c\frac{1}{2}R\delta\gamma z_c^2 - wz_c)\frac{1}{\hat{b}(2+e)(2-e)}\left((\tilde{z} - z_c)(\hat{a} - w(1+\theta)) + (1+\theta)(\hat{a} - w - w\theta)(1-\tilde{z})\right) \quad (33)$$

Using (33), we obtain

$$\frac{dL^T}{dw} = \frac{\partial L^T}{\partial w} + \frac{\partial L^T}{\partial R}\frac{dR}{dw} < 0 \quad (34)$$

The proof of (34) is given in Appendix. 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 labour demand. 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, as both factors are technically complementary, in the demand for labour.

We also have

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

i.e.,

$$\frac{dL^T}{d\tilde{z}} = \frac{-\theta(\hat{a} - w(1+\theta))}{\hat{b}(2-e)(1+e)} + \frac{\delta z_c}{\hat{b}(2+e)}(1 + \frac{z_c\gamma}{2})\frac{w\theta\delta\gamma}{\delta^2(1+\tilde{z}\gamma)^2} \tag{35}$$

The proof of (35) is given in Appendix. The sign of $\frac{dL^T}{d\tilde{z}}$ is ambiguous. First, When $\tilde{z}$ increases, more sectors invest in capacities. This extensive-margin effect induces an increase in the demand for capital and the demand for labour. The second effect is the intensive-margin effect: an increase in $\tilde{z}$ results in a fall in R at a given wage w (see (3)). This reduces the production cost of investing sectors and increases their demand for labour. When $\tilde{z}$ is close to 0, very few sectors have invested in capacities and the second effet is very weak. The first effect thus prevails such that $\frac{dL^T}{d\tilde{z}} < 0$. 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 Figure 2. The equilibrium on the capital market is represented by an increasing curve while the equilibrium on the labour market is represented by a concave curve.

5 Firm export behavior

5.1 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). As 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 $(2\Pi_D)$. But they have to pay the financial costs of export $(\Phi r(z))$.

- If no firm exports, they both earn the monopoly profit on their domestic market.

- If one firm exports while the other one does not, the exporting firm earns the monopoly profit on its domestic market and duopoly profit on the foreign market $((2\Pi_D + \Pi_M)$ minus the financial costs of export $(\Phi r(z))$ while the non-exporting firm earns the duopoly market on its domestic market (Π_D)[3].

This can be summarized in Table 1. The first entry in each cell corresponds to the domestic firm's duopoly equilibrium profit while the second entry corresponds to the foreign duopoly equilibrium profit.

$domestic \setminus foreign$	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 ; $\Pi_M - \Pi_D - \Phi r(z)$	$\Pi_M ; \Pi_M$

Table 1: Profits and firms' decisions to export

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[3]As this reasoning is made at each (infinitesimal sized) sector-level, its impact on general equilibrium can be considered as negligible.

From Table 1, it is straightforward to derive the following proposition:

Proposition 3

Within a given sector,

(a) *The situation where 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 where neither the domestic nor the foreign firm export is a Nash equilibrium if the duopoly profit is weaker than the financial costs of export*[4]

Proposition 3 states that the decision to export only depends on export costs and the duopoly profits of firms but not on their monopoly profit. This comes from the fact that, *given the choice of the other firm*, a firm takes 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, while the marginal cost is $\Phi r(z)$, the marginal profit attached to the decision to export is Π_D.

