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A microeconomic model with co-operation for the production of a differentiated agricultural good

Jean-Marc Callois

CESAER
Centre d'**E**conomie et **S**ociologie appliquées à l'**A**griculture et aux **E**spaces **R**uraux
BP 87999 – 26, Bd Dr Petitjean- 21079 DIJON cedex

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Jean-Marc CALLOIS[1,2]

Résumé

Certaines stratégies de développement rural sont basées sur l'hypothèse que les signes de qualité peuvent engendrer par effets induits une croissance économique et l'arrivée de nouvelles populations. Afin d'étudier la validité de cette hypothèse, nous utilisons un modèle d'économie géographique. Un bien agricole différencié est supposé être produit par des agriculteurs qui coopèrent pour fixer un prix de monopole et contrôler le nombre de producteurs. Il existe un arbitrage entre le nombre de producteurs de bien de qualité et leur revenu individuel. De plus, l'effet positif sur le développement rural dû à l'augmentation de demande de la part des agriculteurs est contrebalancé par un effet opposé dû à l'augmentation des salaires urbains. Un coût de transport supérieur pour le bien de qualité renforce l'effet positif sur l'industrialisation rurale, mais limite la taille du secteur agricole différencié.

Mots clés : développement rural, signes de qualité, nouvelle économie géographique.

Abstract

Some rural development strategies are based on the assumption that quality labels may act as levers for inducing economic growth and population migration. To investigate the validity of this assumption, we use a new economic geography model. A differentiated agricultural good is assumed to be produced by farmers who co-operate in order to set a monopoly price and control the number of producers. We find that there is a trade-off between the number of differentiated farmers and their individual income. Besides, the positive effect of agricultural differentiation on rural industrialization, due to increased demand for industrial goods, is offset by an opposite effect produced by urban wage rise. Higher transport costs foster the positive induced effects but limit the size of the differentiated agricultural sector.

Keywords: rural development, origin labelled products, new economic geography.

JEL Classification: Q10, R12.

[1] UR dynamiques et fonctions des espaces ruraux, Cemagref, BP 50085, 63172 Aubière Cedex
[2] Economie et sociologie rurales, UMR INRA-ENESAD, BP 1607, 21036 Dijon Cedex
Jean-Marc.Callois@clermont.cemagref.fr
Phone: 00 33 4 73 44 06 52
Fax: 00 33 4 73 44 06 98

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Introduction

Rural development strategies are often based on the production of differentiated agricultural goods, that may be sought after by consumers, because of their typicality, health quality, or environmental innocuousness. These goods' specificity is generally closely associated to the area where they are produced, so that they represent an immobile comparative advantage that can be used as a lever for developing economic activity in remote and/or underprivileged regions.

Producing specific products can be more profitable than generic agricultural goods for two reasons. First, differentiation in itself generates a monopoly power that may be exploited through appropriate organization. Second, these products may have specific characteristics that are desired by consumers, who will have a higher tendency to buy them, provided that appropriate communication is done. For instance, Steiner (2001), using hedonic price theory, finds a significant mark-up for wines from famous French *terroirs*, in the British wine market. Note that quality is not necessarily objective, it can be linked, for instance, to a specific image the region of origin may have. Moreover, these products need not to be agricultural nor physical goods. Their main characteristic is to be linked to the region. They may well for instance consist of tourism activities.

Such strategies have long been undertaken, in particular in France with cheeses and wines. This process has been generalized in the European Union, through official quality labels that are linked to the area of production, namely Protected Designations of Origin (PDO) and Protected Geographical Indications (PGI). In 1997, about 10% of the turnover of the French milk products sector consisted of PDO cheese, and 17% of the cheese produced in the UE was under PDO (Lagrange *et al*. 2000). However, quality products differ greatly in specificity. For instance, quality labels for wine are so numerous that many of them could hardly be considered as really differentiated products. Moreover, as several studies point out, success in capturing the rent resulting from differentiation varies greatly among regions and labels (see for instance Perrier-Cornet and Sylvander (2000), Chappuis and Sans (2000), or Wilson *et al*. (2000)). Commercial success also greatly depends on consumer information (van der Lans *et al.* (2001)).

The aim of this paper is to study the consequences of quality labels on the repartition of income and activities between rural and urban regions. We are not only interested in the income directly generated by producing under quality label, but also to the effect of this agricultural differentiation. It is often taken for granted that a higher income for farmers would generate positive effects on the local economy, thanks to demand multiplier effects. However, this assumption needs to be studied under more scrutiny. To this end, we use the analytical framework of new economic geography. In most theoretical papers on economic geography, the agricultural sector is not a subject of interest *per se*, but is mostly introduced as a dispersion force that tempers agglomeration effects. Accordingly, in most papers, a very crude representation of agriculture is used. Nevertheless, some economic geography models do include refinements on the agricultural sector. Calmette and Le Pottier (1995) and Fujita *et al.* ((1999), chapter 7) study the effect of introducing transport costs in agriculture, and show that they act as a supplementary dispersion force, leading to a fall in agglomeration effects when transport costs are very low. Similar results are obtained in Puga's (1999) model, where agriculture uses both labour and land, instead of labour only.

Closer to our topic of agricultural differentiation, Picard and Zeng (2003) consider a model with two different and partly substitutable agricultural products, each produced in a particular region. In their model, the outcome in terms of economic geography depends heavily on the parameters of the agricultural sector, in particular agricultural transport costs, which slow down agglomeration processes as usual. In that model, both varieties play a symmetric role. Closer to the purpose of our article is the model proposed by Kilkenny and Daniel (2001) which also aims at determining the effect of quality label production and consumer preference for quality products on rural development. In order to analyse the effects of public subsidies to agriculture on the location of production, they build a model in which each region can produce both a generic and a specific (quality) agricultural good. They find that subsidies affect spatial distribution of agriculture, but not the propensity of other activities to agglomerate. Our approach differs in several important points from theirs however, and the research questions of these two papers should be seen as complementary. One of the key differences is that we state very different hypotheses on the functioning of the quality label sector. We assume that the specific agricultural sector (producing the quality label) has a strong organisation, equivalent to collusion in the polar case we consider, whereas Kilkenny and Daniel's model assumes competition. A second significant difference of our work is that we study the relationships between agriculture and industry. While Kilkenny and Daniel consider rural development in terms of farm income, farming population, and land use, we consider it in terms of income, total population and economic structure. We integrate industrial inputs in our model, but we do not integrate land. This is because we are interested in remote rural areas, in which there is already much vacant land. This assumption also justifies the fact that we study a core-periphery configuration. Conversely, Kilkenny and Daniel (2001) are interested in land use (they consider vacant land as a negative feature for rural development), and show the influence of product differentiation on vacant land. A last, more technical, difference is that while they use numerical simulations, our simplifying assumptions allow us to obtain analytical results and general qualitative propositions. The two main new insights of our model is that quality labels need to be differentiated enough to be profitable (in Kilkenny and Daniel's model, they are always produced because of the Cobb-Douglas form of utility), and that there may be reverse forces offsetting the positive effect of agricultural development on industry.

