Applied Economics, 2004, **36**, 731–737

The price premium of generic to brand-names and pharmaceutical price index

YING KONG

School of Business and Economics, University College of the Cariboo, Kamloops, British Columbia, Canada V2C 5N3
E-mail: ykong@cariboo.bc.ca

The price premium of generic pharmaceuticals to brand-names is examined under different competitive market situations. The result of this study shows that the number, market share, and the age of both brand-name and generic products have the most explanatory power for explaining the price premium. This study further applies this method to a pharmaceutical price index in order to explain 'Drug Price Index Perplexities.'

I. INTRODUCTION

The determination of drug prices in the pharmaceutical industry has received a great deal of attention from policy makers. It is widely believed, for example, that innovative drug manufacturers price their drug products differently than generic drug manufacturers to recover the costs of research and development effort. While arbitrage would imply that, if the brand-name and the generic drug are identical,[1] no difference should be observed in the price of the two products. However, despite a chemical equivalence, generics are typically sold at substantial discounts from their brand name counterpart. In this study a different interpretation for the cause of price premiums is offered.

In the literature on branded and generic products, economists such as Klein and Leffler (1981), De Vany and Saving (1983) and Landes and Posner (1987), hold the view that objective measures of product quality primarily drive prices. From this perspective, brand-names and the associated price premiums are seen as efficiency enhancing. That is, the brand-name represents an identifier or marker of higher quality and consumers are willing to pay a price premium as compensation for the quality 'guarantee'. Other economists, such as Bian (1956), Scherer (1980), and others, contend that simple product differentiation is the key determinant of relative price. To distinguish between these hypotheses, Wiggins and Raboy (1996) have tested the price premium in the North American banana market and conclude that objective quality characteristics explain the bulk of price variation and that subjective factors like brand-names explain little of the price variation. However, the banana differs in a number of significant ways from pharmaceutical products. For example, there exist obvious quality characteristics for bananas. Consumers can easily identify differences in banana quality from the observable damage done in transportation and time spent in storage. In this sense, brand names are not needed to identify quality and hence would not be expected to play a very important role in the determination of price. In addition, consumers can be expected not to be too concerned about changes in banana prices because of the very small size of the income effect involved.[2]

No matter whether the explanation given for the price difference between brand-name and generic products

[1] According to the US Food and Drug Administration, the Centre for Drug Evaluation and Research, a generic drug is identical, or the bioequivalent, to a brand name drug in dosage form, safety, strength, and route of administration, quality, performance characteristics, and intended use.
[2] Because bananas make up only a small part of the North American's fruit consumption basket, the incentive for the consumer to overcome additional product uncertainty is muted.

Applied Economics ISSN 0003–6846 print/ISSN 1466–4283 online © 2004 Taylor & Francis Ltd
http://www.tandf.co.uk/journals
DOI: 10.1080/0003684042000222106

involves an objective or subjective cause, the existing literature on brand name price premium focuses only on the consumer's side of the story and ignores both producer behaviour and the competitive nature of the market structure.

Frank and Salkever (1992, 1995) show that the prices of brand-name drugs increase with generic entry at the same time that entry is accompanied by large decreases in the price of generic drugs. This situation is called 'Generic Competition Paradox' in the literature.[3] The entry effects on pharmaceutical prices have also been found by Caves *et al.* (1991) and Grabowski and Vernon (1992). Their findings show that the price gap between brand-name and generic drugs increases when more generic drugs become available in the market. Neither of these findings is easily explained as objective or subjective quality measurement issues. More promising is a producer behaviour and/or market structure approach to explaining this price gap.

In this study, a market competition hypothesis designed to explain the price ratio between generic and brand-name pharmaceuticals is tested. The special focus is on generic entry in one Canadian provincial drug market, the Province of British Columbia. Furthermore, the method applied to the pharmaceutical price index provides one way of explaining 'Drug Price Index Perplexities'[4] which states that it is very difficult to determine the base year's generic drug's price because the quantity of generic drugs in the base year is zero. To do this, the argument is organized into five sections. Following this introduction, Section II explains the econometric model and data estimation results. The analysis of the estimation is provided in Section III. Section IV presents one application of the estimation to the problem of 'Drug Price Index Perplexities.' A discussion of the implications of the findings appears in Section V.