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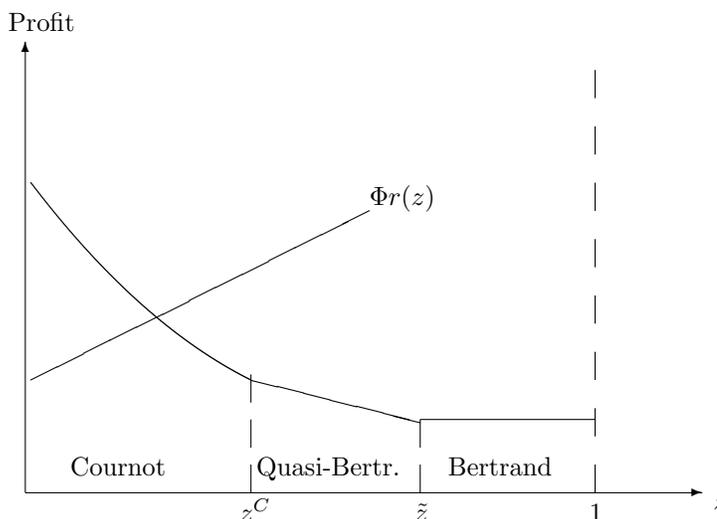

Figure 4: Firms' decision to export: comparison between firms' duopoly profit and export cost

The comparison between the financial export cost curve and the profit curve allows us to determine which sectors export. Sectors for which the cost curve is above the profit curve do

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[4]It could be argued that the financial cost of export is not the same according to whether both firms export (E/E) or only one firm exports (E/NE or NE/E). Indeed, when both firms export, they resort to external funders to finance export costs. Hence the demand for external funds is larger than when only one firm exports. Hence, the interest rate should be higher in the latter case than in the former case. But the individual impact of each sector on the general equilibrium is negligible. For this reason, one can consider that the financial cost of export is the same in all cells of Table 1 and that the determination of the Nash equilibrium is not affected.

not export while those for which the cost curve is below the the profit curve export. Hence we can define the threshold z^* such that

$$\Phi r(z^*) = \Pi_D(z^*). \tag{36}$$

We have to consider three cases according to whether the threshold sector z^* may belong to Cournot-type of sectors or Quasi-Bertrand-type of sectors, or Bertrand-type of sectors.

In the Cournot case ($z^* \in [0; z_c]$), z^* is characterized by

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

In the Quasi-Bertrand case ($z^* \in [z_c; \tilde{z}]$), z^* is given by

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

Finally, in the Bertrand case ($z^* \in [\tilde{z}; 1]$) z^* is given by

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

This allows us to obtain the following proposition:

Proposition 4

If Φ is low enough[5],

(a) *There exists a unique threshold denoted z^* such that sectors with $z < z^*$ export while those with $z > z^*$ do not export,*

(b) *z^* is decreasing in Φ, w and γ.*

The proof of Proposition 4 is given in Appendix. Part a) of Proposition 4 states that financial constraints prevent some sectors to export: more financially vulnerable sectors (having a low z) do not export while those who are less vulnerable (high z) export. Moreover, as stated by Part b) of Proposition, when the level of export costs (Φ) increases, it becomes more costly to finance these costs. Consequently, less sectors export. Similarly, when the cost of labour w increases, one observes a decrease in the demand for labour and capital, such that there are less capacity-user sectors. Consequently, less sectors export. Finally, when the level of financial development is high (weak γ), less sectors are able to export.

Proposition 4 is globally in line with the theoretical findings of Chaney (2005) and Manova (2014). It is also consistent with the empirical literature, which documents that financially constrained sectors are less likely to export (Berman and Héricourt, 2010, Bellone et al., 2010, Muûls, 2012, Askénazy et al., 2011). Finally, our model suggests that interactions between financial development (measured by γ) and sector-level financial vulnerability crucially drive export decision. This is in line with the empirical observation that financial development has a significant and positive effect on industry-level exports, especially for industries that heavily rely on outside finance (Beck, 2002, 2003).

A major contribution of our paper is to provide innovative rationale for the link between financial constraint and decision export. Indeed, in our model, export decision is narrowly

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[5]If Φ is too large, there is no trade.

linked to the mode of competition in which sectors are engaged. Proposition 4 indicates that sectors that price as in a Cournot equilibrium are more likely to export than others. This comes from the fact that their duopoly profit (i.e. the profit they earn when they export) is higher when they behave as in a Cournot equilibrium than when they price as in a Quasi-Bertrand or Bertrand equilibrium. Hence, the impact of firms' financial health on export is twofold. First, less vulnerable firms can invest in capacities and engage in a Cournot pricing scheme, thus yielding a higher duopoly profit. Second, a high level of financial health allows firms to finance their export costs at a lower cost.

