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PRODUCT DIFFERENTIATION AND EXPORT INCENTIVE SCHEMES: A GAME THEORY APPROACH

ABSTRACT: *In order to improve economic growth, many governments use public policies to promote their countries' degree of internationalisation. When designing optimal public incentive schemes for internationalisation it is fundamental to consider the characteristics of export markets, such as size, competition degree, tax system, and product differentiation. This paper analyses whether product differentiation has any impact on optimal internationalisation incentive policies, focusing on export subsidy schemes. We develop a two-stage game for three different scenarios: (1) no subsidy, (2) a fixed-subsidy scheme, and (3) a subsidy-per-quantity-exported scheme. Using numerical analysis, we revisit the analysis of schemes designing optimal public incentives for internationalisation and conclude that for export markets with low product differentiation a subsidy-per-quantity exported scheme is best at stimulating internationalisation, while for export markets with high product differentiation a fixed-subsidy scheme is the preferable policy.*

KEY WORDS: *export subsidy schemes, internationalisation, product differentiation, game theory.*

JEL CLASSIFICATION: D43, F19, L13

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1. INTRODUCTION

Many governments provide support to their industries and firms. They do so for a variety of reasons, namely (1) to support fragile industries or regions, (2) to compensate for exceptional situations, (3) to foster national industries to compete in either the European or the global market, (4) to provide goods or services in the event of market failure, and (5) to promote internationalisation and R&D (Lin, 2021; OECD, 2021). In general, the aim of government support is to increase social welfare (Wilkinson & Brouthers, 2006). This type of government intervention gained momentum after the financial crisis at the end of the first decade of the 21st century and it has been argued that it has given industrial policy a new life; however, research on its effects and functioning is lacking (Criscuolo et al., 2019).

One of the areas of governmental support is internationalisation. Politicians have traditionally supported internationalisation because of its benefit to the economy and the difficulties firms face during the internationalisation process. Promoting internationalisation involves developing measures to address the lack of skills and internal resources and mitigate the economic and political risk to which firms are exposed (Zaheer, 1995; Bannò & Sgobbi, 2010). Therefore, governments introduce political measures that provide financial or knowledge resources to assist and enhance firms ‘capacity to handle the specificities related to the internationalisation process (Varum & Piscitello, 2011; Bannò & Sgobbi, 2010; Ciszewska-Mlinarič, 2018). Government intervention is justified by market failures, the achievement of social equality, and the distribution of income and welfare (Alcântara et al., 2013; Krugman et al., 2012). From a public policy perspective, the aim is to enable businesses to exploit existing possibilities under better conditions (Maeseneire & Claeys, 2007).

In recent years more than 70% of policies and programmes to support internationalisation have been export-related. Since 1980 many studies have used game theory to examine trade policy focusing on exports (European Commission, 2014). Eaton and Grossman (1983) discuss the effects on social welfare of a commercial and industrial policy under an oligopoly industrial structure, and identify the ideal form of intervention through qualitative analysis. The authors conclude that a production subsidy and an export tax added to the production subsidy can increase national welfare. Dixit and Grossman (1986) analyse the effect of an export subsidy. Starting from a duopoly as in Cournot, they show that an export subsidy transfers profits from the government to the domestic firm, increasing social welfare. Comparing a domestic firm and a foreign firm, and assuming that both use the same factor of production and that the economy is perfectly competitive, the authors find improvements in national well-being. Brander and Spencer (1985) analyse the impact of the application of a specific export subsidy on welfare. They consider a domestic and a foreign firm operating as in Cournot and producing for a third market with entry barriers (high fixed costs), with homogeneous products, and without domestic consumption. They show that when applying a subsidy to the quantity exported the marginal costs of the domestic firm decrease, while its exports increase. As a result, the subsidy moves the Cournot-Nash equilibrium, reducing the foreign firm's earnings. Hwang et al. (2015) introduce the cost of welfare from distorted taxation in the framework of Brander and Spencer (1985) and use it to compare welfare levels under specific export subsidies and ad valorem subsidies. They find that well-being under the specific subsidy scheme is higher (lower) than in the ad valorem subsidy scheme if the social cost of 'taxation distortion' is low (high). In addition, the signs of the two optimal subsidies are also dependent on this social cost, being positive (negative) if the social cost is low (high). According to Beenhakker (2001), defenders of the application of export subsidies believe that they deter investment and production by foreign firms, which can increase the profits of the national firm in a greater proportion than the subsidy and consequently increase social well-being. He shows that export subsidies can affect the structure of the game between a small number of either domestic or foreign firms (oligopoly) to allow the subsidized firm to profit from exports at the expense of foreign competitors. For Dobre (2008), strategic trade policies aim to promote exports in specific sectors to increase a nation's well-being. Therefore, she questions whether government intervention can increase national well-being by shifting oligopoly income from abroad to national firms. The author shows that, in principle, government policies such as export subsidies can serve the strategic objective of changing the subsequent incentives of firms acting as a deterrent to foreign competitors.

In general, most studies consider a homogeneous product market and do not consider a differentiated product market or explore whether product differentiation impacts the incentive policy chosen by governments. The present paper is the first to explore, through game theory, the conditions under which the degree of product differentiation affects decisions regarding the most appropriate internationalisation incentive. This study is relevant to the extent that innovation and internationalisation strategies develop conjointly, and government policies aim to provide the means to help firms to compete internationally through both. In Portugal the government's incentive policy stresses the importance of firms investing in the development of their products before addressing foreign markets, in order to differentiate themselves from other firms, thus supporting the need to analyse the impact of product differentiation. To the best of our knowledge, no previous work analyses the influence of different degrees of product differentiation on internationalisation incentive policies. Therefore, regarding export subsidies, we developed a two-stage game for three different scenarios: (1) no subsidy, (2) a subsidy for investment in internationalisation, and (3) a subsidy based on the quantity exported. Using numerical analyses, we explore which internationalisation subsidy is more effective for different degrees of product differentiation and show that the degree of export market product differentiation has an impact on the optimal internationalisation incentive policy. Moreover, we explore how demand, cost, and other model parameters affect this analysis.