Apart from Kilkenny and Daniel's work, there have been some attempts at microeconomic modelling of some aspects of quality labels. Most works are focussed on industrial organisation topics such as cartel behaviour (Marette et al. (1999)), and institutional regulation in a context of information asymmetries (Jayet and Fuentes-Castro (2001)). Giraud-Héraud *et al.* (1999) focus on the organisation of agro-food chains and the problem of double marginalisation when several levels of quality can be supplied, while Chambolle and Giraud-Héraud (2003) study the trade-off between a collective quality label and a private brand for an industrial firm.

In this paper, we use a microeconomic model, stemming from Krugman's (1991) seminal article on economic geography, to investigate the conditions under which a differentiation strategy based on quality labels may lead to economic growth in a rural region. Despite very specific functional forms, this framework fits our question well, as it has been designed to study how positive externalities in industry may lead to situations where all footloose economic activity becomes concentrated in one region. As it is a general equilibrium model, it allows us to study indirect effects between sectors. An alternative possibility would have been to use Ottaviano, Tabushi and Thisse's (2002) framework, which has the advantage of leading to analytic expressions, because of the linear form of the demand functions. It cannot account for income effects however, and that is why it was not chosen here. As we want to study the impact of increased demand on other sectors, we need to have income effects.

The main result of Krugman's (1991) model is that in the long run, because of the fall of transport costs and the increase of product differentiation, industrial activities totally leave one of the two regions of the model (which is thereby labelled as "rural"), in which only agriculture remains, with a very low *per capita* income. Other papers exogenously introduce rural amenities or congestion costs in urban areas in order to temper this very clear-cut result (Brakman *et al*., (1996); Cavaillès et al., (2002)) and allow for some activities to exist in the rural/remote areas. Here, differentiation and co-operation between farmers are the ways by which the income of some part of the farming population is increased, which leads to and increased demand for other goods, and possibly to the development of other activities.

In our model, the agricultural sector produces two commodities, a generic and a specific (quality) product. The origin labelled product is supposed not to be perfectly substitutable with the generic agricultural product. It is made by specialised farmers who collude to maximise their joint profit. These assumptions are consistent with empirical studies, that show that key success factors of such products are product specificity and coordination of the supply chain (see for instance Barjolle and Sylvander (2000), and Barjolle *et al*. (2000)). The assumption of collusion may seem excessive to account for coordination – it is commonly admitted that a condition for efficiency in a local production district is to find the right mix between competition and cooperation (see for instance Becattini (1990)). However, our assumption has the advantage of allowing us to study formally the best possible conditions for quality good production. In the real world of course, some level of competition is necessary to maintain appropriate incentives to produce in an efficient way.

The objective of this paper is twofold. First, it aims at clarifying the conditions under which agricultural differentiation (quality good production) is profitable for farmers. Second, it investigates whether increased demand for manufactured products in the rural region, generated by specific good production, may induce rural industrialization. We find that there is generally a trade-off between the number of farmers producing the differentiated good and their individual income. Concerning the induced effects on industry, the positive effect on rural industrialization, due to increased demand for final and intermediary industrial goods from differentiated farmers, is offset by an opposite effect, due to urban wage rise. In the simple model without transportation costs in agriculture, the net effect is zero. In other words, quality good production does not modify the possibility of rural industrialisation. However, as can be expected, adding higher transport costs for the differentiated product favours rural industrialization.

The rest of the paper is organised as follows. Section 2 presents the basic economic geography model, and in particular the assumptions made for the specific agricultural sector. It explains how prices and quantities are determined, and the condition under which differentiation occurs. Section 3 gives some results on the comparative static of the main parameters. Section 4 investigates whether agricultural differentiation may induce industrial activity in a rural region. Section 5 studies how the previous results are affected if we introduce transportation costs in agriculture. Section 6 concludes.

1. The model

1.1. Consumers

Following Dixit and Stiglitz (1977) and the particular case used by Krugman (1991) and many subsequent papers (Fujita *et al*., (1999)), we assume that households consume two types of goods, agricultural and manufactured (remember that agriculture includes all immobile activities, such as tourism[1]), and that utility function is of the form:

$$U = A^{1-\mu} M^{\mu}$$

where A and M are sub-functions related to each type of good respectively. Parameter μ corresponds to the share of manufactured goods in consumption. The original model of Krugman (1991), as most new economic geography models, does not suppose that the agricultural good is differentiated. To introduce differentiation, following Fujita, Krugman and Venables (1999), we simply use the same form as with industrial goods, namely a CES form. Sub-functions A and M can then be written:

[1] Note that retailing can also be considered to belong to that sector, provided that there is no population change

$$A = (a_G^{\delta} + k.a_S^{\delta})^{1/\delta} \text{ and } M = \left(\int_0^n m(i)^{\rho}\, di \right)^{1/\rho}$$

a_G is the quantity of a (composite) generic agricultural good, a_S is the quantity of a specific (differentiated) agricultural good, and the $m(i)$ are quantities of a continuum of length n, representing varieties of a single manufactured good. Exogenous parameters δ and ρ, which are comprised between 0 and 1, are reverse indices of differentiation of agricultural and manufactured goods respectively: the closer to 0, the less substitutable those commodities are. γ =1/(1-δ) is the elasticity of substitution between the two kinds of agricultural goods, whereas σ=1/(1-ρ) is the elasticity of substitution between any two varieties of manufactured goods (we thus have γ and σ >1). Finally, parameter k is an index of the importance of the specific agricultural good in the representative consumer's expenses. The higher k is, the more the consumer tends to favour quality labelled products. The Cobb-Douglas form of the utility function, as well as the CES form of the sub-functions guaranties that agricultural and manufactured goods represent shares of (1-μ) and μ respectively in the consumer's expenses, which considerably simplifies the analysis. More precisely, if we denote income by Y, agricultural prices by p_G and p_S, and industrial prices by $p(i)$, demand functions (indicated by exponent D) are:

$$a_G^D = (1-\mu)Y \frac{p_G^{-\gamma}}{p_G^{1-\gamma} + k^{\gamma} p_S^{1-\gamma}}, \; a_S^D = (1-\mu)Y \frac{k^{\gamma} p_S^{-\gamma}}{p_G^{1-\gamma} + k^{\gamma} p_S^{1-\gamma}} \text{ and } m^D(i) = \mu Y \frac{p(i)^{-\sigma}}{\int_0^n p(j)^{1-\sigma}\, dj}.$$

We assume that the specific agricultural good represents a small part of total expense for agricultural goods, namely that k^{γ} is small with respect to $(p_S / p_G)^{\gamma-1}$. Indeed, most expenses in food products consist in generic, quality products being bought as extras by households, in particular for special occasions. If it were not the case, then our specific product could precisely not be considered as really specific, since it would appear frequently in the regular housewife's shopping basket.

