Managing product life-cycle in the auto industry: evaluating carmakers effectiveness

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MANAGING PRODUCT LIFE-CYCLE IN THE AUTO-INDUSTRY: EVALUATING CARMAKERS EFFECTIVENESS

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"Product Life Cycle": a useful (although criticized) tool for managers of the automotive industry

The Product Life Cycle concept (PLC) is well known for a long time both in the studies of general economy and management. In the economic discipline the first formal application of PLC is probably that presented by Raymond B. Prescott (1922). The author introduces PLC as a tool to analyze the demand at the industry level. As far as we know, Joel Dean (1950)[1] introduces the PLC concept in the management literature with the aim to establish a tool for defining price decisions. The basic idea later developed (e.g.: Rogers 1962; Levitt, 1965; Bass, 1969; Day, 1981), claims that the sales of a new product - from the moment of its entry until its withdrawal from the market - could be somehow predicted as far their trend concerns and fairly independently from product specific features, since sales of a new product are mainly depending on the adoption rate of the innovation by the consumers[2]. Consequently, the overall trend of sales could be described as a sequence of stages, each one showing its own peculiar rate of demand variation strictly related to innovation adoption rate. According to the PLC theory, the firm that can predict the shift from one stage to another would be able to manage sales tendency adopting proper marketing-mix policies, in order to deal with the changing situation and, possibly, gain the better advantages in terms of profits, sales, etc. (e.g.: Rogers 1962; Levitt, 1965; Bass, 1969; Day, 1981). In such terms, PLC theory is commonly alleged as useful (e.g.: Cox, 1967; Polli e Cook, 1969; Goldgehn, 1983), although some points and/or application of PLC are arguable (Dhalla e Yuspeh, 1976; Wood, 1990). Anyway, PLC theory occupies its own space in any marketing course and handbook and in someone's opinion it is definitely "the most fundamental variable in determining an appropriate business strategy" (Hofer, 1975, 798).

The twofold nature of the PLC concept (referred to industries and referred to product) implies very different point of views and generates different methodological implication. The simplistic transfer of the concept from one field of application to the other one, very often, has created misunderstanding, but also

[1] The original article has also been republished in 1976 on Harvard Business Review: 54 (6) 141-153.

[2] A recent mainstream of studies use the expression "Product Life Cycle Management" for the organization and supervision of a product from its first design to its disposal or recycling. In this article, of course, we talk about the PLC as the traditional marketing notion related to the trend of sales of a product along time.

trivial approaches to the underlying issue. In recent literature it is common to find contributions exalting the PLC, as well as authors laughing at it; here we claim that the study of PLC has a key role in the managerial practice and, particularly, in the automotive industry, but the noticeable confusion that might be generated by a misleading approach should first be dissolved.

The first, most evident, specification concerns the various definitions of "product", that might be very different according to the scope of the analysis. In the general economics literature "product" is intended as *Product Class*[3] or *Industry*, therefore it refers to a broad category of goods that distinguishes an industry, with no distinction between firms nor versions (e.g.: car, television). For instance, Vernon (1971) explains the passage of an industry from developed economic systems towards emerging ones as an effect of the different degree of maturity/saturation of such "product" in the original systems.

The notion of "product" most commonly used in management literature is, instead, *brand* or a specific version of product offered by a firm (e.g: BMW sedan 328i, Panasonic LCD Tc-26Lx70) (Polli e Cook, 1969). An intermediate notion between the two mentioned above is *Product form*, related to a class of product (sedan, LCD). Of course, it makes little sense to argue about the usefulness of the PLC as a management tool, without a clear statement on the underlying notion of product. Such statement might seem trivial, but is a fact that the use of PLC is very commonly based on a generic, when not inappropriate, concept of product[4]. One of the most undesirable consequences of a superficial debate on CVP is the widespread idea of the CVP pattern as a "natural" one, associated to the existence of the product in itself and to a "deterministic" acceptation by the customers (Rogers, 1962). Thus, it is not surprising that the complex issue related to the PLC theory and its use as a management tool is very often associated with (and reduced to) the typical bell-shaped curve that the great majority of marketing handbooks present without a proper discussion of the theoretical assumptions underlying, and that millions of students have learned in a very mechanical way. On the contrary, the actual PLC of a product is the result of the competitive situation triggered by the interactions between the firm, its customers and the work against it done by competitors. PLC curves might be of all kind in relation to the peculiarity of the product taken into consideration[5]. Anyway, although it is common to stumble on trivial or improper statement on the CVP as a management tool, the PLC conception, in its several, different possible formulations, is neither useless nor unknowable: those who generally criticize the PLC without distinguishing its underlying notions and its field of application (e.g.: Dhalla and Yuspeh,1976; Mahajan and Muller, 1979) also lose sight of the strategic importance of time for marketing mix policies along the product life. The PLC notion seems the only tool, at present times, to which managers can refer to optimize the timing of marketing mix policies in a wide range of situation (product innovation, advertising planning, competitive analysis, price modifications and so on.).

The weak point of PLC stands in its alleged predictive capability; we claim that PLC is not (and can't be) a "predictive tool", but it should be a "prediction object": firms should investigate PLC trends to define strategies and/or policies. This requires the identification of the critical variables related to each stage and the characteristics of the demand, as well as to measure the potential performances of new products (Suomala, 2004). Of course, there is no "mechanical", neither "natural" components in the pattern of PLC, so it's not by chance that the most controversial question involves the frequent absence of regularities in PLC curves related to different products of same market and even between different products of the same firm over time. PLC trend is often assumed as a target rather than a descriptive and/or predictive model. For this reason, several authors focussed on identifying key-variables and related strategies relevant in each stage of PLC (e.g.: Levitt, 1966; Catry e Chevalier, 1974; Hofer, 1975; Anderson e Zeithaml, 1984; Parker e Neelamegham, 1997; Narayanan S. et al., 2005; Moon Y., 2005). From this point of view sales data are insufficient, since other information like cross-elasticity between concurrent products, nature of demand (if first-purchase or replacement purchase), and so on, should be known (Midgley, 1981).