The paper is structured as follows. The next section presents the theoretical background to this study. The third section develops the model and presents the main results. Finally, the conclusion summarizes the principal results and derives policy implications.

2. THE MODEL

The model consists of a foreign market where there is an external firm (E) and where the domestic firm (D) will enter. In the country of the domestic firm the government seeks to help firm D enter the foreign market. Using a two-stage game the model will assume that first, the domestic firm chooses how much it is willing to invest to enter the foreign market (θ) and second, after observing the choice of firm D, both firms (E and D) choose prices simultaneously. Therefore, in this game we have complete and perfect information.[1]

[1] The choice of the domestic company is observable by the foreign company. Only after the domestic company chooses θ do the companies choose prices.

To define the demands of the foreign market and introduce product differentiation, we use the inverse demand functions proposed by Dixit (1979):

$$\begin{cases} p_D = a - bq_D - dq_E \\ p_E = a - bq_E - dq_D \end{cases}$$

where, a, b, and d are positive constants, q_D and q_E are the quantities of each product offered by the domestic and foreign firm respectively, and p_D and p_E are the prices fixed by each firm. The parameter $d \in [0, b]$ measures the degree of differentiation between the two products. When $d \rightarrow b$ the products become homogeneous, and when $d \rightarrow 0$ the products are completely differentiated.

Since in the first stage of the game the domestic firm chooses how much it is willing to invest to enter the foreign market, we decided to introduce a parameter in the demand function of firm D that measures the internationalisation effort made by the domestic firm. To define this parameter, we adapted the model developed by Liu and Li (2014) and considered θ as an indicator of the expense/effort that company D performs ex ante, that is, before starting its internationalisation process.

Studies in the literature highlight the importance of domestic firms making the necessary investment before entering foreign markets in order to overcome the difficulties it will face (see Wilkinson & Brouthers, 2006). Thus, in our model, θ is seen as an investment that better prepares the firm to face international markets.[2]

This internationalisation investment indicator will be influenced by a positive constant (r) that measures the impact of this investment on individual foreign country demand (see Banker et al. 1998, which addresses a quality competition framework). The inverse functions of market demand are given by:

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[2] To better justify the use of this argument we refer to the Portuguese case, where the government's internationalisation incentive represents a percentage of the investment/cost that the company has to bear before exporting. When approving applications, the responsible entities analyse whether the investment made has resulted in marketing innovation or organizational innovation. If neither of these improvements has occurred, the application is refused.

$$\begin{cases} p_D = a + r\theta - bq_D - dq_E \\ p_E = a - bq_E - dq_D \end{cases}$$

For simplicity, we assume that the costs of this investment are $I\theta^2$, which ensures that the profit function is concave at θ. Thus, it is guaranteed that it is not optimal to choose an infinitely high θ to infinitely expand the demand. The marginal production costs of the two firms are constant and given by c_D and c_E for the domestic and foreign firms, respectively, where $c_D > 0$ and $c_E > 0$. We assume that the domestic firm costs are larger than the foreign firm costs.

Solving the system, in order of quantities, we obtain the following market demand functions:

$$\begin{cases} q_D = \frac{a(b-d)}{b^2-d^2} + \frac{br\theta}{b^2-d^2} - \frac{b}{b^2-d^2} p_D + \frac{d}{b^2-d^2} p_E \\ q_E = \frac{a(b-d)}{b^2-d^2} - \frac{dr\theta}{b^2-d^2} + \frac{d}{b^2-d^2} p_D - \frac{b}{b^2-d^2} p_E \end{cases} \tag{1}$$

Accordingly, we have the following profit functions for both firms:

$$\begin{cases} \pi_D = (p_D - c_D)q_D - I\theta^2 \\ \pi_E = (p_E - c_E)q_E \end{cases}$$

Finally, we also consider that $a > c_D, a > c_E, c_D > 0$.

In the sections that follow we find the subgame perfect equilibrium by considering three scenarios:

(1) Base scenario. No subsidy scheme, where the domestic firm exports without any type of government support.
(2) Scenario 1. Fixed subsidy scheme, where a lump sum subsidy covers part of the investment that the firm makes to achieve internationalisation.
(3) Scenario 2. Quantity-exported subsidy scheme, where a subsidy for the quantity exported is applied.

2.1. Base scenario: No subsidy

In the base scenario, the firm starts the export process without any government support. Using backward induction, we start by maximizing π_D and π_E as a function of p_D and p_E, simultaneously:

$$Max\pi_D = (p_D - c_D)q_D - I\theta^2$$

where q_D is the demand function D given in (1). Computing the first order condition:

$$\frac{\partial \pi_D}{\partial p_D} = 0 \Leftrightarrow p_D = \frac{a(b-d)}{2b} + \frac{br\theta}{2b} + \frac{d}{2b}p_E + \frac{b}{2b}c_D$$

And also, from:

$$Max\pi_E = (p_E - c_E)q_E$$

where q_E is the demand function E given in (1), we compute:

$$\frac{\partial \pi_E}{\partial p_E} = 0 \Leftrightarrow p_E = \frac{a(b-d)}{2b} - \frac{dr\theta}{2b} + \frac{d}{2b}p_D + \frac{b}{2b}c_E$$

Solving the system with the two first order conditions, we achieve:

$$\begin{cases} p_D = \frac{a(b-d)(2b+d)}{4b^2-d^2} + \frac{r\theta(2b^2-d^2)}{4b^2-d^2} + \frac{db}{4b^2-d^2}c_E + \frac{2b^2}{4b^2-d^2}c_D \\ p_E = \frac{a(b-d)(2b+d)}{4b^2-d^2} - \frac{dr\theta}{4b^2-d^2} + \frac{db}{4b^2-d^2}c_D + \frac{2b^2}{4b^2-d^2}c_E \end{cases} \qquad (2)$$