1.2. Agricultural sector

Let us now turn to the supply side in agriculture. The generic agricultural product is assumed to be produced with constant returns to scale under perfect competition, labour being the only production factor. As usual in this type of model, it will be used as numéraire. In most such two-sector models (and in particular in Krugman 1991), the income for farmers producing the generic good w_G is assumed to be independent of production. This is due to the fact that farmers are supposed to be in perfect competition with constant returns to scale. Indeed, especially in peripheral regions, many farmers must still content themselves with a very low income, close to the subsistence level. This is partly what motivates the development of quality labels in such regions.

Production of specific agricultural products differs from that of generic products in two ways. First, we make the assumption that specific products require industrial inputs. This is justified by the fact that quality labels often require specific investments to fulfil various requirements. Moreover, these products often undergo transformation on the spot. For instance specific farmers may make cheese, whereas generic farmers just sell milk in bulk to dairies. The second major difference is that while "generic farmers" are independent, "specific farmers" collude and behave as a monopolist. There exists an institution that manages production and trade of the specific good. Such institutions are common in quality label systems (Barjolle and Sylvander (2000)). They are responsible for elaborating and checking specific requirements for the production technology, and carry out advertising. In this model, the specific product is treated as if it were produced by individual farmers, but we can also more realistically assume that there are small processing firms composed of farming workforce. We assume that no farmer can break the collusion and free ride by setting a lower price because of the common labelling policy that is common in quality label production.

We assume that there are two factors of production for the specific agricultural product, namely labour and intermediate goods. In other words, land is supposed not to be restrictive. This is a reasonable assumption, considering that many remote rural regions are facing a continuous decay of land use, especially in remote areas, where precisely many typical quality products come from. Suppose in addition that the production function has a Leontief form:

$$a_S(j) = \min(\alpha l(j), \beta\left(\int_0^n x(i)^{(\sigma-1)/\sigma} di\right)^{\sigma/(\sigma-1)})$$

$a_S(j)$ denotes the supply of specific agricultural good from farmer *j*, α is the maximum quantity a unit of labour may produce, *l*(*j*) is the labour provided by farmer *j*, β is a productivity index of intermediate goods, and the *x*(*i*) are inputs of intermediate goods. The choice of a Leontief functional form may be justified by the fact that the specific good is produced by individual farmers or small family firms, which rules out the possibility of labour-capital substitution, as well as economies of scale. This is also the form used by Daniel and Kilkenny (2002), except that they used land instead of industrial inputs. Another justification for excluding factor substitutability is that origin label products often have restricting requirements about production technology. We make the same simplifying assumptions as Krugman and Venables (1995) for intermediate goods. In particular, intermediate goods have the same elasticity of substitution σ as in the utility function.

To complete the description of specific product supply, we need to specify the behaviour of the collusive institution. This institution controls the number of farmers (as farmers need to have an official licence to sell the specific good) and then sets the price. A first idea would be to suppose it aims at maximising *per capita* profit, but this would obviously imply that only one farmer would produce the specific good (in order to be able to set the highest possible price). So we shall assume that its goal is to maximize total profit. Consequently, the institution acts in a way as a rural development agency: it tries to maximise income flow inside the rural region.

Now we have described the features of the agricultural sector and of demand, we are now able to derive price, income and quantities in the specific agricultural sector. In this section, industrial prices and income are taken as exogenous. If production cost is minimized, intermediary goods needed to produce a given quantity of a_S are given by:

$$x(i) = \frac{p(i)^{-\sigma}}{\left(\int_0^n p(j)^{1-\sigma} dj\right)^{\sigma/(\sigma-1)}} \frac{a_S}{\beta}$$

If we denote the price index for manufactured goods by $P_M = (\int_0^n p(i)^{1-\sigma} di)^{1/(1-\sigma)}$, that quantity can be rewritten as $x(i) = [p(i)/P_M]^{-\sigma} a_S/\beta$ so that total expense necessary to produce a_S equals $\int_0^n p(i)x(i) = a_S P_M/\beta$.

Using the demand function yields the expression of profit: $\pi = (1-\mu)Y \dfrac{k^\gamma p_S^{-\gamma}}{p_G^{1-\gamma} + k^\gamma p_S^{1-\gamma}}(p_S - P_M/\beta)$

The next step is to maximize this expression in p_S, which gives for the first-order condition the implicit equation: $(\gamma-1)\beta p_G^{1-\gamma} p_S^\gamma = \gamma P_M (p_S/p_G)^{\gamma-1} + P_M k^\gamma$ (1)

That equation cannot be solved analytically for p_S. Remember however that k^γ is supposed to be small as regards to $(p_S/p_G)^{\gamma-1}$. Note that a limited development of p_S at the first order in k^γ yields:

$$p_S \approx \frac{\gamma}{(\gamma-1)} \frac{P_M}{\beta} + \left(\frac{\gamma-1}{\gamma} \frac{\beta p_G}{P_M}\right)^{\gamma-1} \frac{P_M}{(\gamma-1)\beta} k^\gamma$$

We can see that p_S rises with the price p_G of the generic good, the index of propensity to consume the differentiated good *k*, and the manufactured products' price index P_M. It decreases with input productivity β and, if *k* is small enough, decreases with elasticity of substitution γ. Thus, the more differentiated agricultural products, the bigger the monopoly price. This is coherent with the significant mark-ups found in empirical studies. For instance, Skuras and Vakrou (2000), in a study of wine consumption in Greece, find that for some particularly renowned wines, price may be as high as twice regular wine's price. Wilson *et al*. (2000) find even higher mark-up rates for early potatoes.

