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Abstract

Product diversity is a long-debated issue in economics. We remind that mainly two questions have been given answers: (a) to which extent does the market provide diversity? (b) why should this diversity be promoted? The first one stands out as the core of most articles on product diversity, whereas the second one is more evoked than really deepened. However, the economic analysis of product diversity stands out as a paradox. Actually, the definition of diversity itself has been somewhat forgotten. We try to give ways to overcome this absence so that product diversity can eventually be concretely assessed.

Key Words: Product diversity, theory of consumer choice, monopolistic competition.

L'analyse économique de la diversité de la production

Résumé

La question de la diversité de la production interpelle les économistes depuis au moins les premiers modèles de concurrence monopolistique. Nous rappelons que la théorie économique a principalement considéré deux aspects du problème : (a) Dans quelle mesure le marché fournit-il une production diversifiée ? (b) Pourquoi faut-il promouvoir cette diversité ? La première question surtout a intéressé la théorie économique, la seconde étant plus souvent évoquée que véritablement approfondie. Il demeure néanmoins un oubli problématique dans l'analyse économique de la diversité culturelle, celui de la définition même de la diversité culturelle. Nous cherchons ici à remédier à cette lacune, dans l'objectif plus général de fournir les outils permettant de mesurer la diversité de la production.

Mots-clés: diversité de la production, théorie du consommateur, concurrence monopolistique.

JEL Classification: D11, D43, L13.

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INTRODUCTION

Diversity is a very important as well as long-debated issue in economics and the least we can say is that many different applications of this concept are studied, from bio- (see for example Weitzman, 1992) to technological or institutional diversity (see for example Cohendet, Llerena and Sorge, 1992; Dosi, Orsenigo and Silverberg, 1988; Saviotti, 1996).[1] Here, we take a special interest in the economic analysis of product diversity, whose growth is an important feature of economic development (Llerena and Oltra, 1999, p.3). Product diversity was first studied by theorists of monopolistic and imperfect competition (notably Hotelling, 1929; Chamberlin, 1933; Robinson, 1934; Lerner and Singer, 1937). In fact, product differentiation is at the core of their models. Since, product diversity has been studied several times. Two kinds of models may be distinguished: on the one hand, the numerous variants of the spatial one (Hotelling, 1929; Lancaster, 1979; Stern, 1972; Salop, 1979; Lerner and Singer, 1937) and on the other hand those that assume convex preferences for consumers (Dixit and Stiglitz, 1977; Suen, 1991).

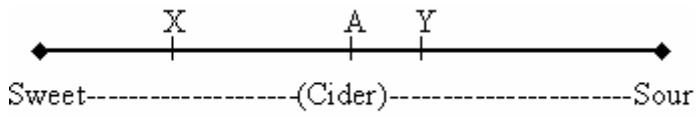

Figure 1: Hotelling's model

The spatial model was at the beginning a linear model (Hotelling, 1929). A line represents the Main Street of a small town. Customers are located all along this line[2] (in fig.1, only one consumer named "A" was represented). There are also sellers[3] (in fig. 1, they are named "X" and "Y"). Every one of them sells the same product to consumers. Thus, they are competing through their selling price and their localisation on the street. Product diversity is here represented by the way vendors are localised on the line, supposing that this line represents a characteristic of a good. Hotelling gives us the example of cider, by supposing that the line represents all the people that want to buy cider. On one extremity, you find the people that prefer it sweet and on the other one people that prefer it sour (p.54). In fig.1, "X" produces a sweeter cider than "Y" but since they are not on the extremities it could be possible to produce a sweeter or a sourer cider. This model has been often used, especially by replacing the line by a circle in order to suppress problems caused by the extremities (Salop, 1979).[4] A generalisation as well as a complexification

[1] At least in these two latter cases, it is worth reminding that institutional and evolutionary economics have played a great role (Stirling, 1998, p.6).
[2] The most simple case consists in an uniform distribution (p.45).
[3] Two at the beginning, but this number after is increased (p.53).
[4] This issue is studied in section 1.1.

of the model consists in the use of many dimensions, just like in the characteristics approach (Lancaster, 1979). Hotelling already foresaw the usefulness of taking more than one dimension into account (1929, p.55) but Lancaster has made mathematically possible to take into account an unbounded number of dimensions.

Product diversity may also be modelled by assuming that consumers have convex preferences (Dixit and Stiglitz, 1977). This assumption means that they prefer mixtures. This type of modelling most of the time takes for granted the fact that consumers as a whole often buy different goods that are close substitutes, instead of all buying the same good, the cheapest for example, as would be the case if assuming a very narrow-minded consumer, or a total lack of diversity. Somewhat, this type of modelling is very alike to models in finance which assume that agents are adverse to risk and then would rather have portfolios with different and if possible uncorrelated capital assets (Markowitz, 1952).
Some authors tried to reconcile these both approaches, either by using probabilities (Perloff and Salop, 1985) or by using aggregate demand systems in the characteristics approach (Anderson, De Palma and Thisse, 1989).

