Skills, Labour Costs, and Vertically Differentiated Industries: A General Equilibrium Analysis

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Abstract

The effect of labour costs on industry profits, employment and labour income is at the heart of the current European debate on industry competitiveness. High wages paid in European countries such as Germany are generally considered harmful for industry profitability. Though, high wages appear also to be associated with high labour skills and then with superior product quality. Similarly, a reduction in labour taxes is often invoked as a tool to improve industry profitability, but this argument hardly takes into account the demand effects of such a tax reform. In this paper we analyse the trade-off between labour costs and industry profits by means of a simple general equilibrium model where one industry is oligopolistic and vertically differentiated. The manufacturing of products of a higher quality requires the employment of a larger amount of skilled labour. Given an underlying skills distribution, the model determines profits, wages and aggregate income and welfare. Results show that high net wages due to a low skills endowment in the economy are typically associated with low profits. Labour taxation unambiguously raises gross wages, but has little effect on net wages. Depending on how the tax revenue is redistributed, higher taxation may either depress or boost industry profits.

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1. Introduction

The effect of labour cost on industry profits, employment and labour income is at the heart of the current European debate on industry competitiveness. Some argue that the high wages paid in European countries such as Germany harm the profitability of industries and will possibly lead to emigration of firms. Others maintain that the observed high wages are coupled with high workers' skills and then with high labour productivity and superior product quality, so that the cost of labour cannot be the only factor to look at when analysing firms' performance and locational incentives. Concerning labour taxation, it is a widespread opinion that too high tax wedges aggravate the competitive problems of the European industry and, consistently, many observers invoke for a reduction of tax rates on labour costs. Such an argument, though, does not take into account the distributional consequences of tax reforms, and the possible repercussions for demand and profitability of particular industries.

In general, the average wage paid in the manufacturing industry or the level of labour taxes can hardly be thought as sufficient statistics to assess the effects of labour costs on the performance of given industries. High wages keep firms' costs high, but also stimulate the supply of skilled labour. High labour taxation may involve a positive demand feedback that offsets the negative direct effect on costs for some industries. Analysing the effects of labour costs on industry performance requires then taking into account general equilibrium effects that are commonly disregarded in current policy debate.

Standard general equilibrium analysis is cast in a perfectly competitive framework, thus neglecting important features of modern industries. Giant corporations are hardly price-takers. Competition in technologically-advanced sectors does not only take place in prices, but also in all those factors that affect the level of product quality perceived by consumers (R&D, advertisement...). The profits accruing to some industries are a non-negligible part of national income and, from a dynamic perspective, they form the incentives for investment and innovation. Perfectly competitive models miss also important aspects of current trade flows among developed countries. A large and increasing share of modern international trade takes place in differentiated goods belonging to the same sector, but perfect competition is not consistent with the observed firms' incentives to differentiate their products. Hence, a useful model to analyse the effects of labour conditions on industry performance should be a general equilibrium one, but it should also incorporate imperfectly competitive features that are commonly disregarded in standard models.

In this paper we develop a simple general equilibrium model to analyse the relation between some features of the labour market and the performance of a vertically differentiated, oligopolistic industry. There are several reasons that lead us to focus on vertical differentiation. First, vertical differentiation models permit us to capture a crucial dimension of the competitiveness of advanced industries, namely, product quality, allowing for a convenient modelling of quality competition. Second, recent empirical evidence shows that vertical differentiation is at the heart of current developments of intra-European trade. European intra-industry trade (IIT) in vertically differentiated goods has increased significantly during the last decade, while IIT in horizontally differentiated varieties has been stagnating.[1] Empirical evidence also shows that differences in factor endowments are positively related with the share of IIT in vertically differentiated goods across European countries.[2] This leads to the presumption that the determinants of competitiveness in vertically differentiated industries are

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2 See Fontagné et al. (1997).

to be studied in a general equilibrium framework, something that is missing in standard imperfectly competitive models (e.g., Gabszewicz and Thisse, 1979, Shaked and Sutton, 1982).

Empirical research indicates that the availability of skilled labour within a country influences the level of product qualities and the resulting international competitive position of domestic industries.[3] Consistently, we assume in our model that producing higher quality products requires a higher amount of skilled labour. In order to analyse currently debated issues concerning labour taxation we also allow for the presence of taxes on labour and the redistribution of resulting revenues to consumers by the government. Firms in the vertically differentiated sector are oligopolistic and decide about prices and product qualities in a two-stage industry game. Given an underlying skills distribution, the model determines the allocation of labour, the distribution of income, as well as the quality and prices of the goods produced in the oligopolistic sector. In such a framework, contrary to standard models of vertically differentiated oligopolies, firms' demand *functions* can only be determined at equilibrium, together with labour allocation and consumers' income. Therefore, firms' conjectures about their own demand functions when setting prices and product qualities must prove to be consistent with equilibrium values, a requirement that is absent in partial equilibrium models. Because of non-linearities, an explicit solution of the model is not possible, and simulations are necessary.

The model is used to examine the effects of changes in the endowment of labour skills and in non-wage labour costs on firms' prices, product qualities, profits, income and overall welfare. Results show that higher net wages due to a low skills endowment in the economy is typically coupled with lower industry competitiveness (measured by the price-quality ratio), profits, and overall welfare. A reduction in labour taxes unambiguously lowers gross wages, but has little effect on net wages. It may either increase or decrease industry profitability, depending on the redistributive income effect of taxation. If tax revenues were fully retained by the government before the tax reform, the positive cost effect related to a tax-cut tends to prevail, creating an advantage to the domestic industry. However, if tax revenues were previously fully redistributed, a negative demand effect offsets the cost effect, leading to reduced industry profits and welfare.

The remainder of the paper is organised as follows. Section 2 develops the model, and presents its main analytical properties. Section 3 reviews and discusses the results of the simulations. Section 4 concludes.