As we have seen, the behaviour of the collusive institution is to set a monopoly price, and to make sure the number of farmers is such that each farmer will produce his maximum output α, and that the market will clear. It implies that labour is not in excess, i.e. that we are at corner points of isoquants in the Leontief production function. Formally, we have:

$$L_S = a_S / \alpha = \frac{(1-\mu)Y}{\alpha} \frac{k^{\gamma} p_S^{-\gamma}}{p_G^{1-\gamma} + k^{\gamma} p_S^{1-\gamma}} \qquad (2)$$

We shall suppose that the optimal number of farmers producing the specific good is small enough not to exceed L_A. Accordingly, an individual farmer's income is:

$$w_S = \pi / L_S = \alpha(p_S - P_M / \beta)$$

We can also express it as a function of the ratio of expense in the specific product to expense in the generic product, $r = k^{\gamma} p_G^{\gamma-1} / p_S^{\gamma-1}$ (see proof in Appendix):

$$w_S = \frac{\alpha(1+r)P_M}{\beta(\gamma-1)} = \frac{\alpha(1+r)(\int_0^n p(i)^{1-\sigma} di)^{1/(1-\sigma)}}{\beta(\gamma-1)} \qquad (3)$$

Note that using the first order development in k^{γ} we have

$$w_S \approx \frac{\alpha P_M}{\beta(\gamma-1)} + \left(\frac{\gamma-1}{\gamma} \frac{\beta p_G}{P_M} \right)^{\gamma-1} \frac{\alpha P_M}{\beta(\gamma-1)} k^{\gamma}$$

Rearranging (3) and noting that farmers seek to produce the specific agricultural good provided that they can get a higher income than regular farmers, we can see that it is profitable for some farmers to produce the specific agricultural good if and only if:

$$w_S > w_G \ \text{ i.e. } \gamma < \bar{\gamma} \equiv 1 + \alpha(1+r)(\int_0^n p(i)^{1-\sigma} di)^{1/(1-\sigma)} / \beta w_G \qquad (4)$$

That condition includes parameter *r* (which is endogenous). Note that a sufficient condition of profitability is: $\gamma < \bar{\gamma}' \equiv 1 + \alpha(\int_0^n p(i)^{1-\sigma} di)^{1/(1-\sigma)} / \beta w_G$

As we can see, collusion does not always make it advantageous to produce the specific good. This may appear counterintuitive, but it results from the existence of intermediate inputs. Product differentiation must exceed a threshold for the quality label to be profitable. This threshold depends on individual labour productivity α and on manufactured products' price index. In particular, if labour productivity is not high enough, it may not be profitable to produce the specific good. Besides, (4) shows that the higher the price index for manufactured intermediate goods, and the lesser the productivity of inputs, the more profitable it is to produce the specific good. This feature simply arises from the monopoly power, which allows costs to be fully transferred to consumers. We shall say more about comparative static results in section 4.

Product differentiation, when profitable, can obviously be a godsend for farmers under a quality label, who are able to capture a rent due to monopolistic organization and consumer attraction to their product. What we are interested in for rural development however, is also to foster the development of new economic activities in rural areas. In the following sections, we shall study the impact of agricultural differentiation on industry. We shall normalise generic agricultural wage to 1 ($w_G \equiv 1$), or equivalently the agricultural good's price ($p_G \equiv 1$).

1.3. Industry

So far, we have studied the production of specific agricultural goods independently of other activities in the economy. This is because the particular form of consumer utility allows a separate study for agriculture and industry. At present, we would like to investigate the impact of agricultural differentiation on other sectors.

Income rise due to product differentiation affects only a limited number of farmers, because of entry barriers, but it is supposed to maximise the rural region's total income. That income rise may bring about two types of indirect effects – on the one hand final demand increase from farmers, and on the other hand demand increase for intermediate goods. This double-sided demand increase for industrial goods could be expected to lead to the establishment of new firms in the rural region. That question is closely related to many theoretical papers initiated by Krugman's (1991) model, that aim at explaining uneven distribution of economic activities (many results can be found in Fujita and Thisse (2002)). That is why we shall use the same framework, except for the representation of the agricultural sector. The present section is devoted to describing the relationship between agricultural and industrial sectors, under total industrial concentration. The condition for rural industrialisation will be examined in section 5.

In the remainder of the paper, the economy is assumed to be made up of two regions, *U* and *R*. In line with Krugman (1991), we start with an extreme core-periphery configuration, where industry is fully concentrated in one region, because of the strength of agglomeration economies. This assumption lightens the calculations, and makes our arguments clearer. Furthermore, we assume that region *U* (urban) has no agriculture, whereas region *R* (rural) bears all farming population. This assumption makes our calculations simpler and helps grasp the essence of the mechanisms at work. Let L_M be the (exogenous) number of workers, who all initially dwell and work in region *U*, and L_A the (exogenous) number of farmers, immovable inhabitants of region R. There is a transport cost *T*>1 for manufactured goods between the two regions, which is supposed to be of the iceberg or Samuelson type – when a consumer orders *x* units of manufactured good in the other region, the firm has to deliver *Tx* units, which is equivalent from the consumer's point of view to price is multiplied *T*. In a first step, we shall assume, as in Krugman (1991), that agricultural products are transported at no cost. We relax this assumption in section 6.

The technology in the industry is $l = F + cx$ (labour is the only production factor, and the amount of labour needed to produce *x* units is *l*). Profit maximisation under monopolistic competition leads to:

$p_U = \frac{\sigma.c}{\sigma - 1} w_U$ (due to symmetry, all firms in the same region offer the same price).

This simple expression is due to the fact that utility function and production function of specific agricultural goods have the same elasticity of substitution σ between manufactured goods (see Krugman and Venables (1995)): total demand is iso-elastic. Then, with free entry, the zero-profit condition yields the supply of any firm $x_U^S = \frac{\sigma - 1}{c} F$ and full-employment of workers gives the number of firms in region U: $n_U = L_M / \sigma F$. Endogenous variables are then fully determined by writing the expression of demand for a manufactured good.

2. Price equilibrium and comparative static

2.1. Industrial price and wage

Suppose first that there is no agricultural differentiation. As we have normalized the income of generic farmers to one, we have, denoting x_U^D the demand facing any single firm:

$$x_U^D = \mu \left[\frac{w_U L_M p_U^{-\sigma}}{n_U p_U^{1-\sigma}} + \frac{L_A T^{1-\sigma} p_U^{-\sigma}}{n_U (T p_U)^{1-\sigma}} \right]$$

Assuming market clearing, substituting for x_U, p_U, n_U, and solving for w_U, we get:

$$w_U^0 = \frac{\mu}{1-\mu} \frac{L_A}{L_M} \qquad (5)$$

Exponent 0 indicates this is the value of urban wage before agricultural differentiation occurs.
Now **suppose we have L_S farmers producing the specific good**, with income w_S, the rest $L_G = L_A - L_S$ going on with the generic good. At present, x_U^D can be written:

$$x_U^D = \mu \left[\frac{w_U L_M p_U^{-\sigma}}{n_U p_U^{1-\sigma}} + \frac{(L_G + w_S L_S) T^{1-\sigma} p_U^{-\sigma}}{n_U (T p_U)^{1-\sigma}} \right] + \alpha L_S \frac{T^{1-\sigma} p_U^{-\sigma}}{\beta \left[n_U (T p_U)^{1-\sigma} \right]^{\sigma/(\sigma-1)}}$$