II. THE ECONOMETRIC MODEL AND THE DATA ESTIMATION

The price premium between generic and brand-name drugs is defined by the price ratio of generics to brand-names P_g/P_b where P_g and P_b represent generic price and brand-name price respectively. Since P_g/P_b is the dependent variable, the econometric model estimates parameters for both brand-name and generic products to assess the impact of generic entry.

At first, it is assumed that consumers consume both brand-name and generic drugs and treat them as imperfect substitutes. Consumer's preferences between brand name and generic drugs are assumed to follow a CES (constant-elasticity-of-substitution) function,

$$u = \left[(Q_b^\rho + Q_g^\rho)^{1/\rho}, Q_0\right] \qquad 0 < p < 1 \tag{1}$$

where, Q_b, Q_g represent the quantities of brand-name and generic drugs and Q_0 is a numarie good that represents other goods in the consumer's consumption basket. Utility maximization requires,

$$\frac{Q_b}{Q_g} = \left(\frac{P_b}{P_g}\right)^{-\sigma} \tag{2}$$

where, $\sigma = 1/(1-\rho)$ which is the constant factor of elasticity substitution between brand-name and generic drugs. Equation 2 can be represented as

$$\frac{P_g}{P_b} = \left(\frac{S_b}{S_g}\right)^{1/\sigma} \tag{3}$$

where, S_b and S_g are the market shares of brand-name drugs and generic drugs respectively.[5] Equation 3 implies that the price ratio of generic drugs to brand-name is positively related to the market share of brand-name drugs, and negatively relates to that of generic drugs.

As in Frank and Salkever (1992, 1995), it is assumed that the price premium also depends on the number of generics. It is also assumed that the length of time that generic products are available in the market affects the price premium. Most consumers lack the necessary knowledge to make immediate informed decisions regarding pharmaceutical products. Consequently, when a patent expires and generic versions of a drug become available, most consumers will not immediately realize that the generic is identical to the brand-name. However, as time passes diffusion of information occurs and the consumers become more aware of the substitutability of the generic and brand-name drug.

Instead of the general linear regression model, a second-order polynomial regression model is used as well as interaction variables in the research. The reason for this is based on two arguments: (i) According to the nature of competition, the price of the brand-name drug will eventually decrease when there are a large number of generic firms entering the market though there exists 'Generic Competition Paradox'. Therefore, it is expected that the price ratio P_g/P_b will decrease with the number of generics but the rate of this decrease will fall. In other words, a curvilinear relationship between the price ratio and the number of generics is expected. (ii) The longer the generic drugs exist in the market, the more consumers will know the generics. By a similar argument, the more the generic drugs are available in the market, and the greater their availability, the more familiar consumers will be with the generics. Familiarity will then lead consumers to switch their

[3] This phrase is first used by Scherer (1993).
[4] This phrase is first used by Scherer (1993).
[5] S_b and S_g are defined as: $S_b = Q_b/(Q_b + Q_g)$, $S_g = Q_g/(Q_b + Q_g)$.

Table 1. *Definitions of independent variables*

Variables	Definitions
$SHAREB(S_b)$	The market share of brand-name products.
$AGEB\ (A_b)$	The age of brand-name products which is measured by the number of years since it first appeared in the market (current year is 1997).
$NUMBERB\ (N_b)$	The number of brand-name products in the market.
$AGEG\ (A_g)$	The age of generic products which is measured by the number of years since it first appeared in the market (current year is 1997).
$NUMBERG\ (N_g)$	The number of generic products in the market.
$NUMBERGS\ (N_g^2)$	The square of the number of generic products in the market.
$AGEG \times NUMBERG\ (A_g \times N_g)$	The interaction variable; that is the product of age and number of generic products.
$SHAREB \times NUMBERG\ (S_b \times N_g)$	The interaction variable; that is the product of the market share of brand-name products and number of generic products.

consumption from brand-names to generics. The age of generic products and the market share of brand-name products are then predicted to influence the effectiveness of a number of generic products on the price ratio P_g/P_b. Therefore, the interaction variables in terms of age of generics to number of generics and the market share of brand-name to number of generics will be considered in the regression model.

Since the main purpose of this research is to test the effect of competition factors on the price ratio P_g/P_b, some factors of brand-name products are included in the regression model such as the age of brand-names and the number of brand-names.[6] Following the arguments above, the regression variables are explained in Table 1.