Proposition 4 also interestingly suggests that sectors that invest in capacities are more likely to export. This result appears particularly innovating, compared to the contributions of Melitz (2003), Chaney (2005) and Manova (2013) in which the investing behaviour of firms are not addressed[6]. From an empirical point of view, the idea that investment and export are positively correlated is in line with Bellone et al. (2006), Bernard et al. (2007) and Forslid and Okubo (2011). This positive correlation may account for the fact that exporting activities are favorable to investment (Campa and Shaver, 2006). On the one hand, exporting allows a firm to provide a positive signal to external funders about its quality. On the other hand, exporting activities allow a firm to diversify its activity, making its cash-flow more stable. By mitigating the firm's financial constraint, both effects make it easier to invest. 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 sustain a higher price than in a Pure-Bertrand pricing policy, firms earn a larger duopoly profit, such that exporting activities become more profitable for them. Kimura and Kiyuta (2006) provide empirical support to this result. They obtain that, over the period 1994-2000, Japanese firms' probability to export increases in 2 percent in the capital-labour ratio.

Finally, our model provides a comprehensive theoretical framework which 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.

5.2 Financial crisis and intensive/extensive margins of trade

We finally address how an international financial crisis, such as the 2007-2008 crisis, can affect firms' export behavior. To do this, we consider that a financial crisis that strikes both economies symmetrically induces a decrease in d, the number of capital unit endowment per household. This credit crunch then affects R and, as a consequence, the intensive and the extensive margins of trade. We thus have

$$\frac{dz^*}{dd} = \frac{\partial z^*}{\partial R}\frac{\partial R}{\partial d}.$$

It is straightforward that a reduction in d, due to an international financial crisis, reduces the cost of capital R:

$$\frac{\partial R}{\partial d} > 0. \tag{37}$$

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[6]of course, the notion that capital-intensive goods are exported (while labour-intensive goods are imported) can emerge from a comparative-advantage approach where countries differ in capital endowment.

The proof of (37) is given in Appendix. Hence, $\frac{dz^*}{dd}$ has the opposite sign of $\frac{\partial z^*}{\partial R}$. To determine the partial derivative of z^* with respect to R, we have to remind that firms' export behavior is determined by equality (36). We thus have to consider three cases according to whether this threshold sector belongs to Cournot-type of sectors or Quasi-Bertrand-type of sectors, or Bertrand-type of sectors. We thus consider these three cases successively.

In the Cournot case ($z^* \in [0; z_c]$), $q^C(z) = \frac{\hat{a}-w-\delta R(1+\gamma z)}{\hat{b}(2+e)}$. Therefore, other things being equal, a decrease in d (i.e. an increase in R) reduces the intensive margin of trade: $\frac{\partial q^C(z)}{\partial R} = \frac{-\delta(1+\gamma z)}{\hat{b}(2+e)} < 0$. Concerning the extensive margin of trade, we have

$$\frac{dz^*}{dR} = -\frac{\Delta_R^C}{\Delta_R^1} = -\frac{(1+\gamma z^*)}{R\gamma} < 0 \tag{38}$$

Proof of (38) is given in Appendix. We thus obtain a first set of results: when $z^* \in [0; z_c]$, other things being equal, by increasing R, a decrease in d reduces the extensive margin of trade (there are less sectors which export) and the intensive margin of trade (in each exporting sector, the quantity exported is decreased).