2. A General Equilibrium Model with Vertically Differentiated Product Qualities, Skills, and Incomes.

The existing literature dealing with vertical product differentiation has focused on the strategic determinants of industry equilibrium. Gabszewicz and Thisse (1979) characterise the price-setting behaviour of a duopoly at given qualities and zero marginal costs, showing how "limit-pricing" strategies may endogenously arise, leading to the exclusion of the low-quality competitor. This result is the basis for the so-called "finiteness property" of vertically differentiated oligopolies, illustrated by Shaked and Sutton (1984). Holding fixed costs constant, the number of active firms in a differentiated industry may not increase even with increasing market size and free-entry, because price strategies adjust in such a way as not to allow positive market shares for potential entrants.

[3] Daly et. al. (1985), Steedman and Wagner (1987) or Mason et. al. (1996) present cross country evidence that endowments with vocational skills tend to affect quality levels in several national industries. Courakis (1991), Webster (1993), Oulton (1996), Torstensson (1996), Jansen (1997) present results indicating that countries with high endowments in skills trade high qualities in intra-industry trade.

Sutton (1991) also shows, with the support of a large set of empirical industry studies, that an endogenous markets structure is likely to arise in vertically differentiated industries because firms build their own entry barriers, increasing the quality level of their goods (and the necessary sunk investments) as market size increases.

While the literature on vertical differentiation under oligopoly has fully developed the demand implications of a rankable product structure, showing how this may be sufficient "per-se" to generate industry concentration, the supply side of the story has so far been neglected. Oligopolistic models with vertical differentiation are indeed developed in a partial equilibrium framework, assuming an exogenous cost structure.[4] In particular, what is missing in theoretical work is the channel linking factor endowments to product quality.

In this section we develop a model where the supply factors necessary to provide higher product quality in an oligopolistic industry are explicitly taken into account. We assume that the manufacturing of higher quality goods requires a more intense use of skilled labour.[5] This is consistent with empirical evidence (Daly et. al., 1985, Mason et al., 1996), and in line with recently proposed trade models incorporating vertically differentiated as well as perfectly competitive industries (Copeland and Kotwal, 1996, Murphy and Shleifer, 1997). The supply of skilled labour within a country is then the factor limiting the quality level of the goods produced domestically. The qualities chosen by domestic firms determine demand for skilled labour, and then skilled workers' income, which, in turn, generates firms' demands. Clearly, incorporating supply determinants of quality into the analysis of a vertically differentiated market necessitates usage of a full-fledged general-equilibrium model in order to take into account the feedback from costs to demand. It is exactly this link between demand and costs that we want to highlight in our model.

We opt for the most parsimonious model capable of capturing the effects generated by the interaction between an imperfectly competitive, vertically differentiated product market and a vertically differentiated, though perfectly competitive labour market. An "outside", perfectly competitive industry also enters the picture, in order to capture competition in both product and labour markets *between* industries.

The oligopolistic industry (henceforth, the x-sector) is modelled borrowing from the standard approach of vertical product differentiation in partial equilibrium (Gabszewicz and Thisse 1979, Shaked and Sutton 1982, Motta 1993). Consumers have identical preferences and different incomes. Differences in income lead to differences in the willingness to pay for a product of a particular quality. Firms offer products of different qualities in one (domestic) market. The firms bear quality-dependent costs and compete in qualities and prices in a *two-stage game*. Since higher product differentiation reduces substitutability between variants supplied by different firms, even ex-ante identical firms will offer distinct qualities in the resulting market equilibrium in order to "reduce price-competition through product differentiation.".

Both sectors use the only production factor: labour. Workers, though, are not homogenous. Each worker is endowed with a unique level of skills and a certain amount of unskilled labor; due to a time or capacity constraint, any worker can either utilize his skill or his unskilled labour, but not both together. As for the competitive industry (henceforth, the z-sector), it faces a technology with constant returns to scale. One unit of the good produced requires a constant amount of unskilled labour input, regardless of the skill level of the workers employed. The oligopolistc industry, instead,

[4] Among the very few exceptions, see Katsoulacos (1984).

[5] See also Gabszewicz and Turrini (1999) for an oligopolistic model where the employment of a higher fraction of skilled labour allows firms to supply higher quality goods.

faces increasing returns to scale. The manufacturing of a product of a given quality, requires a certain amount of skilled labour as an input, independent of the produced quantity.[6] We further assume that the quality developed is increasing in the mass of skilled labour employed. Once a product of certain quality is developed, it is produced at constant variable cost. In the analysis we assume this marginal cost to be zero, as it is done in partial equilibrium models (Gabszewicz and Thisse, 1979, Motta, 1993). This assumption is highly useful in that it simplifies the determination of quality levels when they are strategically set by firms in a two-stage game, allowing for explicit solutions in a partial equilibrium framework (Motta, 1993). In our analysis, this assumption has also another important implication. While the competitive industry offers a wage per unskilled labour unit effectively tying wage to marginal cost, workers in the x-sector are paid in proportion to skills, tying wage to fixed cost.[7] Therefore, the ratio of the wage paid in the x and in the z sector uniquely determines the allocation of labour between the two industries. We also allow the government to levy a proportional tax on labor for fiscal or redistributive purposes; the resulting tax revenue can be either retained or redistributed to households. While in the z-sector taxes are completely transferred on to the consumer, in the x-sector, they may be partially paid by workers in terms of lower equilibrium wages and by shareholders in terms of lower profits.

Labour supply is rigid for each household. Income distribution is determined by the distribution of skills, the distribution of unskilled labour, the distribution of claims to firms' profits, the allocation of labour between sectors, and a rule for distributing tax revenue. Income distribution determines in turn the allocation of demand between industries and between firms within the x-sector.