Using backward induction, we now focus on the domestic firm's decision regarding the investment θ_D^B, by replacing the expressions obtained in (2) in the profit function of the domestic firm:

$$\pi_D = (p_D - c_D)q_D - I\theta^2 \Leftrightarrow$$

$$\pi_D = \left(\frac{a(b-d)(2b+d)}{4b^2-d^2} + \frac{r\theta(2b^2-d^2)}{4b^2-d^2} + \frac{db}{4b^2-d^2}c_E - \frac{2b^2-d^2}{4b^2-d^2}c_D\right)\left(\frac{ab(b-d)(2b+d)}{(b^2-d^2)(4b^2-d^2)} + \frac{r\theta b(2b^2-d^2)}{(b^2-d^2)(4b^2-d^2)} + \frac{db^2}{(b^2-d^2)(4b^2-d^2)}c_E - \frac{b(2b^2-d^2)}{(b^2-d^2)(4b^2-d^2)}c_D\right) - I\theta^2$$

Thus, we maximize π_D by calculating the first order condition:

$$\frac{\partial \pi_D}{\partial \theta} = 0 \Leftrightarrow \theta_D^B = \frac{rb(2b^2-d^2)[(a(b-d)(2b+d) + dbc_E - (2b^2-d^2)c_D]}{I(b^2-d^2)(4b^2-d^2)^2 - br^2(2b^2-d^2)^2}$$

Replacing θ_D^B in p_D and p_E we have the perfect Nash equilibrium of prices in all subsets, which are given by:

$$p_D^B = \frac{I(b^2-d^2)(4b^2-d^2)[a(b-d)(2b+d) + dbc_E + 2b^2c_D] - br^2(2b^2-d^2)^2c_D}{I(b^2-d^2)(4b^2-d^2)^2 - br^2(2b^2-d^2)^2}$$

$$p_E^B = \frac{a(b^2-d^2)[(b-d)(2b+d)I(4b^2-d^2) - br^2(2b^2-d^2)]}{I(b^2-d^2)(4b^2-d^2)^2 - br^2(2b^2-d^2)^2} + \frac{b^2[I(b^2-d^2)(4b^2-d^2) - br^2(2b^2-d^2)]c_E}{I(b^2-d^2)(4b^2-d^2)^2 - br^2(2b^2-d^2)^2} + \frac{dbI(b^2-d^2)(4b^2-d^2)^2c_D}{I(b^2-d^2)(4b^2-d^2)^2 - br^2(2b^2-d^2)^2}$$

and also, we achieve:

$$q_D^B = \frac{Ib(4b^2-d^2)[a(b-d)(2b+d) + dbc_E - (2b^2-d^2)c_D]}{I(b^2-d^2)(4b^2-d^2)^2 - br^2(2b^2-d^2)^2}$$

$$\pi_D^B = (p_D - c_D)q_D - I\theta^2 \Leftrightarrow \pi_D^B = \frac{Ib[(a(b-d)(2b+d) + dbc_E - (2b^2-d^2)c_D]^2}{I(b^2-d^2)(4b^2-d^2)^2 - br^2(2b^2-d^2)^2}$$

2.2. Scenario 1: Fixed subsidy scheme

We consider the introduction of a lump sum subsidy that covers part of the investment in internationalisation. As stated before, $I\theta^2$ is the investment cost that better prepares the firm to face international markets. Our subsidy will be a percentage of the expense spent on internationalisation. This subsidy of investment costs covers expenses associated with, for example, conducting market studies, participating in international fairs, and directing the firm's marketing to the chosen markets. The government's support in the form of a subsidy is given by $sI\theta^2$, while $(1-s)I\theta^2$is the domestic firm's investment cost.

Using backward induction we follow the above reasoning, starting by maximizing π_D and π_E as a function of p_D and p_E (as in the base scenario), and obtain:

$$Max\ \pi_D = (p_D - c_D)q_D - (1-s)I\theta^2$$

$$p_D = \frac{a(b-d)}{2b} + \frac{br\theta}{2b} + \frac{d}{2b}p_E + \frac{b}{2b}c_D$$

and

$$Max\ \pi_E = (p_E - c_E)q_E$$

$$p_E = \frac{a(b-d)}{2b} - \frac{dr\theta}{2b} + \frac{d}{2b}p_D + \frac{b}{2b}c_E$$

Thus, the equilibrium prices do not change:

$$\begin{cases} p_D = \frac{a(b-d)(2b+d)}{4b^2-d^2} + \frac{r\theta(2b^2-d^2)}{4b^2-d^2} + \frac{db}{4b^2-d^2}c_E + \frac{2b^2}{4b^2-d^2}c_D \\ p_E = \frac{a(b-d)(2b+d)}{4b^2-d^2} - \frac{dr\theta}{4b^2-d^2} + \frac{db}{4b^2-d^2}c_E + \frac{2b^2}{4b^2-d^2}c_D \end{cases} \quad (3)$$

It remains to computeθ_D^1 by maximizing the profits of firm D in this scenario:

$$Max\ \pi_D = (p_D - c_D)q_D - (1-s)I(\theta_D^1)^2$$

$$\theta_D^1 = \frac{rb(2b^2-d^2)[(a(b-d)(2b+d)+dbc_E-(2b^2-d^2)c_D]}{(1-s)I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2}$$

Replacing θ_D^1 in the equilibrium prices we reach the perfect equilibrium prices:

$$p_D^1 = \frac{(1-s)I(b^2-d^2)(4b^2-d^2)[a(b-d)(2b+d)+dbc_E+2b^2c_D]-br^2(2b^2-d^2)^2c_D}{(1-s)I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2}$$

$$p_E^1 = \frac{a(b^2-d^2)[(b-d)(2b+d)(1-s)I(4b^2-d^2)-br^2(2b^2-d^2)]}{(1-s)I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2} + \frac{b^2[(1-s)I(b^2-d^2)(4b^2-d^2)-br^2(2b^2-d^2)]c_E}{(1-s)I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2} + \frac{db(1-s)I(b^2-d^2)(4b^2-d^2)^2c_D}{(1-s)I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2}$$