Thus, economics shows an old interest for the analysis of product diversity. Anyway, as we show in this paper, some important questions have not been sufficiently discussed. In the first section we will see that two major questions have been given replies: First, does the market tend to promote diversity? And also, is product diversity a good thing? However, as we will show in the second section, the fundamental issue of defining product diversity has been almost forgotten. It is however a crucial issue with important implications. This is why we will define this diversity and give a general framework for its measurement.

1. The already explored questions and the given answers

1.1. Does the market tend to promote product diversity?

The concept of product differentiation was introduced in order to give an answer to this question: does the market perform well in offering diverse products? The answer is rather pessimistic. Actually, the market rather deters product diversity.

The main reason is that there is an opposition between efficiency and diversity (Hotelling, 1929, p.54; Lancaster, 1979, p.1; Dixit and Stiglitz, 1977, p.297; Meade, 1974, p.367; Chamberlin, 1950,

p.89)[5] as soon as there are economies of scale in the production process.[6] On the one hand, firms are incited to produce a great amount of a restricted set of products. Thus, they can save money, which sometimes might decrease their selling prices, making consumers more satisfied. On the other hand, consumers may prefer a diverse production.[7] In order to sell more goods – possibly at a higher price – firms could decide to offer a more diverse production. As a result there is a trade-off between efficiency, that is to say to reduce costs, and diversity. Lancaster adds that equity is to be taken into account, since when diversity is increased, some consumers face higher selling price for products that would have been produced even if diversity had not been increased:

> « *Thus the change, which brings* efficiency *(…) by reducing* [diversity] *(…) introduces the problem of* equity *by making some better off while making other worse off.* » (1979, p.1)

Chamberlin is often interpreted as concluding that monopolistic competition leads to too diverse a production since every good is produced in a quantity less than the quantity necessary to minimize the mean cost (Lancaster, p.214; Dixit and Stiglitz, 1977, p.301).[8] However, this conclusion must be discussed since it does not take into account the fact that consumers may to some extent prefer more diversity to a lower price (Lancaster, 1979; Dixit and Stigltiz, 1977, p.297, Meade, 1974, p.367). The authors generally conclude that, depending upon the parameters, the market may lead to less or to more diversity that would be optimal (Dixit and Stiglitz, 1977, p.308; Meade, 1974, p.359) but it seems anyway that there is an opposition between two kind of interests: the firms' and the consumers' (Dixit and Stiglitz, 1977, p.308; Meade, 1974, p.367).[9] The argument may be generalized when considering that there is an opposition between product diversity and not only the existence of economies of scale but of any phenomenon of positive feedbacks (Arthur, 1988) in the production process, such as for example the "*learning by doing*" (Arrow, 1962). Actually, these phenomena make the firms tend to focus on one product. Moreover, diversity may lead to increased transaction costs (Stirling, 1998, p.30). Such an

[5] In fact, Lancaster uses the word "*variety*", but it is more alike to what we after call "diversity", see 2.1.
[6] Lancaster (1979, p.4) also mentions the fact that there are two other hypotheses: there is diversity in individual preferences and potentially in products. Thus, if all individuals have the same taste for one type of good or if only one type of product can be produced, there cannot be any opposition between efficiency and diversity.
[7] The reasons why are detailed in the next section.
[8] According to Chamberlin, this is an abusive interpretation of his conclusions (1950, p.89).
[9] We must precise that in these models, most of the time (apart from a slight exception in Lancaster, 1979, p.282) every producer is supposed to produce only one product. Thus concentration is almost automatically negatively correlated with product diversity. And of course, the less there are firms, the more they exploit economies of scale.

opposition may arise even in the absence of any assumption on the existence of economies of scale, as Gabszewicz (1983) shows. Actually, in the case of a multi-product monopolist, it may ensue from the demand conditions, and implicitly from the impossibility for the monopolist to discriminate between consumers. [10]

Such phenomena may be amplified by lock-in (Stirling, 1998, p.23). It means that product diversity on a market may be necessary to grant diversity either on another market or on the same market in the future. In the first case, it can be understood for example when goods on both markets are complementary and when in the same time there are possible incompatibilities. The second case simply means that some processes may be irreversible: on some markets, diversity can not be easily restored.[11] Quite on the contrary, we must remind that diversity and efficiency can be compatible, as soon as there are economies of system or of scope (Stirling, 1998, p.12), which is far from being rare.