A first characterization for the general equilibrium of an economy with imperfectly competitive firms is found in Negishi (1961).[8] Under the assumption of constant returns to scale in production, Negishi (1961) proves existence of a price vector under which markets clear, monopolistic firms maximize profits, and firms' conjectures concerning their demand *functions* are consistent.[9] Wheareas under partial equilibrium the demand function is a given for imperfectly competitive firms, under general equilibrium, demand functions are determined at equilibrium as well. Hence, the additional requirement concerning consistency of firms' conjectures about demand functions is also necessary in our model for the characterization of equilibrium.

2.1. Vertical Product Differentiation: The *x*-sector

Both theoretical literature and empirical evidence show that the number of firms tends to be low in industries characterised by vertical product differentiation.[10] We therefore limit the analysis to the duopoly case, gaining in model tractability, without losing too much in terms of generality and realism. From the assumption of Bertrand competition in the second stage, we know that the two firms will never select the same quality level at a first stage equilibrium. It is then possible to denote by h the

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[6] Empirical evidence concerning the determinants of IIT in vertically differentiated industries is consistent with the assumption of the existence of relevant scale economies in the production of vertically differentiated goods (Fontagné et al., 1997).

[7] Costs are marginal or fixed with respect to quantity produced. So the "fixed" costs of the x-sector change when quality produced is changed, but not in response to pure quantity changes in output.

[8] A different approach to general equilibrium under imperfect competition is offered in Gabszewicz and Vial (1972). See Hart (1985) for a survey on the topic.

[9] In Negishi (1961), firms are assumed to take in to account the income effects originating from their actions when conjecturing demand functions. As will be clear in the folllowing of the paper, in our approach income effects are neglected by firms.

[10] See, e.g., Sutton (1991).

firm supplying the good of higher quality, and by l the firm supplying the lower quality.[11] If both firms remain in the market, then they produce distinct goods, sold at prices p_h and p_l, respectively. The two products carry a single quality attribute denoted by u_h and u_l, respectively. Either firm faces fixed production costs that are increasing functions of quality. We further assume that fixed costs are quadratic in the quality level (see, e.g., Motta, 1993 and Lutz, 1996). This corresponds to assuming that there are decreasing returns in quality design. The quality level supplied by firm i, i=h, l, increases in fact with the square root of the mass of skills (or, the effective labour units) employed, el_i:

$$u_i = \sqrt{el_i}, \qquad i = h, l \tag{1}$$

Denoting total costs for firm i, i=h, l, by C_i, the wage rate per unit of skill in the x-sector by w_x, the fiscal wedge by (1+t), and recalling that variable costs are set to zero, we have:

$$C_i = w_x(1+t)u_i^2 = w_x(1+t)el_i, \qquad i = h, l \tag{2}$$

Skills are uniformly distributed, with density d, on the interval [0, S] on which households[12] (indexed by s) are ranked according to their skill level. Unskilled labour endowments m_s are weakly monotonically increasing in skills endowments.[13] Households are uniformly distributed on [0, S] with density 1.[14] Households derive utility from consumption of the outside good z (produced in the competitive z-sector) and one variety, at the exclusion of the other, of the quality good x. Then, each consumer (household) purchases at most one unit of either firm h's product or firm l's product and spends the rest of her (his) income to buy some quantity of the outside good z. Income of each household s, y_s, contains a share of total profits in the x-sector, P_s and a share of the tax revenue t_s. The higher a consumer's income, the higher is her (his) reservation price (ceteris paribus). In order to have a monotonic relation between households' income and skill level, we assume in the following that profits and tax revenue are redistributed in such a way to guarantee $y_{s'} \geq y_s \Leftrightarrow s' \geq s$. Let s_i (i = h, l) be the poorest consumer who buys one unit of good x supplied by firm i. Then the demands for the two firms supplying good x take the following form:

$$q_h = S - s_h, \qquad q_l = s_h - s_l \tag{3}$$

The two firms play a two-stage industry game. In the first stage, firms simultaneously determine qualities to be produced and incur costs C_i (i = h, l). In the second stage, firms choose prices (Bertrand competition). Labour allocation (between sectors and firms) and wage determination take place in the first stage of the game, while consumption occurs in the second stage.

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[11] Quality differentiation will emerge as the result of quality competition in the first stage of the industry game. See Shaked/Sutton (1982).

[12] We assume single-person households, acting as consumers and workers.

[13] Each worker s has an unskilled labour endowment of $m_s=(m_0+ms)$ units of good z, where m_0, m are parameters of the distribution of unskilled labour. With m_0=1 and m=0, each household s has the same unit unskilled labour endowment. Due to a time or capacity constraint, any worker can either utilise his skill or his unskilled labour, but not both together.

[14] A uniform distribution of skills does not have an empirical justification, but is desirable for its tractability. For this reason uniform distributions are common in vertical differentiation models. In our setting, the mass of households is equal to S and each household is endowed with skills ds The total mass of skills in the economy is thus equal to $\frac{dS^2}{2}$, while the average per-capita skill is given by $\frac{dS}{2}$. Varying d modifies proportionally the supply of skills and the average skills level, widening also the variance of skills across the population.

2.1.1. Utility and Demand

Explicit derivation of firms' demand requires a parametric representation of preferences. For simplicity, and in analogy with existing work (e.g., Copeland (1997), Murphy and Shleifer (1997)), we assume that the consumption level of the homogenous good z and the quality level of the differentiated good x enter the utility of each consumer s by means of a Cobb-Douglas aggregator:

$$U_s = (u_s + u_0)^a q_{z,s}^{1-a}, \qquad s \in [0, S] \tag{4}$$

where u_s denotes the *quality* of the x-good consumed by household s and $q_{z,s}$ the *quantity* of the z-good. u_0, u_0 >0, is a parameter representing the utility level obtained when not buying good x. As usual, $0<a<1$.