For scenario1 we also achieve:

$$q_D^1 = \frac{(1-s)Ib(4b^2-d^2)[a(b-d)(2b+d)+dbc_E-(2b^2-d^2)c_D]}{(1-s)I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2}$$

$$\pi_D^1 = (p_D-c_D)q_D-(1-s)I\theta^2 \Leftrightarrow \pi_D^1 = \frac{(1-s)Ib[(a(b-d)(2b+d)+dbc_E-(2b^2-d^2)c_D]^2}{(1-s)I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2}$$

Lastly, the government expenditure on this subsidy is given by:

$$G_D^1 = sI\theta^2$$

$$\Leftrightarrow$$

$$G_D^1 = sI\big(br(2b^2-d^2)\big)^2\left[\frac{(a(b-d)(2b+d)+dbc_E-(2b^2-d^2)c_D}{(1-s)I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2}\right]^2$$

2.3. Scenario 2: Quantity-exported subsidy scheme

Finally, we consider the introduction of a subsidy per quantity exported. In this scenario the government applies a subsidy *e* for each exported unit, which changes the profit function of the domestic firm to:

$$\pi_D = (p_D - c_D + e)q_D - I\theta^2$$

$$\Leftrightarrow \pi_D = (p_D - c_D + e)\left(\frac{a(b-d)}{b^2-d^2} + \frac{br\theta}{b^2-d^2} - \frac{b}{b^2-d^2}p_D + \frac{d}{b^2-d^2}p_E\right) - I\theta^2$$

Solving the game by backward induction, we start by maximizing π_D as a function of p_D and obtain:

$$Max\ \pi_D$$

$$p_D = \frac{a(b-d)}{2b} + \frac{br\theta}{2b} + \frac{d}{2b}p_E + \frac{b}{2b}(c_D - e)$$

whereas Max π_E calculation remains unchanged. Thus, the subgame perfect Nash equilibrium prices are:

$$\begin{cases} p_D = \frac{a(b-d)(2b+d)}{4b^2-d^2} + \frac{r\theta(2b^2-d^2)}{4b^2-d^2} + \frac{db}{4b^2-d^2}c_E + \frac{2b^2}{4b^2-d^2}(c_D - e) \\ p_E = \frac{a(b-d)(2b+d)}{4b^2-d^2} - \frac{r\theta bd}{4b^2-d^2} + \frac{db}{4b^2-d^2}(c_D + e) + \frac{2b^2}{4b^2-d^2}c_E \end{cases} \tag{4}$$

Computingθ_D^2, from $Max\pi_D$:

$$\frac{\partial \pi_D}{\partial \theta_D^2} = 0 \Leftrightarrow \theta_D^2 = \frac{rb(2b^2-d^2)[(a(b-d)(2b+d) + dbc_E - (2b^2-d^2)(c_D - e)]}{I(b^2-d^2)(4b^2-d^2)^2 - br^2(2b^2-d^2)^2}$$

Finally, the subgame perfect equilibrium of scenario 2 is given by:

$$p_D^2 = \frac{I(b^2-d^2)(4b^2-d^2)[a(b-d)(2b+d) + dbc_E + 2b^2(c_D - e)] - br^2(2b^2-d^2)^2(c_D - e)}{I(b^2-d^2)(4b^2-d^2)^2 - br^2(2b^2-d^2)^2}$$

$$p_E^2 = \frac{a(b^2-d^2)[(b-d)(2b+d)I(4b^2-d^2)-br^2(2b^2-d^2)]}{I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2} + \frac{b^2[I(b^2-d^2)(4b^2-d^2)-br^2(2b^2-d^2)]c_E}{I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2} + \frac{dbI(b^2-d^2)(4b^2-d^2)^2(c_D+e)}{I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2}$$

For scenario2 we also achieve:

$$q_D^2 = \frac{Ib(4b^2-d^2)[a(b-d)(2b+d)+dbc_E-(2b^2-d^2)(c_D-e)]}{I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2}$$

$$\pi_D^2 = (p_D-c_D+e)q_D - I\theta^2 \Leftrightarrow \pi_D^2 = \frac{Ib[(a(b-d)(2b+d)+dbc_E-(2b^2-d^2)(c_D-e)]^2}{I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2}$$

Finally, the government expenditure is given by:

$$G_D^2 = eq_D^2 = eIb(4b^2-d^2)\left[\frac{(a(b-d)(2b+d)+dbc_E-(2b^2-d^2)(c_D-e)}{I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2}\right]$$

3. DISCUSSION

To ensure non-negativity equilibrium conditions, i.e., such that guarantee that p, q, and θ are positive in all scenarios, we must assume:

$$\begin{cases} (1-s)I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2>0 \\ a(b-d)(2b+d)+dbc_E-(2b^2-d^2)c_D>0 \end{cases}$$

$$\begin{cases} a(b-d)(2b+d)-dr\theta+dbc_D+2b^2c_E>0 \\ a(b-d)(2b+d)-dr\theta+dbc_D-(2b^2-d^2)c_E>0 \end{cases}$$

Under these conditions, Table 1 summarizes the main results of the scenarios presented.