Another very different kind of argument deals with mimicry strategies. It was developed in the spatial model (Hotelling, 1929). His finding was that two competing producers tend to come nearer one to another that would be optimal. Such a situation may favour consumers locating in the centre, between both producers but it harms customers located in the extremities. Hotelling easily shows that firms should be located at the same distance from the centre and these extremities in order to minimize the social cost of transportation (p.53).[12] On the contrary, firms tend to "*crowd together as closely as possible*" (p.53).[13] In our words, it would be socially better if firms had a diverse production that would take into account the customers that have different tastes, whereas they just try to make their products look like the one of their competitors. And according to Hotelling, new entrants just act the way the former firms have been acting (1929, p.53).

Hotelling's argument has been since contested many times. Chamberlin first, though recognizing the "*great importance*" of Hotelling's conclusion in the case of duopoly (1933, p.195) believes that more than two sellers will tend to disperse. Lerner and Singer find more complicated and complete results: Hotelling's result is confirmed by their model with two, and in some cases with

[10] Gabszewicz's model fast reaches its limits. Actually, apart from those inherent to any neoclassical model, his results heavily depend on the parameters used and then are far from being robust. Anyway, Gabszewicz himself recognizes that it is only an example (p.204).
[11] Of course such an argument seems particularly clear in the case of biodiversity. Here it might be linked with the time necessary to develop and to promote new products.
[12] Thus, two producers should be located at respectively one and three quarters.

three firms. However, with three or more firms, sellers are not necessarily located close one to another. Nor are they uniformly spread on the line (1937, p.177). D'Aspremont, Gabszewicz and Thisse (1979) even contest Hotelling's results with a duopoly for two reasons. First, in his model, there is no equilibrium price when firms are not far enough one from another (p.1145).[14] And then, in a modified version of this model where there is such a price, sellers will rather maximize their differentiation (p.1145). Another kind of problem is pointed out by Lancaster (1979) and Salop (1979). It is the importance of the extremities.[15] Actually, firms tend to behave differently – that is to say to group together - just because the borders are too close, whereas they will spread more uniformly if these borders are far enough. There are two ways to solve this problem (Lancaster, 1979, p.193). On the one hand, one may suppress the borders, either by using a circular model, just like Salop's (1979), or by supposing that the line is infinite. On the other hand, it seems possible just to make some assumptions on the extremities. In fact, Lancaster prefers the latter solution because the use of a circular model stands out as improper to represent problems of diversity[16](1979, p.190).

Anyway, the question of the ability of the market to promote enough diversity has been much studied, and the answer is far from being optimist, especially when suppliers are few. This normative question is naturally linked to a more positive one, about the reason why product diversity is valued by consumers and then why it looks like a good aim for industrial policies.

1.2 Why should product diversity be promoted?

The question of why product diversity should be promoted had been rather ignored until recently. It does not mean that the question was not asked but it was fast answered and/or explained, most of the analysis being devoted to the issue examined before. However, every economist seems to agree on the fact that product diversity is good because it is valued by consumers. Actually, consumers as a whole have a taste for diversity. Then, as well as for the firms, there is also a trade-off for them between diversity and efficiency, but the product diversity

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[13] In fig.1, "X" and "Y" are going to be even closer.

[14] We must precise here that Hotelling had foreseen such an objection. He used a "*continuous function* [that] *seem*[s] *to violate the doctrine that in one market there can at one time be only one price*" (p.44). The unicity of price on a market may appear itself as an assumption more than an established truth.

[15] Lancaster calls it "*the end-firm problem*" (1979, p.190) and Salop the "*"the corner difficulties""* (1979, p.142).

[16] Actually, few characteristics may be represented by using a circle: as far as we know, there are the localisation on any circular place and the colours (see for example the representation of colours on the chromatic circle). Any other characteristic would better be represented on a line, if it can be represented at all, that is to say, if goods that differ in one characteristic remain comparable.

supplied by the firms may not correspond to the best solution[17] from the consumers' point of view, as we saw in 1.1.

The fact that consumers as a whole have a taste for diversity can be explained at the individual level: either consumers have *diversity of tastes*, or they have *a taste for diversity*. Diversity of tastes appears as the first explanation more or less explicitly used by models which deal with product diversity, notably in Hotelling (1929): the diversity of localisation of the consumers symbolizes the diversity of tastes of the consumers. Thus, consumers tend to choose the product nearer to their localisation by comparing the distances between them and respective producers. In fig.1, consumer "A" compares distances AX and AY and then chooses to buy to producer "Y". Hotelling gives us an example with cider. There is a continuum between consumers who love it sweet and others who prefer it sour (p.54).[18] Subsequent models also use this explanation, notably Lerner and Singer (1937) and Lancaster (1979). The latter insists on the fact that the diversity of tastes appears less in the diversity of chosen products that in the diversity of these products' characteristics (P.7). A more general way of expressing this reason why promoting diversity is to say that it helps accommodating plural perspectives (Stirling, 1998, p.34).