[3] A categorization of the different ways products can be defined is in Polli e Cook V. (1969).

[4] This has been done, in our opinion, by Levitt T. (1965), Buzzel (1966), Katz (1970). Also Polli and Cook (1969), although giving a relevant contribute in distinguishing and classifying the different notions of "product", agree on the validity of PLC as a forecasting tool, idea that lack of theoretical foundation, especially for the *brand* and *product form* notion of product.

[5] On this topic see *Journal of Marketing*, 1981, number 4 (Fall), a special issue on PLC, particularly Midgley D. F., (1981); Torelli and Burnett (1981). Among reviews on the PLC literature see: Rink and Swan (1979), Day (1981).

In the automotive industry CVP strategies assume a key-role for competitiveness both on the side of demand and on the side of production efficiency.

On the demand side, the extraordinary level of competition in car industry (Freyssenet et al., 2003a and 2003b) pushes carmakers to produce with a higher degree of differentiation and boosting the elasticity of demand towards product newness, hence feeding a time-base competition (Blackburn, 1991). Most of the western car markets entered into the saturation stages already in the '70s. In Europe and USA, specifically, there is a high "motorization rate" (car per family or car per persons) and the demand is almost entirely constituted by replacement purchase. The decision of purchasing a new car is driven primarily from the search of a better car with innovative solutions, rather than from technical default or obsolescence of the vehicle the customer already have. To retain customer carmakers must be able to offer a new and/or better product at any moment the customer decide it's time to replace the old product; any delayed or untimely move in product innovation across life-cycle is a potential source of loss of customers.

Moreover, since PLC strategy has a key-role in determining market performance of a new model, consequently it has a significant effect on the average unit costs. In fact, because of the specific cost structure of automotive production processes, the effectiveness of PLC policy is crucial in this industry since it is related to the saturation of plants and to the re-definition of the operations in relation to the passage from the old model to the new one.

However, in spite of the clear importance that PLC policies have on car industry, few studies investigated this issue using historical data-series. As far as we know, no study has tried to investigate the evolution and the effectiveness of carmaker life-cycle policies, probably because of the difficulties in obtaining past data related to car registration and features. The only point upon which everybody actually agree, both in academic articles and car magazines reports, is a very general phenomenon already noted by Clifford in 1965 and becoming more and more relevant: "in recent years (...) products have been maturing more rapidly and life cycle getting shorter"

Data and method

The analysis includes sales historical data series[6] of a 37-years long period (1970-2006) regarding 212 models in three major European markets (Italy, France and Germany); 157 of these models have completed their life-cycle (LC), while 55 where on the market at the end of 2006. As a whole, 13 brands and six segments are involved (table 1). Both models LC (e.g.: Peugeot 205) and brand-segment LC (all Peugeot model in segment "B" from 1970 to 2006) are evaluated. We also focussed on differences among different periods within the 37 years under analysis, dividing the whole duration into three phases, each one having a specific significance for car industry:

- ✓ 1970-1983, as the years of the "oil crisis";
- ✓ 1984-1993, as the years of "increasing demand";
- ✓ 1984-2006 as the years of the "increasing competition".

The amount of models and brand-segment LC for each phase, as well as the whole period, are shown in the table 1.

Table 1. - The sample

Time periods	1970-2006	1970-1983	1984-1993	1994-2006
Total number of models	212	48	51	113
Complete life-cycle models	157	48	51	58
Ongoing life-cycle at 2006	55	-	-	55

Source: own analysis on data from Quattroruote, Anfia, Unrae, CCFA, VDA.

[6] Data have been collected from publications made by ANFIA, UNRAE, VDA and CCFA.

Collected data are of three main kinds:

- ✓ sales of car models[7] in Italy, Germany and France from 1970 to 2006;
- ✓ product performance and introduction of relevant modifications from 1982 to 2006 (new engines, restyling, new models);
- ✓ sales of car versions from 1998 to 2006 for the Italian market.

Sales data are in terms of units (from now on just: "sales"). The availability of car sales at the version-level allow a better analysis of the LC duration; where specified, some considerations referred to the sub-sample and to the period 1998-2006 will be presented, although they are not directly comparable with the analysis developed on the whole sample.

In any case, the life-cycle is always referred to the "model-level", that is: a new version, a restyle as well as the availability of new engines are not considered as the introduction of a new model. On the other hand, if the complex body-chassis is deeply modified then this is considered a new model.

Collected data are related to a sample of European top-seller brands (Alfa Romeo, Audi, BMW, Citroën, Fiat, Ford, Lancia, Mercedes, Opel Peugeot, Renault, Toyota, Volkswagen). These brands account for a large part of segment demand share within own segments, although such share has been decreasing in recent years, mainly as a result of "new entry" brands (Nissan, Mazda, Suzuki, Chevrolet-Daewoo, Hyunday, etc.). Anyway, since our study focuses on evolution of product strategies and product life cycle we decided to consider only product offers characterized by a persistent presence (at least 20 years long) in each segment.

Segments have been identified taking into account some main product features: car dimension (length and internal space) price, engine displacement and/or horsepower, body. Actually, segments should be referred to demand preferences instead that product features, but it is a common practice in car market to base segments definition on product characteristics; for instance, in this study the "B" segment groups cars with the following features:

1. wheelbase between 230 and 269 cm.;
2. entry-level price below 13.000 euros (2005);
3. displacement between 900 and 1500 cc for petrol engines, less than 1700 cc for diesel engines;
4. sedan or hatchback.

Segments boundaries have been delineated at car model level, although very often in a model are included one or more versions featuring attributes overtaking those specified for that segment (e.g. Renault Mégane Sport Power – 225 CV; Peugeot 206 RC – 180 CV). Where possible, data regarding special versions have been removed.

For the last 22 years (1984-2006) were also available data related to number of versions and major technical improvement of each model (that is: new version, new engines, re-styling). Thus we had a chance to focus on some specific aspects about possible effects of product policies on sales performance on a sub-sample of 10 brands in four segments (from "B" to "E") in the mentioned period.