In the Quasi-Bertrand case ($z^* \in [z_c; \tilde{z}]$), the quantity exported by each firm in Quasi-Bertrand sectors is $q^{QB}(z) = \frac{\hat{a}-w(1+\theta)}{\hat{b}(2-e)(1+e)}$. Therefore, other things being equal, an increase in R does not change the intensive margin of trade in Quasi-Bertrand sectors. Concerning the extensive margin of trade, we obtain again

$$\frac{dz^*}{dR} = -\frac{(1+\gamma z^*)}{R\gamma} < 0 \tag{39}$$

Proof of (39) is given in Appendix. Hence, when $z^* \in [z_c; \tilde{z}]$, other things being equal, a decrease in d reduces the extensive margin of trade (there are less sectors which export), and the effect is larger as compared to the first case (it varies positively with $z*$). Moreover, because an increase in R affects the intensive margin of trade (in each sector exporting, the quantity exported is decreased) only in Cournot sectors while the intensive margin of trade in Quasi-Bertrand is unchanged, the impact of a variation of R on all sectors' intensive margin is smaller on average.

Finally, in the Bertrand case, $z^* \in [\tilde{z}; 1]$, the quantity exported by each firm in Bertrand sectors is $q^B(z) = \frac{\hat{a}-w(1+\theta)}{\hat{b}(2-e)(1+e)}$. Therefore, other things being equal, a reduction in d does not change the intensive margin of trade in Bertrand and Quasi-Bertrand sectors while it decreases the intensive margin of firms in Cournot sectors. Turning to the extensive margin of trade yields

$$\frac{dz^*}{dR} = -\frac{(1+\gamma z^*)}{R\gamma} < 0 \tag{40}$$

Proof of (40) is given in Appendix. We obtain a third set of results: when $z^* \in [\tilde{z}; 1]$, other things being equal, an increase in R reduces the extensive margin of trade (there are less sectors which export), and the effect is larger as compared to the first and second cases (it varies positively with z). Because a rise in R affects the intensive margin of trade (in each sector exporting, the quantity exported is decreased) only in Cournot sectors while the intensive margin of trade in Quasi-Bertrand and Bertrand sectors is unchanged, the impact of a variation of R on all sectors' intensive margin is smaller on average.

These results are summarized in the following proposition:

Proposition 5

Other things being equal, an increase in the equilibrium remuneration of capital R decreases the extensive and the intensive margins of trade. The greater the initial number of trading sectors, the greater the impact on extensive margin, the smaller the average impact on intensive margin.

Proposition 5 is consistent with the literature on the harmful effects of financial crisis on exports. 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 with high interbank rates exports less to the US, particularly in sectors that are highly reliant on external financing. This effect is amplified during the 2008 financial crisis. This result is corroborated by Berman et al. (2012). Relying on a sample of countries between 1950 and 2009 ans 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 crisis magnify the adverse effect of external financial dependence on sectors' export growth rates.

More interestingly, Proposition 5 states that the sensitivity of exports to a financial shock differs according to whether one considers the intensive or the extensive margin.

On the one hand, we show that the detrimental effect of a financial shock on the intensive margin of trade is, in average, weaker when the initial number of trading sectors is high. This comes from the fact that once firms have decided to export, the quantity they produce and export only depends on the level of their capacity. For this reason, the three types sectors are not affected in a similar way by a financial shock. First, because they do not invest in capacity, Bertrand sectors are not affected by an increase in the cost of capital. Second, because Quasi-Bertrand firms behave as if they incurred a marginal cost of c^L rather than $c^K(z)$, the cost of external finance is also neutral as regards their production. Hence, when the number of trading sectors includes Bertrand and Quasi-Bertrand firms, the average impact of a financial shock on exports in lower than when only Cournot sectors export.