Lancaster also mentions another way of justifying the promotion of product diversity: it is the fact that every consumer may have taste for diversity (p.95). He mentions two ways of modelling this taste. The one he uses afterward consists simply in assuming that the number of different available goods represents a positive consumption externality: the more there are different goods, the more consumers feel satisfied.[19] He also evokes a stochastic modelization, in which every customer's tastes are randomly chosen at every period and no longer stable.[20] In this case, the more diverse the set of products, the more the consumer is likely to be fully satisfied. Lancaster's modelization is worth mentioning since it seems to have much inspired Suen (1991). In his model, the value of any good from the consumers' point of view may be decomposed in a fixed value proper to the customer and a variable one that depends on the context of the use or the

[17] The use of the concept of "best solution" (or we could say optimal or paretian solution as well) is relevant here since most of the models we are studying here belong to the neoclassical approach.
[18] It might be more than just tastes since Hotelling also speaks of different religions or different political choices (p.54 and 57).
[19] Using our terminology (see section 2.1), it is worth noticing that, in this approach, Lancaster actually speaks of variety and not of what we call diversity, although the rest of the book deals with what we call diversity (which he calls variety). Actually, for the taste for diversity, he only takes into account the number of different products and not any longer the distance between the available goods, that is to say the extent to which thy are different one from another.
[20] Maybe he does not develop this method because it seems to stand in opposition with his former assumption that tastes are rather stable (p.5).

consumption of the good. For example, someone may prefer to use their car in order to go to work but when it rains, they would rather take the train. The consequence is that the more the number of different products, and most of all the larger the set of available products, the better for the consumers. Moreover, product diversity may help not only in case of risk but more generally as soon as there is uncertainty or ignorance, which are cases in which there are not even probabilities on the appraisal of events, contrarily to the case of risk (Stirling, 1998, p.15).[21]

Suen's model was developed in order to justify Dixit and Stiglitz's approach (Suen, 1991, p.217). Actually, in their model, nothing is done in order to explain why consumers as a whole like diversity: it can be individual taste for diversity as well as diverse individual tastes: "*Product diversity can then be interpreted either as different consumers using different varieties or as diversification on the part of each consumer*" (Dixit and Stiglitz, 1977, p.298). Dixit and Stiglitz's approach remains much used anyway because it is practical to use. In order to combine this feature and the concreteness of the spatial, some authors have tried to link both (Weitzman, 1994). It seems at least natural from our point of view since they speak of the same thing: product diversity.

It appears that economists have said a lot about the reasons why product diversity should be promoted.[22] The fundamental explanation is the taste of consumers as a whole for diversity, which itself can be explained by individual tastes for diversity or diversity of tastes of consumers. It is worth noticing that every economist has not necessarily developed an argument on this question. They have been more talkative on the issue of to which extent the market tends to provide diversity. Anyway, one issue concerning product diversity is put aside, which, as we show in the next section, is very harmful to any attempt to measure product diversity.

2. The missing link in the study of product diversity: towards a measurement of this diversity

2.1. The absence of definition for product diversity

In the economic analysis of product diversity, something very important is missing: it is a clear and practical definition of this diversity. However, until recently, this was true for any economic study of diversity. Stirling (1998) tried and, in our opinion, succeeded in giving a definition of

[21] A way of expressing the difference between the case of uncertainty and the one of ignorance is to say that in the latter "*we don't know what we don't know*" (Stirling, 1998, p.17), whereas, as soon as there are probabilities you have at least an insight of the set of possible events.

[22] A reason we only briefly mention here is that diversity in general may foster innovation (Stirling, 1998, p.6) since it does not seem to work with product diversity when considering a radical distinction between producers and consumers. In this case, once consumed, the good disappears or is of no use for the producers. However it becomes discussable when considering that some goods are useful in order to produce other goods, because they are used as intermediary goods or because they inspire new goods.

technological diversity that may apply to whatever kind of diversity, and notably to product diversity.