The basic econometric model is chosen as follows:

$$\left(\frac{P_g}{P_b}\right)_{it} = f(SHARE\,B_{it}, AGE\,B_{it}, NUMBER\,B_{it}, AGE\,G_{it}, NUMBER\,G_{it}) \quad (4)$$

The explanation of the panel data set is provided in the Appendix and the following partial translog quadratic estimate equation is used,

$$\ln\left(\frac{P_g}{P_b}\right) = \alpha + \beta_1 \ln S_{bit} + \beta_2 A_{bit} + \beta_3 N_{bit} + \beta_4 A_{git} + \beta_5 N_{git} + \beta_6 N_{git}^2 + \beta_7 (A_g \cdot N_g)_{it} + \beta_8 (S_b \cdot N_g)_{it} + \varepsilon_{it} \quad (5)$$

The regression results (the regression coefficients with standard errors) are presented in Table 2.

Table 2. *The Estimating results*

Independent variables	Dependent variables $\ln(P_g/P_b)$ ($R^2 = 0.68$, Adjusted $R^2 = 0.67$)
$\ln S_b$	0.0721** (0.0384)
A_b	0.0121* (0.0044)
N_b	0.2103* (0.0540)
A_g	−0.0869* (0.0196)
N_g	−1.5647* (0.2818)
N_g^2	0.3150* (0.0521)
$A_g \times N_g$	0.0165** (0.0090)
$S_b \times N_g$	0.3005* (0.0930)

Notes: *Indicates statistical significance at the 5% level. **Indicates statistical significantce at the 10% level.

III. THE ANALYSIS OF ESTIMATION RESULTS

The regression result in Table 2 indicates that there is a positive relation between the price ratio of generic to brand-name drugs and market share of brand-name products as predicted. With generic entry, on one hand, the price of the brand-name product increases or decreases and the price of generic product decrease so that the ratio of P_g to P_b decreases.[7] On the other hand, as more and relatively cheaper generic products become available in the market this will lead to consumers switching from brand-name products to generic products. Therefore, the market share of the brand-name product will decrease. However, the impact of changes in the brand-name's market share on the price ratio of generic-to-brand-name drugs is relatively small (the coefficient between these two variables is only 0.0721).

The factors that have a relatively large impact on the price ratio P_g/P_b are the number of brand-names and

[6] See Appendix for the explanation.
[7] The price movement of brand-name products is not so clear. It may decrease with generic entry because the market becomes more competitive. However, it may increase if there is 'Generic Competition Paradox' with generic entry. Although the price of brand-name may decease, the scale of this decrease is smaller than that of generic price decrease.

the number of generics in the market. The parameter of N_b positively influences the price ratio P_g/P_b. This situation is easily understood in that the price of brand-names will decrease as more brand-name drugs having a similar function enter in the market. As Frank and Salkever (1992, 1995) and other economists predicted, if the 'Generic Competition Paradox' is presented, the number of generic firms play a main role to explain the changes in the price ratio. The negative sign of the coefficient N_g implies the price ratio P_g/P_b will decrease as the number of generics increases. However, in this study it is not intended to repeat the same test that Frank and Salkever (1992, 1995) and other economists did before to prove that 'Generic Competition Paradox' exists. The important contribution of this study is that a test for a curvilinear relationship is undertaken rather than for a linear relationship between the price ratio and the number of generics in the market. The variable of N_g^2 shows that there is a curvilinear relationship between the price ratio and the number of generic producers. Given an assumption that the 'Generic Competition Paradox' exists, although a small number of generic firms tend to increase the price of brand-name drugs, at some point this process reaches a limit and any additional number of firms will bring the price of the brand-name drug down. In this sense, the 'Generic Competition Paradox' is quite fragile. This prediction makes sense in terms of the nature of competition. If there are a large number of generic substitutes of brand-name drugs entering the market, the brand-name producer has to decrease his price to try to maintain some market share.

The effect of age of generic drugs on the price ratio can be explained in two ways. In one aspect, the longer the generic product is in the market the more generic firms there are likely to be in the market. Therefore, the negative coefficient of -0.0869 between the age of generic drugs and the price ratio can be explained as it was for the effect of the number of generic firms. Another explanation is that the longer the generic product is in the market the more aware the consumers will be to the existence of substitutes. Then, more and more consumers switch their demand from brand-name drugs to the generics.