In order to assess the possible relation between line extension and sales we define an indicator "PLE" (Product Line Extension), related to each model and each year, based upon number of version, price range, number of engine options:

A) $PLE = PR \cdot 10+(V \cdot M)-1;$

[7] A "model" is here defined as a car that can be produced in several different versions and whose basic structure (the group chassis-body) is substantially different from those of other models. Versions are different configurations of the same model. Thus, it is possible that different versions of the same model have very different performances, due to different engines, transmissions, etc. Such definitions of "model" and "versions" does not focus on performances, but on the part of the development stage requiring heavy and specific investment.

1. PR (Price Range) = (Pmax-Pmin)/Pmin; Pmin is the entry-level price of a specific model in that year and Pmax the maximum price for the same model in the same year; index refers to list prices at their current values (not deflated);
2. V is the number of versions offered for that model;
3. M is the number of engine options (so called "motorizations").

PLE is built so that it is equal to 0 if only one version of a model is offered, then it increases of 1 for each additional version sold at the same price with the same engine. Each additional 10% spread in price range make it raise of 1, while an additional engine option cause PLE to increase of 2[8]. The overall PLE of each segment has been calculated using the same formula at the whole segment; therefore, since it is related to the total number of version, of engine options and to a wider price range, PLE referred to a segment is obviously much bigger than the PLE of each brand.

A second indicator is related to Product Line Innovation (PLI) and is based on product renewal and on the increasing in the number of product version:

B) PLI = $\alpha + \beta$;

1. vary in each year for a specific product offer in relation to following events:
   - ✓ α= 0,5 if new engine options are introduced,
   - ✓ = 0,7 if a significant style modifications are introduced (*restyling*),
   - ✓ α = 0,9 if a new model is presented,
   - ✓ α = 0 in all other cases.

Each α value has been assigned to the year in which the innovation arouses a noteworthy difference in commercial performance, due to the actual timing of innovation (therefore, not necessarily in the same year of the new model, or engine, or style presentation): e.g., if the launch has been made in September while the rising in car registrations take place starting from next January.

2. depends on the variation of number of versions with respect to previous year:
   - ✓ $\beta = (V_t - V_{t-1})/(V_{t-1}) \cdot 2$ if $V_t > V_{t-1}$;
   - ✓ = 0 if the number of version is decreased with respect to previous year.

The PLI index actually do not measure how much innovative is a model or a version compared to the previous one, rather it shows how often that brand renew its line.

The correlation between PLE and sales, as well as PLI and sales, has been measured through the Pearson's index; anyway, such analysis at the moment has an exploratory nature and is to be considered just like a test of the method, since the sample has been selected in accordance with data availability and can't be considered representative of the population.

Reduction and remodelling of the life cycle

The most striking aspect is the average duration of car models life cycle; as one could easily expect, comparing the earlier period (1970-1983) to the latest one (1994-2006) the average life-cycle of car models has decreased in all analysed segments (from "A" to "E"; table 2), The average LC of all the models included in the sample in the whole period has been 9,3 years and decreased from 10,6 to 8,4 (-20,8%; table 2). The most significant reduction took place among the small cars: segment "A" models life on the market decreased from 14,7 to 8 years (-45,6%). Segment "B" models are presently those with the shorter LC: 7,2 years in the period 1994-2006, 24,2% less compared to the earlier period. In the last period (1994-2006) the average duration of model LC is 8,4 years, that is 2,2 years less with respect to the first period.

The general reduction of LC duration is much greater if we look at the data of the sub-sample concerning model introduced after 1998: according to such data, the models of segment from "A" to "D" stay on the

[8] Obviously, the number of versions is greater or equal to the number of motorizations.

market for no more than 6 years, while the average LC of segment "E" models introduced after 1998 is 8 years. On average, from 1970-1983 to 1998-2006 the PLC almost halved (-47,5%; table 2).

Table 2. - PLC duration (Italy, France, Germany)

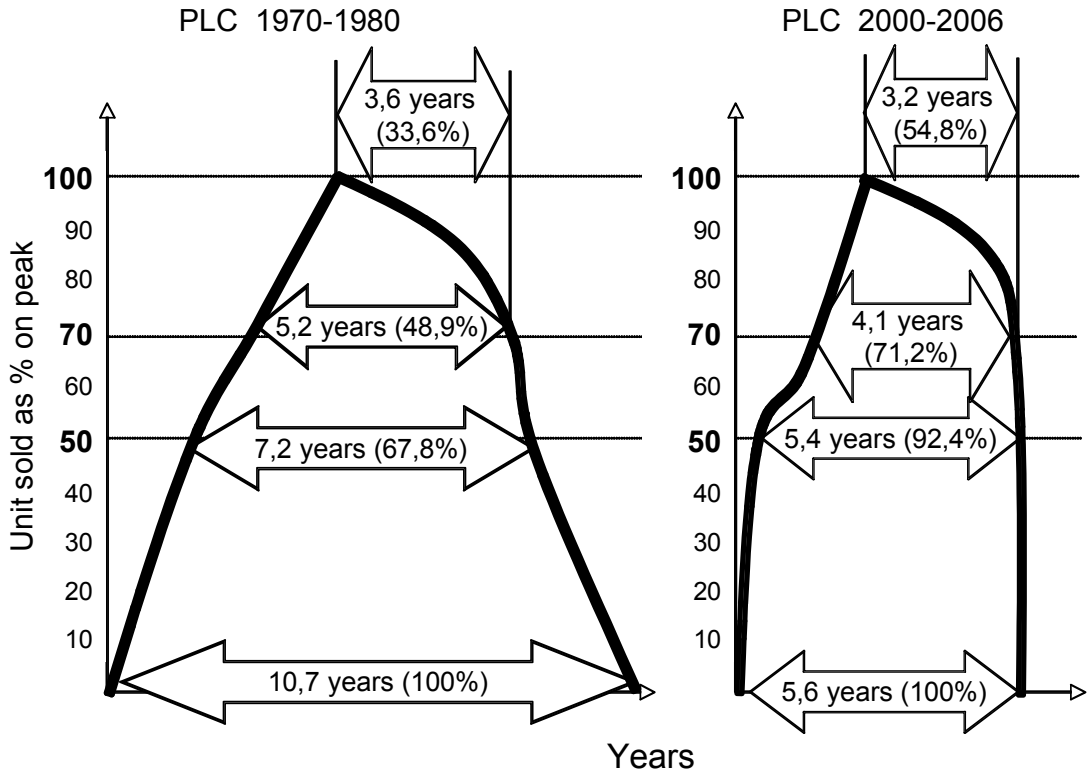
Segments	Average models duration (years)					Var. % '70-'83 vs ''94-'06*	Var. % '70-83 vs '98-'06*
	1970-2006*	1970-1983	1984-1993	1994-2006*	1998-2006*		
A (city cars)	10,2	14,7	10,3	8,0	5,3	-45,6%	-63,9%
B (compact)	8,5	9,5	8,9	7,2	5,0	-24,2%	-47,4%
C (medium)	9,4	10,5	9,5	8,6	6,0	-18,1%	-42,9%
D (upper medium)	8,7	9,0	9,0	8,0	5,2	-11,1%	-42,2%
E (large)	11,1	12	10,9	10,2	8,0	-15,0%	-33,3%
Average	9,3	10,6	9,7	8,4	5,6	-20,8%	-47,2%