One clue of the absence of a clear, universal definition of product diversity is the fact that many terms are used as synonymous. Hotelling (1929) mainly uses the words "*different*" (p.54 and 56) and "*contrasted*" (p.54), which are not really synonymous to diversity but he employs many words signifying the contrary of diversity: "*standardised*" (p.44) and "*standardisation*" (p.54), "*sameness*" (p.54), "*similarity*", "*homogeneous*" (p.57). Being grounded on this article, Lerner and Singer (1937) use the same term (p.145, 147 and following). Chamberlin (1933) uses a term that has the same root but who can be understood as a synonymous to diversity: "*differentiation*".[23] This word remains has been much used (for example in Salop, 1979; d'Aspremont, Gabszewicz and Thisse, 1979; Lancaster, 1979, p.26). The terms of "*variety*" (Lancaster, 1979; Gabszewicz, 1983; Meade, 1974; Dixit and Stiglitz, 1977, p.297) and "*heterogeneity*" (Chamberlin, 1950) are also used. "*Quality*" is the most ambiguous. Actually, to have goods of different qualities means to have diverse goods in Chamberlin (1933) whereas in Lancaster (1979, p.216) or Cooper and Ross (1984), it means that some goods are better than the others. Lastly, "*product diversity*" was popularized by Dixit and Stiglitz (1977)[24] and since has stood out as a very common term (Deneckere and Rothschild, 1992; Scherer, 1979).

This abundance of synonyms hardly hides the blur around the notion of "product diversity". As far as we know, no article even gives a clear definition of what it corresponds to. They all speak of it as if this definition was of common knowledge. For example, Lancaster defines product variation "*to mean variations in the characteristics contents of goods within the same closely defined group.*" (1979, p.26). Such a definition brings little to the definition since "*variations*" remains undefined. As for Meade, he seems to define "*variety*" as the "*number and assortment*" (Meade, 1974, p.359).[25] As a last example, Dixit and Stiglitz hardly define "*less variety*" as "*fewer goods and larger quantities of each* [produced]" (p.297). They also say that "*the desirability of variety* [of a consumer is reflected by the fact that he] *prefers the mix (…) to either extreme*" (p.297). This lack of precision prevents us from building tools in order to measure it. In our point of view, just like biodiversity in the case

[23] Chamberlin even asserts that the use of the expression "*product differentiation*" is due to the development and the spread of the monopolistic competition theories (Chamberlin, 1950, p.85).
[24] Dixit and Stiglitz (1977) use "*variety*" and "*diversity*" for the same concept. As we see afterward this may raise some problems.
[25] According to our definition (see at the end of the section) it corresponds more to a mixture of variety and balance.

of ecology, "*clarification of the concept of diversity, its relation to other* [economic] *concepts, and agreement as to its use and measurement are (…) more than matters for semantic wrangling.*" (McIntosh, 1966, p.392).

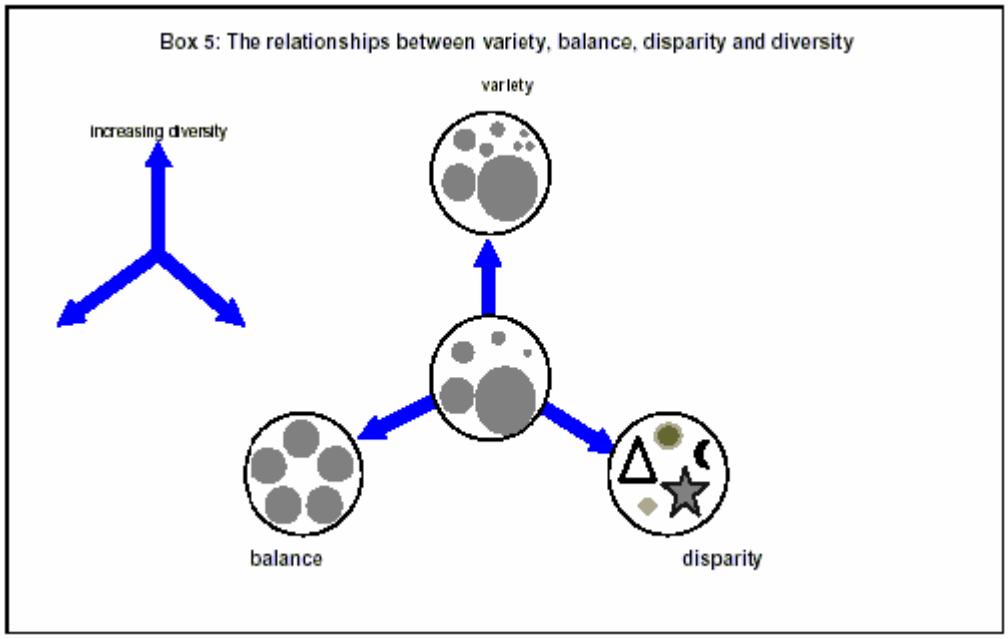
So what is product diversity? Some might say it is when there are many different goods available on the market. Others might say, it is when every available product has the same market share, otherwise when every consumer has a good produced whose characteristics are close to his preferences. Or a third preliminary definition would be the case when the available goods are very different one from another. Our definition of product diversity, inspired by a seminal article written by Stirling (1998),[26] tries to take into account these three points of view by describing diversity as being a mixture of variety, balance and disparity. These components are also directly related to diversity, so that the more either variety or balance or disparity, any equal things, the more diversity.