The interaction variables give the slope parameter for one variable's change as a function of the other variable. The result in Table 2 shows that there exists a positive relationship between percentage changes in the price ratio P_g/P_b and $A_g \times N_g$ as well as $S_b \times N_g$. Both the age of generic products in the market and the market share of brand-name products make the effect of the number of generic products on the price ratio P_g/P_b less effective. Also, it is knows that between the variables of the age of generics and the market share of brand-name, the latter one makes a larger contribution on the price ratio of the generic entry. In other words, given the number of generic products in the market, the market share of the brand-name product plays a very important role in explaining the price difference between generic and brand-name products.

IV. THE APPLICATION TO DRUG PRICE INDEX PERPLEXITIES

The price index measurement for generic goods is an important issue which stimulates much discussion for economists. The purpose of a price index is to measure changes in prices over time. In order to formulate aggregate price index, it is necessary to understand the price relationship between brand-name products and generic products. Ideally, price data are collected for the same set of items at several times, and then the index is computed. A basic assumption is that the prices are identified for the same items for each time period. A problem is encountered when a generic product enters the market.

The existing method of most official statistics organizations and literatures treat the generic products either as the perfect substitutes to the brand-names or as entirely separate 'new commodities' which are not linked to the previously existing brand-names.[8] For example, the generics are treated as new products in their own right, not as a lower-price substitute to some existing product in Bureau of Labour Statistics price indices in the USA.

In Canada, there are two pharmaceutical price indexes which are available. Statistics Canada is responsible for the pharmaceutical component of the Industrial Product Price Index (IPPI Pharma). There is also the Patented Medicines Price Index (PMPI) which is calculated by the Patented Medicines Prices Review Board (PMPRB). Both indexes are based upon *ex-factory* gate prices and therefore exclude wholesale and retail margins, as well as dispensing fees and while the IPPI Pharma is based upon a sample of drug products regardless of patent status, the PMPI is based upon all patented drugs offered for sale in Canada. Non-patented drugs are excluded from the calculation of the PMPI.

The other problem in measuring the price index of pharmaceuticals is the prices of generic products since they are not available in the base year (i.e. time period 0); thus there is no observation for the price (P_0) and quantity (Q_0) of the goods at zero time. The theoretical answer to this problem is well known: estimate the reservation price of the new commodity in period zero. That is, the price in period zero at which the demand for this particular commodity (or version) would be zero. Thus, in the case of generic products, the aggregate Paasche price index of

[8] See Scherer (1993) for discussions of various problems of generic substitute products in standard price indices.

pharmaceuticals can be written as (taken the current year as time period 1),

$$P_{01} = \frac{Q_{b1}\,P_{b1} + Q_{g1}\,P_{g1}}{Q_{b1}\,P_{b0} + Q_{g1}\,P^r} \tag{6}$$

where P^r is the estimated reservation price of consumers for the generic drugs and P_{b0} is brand-name price in the base time while Q_{b1}, P_{b1}, Q_{g1} represent the quantity and price of brand-name products and quantity of generic products at the current time. However, it is very difficult to observe consumers' reservation price for generic drugs and there is no perfect answer for this problem so far. One way is to assume that the price of generic drugs is the same as the brand-name drugs in the base year. Thus, economists believe that official price indexes may overstate the rate of price increases for pharmaceuticals. However, the magnitude of the bias remains uncertain.

The important contributions to the topic of reservation price for generic drugs come from Feenstra (1994) as well as Griliches and Cockburn (1994). Feenstra (1994) provided an approach to formulate the producer price index with new product varieties which he called the CES index. He takes the reservation price as infinite but assumes a CES form for a CES unit-cost function allowing for different sets of product varieties over time and quality changes in some of the varieties. However, this still leaves one problem of estimating the elasticity of substitution. It means either an assumption is made on elasticity of substitution or a way to estimate elasticity of substitution must be found.