Source: own analysis on data from Quattroruote, Anfia, Unrae, CCFA, VDA.
* Data related to 2006 are provisional

The shrinking of the PLC did not take place simply through a symmetric diminishing of all phases; in short, the introduction and decline phases have been cut. This is what emerges evaluating the periods in which, for each model, sales remain above a defined level expressed as a percentage of peak sales for that model. Specifically, we measured:

a. the number of years in which unit sold have been equal or superior to 50% and 70% of maximum model's sales (peak);
b. the number of years elapsing between the peak and the decline of sales below 70% of it.
c. Figure 1 briefly shows the results of such analysis in form of two different PLC built on the average values for period 1970-1983 and for the period 1998-2006.

Figure 1. - Remodelling of the Product Life Cycle between 1970 and 2006



Source: own analysis on data from Quattroruote, Anfia, Unrae, CCFA, VDA.

The overall average LC of car models in our sample has diminished from 10,7 years to 5,6 (-47,2%), but if we look at the "saturation phase", that here we identify with the period included between the peak of sales (100%) and the decrease below 70% of the peak, we see that the time reduction has been equal "only" to 10,7%: from 3,6 to 3,2 years. A similar result emerges comparing the LC span in which yearly sales remains, respectively, above 50% and 70%, periods that approximately circumscribe the late development, maturity and saturation stages: the decrease are respectively from 5,2 to 4,1 years (-21,1% for sales above 70% of the peak) and from 7,2 to 5,4 years (-25% for sales above 50% of the peak). In short, the contraction of maturity and saturation stages is much lower than the PLC reduction; at present, this two phases constitute the greatest part of the whole life cycle. A model introduced in 1970 spent, on average, from 49% to 69% of its life into maturity and saturation (depending on the fact that 70% or 50% is chosen as a threshold), while this time span is between 71% and 92% for a model born in 2000 (fig. 1).

Product policy: variety or innovation?

We also tried to investigate the policies to support demand during the maturity and decline stages. According to our analysis, automotive producers are systematically more inclined to increase product variety (new product versions) rather than to introduce product innovations (new engines, restyling, new models). We studied this aspect through the index previously described (PLE and PLI) in the period 1984-2006 for Italy, Germany and France[9].

With relation to our sample, table 3 and figure 2 show the PLE and PLI indexes between 1984 and 2006, as well as the trend of the number of versions and the price range. In this period the product-line innovation rate (roughly measured by the PLI index) has changed very little with relatively small wavering: PLI was 0,75 in 1984 and 0,81 in 2005, while the period average is equal to 0,82. On the contrary, the product-line extension (PLE) has increased remarkably: from 30,5 in 1984 to 118,0 in 1986. Specifically, this increase in variety derives from the proliferation of versions while price range almost remained the same.. The number of versions offered by producers included in our sample for this analysis increases from 284 to 832 between 1984 and 2006 (+293%)[10], while in the same period the price range changed only from 1,2 to 1,5 (+25%) (tab. 3).

Table 3. - Average values for PLE, PLI, number of versions and price range for Italy, Germany and France between 1984 and 2006

	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94
PLE	30,5	29,6	36,7	38,8	40,8	49,4	57,1	58,5	71,1	57,5	61,4
PLI	0,75	0,70	0,71	0,87	0,84	0,98	0,94	0,79	1,17	0,54	0,79
N. Vers.	284	295	323	339	373	422	502	493	590	477	521
PR	1,2	1,6	1,7	2,2	1,9	2,1	2,9	2,7	2,6	2,2	2,6

	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06
PLE	65,7	65,3	59,6	65,5	75,4	88,2	93,3	86,0	101,7	107,8	113,1	118,0
PLI	0,72	0,76	0,76	0,87	0,78	0,97	0,99	0,73	0,91	0,78	0,81	0,84
N. Vers.	525	518	507	545	576	664	695	700	747	810	825	832
PR	2,6	2,2	2,4	1,9	1,9	2,0	1,9	2,2	1,6	1,4	1,4	1,5