Table 1: Main results for the three scenarios

	Quantities
Base Scenario	$q_D^B = \dfrac{Ib(4b^2 - d^2)[a(b-d)(2b+d) + dbc_E - (2b^2 - d^2)c_D]}{I(b^2 - d^2)(4b^2 - d^2)^2 - br^2(2b^2 - d^2)^2}$
Scenario 1	$q_D^1 = \dfrac{(1-s)Ib(4b^2 - d^2)[a(b-d)(2b+d) + dbc_E - (2b^2 - d^2)c_D]}{(1-s)I(b^2 - d^2)(4b^2 - d^2)^2 - br^2(2b^2 - d^2)^2}$
Scenario 2	$q_D^2 = \dfrac{Ib(4b^2 - d^2)[a(b-d)(2b+d) + dbc_E - (2b^2 - d^2)(c_D - e)]}{I(b^2 - d^2)(4b^2 - d^2)^2 - br^2(2b^2 - d^2)^2}$
	Prices
Base Scenario	$p_D^B = \dfrac{I(b^2 - d^2)(4b^2 - d^2)[a(b-d)(2b+d) + dbc_E + 2b^2c_D] - br^2(2b^2 - d^2)^2c_D}{I(b^2 - d^2)(4b^2 - d^2)^2 - br^2(2b^2 - d^2)^2}$
Scenario 1	$p_D^1 = \dfrac{(1-s)I(b^2 - d^2)(4b^2 - d^2)[a(b-d)(2b+d) + dbc_E + 2b^2c_D] - br^2(2b^2 - d^2)^2c_D}{(1-s)I(b^2 - d^2)(4b^2 - d^2)^2 - br^2(2b^2 - d^2)^2}$
Scenario 2	$p_D^2 = \dfrac{I(b^2 - d^2)(4b^2 - d^2)[a(b-d)(2b+d) + dbc_E + 2b^2(c_D - e)] - br^2(2b^2 - d^2)^2(c_D - e)}{I(b^2 - d^2)(4b^2 - d^2)^2 - br^2(2b^2 - d^2)^2}$
	Profits
Base Scenario	$\pi_D^B = \dfrac{Ib[(a(b-d)(2b+d) + dbc_E - (2b^2 - d^2)c_D]^2}{I(b^2 - d^2)(4b^2 - d^2)^2 - br^2(2b^2 - d^2)^2}$
Scenario 1	$\pi_D^1 = \dfrac{(1-s)Ib[(a(b-d)(2b+d) + dbc_E - (2b^2 - d^2)c_D]^2}{(1-s)I(b^2 - d^2)(4b^2 - d^2)^2 - br^2(2b^2 - d^2)^2}$
Scenario 2	$\pi_D^2 = \dfrac{Ib[(a(b-d)(2b+d) + dbc_E - (2b^2 - d^2)(c_D - e)]^2}{I(b^2 - d^2)(4b^2 - d^2)^2 - br^2(2b^2 - d^2)^2}$
	θ
Base Scenario	$\theta_D^B = \dfrac{rb(2b^2 - d^2)[(a(b-d)(2b+d) + dbc_E - (2b^2 - d^2)c_D]}{I(b^2 - d^2)(4b^2 - d^2)^2 - br^2(2b^2 - d^2)^2}$
Scenario 1	$\theta_D^1 = \dfrac{rb(2b^2 - d^2)[(a(b-d)(2b+d) + dbc_E - (2b^2 - d^2)c_D]}{(1-s)I(b^2 - d^2)(4b^2 - d^2)^2 - br^2(2b^2 - d^2)^2}$
Scenario 2	$\theta_D^2 = \dfrac{rb(2b^2 - d^2)[(a(b-d)(2b+d) + dbc_E - (2b^2 - d^2)(c_D - e)]}{I(b^2 - d^2)(4b^2 - d^2)^2 - br^2(2b^2 - d^2)^2}$
	Subsidies
Scenario 1	$G_D^1 = sI\big(br(2b^2 - d^2)\big)^2 \left[\dfrac{(a(b-d)(2b+d) + dbc_E - (2b^2 - d^2)c_D}{(1-s)I(b^2 - d^2)(4b^2 - d^2)^2 - br^2(2b^2 - d^2)^2}\right]^2$
Scenario 2	$G_D^2 = eIb(4b^2 - d^2)\left[\dfrac{(a(b-d)(2b+d) + dbc_E - (2b^2 - d^2)(c_D - e)}{I(b^2 - d^2)(4b^2 - d^2)^2 - br^2(2b^2 - d^2)^2}\right]$

Comparison of the domestic firm's investments in internationalisation (θ)

Proposition 1: $\theta_D^1 > \theta_D^B$ and $\theta_D^2 > \theta_D^B$ Proof: See Appendix.

Both investments are higher under export subsidy schemes. Moreover, we show that:

$$\theta_D^1 > \theta_D^2 \text{ for } e < \frac{sI(b^2-d^2)(2b^2-d^2)(4b^2-d^2)\left[a(b-d)(2b+d)+dbc_E-(2b^2-d^2)c_D\right]}{(2b^2-d^2)[(1-s)I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2]}.$$

This result indicates that θ_D^2 is not always greater than θ_D^1. For a given *s*, when *e* is low, the domestic firm's investment in internationalisation is greater in scenario 1 than in scenario 2 for a large subset of product differentiation degrees. Thus, the investment depends on the degree of product differentiation.

Comparison of quantities exported

Proposition 2: $q_D^1 > q_D^B$ and $q_D^2 > q_D^B$ Proof: See Appendix

The domestic firm exports more with the existence of a subsidised export scheme than without the application of any subsidy. Additionally, $q_D^1 > q_D^2$ only when:

$$e < \frac{sbr^2(2b^2-d^2)[a(b-d)(2b+d)+dbc_E-(2b^2-d^2)c_D]}{(1-s)I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2}$$

For a given *s*, for high levels of *e*, scenario 1 is no better than scenario 2 in terms of subsidy for the quantity exported. However, for low levels of *e*, for a given *s*, the quantity exported in scenario 1 is higher than in scenario 2 per degree of low product differentiation.

Comparison of subsidy expenses

In terms of the comparison of subsidies expenses, we conclude that $G_D^1 > G_D^2$ when *e* is lower than:

$$\frac{a(b-d)(2b+d)+dbc_E-(2b^2-d^2)c_D}{(1-s)I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2}\sqrt{\frac{sbr^2(2b^2-d^2)[I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2]}{(4b^2-d^2)}}$$

For a fixed value of s, it turns out that for low levels of e, public expenditure in scenario 1 is higher than in scenario 2. However, for high levels of e, given a fixed value of s, public expenditure in scenario 2 is higher than in scenario 1. Table 2 summarizes the main results.