On the other hand, we find that a financial crisis reduces the extensive margin of trade all the stronger when the initial number of trading sectors is large. When firms take their decision to export, two effects are at play. First, a financial shock raises the financial cost of exporting. This effect is not very different to the one described in the literature on finance and trade. The second transmission channel, however, is new. Due to a rise in the cost in external finance, firms have weaker incentive to invest in production capacities. This makes it difficult for them to engage in a more profitable pricing scheme. Taken together, both effects reduce firms' probability to export. Let us now explain why the strength of this impact 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 only Cournot-type sectors export. When a financial shock strikes both economies, a certain reduction in financial vulnerability is necessary to balance the decrease in R and maintain equality between the financial cost of exporting and the duopoly profit (see (36) . Because this balancing effect divides into reduced

cost of capital and increased duopoly profit, the required decline in financial vulnerability does not need to be very large. Let us now consider Quasi-Bertrand sectors. They incur a marginal cost $c^K(z)$ but set their price and quantity according to the marginal cost c^L such that their profit is less sensitive to financial vulnerability 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 financial vulnerability that allows to maintain equality (36) has to be larger than when only Cournot sectors export. Let us finally turn to Bertrand sectors. Because their profit does not depend on the cost of capital, the balancing effect mentioned above goes only through the financial cost of exporting. Consequently, the reduction in financial vulnerability that is necessary to maintain equality (36) is even larger than in both previous (Cournot and Quasi-Bertrand) cases.

Overall, Proposition 5 interestingly 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 less sensitive to a financial crisis in terms of intensive margin of trade (because exporting sectors include labour-intensive sectors, whose production weakly reacts to a financial shock) but more sensitive in terms of extensive margin (because the duopoly profit of labour-intensive sectors is not high enough to allow them to continue to export).

6 Conclusion

The goal of our paper was to introduce the notion of financial constraint in a trade model with endogenous mode of competition to explore the relation between finance and trade. Our main result is that firms' competitive behavior is crucial to analyze the impact of financial factors on firms' production capacity decision and export behavior. We obtain that sector-level financial vulnerability not only increases firms' financial cost of export but also increases the cost of investing in capacities and reduces firms' ability to engage in a (more profitable) Cournot pricing scheme. This finally decreases firms' incentive to export. This impact is all the stronger as the level of financial development is weak. We also emphasize a new transmission channel of financial 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 export (intensive margin). By making it more difficult to engage in a Cournot pricing behavior, it also reduces firms' duopoly profit and probability to export (extensive margin). Finally, while the literature usually deals with the impact of financial factors on investment and trade separately, it is noteworthy that our model provides a comprehensive framework that accounts for the reduction in both firms' investment and exports due to an international financial crisis.

Finally, our article undoubtedly calls for further investigations. First, in line with Besedes et al. [2014] and Kohn et al. [2012], it would be interesting to extend our model in a dynamic framework with endogenous financial constraint. We could explore how financial constraint's strength is affected by past exporting experience and determine in what extend firms' investment and export behavior are subject to some kind of hysteresis. Our approach could be also fruitfully enriched by examining the impact of trade and financial reforms

on firms' export performance. We could notably investigate how both kinds of reforms interact and whether they are complementary (the implementation of the one increases the effectiveness of the other) or substitute (the implementation of the one decreases the effectiveness of the other). Such development could allows us to formulate useful policy recommendations concerning the bundling of both (trade and financial) reforms.

Acknowledgments

7 Appendix

Proof of (19)

From (18), it is straightforward that $\frac{\partial K^a}{\partial w} = -\frac{\partial}{2\hat{b}}\tilde{z} < 0$ and $\frac{\partial K^a}{\partial R} = -\frac{\delta^2}{2\hat{b}}(\tilde{z}^2 + \frac{1}{2}\gamma^2\tilde{z}^2) < 0$. From (3), we have $\frac{dR}{dw} = \frac{\theta}{\delta(1+\gamma\tilde{z})} > 0$. Hence, we obtain $\frac{dK^a}{dw} = \frac{\partial K^a}{\partial w} + \frac{\partial K^a}{\partial R}\frac{dR}{dw} < 0$.