After substitution, we get an expression for w_U as a function of the variables characterising the agricultural sector w_S and L_S, and of exogenous parameters:

$$w_U = \frac{\mu (L_A - L_S + w_S L_S)}{L_M \left((1-\mu) - \frac{c \alpha L_S T}{\beta (\sigma - 1) F} \left(\frac{\sigma F}{L_M} \right)^{\sigma/(\sigma-1)} \right)} \qquad (5)'$$

This expression cannot be used to calculate w_U, because w_S and L_S are endogenous. However, it is easy to see that $w_U > w_U^0$, i.e. nominal industrial wage is higher than without agricultural differentiation, because we must have $w_S \geq 1$ so that differentiation may be profitable for farmers. Consequently, we can see that agricultural differentiation has a positive impact on industrial wages, which is not surprising as it implies a higher demand for industrial goods. The impact on welfare for urban workers is even higher, as urban workers are now able to consume another product. Note that the impact of agricultural differentiation on generic farmers' welfare is ambiguous: on the one hand they can afford fewer manufactured products because of price rises, on the other hand they can now buy specific agricultural products.

In section 5, we shall study the possibility of rural industrialisation due to the changes brought about by agricultural differentiation. Before we do that, we shall discuss the size of the specific agricultural sector, in the light of the results of this section.

2.2. Comparative static

The results of the former section allow us to get some insights about the number of differentiated farmers L_S. It is not possible to derive an analytical expression of L_S as a function of exogenous parameters, but putting together the results of sections 2 and 3, we can show that the percentage of specific farmers is (see proof in appendix):

$$\frac{L_S}{L_A} = \frac{1}{1 + \frac{\gamma + r}{r(1+r)} w_S} \qquad (6)$$

and is bounded from above by: $$\left(\frac{L_S}{L_A}\right)_{\max} = \frac{r(1+r)}{\gamma + 2r + r^2} < \frac{r}{1+r} \qquad (7)$$

Remember that *r* is the ratio $k^{\gamma} / p_S^{\gamma-1}$ (ratio of expense for the specific good out of expense for the generic good), and note that this result does not rely on any approximation as to the small size of *r*. It shows in particular that the percentage of differentiated farmers can never be higher than the share of expenses for specific agricultural products. The existence of this upper bound to the number of specific farmers is mainly due to collusive behaviour, which imposes barriers to potential entrants in order to maximise the monopoly rent. Besides, equation (7) shows that one should not expect a massive conversion of farmers to the production of specific goods. Moreover, as *r* increases, the potential number of specific farmers increases less than proportionally.

As *r* and w_S are endogenous, numerical simulations are necessary to state results about comparative static. They allowed us to state the following proposition[2]:

Proposition 1

- *A rise in γ (substitutability of agricultural goods) increases the share of farmers who differentiate and industrial wage, but decreases specific farmers' wage.*
- *A rise in σ (substitutability of manufactured goods) increases the share of farmers who differentiate, but decreases specific farmers' and industrial wages.*
- *A rise in T (transport costs for manufactured goods) decreases the share of farmers who differentiate, but increases specific farmers' and industrial wages.*
- *A rise in k (preference for quality labelled products) increases both the share of farmers who differentiate and specific farmers' wage, and increases also the industrial wage.*

These results show that the more the specific product is differentiated (γ is low), the more it is profitable, but the fewer the farmers who benefit from income rises due to differentiation. This confirm the "elitist" character of the specific product. However, if the consumer's preference for specific product rises (*k* rises), both income and number of differentiated producers increase. A final interesting feature is that L_S / L_A increases as industrial transport cost *T* decreases (because price index and income w_S both decrease). That implies that the less remote the rural region, the more farmers may specialise in the specific good.

3. Induced effects on industry – possibility of rural industrialisation

As we are concerned with rural development, we shall now study the conditions under which an industrial settlement would be profitable in the rural region. Agricultural differentiation appears to increase inequality between generic farmers and industrial workers. On the other hand, it implies higher wages for the farmers who manage to differentiate. Then, we can envisage two ways by which agricultural differentiation could induce industry to settle in the rural region. First of all, firms could take advantage of lower relative income for regular farmers (because of wage rise in the urban region)

[2] Detailed results of these simulations are available at request to the author.

to relocate, using farmers as unskilled labour. That possibility will not be studied here, for we wish to focus on industrialization which is due to the rise in demand from specific farmers. The possibility of inducing industrialization through unskilled labour has already been studied in a similar framework by Gaigné (2001)[3]. The second potential cause of industrialisation, which will be the one investigated here, is that the rise of demand from differentiated farmers would make it profitable for a firm to settle in the rural region. That demand rise concerns both final and intermediate goods (which in our model happen to be the same). We shall assume that urban workers could be interested in moving to the rural region, provided that a firm offers them a real wage which is at least equal to urban real wage.

So in that section, we suppose that urban workers can migrate to the rural region, provided that a firm is able to offer them a wage which is high enough. We do not consider the possibility that generic farmers could convert themselves into workers. Indeed, most rural development strategies aim at attracting new skills to rural regions, given that farmers are generally hired as unskilled labour.

It is not clear whether the existence of agricultural differentiation is or not favourable for rural industrialisation in our model. On the one hand, there is a rise of demand for industrial goods in the rural region, which tends to attract industry. But on the other hand, urban wage rise (see equation (5)') counterbalances that effect by increasing urban demand for manufactured goods.

In this article, we only study the stability of an initial situation of complete agglomeration – we do not mean to fully determine migration equilibria. The framework we use generally only yields very clear-cut equilibria, namely full agglomeration or symmetric dispersion. This is not annoying in our case, as our purpose is only to examine whether agricultural differentiation could possibly induce rural industrialization, and thus be a genuine way of rural development, not only a way to enrich some farmers.

One can show (see Appendix) that a necessary condition for rural industrialisation is:

$$\mu \frac{(\sigma-1)F}{c} T^{1-\sigma-\mu\sigma} + \mu \frac{(\sigma-1)F}{c} \frac{(L_G + w_S L_S)}{w_U L_M} T^{\sigma-1-\mu\sigma} + \frac{\alpha L_S}{\beta \left[L_M / \sigma F\right]^{\sigma/(\sigma-1)}} T^{(1-\mu)\sigma} \geq \frac{\sigma-1}{c} F \quad (8)$$

The first two terms of the left-hand-side of (8) correspond to urban and rural final demands respectively, whereas the third term stands for demand of intermediate inputs. The right-hand-side is the minimal quantity a firm must send to have a nonnegative profit. This expression shows the trade-off induced by agricultural differentiation: the fact that $w_S > 1$ and $L_S > 0$ acts in favour of rural industrialisation, but the fact that $w_U > w_U^0$ acts in the other way. Substituting for w_U, using equation (5)' in equation (8) eventually leads to the following proposition:

Proposition 2
A necessary condition of rural industrialisation is $\left[\mu T^{1-\sigma} + (1-\mu) T^{\sigma-1}\right] T^{-\mu\sigma} \geq 1$ (9)

This condition is the same as the one we would have obtained, if agricultural differentiation had not occurred! In other words, agricultural differentiation does not alter in either way the possibility of rural industrialisation. This result is a quite unforeseen feature of our model: parameters related to specific good production, namely α, γ, and k have no impact at all on the condition of differentiation. The trade-off between urban wage rise and rural demand which appears in equation (8) happens to lead to a perfect balance. To be sure, this feature is due to the particular specifications used in the model, and the fact that we are only considering the stability properties of the core-periphery configuration. However, this result shows that one should not take for granted that income rise in the rural region automatically implies positive induced effects in other sectors.