Consumers take as given quality levels and prices for the variants h and l. Denote, respectively, by $U_s(h)$, $U_s(l)$ and $\overline{U_s}$ the utility levels reached at equilibrium by household s when buying one unit of variant h, one unit of variant l and when not buying at all good x. The poorest household willing to buy the higher quality variant, s_h, satisfies with equality the condition $U_s(h) \geq U_s(l)$; analogously, household s_l satisfies with equality $U_s(l) \geq \overline{U_s}$. These cut-off individuals can be characterised in terms of their income, y_s, once their budget constraint is substituted into their utility function (recall that all residual income after the purchase of good x is spent in good z). Income of households s_h and s_l are, respectively, given by:

$$y_{s_h} = \frac{(u_0 + u_h)^{\frac{a}{1-a}} p_h - (u_0 + u_l)^{\frac{a}{1-a}} p_l}{(u_0 + u_h)^{\frac{a}{1-a}} - (u_0 + u_l)^{\frac{a}{1-a}}} \tag{5}$$

$$y_{s_l} = \max\left[y_{s=0}, \frac{(u_0 + u_l)^{\frac{a}{1-a}} p_l}{(u_0 + u_l)^{\frac{a}{1-a}} - (u_0)^{\frac{a}{1-a}}} \right] \tag{6}$$

The cut-off income level for the individual indifferent between buying quality l and not buying cannot be lower than the income of the least skilled individual, namely, individual 0. If it happens that $\max\left[y_{s=0}, \frac{(u_0 + u_l)^{\frac{a}{1-a}} p_l}{(u_0 + u_l)^{\frac{a}{1-a}} - (u_0)^{\frac{a}{1-a}}} \right] = y_{s=0}$, then all households are willing to purchase one unit of the x-good, namely, the market is said to be *covered*.[15]

From the definition of income, and denoting by t_{s_i} the amount of tax revenue redistributed to the cut-off household s_i, and by w_x and w_z, respectively, the wage rate in the x and z-sector, it is obtained that:

$$y_{s_i} = w_x d s_i + \Pi_{s_i} + t_{s_i}, \qquad i = h, l \tag{7}$$

[15] In our analysis we focus on the case where the market is uncovered.

if the cut-off household i is working in the x-sector, or

$$y_{s_i} = w_z m_{s_i} + \Pi_{s_i} + t_{s_i}, \qquad i = h,l \tag{8}$$

if household i is working in the z-sector.

It is to notice that equations (5)-(6) and (7)-(8) are not sufficient to determine firms' demands as functions prices and qualities. In fact, income levels y_{s_h} and y_{s_l} are endogenous to the model, being affected by the level of w_s and by the distribution of profits and tax revenue. So, contrary to the standard vertical differentiation models developed in partial equilibrium, the exact form of the demand function can only be determined once the full solution of the model is obtained. This means that after obtaining the full solution of the model the consistency of the assumed demand expressions for each firm has to be checked.[16]

2.1.2. Quality and price determination

Firms choose simultaneously the quality level of their product in the first stage and simultaneously set prices in the second stage[17]. Then, when setting prices, firms take qualities as given. It is further assumed that firms take as given households' income both in the quality and price-setting stage. Firms are therefore not aware of the repercussions that their actions have on income distribution, and then on their own demand. In other terms, we ignore "Ford" effects", maintaining the standard assumption that firms, though strategic, neglect the feedback to their demand coming from changes in consumers' revenue.[18] Firms, in any case, have to make conjectures on demand and then on households' income, which must prove to be correct at equilibrium.

Profit maximisation with respect to prices yields the following system of first order conditions:

$$p_h = \frac{S - s_h}{\frac{\partial s_h}{\partial p_h}} \qquad\qquad p_l = \frac{s_h - s_l}{\frac{\partial s_l}{\partial p_l} - \frac{\partial s_h}{\partial p_l}} \tag{9}$$

where $\frac{\partial s_i}{\partial p_j}$ $i,j=h,l$ denotes partial derivatives. As for quality determination, first order conditions are as follows:

$$u_h = \frac{\frac{dp_h}{du_h}}{2w_s(1+t)}, \qquad\qquad u_l = \frac{\frac{dp_l}{du_l}}{2w_s(1+t)} \tag{10}$$

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[16]Firstly, it needs to be verified that resulting quantities demanded are consistent with the (un)covered market assumption. Secondly, depending on whether low quality is bought by workers in the x-industry or not, equation (5) has to be equalised with either equation (7) or (8), respectively.

[17]In this formulation, firm i not entering the market is equivalent to firm i choosing $u_i = 0$. The entry decision by firms is made simultaneously when choosing quality.

[18]It is well-known that keeping wages of his workers high has been an explicit strategy through which Ford was keeping demand for his own cars high. For a general equilibrium model with Ford effects we refer the interested reader to D' Aspremont et al. (1989)

where π_i denotes *operating* profits of firms i computed at a pair of prices that is the solution to (9) and $\frac{d\pi_i}{du_i}$ denotes total derivatives at given incomes.

Equilibrium in the industry is determined by a pair of prices that are mutual best replies in the second stage, a pair of quality levels that are mutual best replies in the first stage, and by a couple of conjectures concerning consumers' income that are consistent with actual values. This last condition derives from the general equilibrium framework in which the model is cast, and is absent in traditional models of vertical product differentiation. In the following we will make the assumption that firms know the rule according to which profits and the tax revenue are distributed among households. Wages (and then total tax revenue) are determined simultaneously with qualities, and are therefore taken as given by firms in the quality setting stage. x-sector profits are instead the firms' objective function in the quality-setting stage, and cannot be taken as given by firms. Yet, when deciding about their qualities, firms also need to make a conjecture about total profits, because they determine consumers' income, and then their own demand. So, in this set-up, making conjectures on consumers' income means making conjectures on aggregate profits in the x-sector.