Table 2: Comparison of scenario results

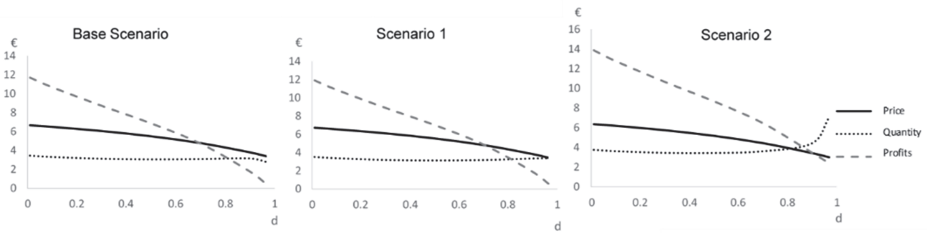
	Base Scenario	Subsidy supporting investment to internationalise	Export-quantity subsidy	Scenario 1 vs. Scenario 2
Quantity	q_D^B	$q_D^1 > q_D^B$	$q_D^2 > q_D^B$	$q_D^1 \lesseqgtr q_D^B$
$\boldsymbol{\theta}$	θ_D^B	$\theta_D^1 > \theta_D^B$	$\theta_D^2 > \theta_D^B$	$\theta_D^1 \lesseqgtr \theta_D^B$
Subsidy	$\emptyset$	$sI\theta_1^*$	eq_D^*	$G_D^1 \lesseqgtr G_D^2$

The analysis of the impact of the degree of product differentiation comparing the subgame perfect Nash equilibrium in the three scenarios proved to be complex. Thus, we resort to a numerical analysis that enables us to explore how product differentiation impacts the better incentive policy to increase exports.

3.1. Numerical Analysis

In this simulation, the value of some parameters of the model is fixed. We assume that b = 1 (standard in the literature) and s = 0.45 (to capture the reality in Portugal, where the government subsidizes 45% of domestic firms' internationalisation investment costs). We assume the following parameters: e= 0.6, a = 10, r = 0.4, I = 1.8, c_D=3.2, and c_E=3. We proceed with the simulation showing the impact on the prices, quantities, and profits of firm D under the three scenarios considered for different degrees of product differentiation (Figure 1).

Figure 1. Comparison of prices, quantities and profits



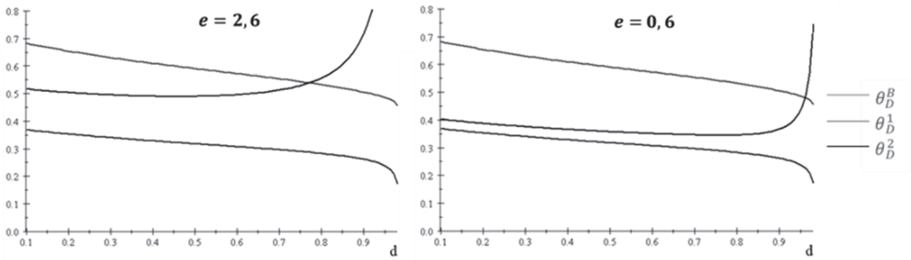
As shown in the previous results, in all the scenarios, product differentiation has a positive impact on the results of the domestic firm. The more differentiated the product is in the foreign market, the better the achieved results. Conversely, the more homogeneous the products are in the foreign market (as d → 1), the more competitive the market becomes and the lower the profits of firm D.

Comparison of the domestic firm's investment in internationalisation (θ)

Figures 2 to 4 show the behaviour of $\theta_D^B, \theta_D^1,$ and θ_D^2under different degrees of product differentiation for the previously defined parameter values.

Given a decrease in the degree of product differentiation (i.e., the more homogeneous the goods) the internationalisation investment is greater in scenario 2 than in scenario 1 (θ_D^2 is higher than θ_D^1), since the impact of the fixed-subsidy incentive scheme (*s*) is almost null as d approaches 1. Thus, Figure 2 shows that the degree of product differentiation has an impact on the firm's investment in internationalisation. With higher product differentiation the internationalisation investment becomes greater in scenario 1 than in scenario 2. The use of a fixed-subsidy incentive scheme leads to stronger incentives, since with a high degree of product differentiation, competition is not so fierce, and thus a lump-sum outweighs the incentives of a quantity-subsidy scheme.

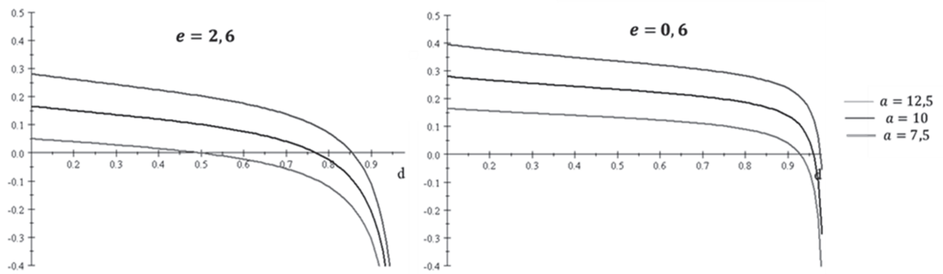
Figure 2. Comparison of *θ* for different levels of *e*



With a decrease in the subsidy per quantity exported (e) and keeping everything else constant, we find that θ_D^2 approaches θ_D^B, making scenario 1 usually superior to scenario 2, for all degrees of product differentiation. Thus, our results show that θ_D^2 is a preferable policy for low degrees of product differentiation and also for more degrees of product differentiation when *e* increases, since $\theta_D^2 > \theta_D^1$ for a larger interval of product differentiation degrees; i.e., increasing e makes the scenario 2 incentive preferable for a large range of degrees of product-differentiated markets, not only those with a very low degree of product differentiation. Therefore, our model illustrates that with a low degree of product differentiation $\theta_D^2 > \theta_D^1$ is always attained, but when the degree of product differentiation starts to increase there is always $\theta_D^2 < \theta_D^1$, for all e.