[3] Note that it also is sometimes considered as an "undignified" way of economic development, at least in developed countries.

It is also important to note that this result is due to the mobility of workers, and the fact that, unlike in other models (Krugman and Venables (1995)), farmers cannot be hired as workers in the rural region. In the latter case, urban wage increment would on the contrary be an incentive for firms to move to the rural region, as they could hire cheaper labour there.

Qualitative effects of the change in the other exogenous parameters are easy to study using equation (9). Not surprisingly, they are the same as in Krugman (1991). Let us quickly recall what they are. First of all, a rise of the share of industrial goods μ in consumption is detrimental to rural industrialisation, because the influence of the agricultural sector as a potential dispersion force is then lower. Concerning transport cost T, the model shows that there is a threshold T^* under which no rural industrialization may occur. This yields a pessimistic prospect for rural development: as transport costs for manufactured goods decrease, it is less and less likely for rural industrialisation to occur. This result gives two sparks of hope however. First of all, remote regions are more likely to attract industry – this is the classical protection effect of distance. Second, potential real rural wage eventually rises when transport cost is very low, but without exceeding urban real wage. Thus, if we add in our model some qualitative aspect, such as natural amenities, that renders the rural region more attractive than the urban one, it is possible that rural industrialisation may occur with very low transport costs. In particular, if there is taste heterogeneity among consumers, the rural region may become attractive (see for instance Tabuchi and Thisse 2002).

The impact of elasticity of substitution for manufactured goods σ is again the same as in Krugman (1991), and is qualitatively similar to that of T, namely that rural industrialisation is all the more likely if manufactured goods are substitutable. This is not surprising as the more goods are substitutable, the greater the incentive for firms to move away from the urban region to escape competition.

4. Introduction of transport costs for agricultural products

So far, as in most economic geography models, we have assumed that there were no transport costs for agricultural products. This simplification can be justified by the fact that there are fewer scale economies in the distribution of industrial products, but it is highly questionable in our case. Introducing transport costs in agriculture does not seem to alter our results much at first sight. As consumers spend a fixed share of their income on agricultural products, and given the specific form of transport costs we use (the iceberg form), expenditure for agricultural products would be unaffected by the introduction of the **same** transport cost for both generic and specific products. The situation with transport costs in agriculture is not equivalent to that without transport costs however. Indeed, if agricultural products are costly to transport, that lowers urban workers' real wages, which increases the incentive to move to the rural region, so as to save on transportation costs on agricultural products. Transport costs in agriculture are in fact well known to act as a dispersion force (see for instance Calmette and Le Pottier (1995), Kilkenny (1998) or Picard and Zeng (2003)).

4.1. Same transport cost for both agricultural products

We first assume that there is a unique transport cost for both agricultural products, T_A. In the former calculations, the demand function for the specific agricultural product remains unchanged, and consequently so is the price equilibrium. However, the condition for rural industrialisation is not the same. We have:

Proposition 3
With transport costs in agriculture $T_A>1$ a necessary condition for rural industrialisation is:

$$\left[\mu T^{1-\sigma} + (1-\mu) T^{\sigma-1}\right] T_A^{(1-\mu)\sigma} T^{-\mu\sigma} \geq 1 \qquad (10)$$

In other words, the presence of transport costs in agriculture fosters rural industrialisation. This is no surprise and is a classical result in new economic geography. Again, the existence of agricultural differentiation does not play any role in this equation. The case when transport costs are different for both agricultural products is more interesting.

4.2. Different transport costs for generic and specific good

It is reasonable to assume that the specific product is more costly to transport than the generic product. For instance, they could be prone to more stringent regulations in order to guarantee their freshness. More generally, as the market is smaller, there should be fewer scale economies for the distribution of this product, than for the generic product. Moreover, if the "agricultural good" consists of tourist services, city dwellers clearly have to travel to the rural region to consume it.

Formally, suppose that there are (iceberg form) transport costs T_G for the generic product and T_S for the specific product, with $T_S > T_G$, and let us first see how the results of section 2 are modified.
Total demand for the specific product is now, denoting rural and urban income by Y_R and Y_U respectively:

$$a_S^D = (1-\mu)\left[Y_R \frac{k^\gamma p_S^{-\gamma}}{1+k^\gamma p_S^{1-\gamma}} + Y_U \frac{k^\gamma T_S^{1-\gamma} p_S^{-\gamma}}{T_G^{1-\gamma} + k^\gamma T_S^{1-\gamma} p_S^{1-\gamma}} \right]$$

The fact that $T_S > T_G$ obviously implies that both p_S and w_S will be smaller than without transport costs.

As above, numerical simulations are necessary to get results on comparative static[4]. We find that:

Proposition 4
The higher the ratio T_S / T_G, the fewer the differentiated farmers, the lower their income and the lower industrial price.

Higher transport costs of the specific product are thus clearly detrimental to the specific agricultural sector, in both income and number.

Let us now turn to the condition for rural industrialisation. Condition (9) and proposition 2 have to be replaced by the following proposition (see Appendix):

Proposition 5
With transport costs in agriculture, a necessary condition for rural industrialisation is:

$$\left[\mu T^{1-\sigma} + (1-\mu) T^{\sigma-1}\left[\frac{T_G^{1-\mu}}{T^\mu}\right]^\sigma\right] \left[\frac{(1+r(T_S/T_G)^{1-\gamma})^{(1-\mu)/(1-\gamma)}}{(1+r)^{(1-\mu)/(1-\gamma)}}\right]^\sigma \geq 1 \qquad (11)$$

Note that $\left[\frac{(1+r(T_S/T_G)^{1-\gamma})^{(1-\mu)/(1-\gamma)}}{(1+r)^{(1-\mu)/(1-\gamma)}}\right]$>1 if and only if $T_S > T_G$. Comparing equations (10) and (11) ,we can see that we need to have $T_S > T_G$ so that agricultural differentiation have a positive impact on the possibility of rural industrialisation. Introducing transport costs in agriculture is not sufficient in itself to have a positive impact of agricultural differentiation on rural industrialisation. Comparing propositions 4 and 5 shows that *ceteris paribus*, a higher transport cost for the specific agricultural product is detrimental to the agricultural sector, but beneficial for rural industry. Thus, the positive effect on rural industrialisation is offset by a lower rise in demand from the farming sector.