Conjectured demands for each firm are obtained once incomes of the cut-off consumers are conjectured. Denoting by a hat conjectured variables and by α_{s_i} and β_{s_i} , respectively, the share of total profits (Π) and total tax revenue (T) accruing to the cut-off consumer s_i conjectured incomes for cut-off consumers are obtained as:

$$\hat{y}_{s_i} = w_x ds_i + \alpha_{s_i}\hat{\Pi} + \beta_{s_i}T, \qquad i = h, l \tag{11}$$

if the cut-off consumer s_i is employed in the x-sector, and

$$\hat{y}_{s_i} = w_z m_{s_i} + \alpha_{s_i}\hat{\Pi} + \beta_{s_i}T, \qquad i = h, l \tag{12}$$

if the cut-off consumer is working in the z-sector.

2.2. The Homogenous "Outside" Good: The Z-Sector

This sector is perfectly competitive. A large number of firms produces a homogenous good z with a constant returns to scale technology, using one unit of unskilled labour to produce one unit of output. This implies the following relationship:

$$q_z = l_z \tag{13}$$

where q_z is quantity produced by the z-sector, and l_z is labour employed in the z-sector. Each worker s has an unskilled labour endowment of $m_s=(m_0+ms)$ units[19] of good z, where m_0, m are parameters of the distribution of unskilled labour. As for employment in z, it is determined by the mass of workers (households) from the least skilled, up to the one that is indifferent between working in the x or in the z-sector. Denoting this cut-off worker by $s_{x,z}$, we have:

$$s_{x,z} = \min\left[m_0 /(\frac{dw_x}{w_z} - m), S \right] \tag{14}$$

[19] With m_0=1 and m=0, each household s has the same unit unskilled labour endowment and l_z=$s_{x,z}$.

$$l_z = \int_0^{s_{x,y}} (m_0 + ms) ds == m_0 s_{x,z} + m s_{x,z}^2 / 2 \tag{15}$$

Since we allow for labour taxation, prices for the z good must not only cover the wage costs (normalised to 1) but also the taxes levied on labour. Therefore:

$$p_z = (1+t), \tag{16}$$

where p_z is price of one unit of z.

As far as expenditure on good z is concerned, it is simply obtained as the difference between aggregate income and total expenditure on good x. So, while aggregate supply of z is fully determined by the relative wage between sectors, aggregate demand is fully determined by equilibrium in the x-sector.

2.3. The Labour Market

Equilibrium in the labour market requires that w_x adjusts to equalise effective labour units demanded in the x-sector with effective labour units available. Demand for skills is obtained as the mass of effective labour units required by quality development by the two firms in the x-sector. The supply of skills is obtained as the mass of effective labour units forming the endowments of all the workers that choose to work in the x-sector:

$$el_h + el_l = d\int_{s_{x,y}}^{S} s ds = \frac{d\left(S^2 - s_{x,z}^2\right)}{2} = \frac{d\left(S^2 - \left(m_0 /(\frac{dw_x}{w_z} - m)\right)^2\right)}{2} \tag{17}$$

Note that skill is a homogenous, interchangeable endowment; i.e. the mass of effective labour units derived from two workers supplying each 0.1 units of skill is the same as that derived from a single different worker supplying 0.2 units of skill. Hence each worker supplying skill is in perfect competition with all other workers; i.e. all workers in the x-sector are wage takers. Since x-sector firms demanding skilled labour are in competition with all z-sector firms demanding unskilled labour (via equation (14)), all x-sector firms are wage-takers.

Whereas supply is only determined by inter-sectoral relative wages, demand for effective labour units is determined by optimal quality choice, which in turn depends on the wage rate in a complex way.

2.4. Solving the Model

Solving the model necessitates the solution of four equations in four unknowns. The unknowns are the wage rate in the x-sector, the quality levels of good x and total profits of industry x. The four equations are the two first-order conditions for quality choice (taking into account the Bertrand pricing rules in the x-sector), labour market equilibrium in the x-sector, and equality between actual profits and those that are conjectured by firms in the x-sector in making their decisions concerning quality and prices. Equilibrium in the market for good z obtains by Walras' law. The system is thus the following:

$$u_h = \frac{\frac{dp_h}{du_h}}{2w_s(1+t)}, \qquad u_l = \frac{\frac{dp_l}{du_l}}{2w_s(1+t)} \tag{18}$$

$$u_h^2 + u_l^2 = \frac{d\left(S^2 - \left(m_0/(\frac{dw_x}{w_z} - m)\right)^2\right)}{2} \tag{19}$$

$$\hat{\Pi} = (S - s_h)p_h - C_h + (s_h - s_l)p_l - C_l \tag{20}$$

System (18)-(20) is non-linear and an analytical solution is not possible. The model behaviour is simple in some aspects and can be envisaged also without an explicit solution. It is evident, for instance, from equation (19) that the higher average quality of the x-good at equilibrium, the lower the supply of the z-good and the higher the wage rate in the x-sector. Though, the working of the model is more complex in other respects, and unambiguous relations cannot always be expected. For instance, a rising tax wedge has an ambiguous effect on supplied qualities because a negative cost effect may be compensated by a positive demand effect (redistributed tax revenue may generate demand from consumers that were previously not buying). The only way to to resolve these ambiguities deriving from the non-linearity of the model is through numerical simulations.

3. Simulations

The paper presents two groups of simulations, corresponding to the baseline model without labour taxes (t=0), D1, and three "policy" models, D2, D3 and D4, where a uniform 100% tax on wage cost is applied in both industries (t=1). In D2, total tax receipts T are redistributed at a *flat rate*, i.e. each households receives T/S. In D3, total tax receipts T are redistributed *proportional* to wage income, i.e. each households receives the exact tax amount levied on her (his) wage bill. In D4, all tax receipts are retained by the government. The first case (D2) corresponds thus to a case where the government redistributes income from firms to workers and then tax revenue from rich to poor, while the second case (D3) is a simple redistribution from firms to workers. In all simulations, we impose u_0=0.01, S=1, a=0.5, w_z=1, m_0=0.25, m=0.75. Total profits are assumed to be distributed in proportion with workers' skills (ds). We choose a proportional distribution of profits in order to focus on cases in which the market appears to be uncovered at equilibrium. The same rationale underlies the choice of a distribution of unskilled labour that is monotonically increasing in workers' skills.[20] Skill density d is let to vary between 1.0 and 1.8.[21] The results are summarised in a table for each simulation.