Before defining more precisely, we must make a semantic precision. We will distinguish the *types*, that is to say the prototypes that are reproduced in the industrial process,[27] from the *goods* or the *products* that stand out as perfect reproductions of their respective original model.[28] Variety corresponds to the number of different types. Balance represents the way every type is represented. It can be measured by the proportion for every type, that is to say the number of goods for every type that is produced or sold as compared to the total number of available goods. Disparity is the dissimilarity between types, for example between the two farthest or for every pair. We borrow the following representation from Stirling (1998) in order to make things clearer:

[26] Stirling (1998) hardly speaks of product diversity but rather of technological and sometimes biodiversity. He applies his definition to the particular case of technological diversity but it seems to work for every kind of diversity (p.38).

[27] One synonymous for *types* could be "*variants*", as used in Anderson, De Palma and Thisse (1989).

[28] One may say that all the goods are different since there is no perfect reproduction. This is a question here of theoretical interest (in fact directly linked to the definition of disparity) but such a radical vision seems irrelevant since it forbids us to take a look at important issues. At least, it is a particular case in our general framework in which only the variety of goods (all the goods produced) is measured.



Source : Stirling, 1998, p.41

This definition has the advantage of being general and relatively simple. Somewhat, it brings nothing new in the sense that the three components of diversity are often already represented in the way authors modelize diversity. For example, in the spatial model (Hotelling, 1929), variety corresponds to the number of available products, i.e. to the number of different producers,[29] no matter where they are located on the line. Balance will correspond somewhat to the way these producers are spread or clustered. If they are all regrouped, types will be less balanced, and it will be the contrary if they are uniformly spread on the line. Disparity seems to have a direct link with the notion of distance. Such a description could also be applied to Lancaster (1979).

For every kind of diversity, the way every component has been studied varies (Stirling, 1998, p.42), some disciplines focusing on one aspect, thus forgetting the others. It is the same in economics, with very different centres of interest according to the object of the study. In technological economics, there seems to be some confusion between diversity and variety (Stirling, 1998, p.42). Economic study of biodiversity tends to focus on disparity (see for example Weitzman, 1992) and finally product diversity is often more interested in variety (see for example Scherer, 1979). Thus Lancaster (1979), though using a model affiliated to the spatial model seems less interested in the issue of balance notably in comparison to variety. Actually, he often refers to the number of different products, for example when he examines the case of the taste for variety (p.97). It is also striking that when he determines the level of optimal differentiation, he refers to

[29] Since every producer produces only one type.

the number of products (p.71 and p.203). The fact that he neglects balance and also disparity may come from the fact that his model results in a uniform spread of producers.

Thus we showed how it was possible to define diversity in a rigorous way, using Stirling's' definition (1998),[30] as a mixture of variety, balance and disparity. As we will see, this is the best way to achieve indexes in order to measure this diversity.

2.2 Towards a measurement of product diversity

The great difference in the measurement of diversity concerning products in comparison with other topics such as bio- or technological diversity consists in the fact that almost nothing has been made in order to measure it. Quite on the contrary, the models often rely on many hypotheses that make it very difficult to apply them to real markets. For example, Anderson, De Palma and Thisse (1989), in their slightly different version of Lancaster's characteristics model, impose, for their model to work well, that, when there are n different types, there are at least n - 1 different characteristics taken into account in order to differentiate between these types (p.32). Thus, such a model seems very difficult to apply in any study on a real market.

When some searches have been conducted, notably in the study of diversity in media and cultural industries (for example Moreau and Peltier, 2004 and Peterson and Berger, 1975),[31] they almost all lacked a robust and complete definition.[32] However, to measure diversity seems interesting for many reasons. First, from a theoretical point of view, it gives us the possibility to have a representation of a feature that appears important in most markets. Moreover, it gives us the ability to make comparisons over time or between countries. Eventually, as a consequence, it becomes possible to analyze the links between the level or the evolution of product diversity and other variables such as the level of concentration or the way the state is intervening.