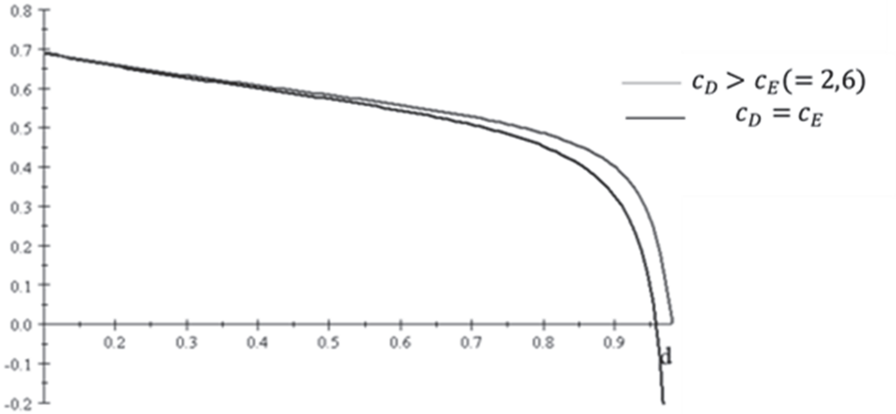
To better understand the impact of the degree of product differentiation, the evolution of θ_D^1- θ_D^2 for different demand parameters (a) was explored (still considering $r = 0.4$ / $I = 0.8$ / $c_D = 3.2$ / $c_E = 3$). As concluded in the previous figure, product differentiation has an impact on the domestic firm's investment in internationalisation (θ), since when products become more differentiated θ_D^1- $\theta_D^2$is positive, but when they are more homogeneous θ_D^1- $\theta_D^2$is negative. Additionally, Figure 3 illustrates that the demand parameter (a) also has an impact on this comparison.We conclude that the higher the demand, for every degree of product differentiation the difference between $\theta_D^1$and θ_D^2 is higher and the range where θ_D^1- $\theta_D^2$is positive increases with a. When $e = 2.6$ this condition is satisfied for $d > 0.5$, but when $e = 0.6$ it is satisfied for d higher than 0.9. Moreover, increasing e decreases the impact of the demand on θ_D^1- θ_D^2, since it outweighs part of the positive effect that increasing demand has on θ_D^1- θ_D^2.

Figure 3. Evolution of $\theta_D^1 - \theta_D^2$ for different values of a



We also highlight the impact of the proximity of firms' costs (still considering $r = 0.4$ / $I = 0.8$ / $c_D = 3.2$ and for $e = 1.5$ / $a = 20$).Figure 4 shows that product differentiation has a higher impact on θ_D^1- θ_D^2 when firms have different production costs (namely, when $c_D > c_E$). Thus, when the domestic firm has a cost disadvantage, scenario 1 leads to higher levels of internationalisation investment, since, for a given *e*, scenario 2 does not outweigh the cost disadvantage as scenario 1 does. Moreover, when firms are more similar, for lower levels of the degree of product differentiation,θ_D^2starts to be better than θ_D^1.

Figure 4. Evolution of $\theta_D^1 - \theta_D^2$ for different values of c_E



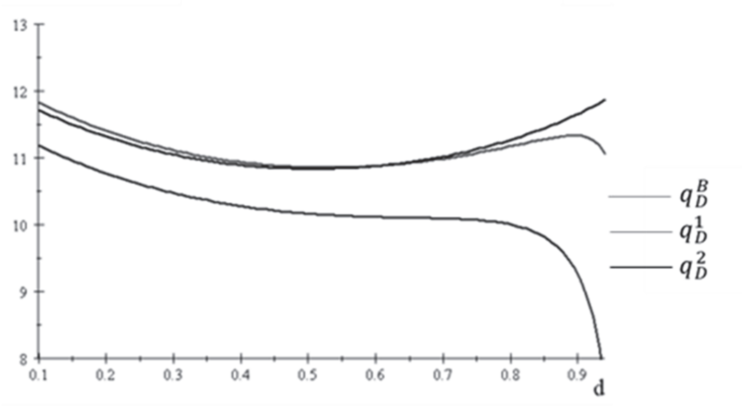
Comparison of quantities exported

We explore the behaviour of q_D^B, q_D^1, and q_D^2, for different degrees of product differentiation, assuming the following parameters: *e*= 1, *a* = 30, *r* = 1, I = 4, c_D=8, and c_E=6 (Figures 5 – 7).

A comparison of the different scenarios allows us to conclude that the degree of product differentiation also has an impact on the quantity exported (Figure 5).

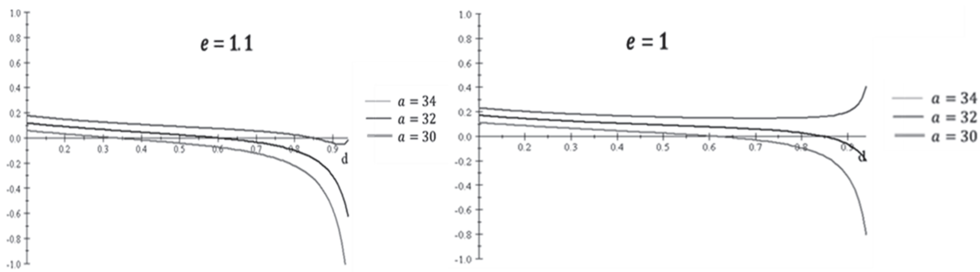
When products are more homogeneous, d→1, the preferable policy to encourage internationalisation is the incentive scheme in scenario 2, given that $q_D^2 > q_D^1$. However, when the degree of product differentiation is higher, the preferable policy to promote internationalisation is the incentive scheme in scenario 1. The use of fixed-subsidy incentive schemes leads to slightly stronger incentives to increase the quantity exported when the degree of product differentiation is high, whereas the opposite occurs with a low degree of product differentiation, since the impact of the lump-sum fixed-subsidy scheme decreases the quantity exported, q_D^1, more than when there is a subsidy per unit exported.

Figure 5. Comparison q_D



Additionally, to better understand the impact of the degree of product differentiation on the quantity exported, we decided to graphically analyse the evolution of q_D^1- q_D^2 for different parameters of the demand (a) (Figure 6).