[20]If the resulting equilibrium income distribution is too flat, also the poorest consumer is willing to buy one unit of the x-good and a covered market results. Assumptions about the distributions of unskilled labour, skills and profits are designed to avoid this case. Concentrating on the uncovered-market case allows us to analyse effects of taxation on the quantities sold in the x-sector that would be absent with a covered market. In general, the more unequal the distribution of skills, labour and profit shares endowments, the more unequal (or steep) will be the income distribution achieved in equilibrium. A steeper income distribution will be accompanied in equilibrium by less market coverage, higher product qualities, higher quality differentiation, and a higher employment share in the x-sector.

The qualitative results are grouped into three classes. The effects of changes in the skills endowments are presented first. Taxation effects are grouped according to whether the negative cost effects or the positive demand effects dominate the results. All results are reported in Tables 1 and 2 in the Appendix.

3.1. Effects of Population-Wide Proportional Increases in Skills

A population-wide proportional increase in skills (higher d) *increases product qualities* while *decreasing the wage per skill unit in the x-sector* (see Table 1). The wage decrease per skill unit almost offsets the quantity increase in skills, hence employment (in number of workers) barely decreases in the x-sector. Consequently, there is a *very small rise in employment and production in the z-sector*. This result is strictly related to the assumptions of the model concerning technology. The earnings in the x-sector are proportional to the skills ds that workers possess, while workers' productivity in the z-sector rises less than proportionally with skills. At almost unchanged wages per person dw_s, then, increasing proportionally the skills endowments of workers will result in a rise in the mass of effective labour units that can be employed in the x-sector. So, *the higher average skills, the higher equilibrium average product quality.* This is a realistic feature of the model, consistent with the available evidence relating workers' skills and product quality (Daly at al., 1985, Mason et al., 1996).

Greater values of d entail a double effect on the wage rate in the x-sector. The first, is a *direct supply effect*. The higher d, the higher the supply of skills, and then, ceteris paribus, the lower the wage rate. The second is an *indirect demand effect*. Higher values of d produce higher income and then higher demand (at given prices and qualities) for the x good. Firms have rational conjectures about the higher consumers' income, and optimally choose to increase both prices and quality levels, generating a higher demand for skills. *This second effect is just strong enough to almost offset the first one, resulting in a slight decrease of average wage income per person* dsw_s.

While the *additional skills endowment is almost fully used to upgrade qualities*, the gains from these upgrades do not go directly to skilled workers but are partially retained as increased profits and partially passed on to consumers. While *absolute prices rise* with increases in the parameter d, *quality-adjusted prices fall*, since cost per quality level falls. Price and profit increases are possible, since competition is somewhat relaxed by an increase in the ratio of qualities, i.e. *increased quality differentiation*. Production *quantities of both quality-varieties fall*: since variable costs are constant and unchanged, cost of providing quality instead of quantity is reduced. Total *profits, aggregate income, and aggregate utility increase* as d rises.

Added (real) income is generated in the form of added profits, which are distributed proportional to skill level s, and reduced prices of quality goods, which are bought by the high-income segment of the population. Income and utility of the lowest-skill household stay unchanged, since they buy no quality goods and earn no share of the profits. Consequently, income and utility dispersion increase.

3.2. Effects of labour taxation

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[21] A change in the value of d changes numerical computations, but does not alter the qualitative results obtained concerning labour taxation.

Labour *taxation implies a redistribution from firms to households*. If the tax revenue is redistributed at a flat rate, a redistribution from rich to poor households is added. In general, income is expected to be distributed more equally, at equilibrium, once taxation is introduced. *Higher firms' costs due to the fiscal wedge on wages* would lead, holding other conditions fixed, to lower profits, lower product qualities (see equations (18)) and, then, to lower demand for skills in the x-sector. *Taxation, though, also increases households' revenues*, and then firms' demand, with positive consequences for profits, product qualities, and for the wage rate in the x industry. The qualitative *net effect of taxation crucially depends on the redistributional effects* on income of the tax policy rule applied, while it is only insignificantly affected by the average level of skills endowment of the economy.

3.2.1. Cost effects of labour taxes prevailing.

This scenario occurs for high taxation and *no (or low) redistribution of tax revenues*, represented by simulations D4 (see Table 2). *Qualities, employment and profits in the x-sector decrease due to taxation, while employment and production in the z-sector increase*. Labour taxation entails a reduction in demand for skills in the x-sector, which is reflected in a lower value for w_s. This decrease in w_s, however, is not nearly large enough to offset the tax cost increase, so, *a tax wedge that increases labour costs leads to an increase in the gross wage rate but a slight reduction in the net wage* rate for high-skilled workers. *Income (weakly) falls for everybody* in the economy, but higher skilled households take higher losses since profits decrease substantially. Due to this redistributional effect of taxation, *income inequality falls*, which in turn leads to *increased sales of quality-goods to lower income households*. However, this positive income effect on demand for the x-industry is not sufficient to outweigh the negative cost effect due to taxation. Hence, quality-adjusted prices must fall in spite of quality reductions. *Aggregate firms' profits fall*, and also the utility of consumers (formerly) buying quality-goods falls due to reduced quality. Even *low-income households not buying quality-goods lose in welfare terms, since taxation leads to price increases in the z-sector not compensated by tax redistribution*. As a result, aggregate utility falls. So, labour taxation faces a trade-off between income inequality and aggregate utility, taken as a (utilitarian) welfare indicator.