The first way to measure diversity consists in building a single index of diversity, which some authors have tried in the cases of technological (see Stirling, 1998[33]) and biodiversity (see Patil

[30] However, as nobody is perfect, Stirling itself seems to make a little confusion when writing that "[a] *wide variety of disciplines and techniques compete for a niche...*" (1998, p.33).
[31] See also Seo (2004) for a short survey on research on diversity in media content.
[32] A notable exception is Moreau and Peltier (2004), but we must precise that Stirling represents an important source of inspiration for this article (p.125).
[33] The application of his work concerned "*diversity in UK electricity supply strategies*" (p.115).

and Taillie, 1982). The first step consists invariably in a clear and rigorous definition of diversity.[34] This necessary step does not lead to exactly the same specification of diversity. Actually, Patil and Taillie (1982) seem to forget disparity, so that Good, commenting their text, suggests to introduce a measure of similarity between any pair of the considered types[35] (1982, p.562), which is very close to what we call disparity. However, this effort of definition enables us to distinguish what are the components of diversity to be measured. After this definition, in both writings existing indexes are remembered[36], the most current being:

$$\text{The Species Count} = N - 1,$$

$$\text{The Shannon index} = -\sum_{i=1}^{N} \pi_i \log(\pi_i),$$

$$\text{The Simpson index}^{37} = 1 - \sum_{i=1}^{N} \pi_i^2,$$

with N being the number of different types and π_i the proportion of the Ith type.[38]

"Species count" only measures variety whereas "Shannon index" and "Simpson index" measure at the same time variety and balance. There are also indexes which measure only balance (Stirling, 1998, p.47). Stirling's objective is to take into account disparity in an "*integrated multicriteria diversity index*" (p.94):[39]

$$M = \sum_{i,j \in [1,n]^2} d_{ij} \pi_i \pi_j,$$

with d_{ij} representing the "distance" between two types, thus measuring how different two types of goods are. He also draws a comparison with two other indexes respectively built by Weitzman (1992) and Junge (1994).

In both articles, indexes are compared in order to identify which one fits the best. In Stirling, they are evaluated on the basis of five criteria (1998, p.90-94). They have to be complete, that is to say to take into account the three components of diversity; parsimonious, that is to say simple enough; transparent, that is to say that they require as few assumptions as possible; robust, that is

[34] Let us note that Patil and Taillie (1982) make an interesting comparison between diversity and rarity, by defining diversity as the average rarity (p.548). They also compare diversity with inequality. Inequality stands out to be much like a relative unevenness (p.558), evenness being quite a synonymous of balance.
[35] Here animals.
[36] Here we write indexes as given by Patil and Taillie (1982, p.549). There are slight differences with their formulation by Stirling (1998, p.47).
[37] This index is better known in industrial economics as the Herfindahl-Hirschman concentration index.
[38] That is to say the number of goods of type *i* as compared to the total number of goods of every type.
[39] He builds another index that also takes into account the interactions between each pair of options (p.110).

to say that they do not rely too much on the values of the parameters; and eventually consistent, that is to say that the values taken by the index must respect some basic principles linked to the definition of diversity.

Consistency is also stated by Patil and Taillie (1982), of course in a different form since they do not take into account disparity. Consistency can be summarized by two criteria. Firstly, as soon as there is only one type, diversity should be equal to zero (Patil and Taillie, 1982, p.549; Stirling, 1998, p.93).[40] Secondly, the more variety or balance or disparity, the more diversity (Patil and Taillie, 1982, p.556;[41] Stirling, 1998, p.93 and 94).

However, the will to build one index that would aggregate every data, though appealing, is itself questionable. First, it supposes that it is always possible to apply the theoretical notions of variety, balance and disparity to the study of concrete things. In the case of product diversity, most problems appear when dealing with disparity. Two types of goods might be said to be different but to which extent is another problem. It supposes to precise which are the crucial dimensions. Such a precision can not necessarily be given objectively. Furthermore, the ability to measure objective distances becomes then necessary. Lancaster met the same kind of problems: he had to suppose that the goods' characteristics[42] were always recognizable and quantifiable, which he recognized as being not true, for example with the colours that are recognizable but not quantifiable (p.17).

Now, if we make it possible to modelize the three components of diversity, another problem is to get access to a sufficient amount of data. In our case, it supposes frequently to have a very acute access to a broad set of data. Stirling (1998) seems to succeed in analyzing the UK energy sector (p.115 and followings). But one may doubt if his approach is really complete. Actually, someone that uses a single index is going to lose some information because they will aggregate abundant data (Sugihara, 1982, p.564). To keep numerous data allows having a more complete view of diversity, that is to say of its level, its evolution but also the connection between the studied diversity and the way ecological communities as well as economic systems are organizing (Sugihara, 1982, p.564; Gerard, 1965). As general and complete as Stirling's approach appears, it can not be applied that simply in our case. And generally speaking, to apply already existing

[40] This situation also corresponds to the case when all types are alike, that is to say when there is no disparity at all (Stirling, 1998, p.94) or when every type except one is represented by no good.
[41] Except of course for disparity.
[42] Let us remember that in his approach, goods are bundles of characteristics (p.17). Goods correspond to what we call types.

indexes to new situations seems a bit dangerous. Sugihara rather suggests an inductive approach from the data to an index (p.564), so that there is not a single index of diversity.[43] Such an approach moreover makes easier the use of incomplete data (p.565), which is a clear asset in our case.