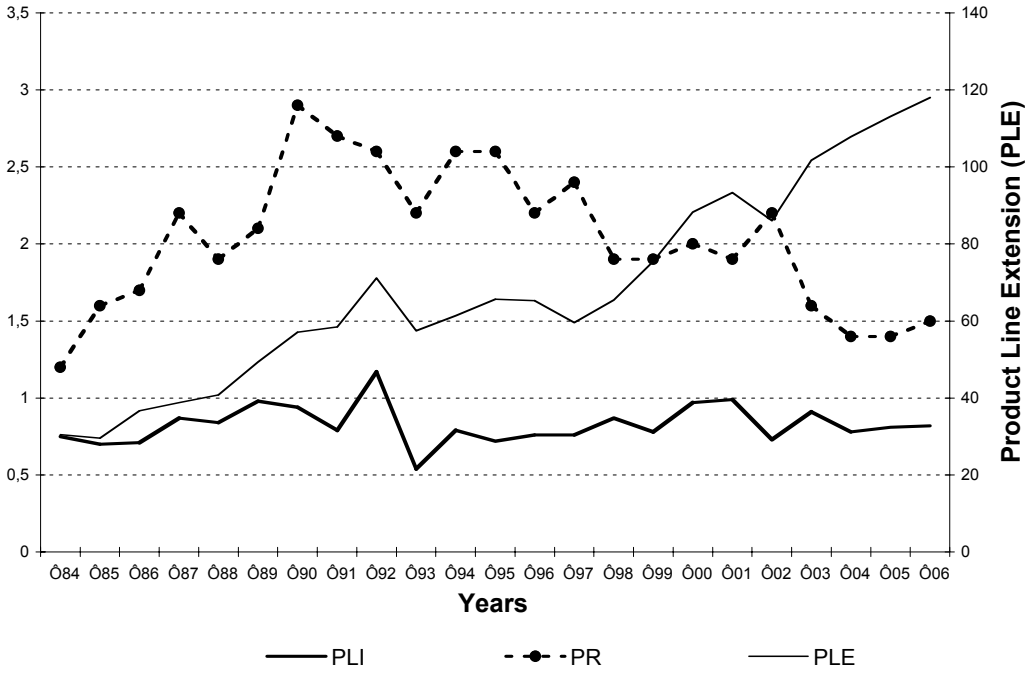
Source: own analysis on data from Quattroruote, Anfia, Unrae, CCFA, VDA.

[9] The time span taken into consideration is relatively shorter, with respect to that previously considered, due to the fact that the data needed for such analysis are not presently available for years before 1984. Moreover, price range is calculated from list prices on Italian market; although list prices could diverge substantially between different countries, especially at the version level, differences between the price ranges for a specific model in different countries are relatively small.

[10] The number of total versions per year includes only versions of segment/model already existing in 1984; that is: in 1984 some models for each brand of the sample are extracted. Then, if one of the brands of the sample launches a new model after 1984 in a segment where no model of that brand has been initially included in the sample, then that model and the related versions are not included either.

A clear picture of the actual dimension of the increase in variety, is shown in Table 4 with some data regarding the whole Italian market: the number of versions sold in Italy in 2006 is almost four times the number sold in 1984 (+394,3%), although the number of brands is almost the same (55 instead than 54). In 1984 each car model was offered, on average, in 4 version, while in 2006 12,2 versions are offered for each model (table 4).

Figure 2. - Average values of PLE and PLI for Italy, France and Germany, and Price Range for Italy between 1984 and 2006



Source: own analysis on data from Quattroruote, Anfia, Unrae, CCFA, VDA.

Table 4. - Increase in the variety of Italian car market: 1984-2006

	1984	2006*	Var.
Number of models	170	281	65,3%
Number of versions	696	3440	394,3%
Average versions per model	4,1	12,2	197,6%
Number of brands*	54	55	1,9%
Average number of models per brand	3,2	5,1	59,4%
Average number of versions per brand	12,9	62,5	384,5%

*Only serial production, micro-car excluded.
Source: own analysis on data from Quattroruote, Anfia, Unrae, CCFA, VDA.

Data presented in table 4 are related only to the Italian market, but we are rather confident that they reflect the general European situation. Anyway, in spite of this strong tendency towards the proliferation of products, we found no evidence of an actual relation between a wider product line and the improvement of sales performances. Surely, the "hyperdifferentiation" of car market is driven by a demand particularly interested in personalization and variety; on the other hand, on the side of the offer the "engine" of this process is settled into the opportunities deriving from the recent evolution of production systems and supply-chain systems, both tending to exploit the advantages of platform-module approach at its best[11].

[11] The platform-module approach allows distributing on several models a relevant share of costs of R&D, engineering and product development; it also allows to apply product differentiation and personalization on the assembly line through short-terms operations. It is therefore possible to increase variety with comparatively small additional costs; moreover, the engineering and development of new models is hastened. See: Volpato and Stocchetti (2002), Gershenson et al (2003).

Anyway, in our opinion the real issue is not in evaluating if and how the demand appreciates a wider range of products, since this is trivial. The real point is to evaluate if a line-extension strategy is more effective than a product innovation strategy in supporting sales performance.

We examined 125 models of eight brands during the period 1984-2005[12] calculating the correlation (Pearson index) between PLE and sales[13], without no evidence of a significant relation: in all cases the Pearson index was between -0,2 and 0,2 in the various segments, with sporadic exceptions for very specific models. In short, we didn't find any element supporting the hypotheses that a greater variety of the offer for a model enhances sales, as far as the model-level analysis concerns. The same analysis developed at the brand level shows similar results but with some exceptions, since the relation between PLE and sales is considerably different between brands. Table 5 shows the correlation at brand level between PLE and sales calculate for the sum of the three markets Italy, Germany and France in the period 1984-2005; eight brand have been evaluated and the brand Ford is the only one whose sales seems to be (weakly) affected by PLE (Pearson index equal to 0,517).

Table 5. - Correlation (Pearson index) between PLE and Brand sales

	Alfa Romeo	Audi	Bmw	Fiat	Ford	Lancia	Opel	Vw
Correlation PLE-Sales	-0,195	-0,276	0,248	-0,044	0,517	-0,345	0,158	0,059
Average PLE value (1984-2005)	0,82	1,47	1,70	1,08	0,97	0,42	1,20	1,43

Source: own analysis on data from Quattroruote, Anfia, Unrae, CCFA, VDA.