3.2.2. Demand effects of labour taxes prevailing.

This scenario occurs in all cases where *tax revenues are fully redistributed*, represented by simulations D2 and D3 (see Table 2). *Qualities, employment and profits in the x-sector increase, while employment and production in the z-sector decrease*. Due to the redistribution effect of taxation, income inequality falls, leading to increased sales of quality-goods to lower income households. The *positive income effect on demand* of the x-industry appears to be strong, strong enough to increase equilibrium qualities. This is reflected in increased demand for skills in the x-sector, and then in a *higher wage for workers employed in the x-industry*. Counterintuitively, then, a tax-wedge that increases labour costs leads in this case the net wage rate for high-skilled workers to rise. Quality-adjusted prices rise, to offset taxation-induced cost effects. *Firms' profits, aggregate income and utility rise*, so that labour taxation in this case not only reduces income inequality, but also increases the value of our welfare indicator. Low-income households not buying quality-goods, weakly gain in welfare terms, because the price increase in the z-sector is compensated by income increases due to tax redistribution.

When the *tax revenue is redistributed proportional to income* (case D3), *inequality falls less* sharply after taxation and the *rise in profits and income are of a lower magnitude* (relative to the initial tax increase). Higher income inequality in case D3 is directly related to the rule of redistribution (indirect redistribution from rich to poor is absent in case D3). The different results with respect to profits and income are less intuitive, and are associated with a different impact of redistribution on demand for the x-good. There are *two effects at play* here. On one hand, *the more equidistributed is the tax revenue, the higher the number of households that start buying from the x-sector* (the higher the extent of market-coverage), and then the higher demand for the x-good, equilibrium profits, qualities and income. This effect is more prevalent in Case D2. On the other hand, *the effects of additional demand for the x-industry generated by a given tax are stronger if the tax revenue is not too much dispersed across the population*. Higher tax revenue for households endowed with higher skills would indeed concentrate demand in the high-income segment of the population, which is the one that buys from the x-sector. This second redistributive effect leads to quality upgrading in the simulations. It is dominant in Case D3.

4. Conclusions

High labour costs are often associated with a poor performance of industrial firms, and then with low industry demand, profits and employment. In this paper we develop a simple general equilibrium model to analyse this presumed trade-off between labour costs and firms' profitability. The model considers a vertically differentiated oligopolistic industry, where firms compete both in prices and in the quality level of their products. This captures basic features of advanced industrial sectors, where R&D, advertisement and product development are important dimensions along which competition is evolving. The general equilibrium structure of the model allows to build a link between product quality and factor endowments that is missing in partial equilibrium models with imperfect competition. Consistently with empirical evidence, we assume that higher product quality requires the employment of a higher amount of skilled labour. In the model, we distinguish between wages and labour taxes as different components of labour costs. So, there is one component (the wage rate) that is endogenous to the model, and another (taxes) that is a policy variable.

Solving the model through simulations we show, first, that *an increase in skills endowment hardly changes employment patterns* (in terms of workers employed) though effective skill use in the imperfectly competitive industry increases. *The additional skills endowment is used for quality upgrades*. The gains from these upgrades are partially passed on to consumers through decreases in price per quality. Consequently, employment and production in the perfectly competitive sector hardly changes. Second we show, that *the effect of taxation crucially depends on its redistributive consequences*. With taxation, income inequality is generally reduced, even if tax revenues are retained by the government in full. *When fully redistributed to households, taxes can lead to quality increases of varieties produced in the imperfectly competitive sector due to their effect of increasing income and demand*. This income effect is the stronger the more redistributive the tax scheme. *When taxes are retained by the government in full, cost effects dominate and income and welfare falls*. When taxes are fully redistributed at a flat rate per household, demand effects dominate and income and welfare rises.

The model is oversimplified and the robustness properties of our results with respect to different model specifications have not yet been established, so that our exercise cannot safely be taken as a guide for policy analysis. We believe, though, that some lessons can be learnt even by our simple exercise. First, it shows formally that neglecting general equilibrium effects when studying the relation between labour costs and industry performance may have relevant consequences for policy prescriptions. Second, it shows that changes in factor endowments or relative factor prices affect the nature of internal competition in imperfectly competitive industries. This in turn leads to additional effects beyond those that can be inferred from using a Heckscher-Ohlin or Specific-Factor framework of analysis. Several specific predictions about changes in relative wages, market shares, demand and prices may be investigated further in empirical research.

We believe that the real potential of this modelling framework lies in applications to trade issues. The incorporation of a quality-differentiated goods sector allows for the analysis of vertical intra-industry trade within a general-equilibrium trade framework. For example, the effects of trade-opening on domestic profits in the imperfectly-competitive sector will depend on where the domestic industry ends up being situated on the international quality ladder. In this context, changes in labour taxation will have a strategic trade policy effect that can be studied using our model.

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Appendix: A GE-Model with Duopolistic X-Industry: Simulation Results

List of Variables

Variable	
d	skills scaling parameter, average skill level is d S/2
t	tax rate on wage costs
ws	skills wage in x-sector, per effective labour unit s
uh	quality of the high-quality good
ul	quality of the low-quality good
qh	quantity of the high-quality good
ql	quantity of the low-quality good
qz	quantity of good z, equals lz
ph	price of the high-quality good
pl	price of the low-quality good
Pih	profit of the high-quality firm
Pil	profit of the low-quality firm
ix	total effective labour units used in industry x, equals (S^2-lz^2)/2
U0	utility of household s=0
US	utility of household s=S
Ut	aggregate utilty
sz	highest wage-earner s employed in the z-sector
sxl	lowest consumer s buying low quality, equals S-qh
sxl	lowest consumer s buying high quality, equals S-qh-ql
T	total tax revenue, equals t (lz wz + ix ws)
Pim	total profits in the x-sector, equals (Pih + Pil)
pz	price of good z
ruhl	ratio of qualities uh/ul
rphl	ratio of prices ph/pl
puh	price/qualty ratio for h: ph/uh
pul	price/quality ratio for l: pl/ul
Yt	aggregate income
Y0	income of household s=0
YS	income of household s=S
Yinequ	ratio of incomes of household S and 0, equals YS/Yl
UtInequ	ratio of utilities of household S and 0, equals US/Ul