Griliches and Cockburn (1994) estimated a reservation price for generics using 'the uniform distribution' method. They assumed that consumers in the drug market have a utility function like:

$$U(Q_b, Q_g) = Q_b + (1 - \delta_h)Q_g \tag{7}$$

where $\delta_h = b_h/P_b$ is the premium for 'brandedness' relative to P_b, and $P^r_h = P_b - b_h$ differs for each individual h. Individual h is then indifferent between buying the branded version of the generic if $p^r_h = p_g$ (P^r_h is the reservation price). If the purchaser switches to a generic, it must be the case that a price decline of $P_g - P^r_h$ occurred. Then, they assumed that the average reservation price for the purchaser is bounded between P_b and P_g and depends on a uniform distribution $F(X)$ .Therefore the reservation price can be estimated as,

$$P_r = \frac{P_{gt} + P_{bt-1}}{2}$$

Note, Equation 7 simply states that branded and generic versions are exactly the same (or homogenous) in consumers' eyes and they are perfect substitutes. If their assumption is correct however, the price of the brand-name and generic drugs would have to be equal as consumers, behaving rationally, would always purchase the cheapest one. If consumers prefer to buy the branded version it must be the case that they are risk-averse regarding quality. However, this assumption is too strong in some specific cases. For example, in the case of pharmaceutical products, the brand name drug and generic drug are differentiated goods. Besides the quality effect, consumers always can point out other differences between them in terms of tastes or other considerations. Therefore, the assumption of perfect substitution may not be true in the case of brand name and generic drugs.

An alternative measurement that can be used is the method developed in the previous section. The price difference between generic and brand-name products can be directly measured using the market data, for example the market share of brand-name products. And then, the consumers' reservation price can be estimated when the market share of brand-name products is equal to one. In order to make a comparison with Griliches and Cockburn's (1994) work, the same data sets have been used e.g. the basic data of Cephalexin® and Cephradine®, two systemic anti-infective drugs from the Cephalosporin family of antibiotics. Since there is only one generic drug in each case, the descriptive regression simplifies as:

$$\ln\left(\frac{P_g}{P_b}\right)_t = \alpha + \beta \ln S_{bt} + \varepsilon_t \tag{8}$$

and the result of the estimation for Cephalexin® (with standard error in parentheses) is:

$$\ln(P_g/P_b) = -0.2381 + 0.5822 \ \ln S_b$$
$$(0.0624)^*\,(0.0447)^*$$
$$\text{Adjusted } R^2 = 0.81,\ n = 41$$

where * indicates that the parameter is statistically significant at the 5% level. The same method is applied for Cephradine® giving

$$\ln(P_g/P_b) = -0.1514 + 0.4758 \ \ln S_b$$
$$(0.0297)^*\,(0.0355)^*$$
$$\text{Adjusted } R^2 = 0.80,\ n = 45$$

Since the quantity of generic product is zero in the base year, the market share of brand-name product will be one. Then it is easy to calculate the reservation price of the generic product in the base year given the price and market share of the brand-name product.

Based on the estimation above, the comparison studies between different measurements are presented in Figs. 1 and 2 where P_u is the price index calculated by Griliches and Cockburn and P_r is the price index calculated by the method of this research. Comparing P_u and P_r in Figs. 1 and 2 it is found that the result of this research presents a very similar price trend as that of the existing study. However, the method provided in this research is much easier and includes the information of market structure.

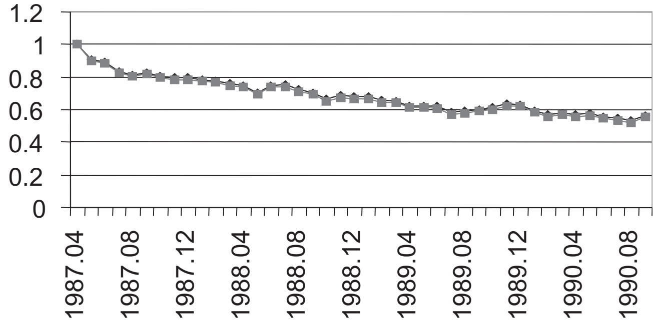

Fig. 1. *Cephalexin®: basic price indexes, 04.1987–09.1990 (—◆—)* P_u, *(—■—)* P_r

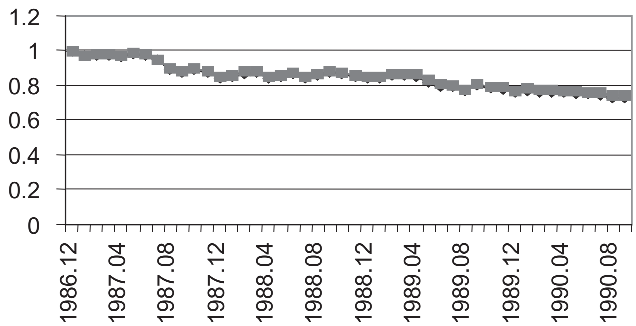

Fig. 2. *Cephradine®: basic price indexes, 12.1986–09.1990 (—◆—)* P_u, *(—■—)* P_r