[4] Detailed results of these simulations are available at request to the author.

5. Discussion - conclusion

Using a now classical economic geography model, we were able to derive some results about the factors determining the size of a differentiated agricultural sector and the relationship with industry. The model used in this paper obviously includes daring simplifying assumptions – we start from a corner solution, manufactured goods play a symmetric role, are indistinctly used as inputs and as final goods, and elasticity of substitution is the same for inputs and for final goods. These assumptions are common in economic geography models, and are necessary to handle an analytical study. Collusion for the quality good is also a strong hypothesis, but this polar case is useful to determine the **maximum income** that could be captured by farmers who decide to produce a specific agricultural good. Moreover, successful cases of quality labels frequently have this characteristic (Barjolle *et al*. (2000)). Such organisation is justified by the necessity to maintain a high level of quality control, even if it may also be viewed as being designed to capture a rent.

The results of our model seem to strongly qualify the common opinion which states that quality labels, or other strategies based on specific characteristics of rural regions, could act as levers for rural development. First of all, even under a collective income-maximising strategy, differentiation is by no means automatically profitable. In particular, individual productivity, and product differentiation must be high enough. Second, few farmers may benefit from that differentiation, and the more the quality good is specific and profitable, the fewer the farmers who produce it (compared to the share of the quality label in agricultural production). Last but not least, unless specific products are more costly to transport than generic ones, agricultural differentiation has no impact on the possibility of rural industrialisation. This is because demand rise in the rural region is offset by an opposite effect in the urban region. Even if this result is due to the particular functional forms we used in our model, the existence of such a compensating mechanism invites us to be cautious when talking about induced effects between sectors. In more general models, the net effect could be either way because of this trade-off. In the case when quality labelled products are more costly to transport, the net effect on rural industrialisation is positive, but at the expense of lower possibilities of development for quality labelled products.

In our model, quality labels are definitely a very selfish way of development, as the rise in some farmers' income does not benefit the rural region as a whole. On the contrary, it benefits urban workers, who get a higher wage and can improve their utility while consuming new products.

However, these results should not lead us to assert that quality labels are only a way of creating a rent for a minority of farmers. First of all, from a social point of view, origin-labelled products can have a positive impact on local cohesion and identity. That remark is corroborated by Barjolle and Sylvander (2000) who assess that social impact is more important than economic impact for PGO-PGIs. From a purely economic point of view, one essential reason why, in our model, the positive effect on urban wages, and increased rural demand rise compensate each other, is that industrial firms are treated as symmetrical. Demand for manufactured goods only depends on relative prices. By contrast, if there were any reason for rural inhabitants to prefer rural manufactured goods, the development of quality labels would have a more significant effect on rural industrialisation. Such a situation could occur because of some sort of parochialism, but also simply because rural industrial products happen to be more suited to rural needs, or because there exist strong complementarities between specific agricultural and rural manufactured sectors. This would in particular be the case if we supposed that rural industry would make products (inputs or final goods) that are specific to the needs of farmers.

Now, co-ordination between economic agents is often pointed out as an important condition for a local development to occur. Our results suggest that it is even a decisive condition to have positive induced effects between sectors. It is not sufficient that a specific comparative advantage has been exploited.

Another strong hypothesis that limits induced effects on rural industrialisation is that potential rural firms hire urban workers migrating to the rural region. If there was a strong training effort directed to rural inhabitants, it would become likely that rural firms could hire local people. The positive effect of agricultural differentiation on urban wage would then have the reverse effect on rural industrialisation. If rural inhabitants are able to become workers, the low relative wages in the rural region is a dispersion force for firms. Studying such a situation would then require another theoretical framework, for instance inspired by Krugman and Venables' (1995) model.

Another refinement that would be worth investigating is the possibility that several complementary goods, linked to the rural region, are produced in the rural region. Such products could for instance be food products and/or tourism services (see for instance Gatti *et al*. (2002) or Lacroix *et al*. (2000)). This could increase the number of inhabitants who benefit from product differentiation and enhance the possibility of induced effects.

A final aspect that has not been mentioned in this paper is the possibility of competition between rural regions. In the real world, there are many regions that are liable to undertake a development strategy based on quality labels. It is clear that the more typical goods are offered to the consumer, the less typical they actually are. There is obviously a limit to the number of successful strategies. As more and more quality labels try to penetrate food markets, that issue probably deserves attention, for it has many possible implications on rural development policies.

Appendix

- Proof of equation (3)

We can first derive an expression of p_S as a function of endogenous parameter $r = k^{\gamma} p_G^{\gamma-1} / p_S^{\gamma-1}$. Remember that p_S is given by:

$(\gamma-1)\beta p_G^{1-\gamma} p_S^{\gamma} = \gamma P_M p_G^{1-\gamma} p_S^{\gamma-1} + P_M k^{\gamma}$. Then, using normalisation of p_G and introducing *r*:

$$p_S = \frac{\gamma+r}{\gamma-1}\frac{P_M}{\beta} \qquad (13)$$

As $w_S = \alpha(p_S - P_M / \beta)$, (13) implies $w_S = \dfrac{(1+r)\alpha}{\gamma-1}\dfrac{P_M}{\beta}$ (3)'.

- Proof of equation (6) and inequality (7)

Let us rewrite equilibrium of supply and demand for a firm in region U:

$$x_U = \mu\left[\frac{w_U L_U p_U^{-\sigma}}{n_U p_U^{1-\sigma}} + \frac{(L_A - L_S + w_S L_S)T^{1-\sigma} p_U^{-\sigma}}{n_U (Tp_U)^{1-\sigma}}\right] + \frac{\alpha L_S T^{1-\sigma} p_U^{-\sigma}}{\beta\left[n_U (Tp_U)^{1-\sigma}\right]^{\sigma/(\sigma-1)}} = \frac{(\sigma-1)F}{c}$$

Using the fact that price index for manufactured goods in region R is $P_M = Tp_U n_U^{1/(1-\sigma)}$, and substituting $p_U = \dfrac{\sigma.c}{\sigma-1} w_U$ and $n_U = L_M \big/ \sigma F$, we get:

$$\mu\left[1 + \frac{(L_A - L_S + w_S L_S)}{w_U L_M}\right] + \frac{\alpha L_S P_M}{\beta w_U L_M} = 1$$