Results concerning the innovation role (measured through the PLI index) are rather different. The correlation between PLI and sales variation is, on average, between, 0,383 and 0,497 in various segments; although not elevated, such values are anyway much higher than those calculated in respect to the PLE index. The "α" parameter in particular, a parameter we introduced to measure the introduction of significant product modification (model, new engine, restyling) is more correlated than PLE with sales; this fact corroborates the hypotheses that product innovation is much more effective than differentiation in boosting sales. Table 6 show the correlation between the variation of "α" and the variation of sales for some brands in three segments[14]: in general, values are higher than those measured to evaluate the relation between PLE and sales (2 - 6 times) and in some cases (Fiat and Opel) they strongly suggest that new car demand is much more elastic towards product innovations rather than product personalization and/or differentiation.

Table 6. - Correlation (Pearson index) between yearly "a" variation and yearly percentage sales variation per brand (1984-2005)

Segment	Alfa Romeo	Audi	Bmw	Fiat	Ford	Lancia	Opel	Vw
Seg. "B"				0,499	0,253	-0,231	0,405	0,238
Seg. "C"	0,406			0,567	0,455		0,362	0,293
Seg. "D"		0,483	0,211	0,618	0,421	0,290	0,443	0,412

Source: own analysis on data from Quattroruote, Anfia, Unrae, CCFA, VDA.

These data raise the question about the actual value of producing a huge number of versions for the existing model instead of a fast-renewing line made by (relatively) few versions. On the other hand, is extremely difficult to give an answer to such question since needed information and data (expressly, the monthly data at the version level) are not available at the moment. We think that the results presented here

[12] The data necessary for such analysis were not available for 2006.

[13] Specifically: a) between PLE and sales, b) between PLE and sales variation, c) between PLE variation and sales variation; for each one of this combination the correlation has been calculated with a lag of 0, 1 and 2 years between the two variables.

[14] Since this analysis requires the sample to be as big as possible, only the segments with a wide dataset have been included.

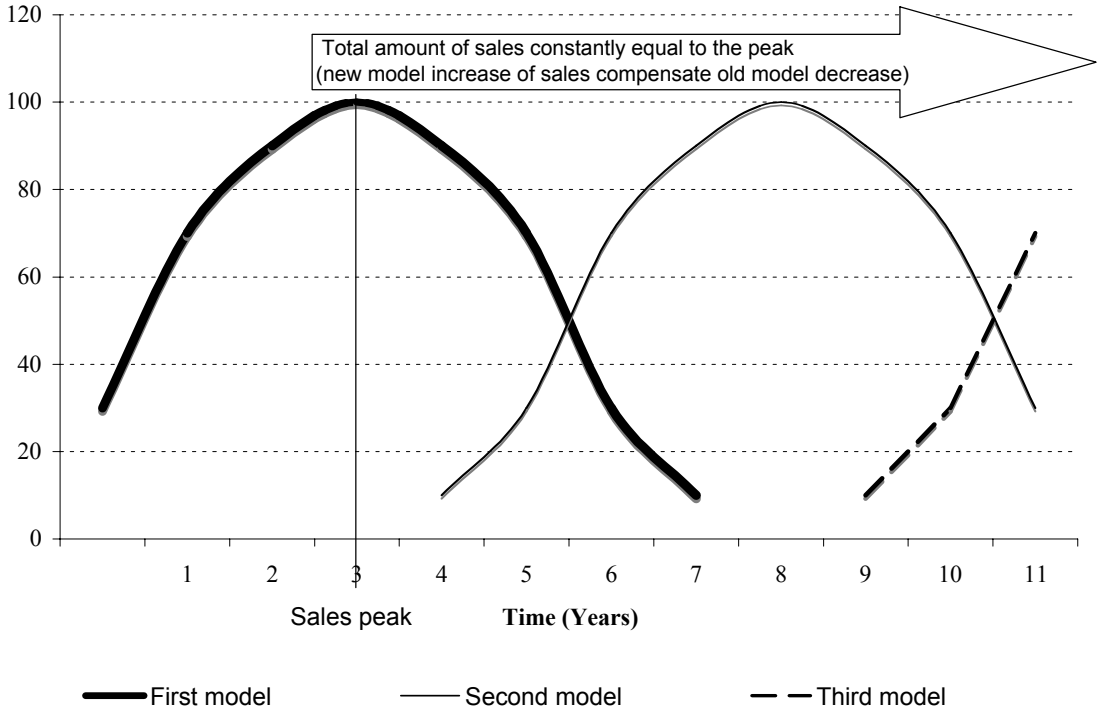
are somehow interesting, although we are aware that this analysis is limited from the relatively small size of the sample (125 models for the period 1984-2005) and from the fact that we could extend such analysis only to the Italian market. What emerges is anyway motivating in defining a research agenda in direction of extending and deepening the research.

Managing decline and the timing of new model introduction

Another interesting research topic strictly related to PLC invests the timing of new model introduction; the question we pose here is the following: is it possible to evaluate if and how carmakers policies on product renewal are effective?

To answer to this question, let's assume as a reference point the traditional, hypothetical curve of PLC; according to such model, the optimal situation for new product introduction could be defined as the one that: a) avoid cannibalization of the previous model, b) compensate (at least) the falling of old model's sales. Therefore, as far as the timing and PLC curve are concerned, we should expect the "optimal" introduction to appear as shown in figure 3, a situation in which the new PLC compensate the old PLC keeping overall sales constant (fig. 3).

Figure 3. - Ideal timing for new model introduction



From a very general point of view, a high-level demand constantly able to saturate the production capacity of carmaker's plant is the most desirable situation; although this theoretical standpoint does not take into account several aspects of operation management (e.g.: the fact that plants saturation depends also from product mix, the possibility to separate demand trends and production operating in a make-to-stock logic, and so on), it underlies the idea of a necessary synchronicity between the old model sales performance and the introduction of a new model. On such basis it makes sense to define the effectiveness of PLC policies according to a logic of sales regularities at a certain level.

We therefore have measured two kinds of parameters:

a. the average sales of various period expressed as a percentage of the peak of sales in each period;
b. the number of years in each brand-segment PLC where sales are equal to 70% of peak or higher.