Figure 6. Evolution of $q_D^1 - q_D^2$ for different values of a

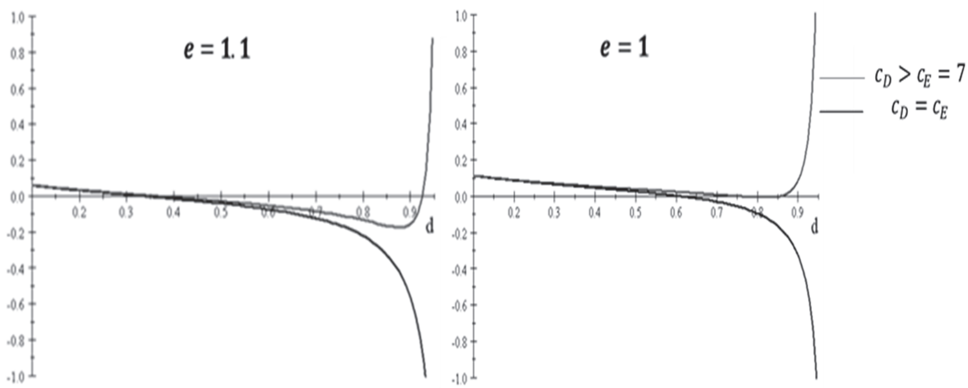


For different parameters of the demand, we find that for the three scenarios there is always some degree of product differentiation that causes q_D^2>q_D^1.

We conclude that for every degree of product differentiation, the higher the demand, the higher q_D^1- q_D^2, and the range where $q_D^1 - q_D^2$ is positive increases with a. For low levels of demand (such as a = 30), q_D^1- q_D^2 is negative for d > 0.3; i.e., when demand is low the range of the degree of product differentiation is wider where the lump-sum fixed-subsidy scheme leads to a lower quantity exported, q_D^1, than q_D^2. For high demand levels, only for almost homogeneous goods, we get $q_D^2 > q_D^1$. With a decrease of *e*, we observe that for higher levels of demand the condition $q_D^1 > q_D^2$ is verified for every possible degree of product differentiation; thus the preferable policy is always scenario 1. Last, we analyse the impact of the similarity of firms' production costs, but now considering $q_D^1 - q_D^2$.

Figure 7 presents the results for $e = 1.1$ and $e = 1$, respectively. For high *e*, the impact of the degree of product differentiation on whether or not firms' production costs affect q_D^1 and q_D^2 is different. There are always some degrees of product differentiation for which $q_D^2 > q_D^1$ regardless of $c_D > c_E$ or $c_D = c_E$. When the domestic firm has a cost disadvantage, scenario 1 leads to a higher quantity exported since, for low *e*, scenario 2 does not outweigh the cost disadvantage as scenario 1 does.

Figure 7. Evolution of $q_D^1 - q_D^2$ for different values of c_E



3.2. Discussion of the numerical analysis

The results obtained from the numerical analysis show that product differentiation has an impact on the incentive policy that the government uses to support the internationalisation of domestic firms, increasing their exports or their internationalisation investment. Product differentiation itself has an impact on the firms' results: a differentiated product means better results for the domestic firm, and a decreasing trend of these results is quite evident the more homogeneous the product becomes. Our results reinforce the idea that product differentiation has an impact on the preferable incentive policy for encouraging internationalisation, through higher exports or higher internationalisation efforts. This is also true when analysing different demands or even when discussing the firms 'similar cost structure when the values of subsidies allocated by the government are changed. Therefore, we find that the use of a fixed-subsidy scheme (scenario 1) is better for the internationalisation of domestic firms when the degree of export markets' product differentiation is high or intermediate. When the degree of export markets' product differentiation is low, we conclude that the use of a subsidy per quantity exported (scenario 2) is more effective in increasing the levels of internationalisation than that in scenario 1. Thus, we find that for different markets, in terms of their degree of product differentiation, the incentive policies to promote internationalisation may differ.

4. CONCLUSION

This paper explores whether product differentiation has an impact on policy that incentivises internationalisation via exports. To encourage internationalisation, governments can make financial resources available or contribute to reducing asymmetric information and economic and political risk by providing, for example, technical advice. The present study focuses on the two most common export incentives in Portugal: a subsidy to finance a part of firms' internationalisation costs and a subsidy based on each unit of product exported.

The existing literature does not consider models that incorporate product differentiation and there is a gap concerning the impact of product differentiation on policies that incentivise internationalisation. Using a game theory model, we compare different incentive policies to promote exports, highlighting and discussing the impact of the degree of product differentiation on the results of different incentive policies. We develop a product differentiation model and explore the subgame of perfect Nash equilibrium, in three scenarios: (1) a domestic firm exports products with no government support; (2) a domestic firm receives an investment subsidy to pay for part of the costs of the internationalisation process, and (3) a domestic firm receives a subsidy per quantity exported. Through numerical analysis, we conclude that product differentiation has an impact on the incentive policy that the government uses to increase the exports of domestic firms.

We find that using a fixed subsidy that covers part of the cost of investing in internationalisation is preferable for the domestic firm as long as the export market's degree of product differentiation is high. When the export market's degree of product differentiation is low, the policy that applies a subsidy per quantity exported generates greater internationalisation.

We have revisited and extended the literature on export incentive schemes, and here present some avenues for future research. In our game we focus on a market with two firms, one domestic and one foreign; in future research it would be useful to extend the analysis to several firms in the market. Additionally, in our game everything that the domestic firm produces is for export and the country's domestic consumption is not taken into account; in future research it would be useful to investigate the composition of domestic consumption.

Disclosure statement

No potential conflict of interest was reported by the authors.

The authors declare that this work is original and has not been published elsewhere nor is it currently under consideration for publication elsewhere.

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APPENDIX

Proof of proposition 1: $\theta_D^1 > \theta_D^B$ and $\theta_D^2 > \theta_D^B$

since both numerators are the same and the denominator of $\theta_D^1$is lower than the denominator of θ_D^{B}. And also since the numerator of θ_D^2 is greater than the numerator θ_D^{B} and both denominators are the same.

Proof of proposition 2: $q_D^1 > q_D^B$ and $q_D^2 > q_D^B$

Since

$\frac{br^2\left(2b^2-d^2\right)\left[a(b-d)(2b+d)+dbc_E-\left(2b^2-d^2\right)c_D\right]}{[I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2][(1-s)I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2]}$ and

$\frac{Ib(4b^2-d^2)(2b^2-d^2)e}{I(b^2-d^2)(4b^2-d^2)^2-br^2(2b^2-d^2)^2}$ are always positive.