Thus, in the case of product diversity, Stirling's definition and especially his index are at the same time insufficient and too much demanding. Too much demanding since to measure disparity causes some problems. And they are insufficient since they do not take into account the fact that diversity is to be assessed on both supply and demand sides (Moreau and Peltier, 2004, p.127 ; Van der Wurff and Van Cuilenburg, 2001). This dimension does not seem to have an equivalent in bio- or technological diversity. In some cases there can be also a link with innovation (Berger and Peterson, 1996, p.176; Llerena and Oltra, 1999, p.3). Eventually, there is the question of the boundaries of the market when measuring product diversity. Every economic approach on product diversity relies on the possibility to clearly distinguish between markets, which is far from being obvious in real market studies.
For all these reasons, the best way to study product diversity seems to take the definition of Stirling (1998) as granted and then to keep as numerous as necessary – or maybe possible – ways of measuring the different components of diversity.

CONCLUSION

As a conclusion, it is worth taking a look backward at the very important contributions given by economists concerning the study of product diversity. As we have seen, much has been said in this field concerning the reasons why product diversity ought to be promoted. The fundamental reason was the fact that consumers as a whole prefer this diversity to similarity of available products. This fact can easily be observed in any market, even if preferences are more or less marked depending on the considered good. It may be explained by the fact that every consumer has a taste for diversity or that tastes differ between consumers. Anyway, as this taste for diversity stands out as granted, economists have naturally turned towards what they seem to consider as the most important question: is the set of available products diverse enough? Otherwise, does the market structure lead to the optimal level of diversity? While not definitely concluding, they seem to agree on an opposition between strategies led by the firms and consumers' desires, generally

[43] In the field of industrial economics, Donsimoni, Geroski and Jacquemin somewhat support the same point of view as for the measurement of concentration (1984).

because of the existence of positive feedbacks in consumption or in production but also because the firms are likely to leave unsatisfied the consumers with the most differentiated tastes.

However, economists seem to have turned their reasoning upside down since they have focused on how to promote diversity, they have given little interest to the reason why to promote and they have forgotten what has appeared to us to be the most important, and indeed what is at the beginning of any reflection upon diversity, that is to say the definition of diversity itself. It sounds a bit strange, but they have developed very sophisticated models that take into account the level of diversity, as an explained variable, while rarely explaining in what it consisted. We have tried to give some insights in order to better understand in what it concretely consists. Our main results are that diversity can be understood as a mixture of variety, balance and disparity (Stirling, 1998, p.39) and that, as appealing as it may seem, the building of a single index of diversity may not always be the solution or even the objective (Sugihara, 1982, p.564). Actually, the measurement of diversity should better rest on many different indexes, in order not to lose information and to adapt the way to measure to the issue, and not the opposite.

In the field of the study of product diversity, a particular place should be given to the study of diversity in media and cultural industries. First because this issue is relevant in a period when cultural diversity stands out as an important political aim according to the Unesco[44] or the European Union. But most of all because this is a field that has shown an old as well as a renewed interest for the study of diversity (see Seo, 2004, p.4). Many disciplines are involved, from sociology (see for example Peterson and Berger, 1975; Lopes, 1992; Dowd, 2001) to law (see for example Baxter, 1974) and also economics (see for example Moreau and Peltier, 2004).[45] This field is worth paying attention from the point of view of the study of product diversity because researchers have tried most of the time to measure diversity (Lopes, 1992; Peterson and Berger, 1975; Moreau and Peltier, 2004; Levin, 1971; Barnett and Greenberg, 1971; Lin and McDonald, 2004; Dowd, 2001; Blank, 1966) in order to determine which kind of links exists between concentration and diversity. They have rather neglected to question why diversity should be promoted but, since they have wanted to measure it, they have made significant efforts to define it. Here again, there is a proof that no significant step towards a systematic measurement of diversity can be made without an effort of definition. In this case, definitions are not always

[44] See notably the recently adopted Convention on the Protection of the Diversity of Cultural Contents and Artistic Expressions. For a study on the importance of cultural diversity for the Unesco, see Keitner (2004).
[45] Economics is not that much represented although sociologists and jurists make a rather abundant use of economic concepts.

consistent and operational (Seo, 2004, p.7) but some seek to analyze the content (Dowd, 2001; see other examples in Seo, 2004, p.7), which obliges to question the notion of diversity. On the other hand, the work of measurement is far from being well mastered[46], and it appears that much remains to be done in this field.

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[46] In our view, the only exception is Moreau and Peltier (2004). Their article stands out as the only one that defines diversity and tries to measure it. Anyway as we have written before, they are much inspired by Stirling, 1998.

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