Both these indicators actually focus on regularity of sales: since brands that achieve irregular successes obtain lower measures than brands with regular low sales, those measures might be considered as a reasonable proxy of PLC effectiveness only within the hypotheses mentioned above.

According to our analysis, several automotive producers have not been able to manage the PLC and the new product introduction in coherence with such scheme. Quite often the launch of new models is delayed with respect to the timing that would allow the stability of sales.

Table 7 shows the average sales of various brand in all segments, measured as percentage of maximum sales (or peak) of that brand in the whole period (1970-2005) [15] and in each sub-period. The maximum value of this indicator is therefore 100, corresponding to a situation of enduring ideal PLC as previously depicted in figure 1. According to our data, in the whole period 1970-2005 several brands kept their sales relatively constant in one or more segment (such situations are highlighted in grey in table 7): Lancia performs 70,8 in segment B, Alfa Romeo and Audi perform respectively 73,4 and 72,5 in segment C, while BMW have 70,5 in segment D[16]. In each subsequent period we can see that the best generalised performances are those of German brands (BMW, Audi, Volkswagen and Mercedes). The trend of the indicator shows that these four German brands have accomplished increasing effectiveness in PLC policies along the years, especially with respect to Italian competitors whose competitiveness, on the contrary, has decreased. Specifically, in the period 1994-2005 Lancia appears at the bottom of the ranking in three segments (B, D and E); and Alfa Romeo as well shows volatile PLC in segments D and E. Fiat and Renault are able to keep a rather regular level of sales in small car segments (A and B), while at the head of segments from C to E there are only the mentioned German brands. In earlier years (1970-83) the situation was definitely different, with Italian and French brands performing highly regular sales in major segments (table 7).

[15] Such analysis has not yet been developed for 2006 due to lack of data.

[16] The indexes for the whole period referred to Opel (segment A) and Mercedes (segment C) have little significance of the period 1970-2005 since such brands in those segments have been evaluated only for one sub-period.

Table 7. - Average sales per brand expressed as percentage on sales peak for each period (Italy, Germany and France)

Segmento A		Segmento B		Segmento C		Segmento D		Segmento E		Segmento F	
1970-2005											
Opel	70,1	Lancia	70,8	Mercedes	76,7	BMW	70,5	BMW	60,5	Audi	61,9
Renault	58,3	Fiat	61,6	Alfa R.	73,4	Audi	66,3	Audi	55,3	Alfa R.	38,1
Toyota	57	Peugeot	59,1	Audi	72,5	Alfa R.	59,4	Ford	52,4		
VW	52,8	Renault	58,1	VW	67	Opel	53,9	Fiat	51,8		
Fiat	48,4	Opel	57,7	Citroen	64,1	Lancia	51,6	Alfa R.	49,7		
Ford	46,6	Audi	56,5	Ford	59,5	VW	48,2	Renault	45,4		
		VW	54,1	Opel	55	Peugeot	45,7	Opel	41,7		
		Ford	50,3	Renault	50	Fiat	45,6	Peugeot	39		
		Citroen	47,9	Peugeot	49,7	Renault	35,5	Lancia	35,9		
				Fiat	49,2						
1970-1983											
Renault	75,8	VW	82,2	Alfa R.	82,6	Renault	81,5	Peugeot	76,7	Alfa R.	76,7
Fiat	66,1	Ford	80,5	Opel	78,6	Alfa R.	81	Fiat	76,7		
		Fiat	79,6	Citroen	77,9	VW	76,6	Alfa R.	73,4		
		Opel	78,6	VW	77,3	BMW	74,7	Renault	72,5		
		Citroen	71,3	Fiat	69,5	Fiat	71,4	BMW	69,2		
		Peugeot	69	Ford	55,4	Opel	66,9	Opel	64		
		Renault	60,9	Peugeot	54,9	Audi	65,5	Lancia	60,7		
				Renault	35,5	Lancia	50,2	Audi	58,4		
						Peugeot	39,6				
1984-1993											
Fiat	63,1	Peugeot	86,7	VW	84	Lancia	80,7	Ford	72,2	Audi	79,4
Renault	49	Fiat	83,9	Citroen	82,4	Audi	79,7	Opel	70,3	Alfa R.	36,2
		Lancia	76,6	Alfa R.	81,5	Alfa R.	74,6	Renault	69,2		
		Renault	70,5	Ford	76,1	BMW	73,2	BMW	67,7		
		Opel	70,3	Peugeot	70,3	Peugeot	64,5	Audi	66,2		
		VW	59,5	Opel	69,1	Opel	63,2	Peugeot	61,1		
		Ford	58,2	Fiat	52,8	Fiat	55,2	Lancia	60,9		
		Citroen	53,6	Renault	46	Renault	51,8	Fiat	59,9		
						VW	50,4	Alfa R.	58,2		
1994-2005											
Fiat	83,8	Renault	85,6	VW	82,5	BMW	86,3	Audi	78,9	Audi	79,6
Renault	74,4	Fiat	76,1	Ford	79,2	Audi	78,8	BMW	74,3		
Opel	70,1	Opel	73,7	Mercedes	76,7	Peugeot	70,1	Fiat	61,4		
Toyota	57	VW	72,8	Renault	75,6	VW	66,5	Renault	46,1		
VW	52,8	Ford	69,9	Alfa R.	74,9	Alfa R.	58,4	Opel	45,8		
Ford	46,6	Peugeot	69,9	Audi	72,5	Opel	55,4	Ford	45,7		
		Lancia	68,2	Peugeot	72,5	Renault	46,2	Peugeot	45,1		
		Citroen	64,4	Citroen	60,6	Lancia	44,4	Alfa R.	40,2		
		Audi	56,5	Opel	60,3	Fiat	40,7	Lancia	33,5		
				Fiat	55,3						

Partially unexpected result relates to the possible dependency of a brand from home country demand; we supposed that a possible cause of weakness for a brand in PLC effectiveness could be the dependency from national demand and a correlated weakness in other countries. Therefore, we measured the difference between the indicator of PLC regularity (or effectiveness) calculated in the three countries (Italy, France and Germany) and the same indicator calculated on the home country (table 8), assuming that a high positive difference between the two indicators would means a high dependency. If we look at the last period (1994-2005) Citroën and Lancia presents the greater value of the mentioned difference (respectively 7,6 and 3,7), and both these brands performs a volatile PLC. On the other hand, Alfa Romeo also seems to perform low effective PLC policies in the same period, but it is also the brand with the supposedly lowest dependency for home country market, since its sales between 1994 and 2005 are less uniform in Italy than in the three country together (-14,3, table 8). These examples, together with the data for other brands in all the periods taken into consideration bring us to claim that the "home-market effect" does not influence PLC regularity.