Proof of (20)

From (18), we have $\frac{\partial K^a}{\partial \tilde{z}} = \delta q^A(c_K(\tilde{z})) > 0$ and $\frac{\partial K^a}{\partial R} = -\frac{\delta^2}{2\hat{b}}(\tilde{z}^2 + \frac{1}{2}\gamma^2\tilde{z}^2) < 0$. From (3), we also have $\frac{dR}{d\tilde{z}} = -\frac{\gamma}{(1+\gamma\tilde{z})^2} < 0$.Consequently, $\frac{dK^a}{d\tilde{z}} = \frac{\partial K^a}{\partial \tilde{z}} + \frac{\partial K^a}{\partial R}\frac{dR}{d\tilde{z}} > 0$.

Proof of (23)

From (22), 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 $\frac{dR}{d\tilde{z}} = \frac{\theta}{\delta(1+\gamma\tilde{z})} > 0$. Hence, we obtain $\frac{dL^a}{dw} = \frac{\partial L^a}{\partial w} + \frac{\partial L^a}{\partial R}\frac{dR}{dw} < 0$.

Proof of (24)

From (22), we have $\frac{\partial L^a}{\partial \tilde{z}} = \frac{1}{2\hat{b}}\left(\hat{a} - w - \delta R - \delta\gamma R - (1+\theta)\hat{a} + w(1+\theta)^2\right)$. Using (1) and (2) and (26) yields $\frac{\partial L^a}{\partial \tilde{z}} = q^A\left(c_K(\tilde{z})\right) - (1+\theta)q^A(c_L)$. According to the definition of $\tilde{z}$ given by (3), this gives $\frac{\partial L^a}{\partial \tilde{z}} = -\theta q^A(c_L) < 0$. From (22), we also have $\frac{\partial L^a}{\partial R} = -\frac{\delta}{2\hat{b}}\tilde{z} - \frac{1}{2}\gamma^2\tilde{z}^2 < 0$. Finally, we have $\frac{dR}{d\tilde{z}} = \frac{\theta}{\delta(1+\gamma\tilde{z})} > 0$. Consequently, $\frac{dL^a}{d\tilde{z}} = \frac{\partial L^a}{\partial \tilde{z}} + \frac{\partial L^a}{\partial R}\frac{dR}{d\tilde{z}} > 0$.

Proof of Proposition 1

a) Let us assume that $z_c \geq \tilde{z}$. It is easy to show that such a situation is not possible. In this case, we would have $r(z_c) \geq r(\tilde{z})$, i.e., $w + \delta r(z_c) \geq w + \delta r(\tilde{z})$. According to (3), this gives $w + \delta r(z_c) \geq c_L$, i.e., $c_K(z_c) \geq c_L$, which yields $p^C\left(c_K(z_c)\right) \geq p^C(c_L)$. Using (27) and by transitivity, this implies $p^C\left(c_K(z_c)\right) \geq p^B(c_L)$. This contradicts expression (25). Hence $r(z_c) < r(\tilde{z})$.

b) Introducing (1), (2) and expressions of $p^B(c_L)$ and $p^C\left(c_K(z_c)\right)$ given by (26) in (25), we obtain

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

24

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 $\Delta^r_w = \frac{2\theta + \theta e + e^2}{(2-e)(2+e)} > 0$ and $\Delta^r_{z_c} = -\frac{(1+e)\partial R\gamma r(z_c)}{(2+e)} < 0$. Hence $\frac{dz_c}{dw} > 0$. Using the same approach, we obtain $\frac{dz_c}{d\tilde{z}} > 0$ and $\frac{dz_c}{d\delta} < 0$.