V. CONCLUSION

The model developed in this research shows that price differences between generic and brand-name drugs stemming from market entry due to patent loss may be explained by the market share of drugs, the number of, and the age of both brand-name and generic drugs in the market. The analysis of the basic model indicates that the price of brand-name drugs may go up while the price of generic drugs goes down with generic entry into the market. Therefore, the price premium, the ratio of a generic drug to a brand-name one, is negatively related to the number of generic drugs in the market. This result is consistent with the other relevant studies in the literature. The other important finding in this paper is that the 'Generic Competition Paradox' would not exist when there are a large number of generic entries.

The study in this paper also provides one way to solve the problem of 'Drug Price Index Perplexities'. Without any pre-assumptions on the demand side, the index constructed by price ratio estimation provides an explanation that is quite close to the existing research in the fields.

Finally, this paper stimulates further studies on the pricing behaviour of generic and brand-name drugs in terms of government health policies. Possible research may be developed in estimating the price ratio in different provinces or states so that different government programmes and their relationship with price trends can be compared.

ACKNOWLEDGEMENTS

I wish to thank Stephen Ferris and Gordon Tarzwell for their very helpful comments. I also thank Ronald J. Corvari for the help in the data.

REFERENCES

Bian, J. (1956) *Barriers to New Competition*, Harvard University Press, Cambridge, MA.

Caves, R. E., Whinston, M. D. and Hurwitz, M. A. (1991) Patent expiration, entry, and competition in the US pharmaceutical industry, *Brookings Papers on Economic Activity, Microeconomics*, 1–48.

De Vany, A. and Saving, T. R. (1983) The economics of quality, *Journal of Political Economy*, **91**(6), 979–1000.

Feenstra, R. C. (1994) New product varieties and the measurement of international prices, *The American Economic Review*, **84**(1), 157–77.

Frank, R. G. and Salkever, D. S. (1992) Pricing, patent loss and the market for pharmaceuticals, *Southern Economic Journal*, **59**(2), 156–79.

Frank, R. G. and Salkever, D. S. (1995) Generic entry and the pricing of pharmaceuticals, *NBER Working Paper* 5306.

Graboski, H. and Vernon, J. (1992) Brand loyalty, entry and price competition in pharmaceuticals after the 1984 Drug Act, *Journal of Law and Economics*, **35**(2).

Grilliches, Z. and Cockburn, I. (1994) Generics and new goods in pharmaceutical price indexes, *The American Economic Review*, **84**(5), 1213–32.

Klein, B. and Leffler, K. (1981) The role of market forces in assuring contractual performance, *Journal of Political Economy*, **89**, 615–41.

Landes, W. M. and Posner, R. A. (1987) Trademarked law: an economic perspective, *Journal of Law and Economics*, October, 265–309.

Scherer, F. M. (1980) *Industrial Market Structure and Economic Performance*, Rand McNally, New York.

Scherer, F. M. (1993) Pricing, profits, and technological progress in the pharmaceutical industry, *Journal of Economic Perspectives*, **7**(3), 97–115.

Wiggins, S. N. and Raboy, D. G. (1996) Price premia to name brands: an empirical analysis, *The Journal of Industrial Economics*, **44**(4), 377–88.

APPENDIX: DATA

This study makes use of a data set of 200 drugs in province of British Columbia to reflect the pricing behaviour across 7 years (1990–1997). All the data used are based on 1997 dollar figures as compiled in the Canadian Drug Store and Audit. Some data used in the tables are also based on a pool data from the Canadian Patented Medicine Price Reviews Board (PMPRB).

All drugs in the data set are identified by a unique Drug Identification Number (DIN number). Based on the same or similar function, there may exist several brand-name drugs and several generic drugs. For example, for the drug of Tylenol with codeine no.2-Tab, there are two brand-name drugs in the market. The one is with DIN number 425370 and the other is with DIN number 2163934. There also are two generic substitutes in the market for this drug: Lenoltec no2 Tab with DIN number 653241 and Novo-gesic C15 with DIN number 687200.