Table 8. - Home-market effect on PLC regularity: difference between regularity of sales of each brand in own home-market and in the sum of Italy, France and Germany.

	1970-2005			1970-1983			1984-1993			1994-2005		
	Ita, D, Fra	Home market	Diff. %	Ita, D, Fra	Home market	Diff %	Ita, D, Fra	Home market	Diff %	Ita, D, Fra	Home market	Diff %
Mercedes	76,7	74,3	-3,2	-	-	-	-	-	-	76,7	74,3	-3,2
BMW	65,5	65,7	0,3	71,9	77,8	7,5	70,5	71,6	1,5	80,3	80,5	0,3
Audi	62,5	61,5	-1,6	61,9	57,7	-7,4	75,1	73,3	-2,4	73,3	72,6	-0,9
VW	55,5	52,2	-6,3	78,7	79,3	0,8	64,6	55,5	-16,5	68,7	65,7	-4,5
Alfa R.	55,1	50,0	-10,2	78,4	75,4	-4,0	62,6	62,9	0,5	57,8	50,6	-14,3
Lancia	52,7	51,8	-1,8	55,4	56,2	1,4	72,8	72,3	-0,6	48,7	50,6	3,7
Fiat	51,3	53,2	3,6	72,7	72,0	-0,9	63,0	65,4	3,6	63,5	62,6	-1,3
Peugeot	48,4	50,9	4,9	60,0	59,1	-1,7	70,7	71,1	0,6	64,4	64,7	0,5
Renault	48,5	50,5	3,8	67,1	69,7	3,7	55,7	56,4	1,4	65,4	62,1	-5,3
Citroen	37,3	42,0	11,2	49,7	48,9	-1,7	45,3	46,4	2,3	41,7	45,1	7,6

Fonte: ns. elaborazione su dati Quattroruote, Anfia, Unrae, CCFA,VDA.

Discussion and managerial implications

PLC theory is a commonly acknowledged concept in management; however, firms' effectiveness in managing PLC is difficult to assess because of underlying problems related to the fact that a detailed analysis of PLC policies and effectiveness would require monthly data concerning sales and product features; such data are unavailable in a period long enough to permit a PLC analysis; moreover, sales data should be integrated with other information actually not available (e.g., cross-elasticity, advertising expenses, product profitability, etc.).

In our study we try to evaluate PLC effectiveness by brand along a 37 years-long data series and to outline line-extension and line-innovation policies of different carmakers from twenty-two year historical series. At the moment we could obtain only data referred to three European countries (Italy, Germany and France) that representing a big portion of the European market as a whole. On the other hand, a complete view of actual successes and failures in PLC policies would require monthly data for the whole Europe at the version level. As far as we know, such data are unavailable. We therefore tried to take the best of what is possible out from available data.

Some common impressions have been confirmed. PLC reduction was expected, but the change in its shape was not. The fact that the introduction and decline phases have disappeared, while maturity and saturation almost remained the same, tell us that producers tend (successfully) to minimize the duration of the less "fruitful" part of the LC reducing, on the side of production, the time span in which plants are not saturated. The shift between the old and the new model is then much faster and preceded by a period of make-to-stock oriented production; today the maturity and saturation stages for a model, defined as the

period in which sales are at least the 70% of peak for that model, occupy on average the 71% of life cycle, while in the '70s such period was less than 49% of life-cycle.

Such policy emerges as a response to time-based competition pressure and have, on our opinion, at least two managerial implications.

The first implication concerns the product development process: since a key-role is assumed by the platform & module approach, the timing of new product development should be planned with respect to the several generations of products that are going to be developed on the same platform, instead of the next generation only. The idea is that the life-cycle of the platform (instead of the model) should be paid attention maybe even more than the life-cycle of the single model; as well, the transition between subsequent platform is at least as important as the shift between product life-cycles

The second implication we would like to comment is related to the transition management from the point of view of marketing. A "radical" changeover between the old and the new product might affect the relationship with customer, at least for two reasons: a) the old model's buyer suffer from a fast obsolescence of their product, although it is recently bought; b) buyers could delay their purchase decisions due to rumours of new model advent. In fact, the disappearance of introduction and decline stages will make segmentation more complex since an additional effort is required to identify the different sensitivity of customers towards differentiation/personalization rather than towards innovation or price, but in a context where such sensitivity might change hastily, for the same customer, according to the marketing mix policies of the producer and its cuncurrents.

Controversial results emerge in relation to the effectiveness of product policies during life cycle. We have found that the differentiation of offer, specifically the proliferation of version, does not have significant effects on sales. On the contrary, product innovation does. In spite of this, between 1984 and 2006 the variety of offer has increased remarkably; almost all carmakers support the maturity and saturation stage with new versions (and very often with lower prices) rather than with product innovation, although the trend of sales in relation with product line extension show that such policy is not effective. On the contrary, product innovation (specifically new engines, restyling and new models) are able to enhance sales.

Finally, we found that not all carmakers, and not always, have been able to overlap old and new models life cycles so to compensate the decreasing sales of the old model and keep overall sales constant, according to an ideal model that see the regularity of sales as an advantage that could be somehow transformed into production efficiency. Along the 37 years taken into consideration (1970-2006) German brands appears the most effective from this particular point of view; wavering performances of French and Italian brands in the different decades are probably a symptom of the greater vulnerability of these brands to the "newcomers" from Japanese and Korean brands.

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