Proof of (30)

From (29), we have $\frac{\partial K^T}{\partial w} = \frac{\partial}{\hat{b}(2+e)}\frac{(1-e)z_c - \tilde{z}}{2-e}$. The sign of this expression is negative because $z_c < \tilde{z}$. Moreover, we have $\frac{\partial K^T}{\partial R} = \frac{\delta}{\hat{b}(2+e)}\left(-(1-e)\frac{\delta z_c}{2-e} - \frac{1}{2}\delta\gamma z_c^2 - \frac{\delta\tilde{z}}{2-e}\right) < 0$ and $\frac{dR}{dw} = \frac{\theta}{\delta(1+\gamma\tilde{z})} > 0$. Hence, we obtain $\frac{dK^T}{dw} = \frac{\partial K^T}{\partial w} + \frac{\partial K^T}{\partial R}\frac{dR}{dw} < 0$.

Proof of (31)

From (29), we have: $\frac{\partial K^T}{\partial \tilde{z}} = \delta q^B\left(c^K(\tilde{z})\right) > 0$, $\frac{\partial K^T}{\partial R} = -\frac{\delta}{\hat{b}(2+e)}\left(-(1-e)\frac{\delta z_c}{2-e} - \frac{1}{2}\delta\gamma z_c^2 - \frac{\delta\tilde{z}}{2-e}\right) < 0$, and $\frac{dR}{d\tilde{z}} = -\frac{\gamma}{(1+\gamma\tilde{z})^2} < 0$. Hence, $\frac{dK^T}{d\tilde{z}} = \frac{\partial K^T}{\partial \tilde{z}} + \frac{\partial K^T}{\partial R}\frac{dR}{d\tilde{z}} > 0$.

Proof of (34)

From (33), we have $\frac{\partial L^T}{\partial w} = \frac{1}{\hat{b}(2+e)}\left(-\frac{z_c(1-e)}{2-e} - \tilde{z} - \frac{(1+\theta)^2\tilde{z}(1-\tilde{z})}{2-e}\right) < 0$, $\frac{\partial L^T}{\partial R} = \frac{1}{\hat{b}(2+e)}\left(-\frac{\delta z_c}{2+e}(1-e) - \frac{1}{2}\delta\gamma z_c^2 - \delta\tilde{z} - \frac{1}{2}\delta\gamma\tilde{z}^2\right) < 0$ and $\frac{dR}{d\tilde{w}} = \frac{\theta}{\delta(1+\gamma\tilde{z})} > 0$. Hence, we obtain $\frac{dL^T}{dw} = \frac{\partial L^T}{\partial w} + \frac{\partial L^T}{\partial R}\frac{dR}{dw} < 0$.

Proof of (35)

From (33), we have $\frac{\partial L^T}{\partial \tilde{z}} = q^C\left(c_k(\tilde{z})\right) - (1+\theta)q^B(c^L)$. Due to (3) and (27), $q^C\left(c_k(\tilde{z})\right) = q^C(c^L) < q^B(c^L)$. Hence, the sign of $\frac{\partial L^T}{\partial \tilde{z}}$ is negative. From (33), we also have $\frac{\partial L^T}{\partial R} = \frac{1}{\hat{b}(2+e)}\left(-\frac{\delta z_c}{2+e}(1-e) - \frac{1}{2}\delta\gamma z_c^2 - \delta\tilde{z} - \frac{1}{2}\delta\gamma\tilde{z}^2\right) > 0$ and $\frac{dR}{d\tilde{z}} = -\frac{\gamma}{(1+\gamma\tilde{z})^2} > 0$. Hence the sign of $\frac{dL^T}{d\tilde{z}}$ is ambiguous.

7.1   Proof of (37)

Using 29, we define Δ^K by equation $\Delta^K \equiv -d\overline{L} - \frac{\delta}{\hat{b}(2+e)}(\hat{a}z_c - \delta Rz_c - \frac{1}{2}R\delta\gamma z_c^2 - wz_c)$ $-\frac{\delta}{\hat{b}(2+e)(2-e)}(\hat{a} - w(1+\theta))(\tilde{z} - z_c) + \Phi R(1+\frac{\gamma}{2})$ equation with $\Delta^K = 0$. The partial derivatives of Δ^K with respect to R and d are denoted Δ^K_R and Δ^K_d respectively. According to the implicit function theorem, we have $\frac{\partial R}{\partial d} = -\frac{\Delta^K_d}{\Delta^K_R}$. It is straightforward that $\Delta^K_R > 0$ and $\Delta^K_d > 0$. This implies that $\frac{\partial R}{\partial d} < 0$.