Appendix: A GE-Model with Duopolistic X-Industry: Simulation Results

(Legend: see List of Variables)

Table 1 - Cases withVarying Skills Endowments

	Case D1: No Taxation				
d	1	1.3	1.5	1.8	(1.8)-(1)%
Variable					
ws	1.0136	0.779266	0.675164	0.562427	-44.51%
uh	0.219772	0.246088	0.261685	0.282933	28.74%
ul	0.04446	0.0481145	0.0502007	0.0529568	19.11%
qh	0.596119	0.593736	0.592475	0.590907	-0.87%
ql	0.298059	0.296868	0.296237	0.295454	-0.87%
qz	0.574391	0.576328	0.577373	0.578691	0.75%
ph	0.861812	0.886587	0.899921	0.916718	6.37%
pl	0.367789	0.381928	0.389555	0.399181	8.54%
Pih	0.464785	0.479206	0.486946	0.496672	6.86%
Pil	0.107619	0.111578	0.113699	0.116362	8.12%
ix	0.0502763	0.0628744	0.0709998	0.0828553	64.80%
U0	0.05	0.05	0.05	0.05	0.00%
US	0.545823	0.578766	0.597516	0.622234	14.00%
Ut	0.282095	0.296026	0.303915	0.314274	11.41%
dws	1.0136	1.0130458	1.012746	1.0123686	-0.12%
sz	0.94840668	0.95040483	0.95148927	0.95285793	0.47%
sxl	0.105822	0.109396	0.111288	0.113639	7.39%
sxh	0.403881	0.406264	0.407525	0.409093	1.29%
T	0	0	0	0	
Pim	0.572404	0.590784	0.600645	0.613034	7.10%
pz	1	1	1	1	0.00%
ruhl	3.92139126	3.60272342	3.43894759	3.2400533	8.08%
rphl	8.27235717	7.93789814	7.75995155	7.53786105	-1.99%
puh	3.92139126	3.60272342	3.43894759	3.2400533	-17.37%
pul	8.27235717	7.93789814	7.75995155	7.53786105	-8.88%
Yt	1.19774096	1.21610829	1.2259554	1.23832522	3.39%
Y0	0.25	0.25	0.25	0.25	0.00%
YS	2.158408	2.1946138	2.214036	2.2384366	3.71%
Yinequ	8.633632	8.7784552	8.856144	8.9537464	3.71%
UtInequ	10.91646	11.57532	11.95032	12.44468	14.00%

Appendix: A GE-Model with Duopolistic X-Industry: Simulation Results

(Legend: see List of Variables)

Table 2 - Cases with Different Taxation Schemes (d=1 for all cases)

	Flat Redistribution		**Proportional Redistrib.**		**No Redistribution**	
Case	D2	D2-D1(%)	D3	D3-D1(%)	D4	D4-D1(%)
t	0.2		1		1	
Variable						
ws	1.01611	0.25%	1.02431	1.06%	1.01271	-0.09%
uh	0.237679	8.15%	0.286085	30.17%	0.212894	-3.13%
ul	0.0469659	5.64%	0.0533579	20.01%	0.0434744	-2.22%
qh	0.618459	3.75%	0.596798	0.11%	0.604055	1.33%
ql	0.30923	3.75%	0.298399	0.11%	0.302028	1.33%
qz	0.565845	-1.49%	0.539327	-6.10%	0.577494	0.54%
ph	1.016	17.89%	1.70034	97.30%	0.78386	-9.05%
pl	0.436444	18.67%	0.741011	101.48%	0.333604	-9.29%
Pih	0.559471	20.37%	0.84709	82.25%	0.381695	-17.88%
Pil	0.132272	22.91%	0.215284	100.04%	0.0969296	-9.93%
ix	0.0586972	16.75%	0.0846918	68.45%	0.0472137	-6.09%
U0	0.055909	11.82%	0.05	0.00%	0.0353553	-29.29%
US	0.558026	2.24%	0.605073	10.86%	0.363575	-33.39%
Ut	0.295699	4.82%	0.306543	8.67%	0.190319	-32.53%
dws	1.01611	0.25%	1.02431	1.06%	1.01271	-0.09%
sz	0.93946113	-0.94%	0.91137764	-3.90%	0.95161966	0.34%
sxl	0.072311	-31.67%	0.104803	-0.96%	0.093917	-11.25%
sxh	0.381541	-5.53%	0.403202	-0.17%	0.395945	-1.96%
T	0.12509756		0.62607766		0.62530779	
Pim	0.691743	20.85%	1.062374	85.60%	0.4786246	-16.38%
pz	1.2	20.00%	2	100.00%	2	100.00%
ruhl	5.06067168	2.38%	5.36162405	8.47%	4.89699685	-0.93%
rphl	2.32790461	-0.65%	2.29462181	-2.07%	2.34967207	0.28%
puh	4.27467298	9.01%	5.94347834	51.57%	3.68192622	-6.11%
pul	9.29278477	12.34%	13.8875593	67.88%	7.67357341	-7.24%
Yt	1.44233772	20.42%	2.314533	93.24%	1.10392865	-7.83%
Y0	0.37509756	50.04%	0.5	100.00%	0.25	0.00%
YS	2.52469356	16.97%	4.173368	93.35%	1.9699592	-8.73%
Yinequ	6.73076505	-22.04%	8.346736	-3.32%	7.8798368	-8.73%
UtInequ	9.98096907	-8.57%	12.10146	10.86%	10.2834653	-5.80%