That allows us to write $w_U L_M$ under the form:

$$w_U L_M = \frac{\mu(L_A - L_S + w_S L_S) + \alpha L_S P_M / \beta}{1-\mu}$$

Now recall that global income is:

$$Y = w_U L_M + L_A - L_S + w_S L_S$$

Let us eliminate $w_U L_M$ in the expression of *Y*:

$$Y = \frac{1}{1-\mu} L_A + \frac{(w_S - 1) + \alpha P_M / \beta}{1-\mu} L_S \qquad (14)$$

Equation (2) also relates *Y* and L_S: $L_S = \dfrac{(1-\mu)Y}{\alpha}\dfrac{k^{\gamma} p_S^{-\gamma}}{1 + k^{\gamma} p_S^{1-\gamma}}$

Or, introducing $r = k^{\gamma} p_G^{\gamma-1} / p_S^{\gamma-1} = k^{\gamma} / p_S^{\gamma-1}$, equation (2) reads: $Y = \dfrac{1+r}{r}\dfrac{L_S \alpha p_S}{(1-\mu)}$ (15)

Putting together (14) and (15), eliminating *Y*:

$$\frac{L_S}{L_A} = \frac{1}{\alpha p_S (1+r)/r + 1 - w_S - \alpha P_M / \beta}$$

Using expressions of p_S (13) and w_S (3)' as functions of *r*, we can rewrite L_S / L_A as a function of endogenous parameters *r* and P_M only:

$$\frac{L_S}{L_A} = \frac{1}{1 + \frac{\gamma + r}{r(\gamma - 1)} \frac{\alpha P_M}{\beta}}$$

Equivalently, we may express L_S / L_A as a function of p_S or w_S:

$$\frac{L_S}{L_A} = \frac{1}{1 + \alpha \frac{p_S}{r}} = \frac{1}{1 + \frac{\gamma + r}{r(1+r)} w_S}$$

To get inequality (7), we simply use the fact that $w_S > 1$, for differentiation to be profitable, which implies:

$$\frac{L_S}{L_A} < \frac{r(1+r)}{\gamma + 2r + r^2} < \frac{r}{1+r}$$

- Proof of condition (8)

Suppose a firm plans to settle in region R. If is sets price p_R, it will be faced with demand:

$$x_R = \mu \left[\frac{w_U L_M T^{1-\sigma} p_R^{-\sigma}}{n_U p_U^{1-\sigma}} + \frac{(L_G + w_S L_S) p_R^{-\sigma}}{n_U (T p_U)^{1-\sigma}} \right] + \frac{\alpha L_S p_R^{-\sigma}}{\beta \left[n_U (T p_U)^{1-\sigma} \right]^{\sigma/(\sigma-1)}}$$

Let us factorise $(p_R / p_U)^{-\sigma}$:

$$x_R = \left(\frac{p_R}{p_U} \right)^{-\sigma} \left[\mu \left(\frac{w_U L_M}{n_U p_U} T^{1-\sigma} + \frac{(L_G + w_S L_S)}{n_U p_U} T^{\sigma-1} \right) + \frac{\alpha L_S T^{\sigma}}{\beta n_U^{\sigma/(\sigma-1)}} \right]$$

That firm should be able to offer a wage high enough to attract workers from region U. If that firms offers wage w_R, then we must have $w_R \geq w_U T^{\mu}$. Factor T^{μ} is necessary to take into account the higher price index in the rural region. Indeed, indirect utility can be written:

$$V_U = w_U \frac{(1-\mu)^{1-\mu} \mu^{\mu}}{\left(1 + k^{\gamma} p_S^{1-\gamma}\right)^{(1-\mu)/(1-\gamma)} \left(n_U^{1/(1-\sigma)} p_U\right)^{\mu}}$$ for workers in region U,

and $V_R = w_R \frac{(1-\mu)^{1-\mu} \mu^{\mu}}{\left(1 + k^{\gamma} p_S^{1-\gamma}\right)^{(1-\mu)/(1-\gamma)} \left(n_U^{1/(1-\sigma)} T p_U\right)^{\mu}}$ for workers in region R.

Obviously, $V_R / V_U = w_R / (w_U T^{\mu})$. Consequently, the firm will have to set a wage at least slightly higher than $w_U T^{\mu}$. Remembering that profit maximisation implies $p_R / p_U = w_R / w_U$ and that profit is positive if and only if $x_R \geq (\sigma - 1) F / c$, a necessary condition for rural industrialization is:

$$\mu \frac{(\sigma-1)F}{c} \left[T^{1-\sigma} + \frac{(L_G + w_S L_S)}{L_M w_U} T^{\sigma-1} \right] T^{-\mu\sigma} + \frac{\alpha L_S}{\beta \left[L_M / \sigma F \right]^{\sigma/(\sigma-1)}} T^{(1-\mu)\sigma} \geq \frac{\sigma - 1}{c} F \quad (8)$$

- Proof of condition (11) in Proposition

The previous proof does not depend on the modifications in demand for agricultural products due to the introduction of transport costs in agriculture. The only element which has to be changed is the ratio of real wages. We now have:

$$V_U = w_U \frac{(1-\mu)^{1-\mu} \mu^{\mu}}{\left(T_G^{1-\gamma} + k^{\gamma} T_S^{1-\gamma} p_S^{1-\gamma}\right)^{(1-\mu)/(1-\gamma)} \left(n_U^{1/(1-\sigma)} p_U\right)^{\mu}}$$ for workers in region U,

and still $V_R = w_R \frac{(1-\mu)^{1-\mu} \mu^{\mu}}{\left(1 + k^{\gamma} p_S^{1-\gamma}\right)^{(1-\mu)/(1-\gamma)} \left(n_U^{1/(1-\sigma)} T p_U\right)^{\mu}}$ for workers in region R.

Consequently:

$$\frac{V_R}{V_U} = \frac{w_R}{w_U} \frac{\left(T_G^{1-\gamma} + k^{\gamma} T_S^{1-\gamma} p_S^{1-\gamma}\right)^{(1-\mu)/(1-\gamma)}}{\left(1 + k^{\gamma} p_S^{1-\gamma}\right)^{(1-\mu)/(1-\gamma)} T^{\mu}} = \frac{w_R}{w_U} \frac{\left(T_G^{1-\gamma} + r T_S^{1-\gamma}\right)^{(1-\mu)/(1-\gamma)}}{\left(1 + r\right)^{(1-\mu)/(1-\gamma)} T^{\mu}}$$

Derivation of condition (11) is then straightforward, the condition for attracting urban workers being:

$$\frac{w_R}{w_U} \geq \frac{\left(1 + r\right)^{(1-\mu)/(1-\gamma)} T^{\mu}}{\left(T_G^{1-\gamma} + r T_S^{1-\gamma}\right)^{(1-\mu)/(1-\gamma)}}$$

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