Proof of Proposition 4

Let us first consider the Cournot case ($z^* \in [0; z_c]$). We define Δ^C by

$$\Delta^C \equiv \hat{b}(2+e)^2 \Phi R(1+\gamma z^*) - \left(\hat{a} - w - \delta R(1+\gamma z^*)\right)^2. \tag{41}$$

We note that $\Delta^C = 0$. The partial derivatives of Δ^C with respect to z^* and Φ are denoted $\Delta^C_{z^*}$ and Δ^C_Φ respectively. According to the implicit function theorem, we have $\frac{dz^*}{d\Phi} = -\frac{\Delta^C_\Phi}{\Delta^C_{z^*}}$. It is straightforward that $\Delta^C_\Phi > 0$ and $\Delta^C_{z^*} > 0$. Hence, $\frac{dz^*}{d\Phi} < 0$. Using the same approach, we can show that $\frac{dz^*}{dw} < 0$ and $\frac{dz^*}{d\gamma} < 0$.

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

$$\Delta^{QB} \equiv \hat{b}(1+e)(2-e)^2 \Phi R(1+\gamma z^*) - \left(\hat{a}(1-e)+w(1+\theta)-(2-e)(w+\delta r(z))\right)(\hat{a}-w(1+\theta)). \tag{42}$$

with $\Delta^{QB}(z^*, R, w) = 0$. The partial derivatives of Δ^{QB} with respect to z^* and Φ are denoted Δ^{QB*}_z and Δ^{QB}_Φ respectively. According to the implicit function theorem, we have $\frac{dz^*}{d\Phi} = -\frac{\Delta^{QB}_\Phi}{\Delta^{QB}_{z^*}}$. It is straightforward that $\Delta^{QB}_\Phi > 0$ and $\Delta^{QB}_{z^*} > 0$. Hence, $\frac{dz^*}{d\Phi} < 0$. Using the same approach, we can show that $\frac{dz^*}{dw} < 0$ and $\frac{dz^*}{d\gamma} < 0$.

Turning to the Bertrand case ($z^* \in [\tilde{z}; 1]$), we define Δ^B as follows

$$\Delta^B \equiv \hat{b}(1+e)(2-e)^2 \Phi R(1+\gamma z^*) - (1-e)\left(\hat{a} - w(1+\theta)\right)^2. \tag{43}$$

with $\Delta^B(z^*, R, w) = 0$. Using the same approach than in Cournot and Quasi-Bertrand cases, we finally obtain $\frac{dz^*}{d\Phi} < 0$, $\frac{dz^*}{dw} < 0$ and $\frac{dz^*}{d\gamma} < 0$.

Proof of Proof of (38), (39) and 40

We use expressions of Δ^C, Δ^{QB} and Δ^B given by (41), (42) and (43).

In the Cournot case, the partial derivatives of Δ^C with respect to z^* and R are given by

$$\Delta^C_{z^*} = \hat{b}(2+e)R\gamma\left((2+e)\Phi + 2\delta q^C(c(z))\right) > 0$$

$$\Delta^C_R = \hat{b}(2+e)(1+\gamma z)\left((2+e)\Phi + 2\delta q^C(c^K(z))\right) > 0$$

According to the implicit function theorem, we have $\frac{dz^*}{dR} = -\frac{\Delta^C_R}{\Delta^C_{z^*}}$. This implies $\frac{dz^*}{dR} = -\frac{(1+\gamma z^*)}{R\gamma} < 0$. This proves (38).

Proofs of (39) and (40) are obtained using the same procedure.

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