THE USES OF THE "TEMPORAL-FARES-OFFERED CURVE" IN AIR TRANSPORTATION*

by Kenneth Button and Henry Vega

The increasing use of Internet booking facilities provides analysts with a rich data source of the profile of airline fares offered for a particular service as the time of departure approaches – "temporal-fares-offered curves." This paper offers a critical assessment of this form of analysis. It also reviews the empirical work that has been done using this type of data and synthesizes the information and insights that it can provide on the operations of an airline market. The subjects covered range from pricing strategies of low-cost and legacy carriers under different degrees of competition, to the extent to which there is price leadership in markets, and to ways in which airlines determine fares-offered when their schedules mean that their own services effectively compete with each other.

INTRODUCTION

Traditionally the airline industry has been one of the most regulated industries with controls over fares and market entry being the norm in both national domestic and international markets. The deregulation of aviation, beginning in the late 1970s within U.S. domestic markets and in the mid-1990s in Europe, provided airlines with, amongst other things, the ability to price discriminate when selling their seats. There is now almost a universal use of dynamic third degree price discrimination – "yield management" – by airlines with markets being segmented by differences in their fare elasticities with respect to when seats are booked. The emergence of new markets and new business models in the airline industry has affected the ways in which carriers use this ability to adjust fares and their usefulness for cost recovery strategies.

The study of the implications of yield management by airlines has been limited in part because of data issues. On the practical side, there are no readily available official sources of information that can be easily inserted into standard econometric software. On the academic interest side, much of the intellectual effort expended has been on macro-questions looking at the broad changes that regulatory reform has generated and at the implications of such innovations as code sharing and hub-and-spoke service networks on the performance of specific carriers. Observing the individual fares offered for a particular airline service, however, can provide not only insights into the pricing strategies of airlines, but also guidance as to the underlying market structures in which they operate – that is, whether there is significant market power present and the extent to which interactions by carriers with different cost structures affect market share.

This paper does not offer any new calculations but is a structured and critical review that looks at the studies that have used this type of micro fare data to examine various aspects of pricing in air transportation markets. The material offered is selective but, while the main objective is to highlight the usefulness of this data source and some of the results that have been generated, the findings that are cited are in no way atypical of what has emerged from the fairly limited literature so far. The work that has been completed tends to be somewhat scattered across a range of journals and conferences.

THE MODERN AIRLINE INDUSTRY

The changes in regulation that have occurred over the past 30 years have allowed airlines to set their own fares and not, as under most regulatory regimes, to simply offer one economy (coach in the United States) and one business (first class on U.S. domestic routes) fare for each service.

Prior to deregulation, the freedom to set fares was limited by government controls on their levels and variability; this "rate-of-return" approach to fare setting was generally that of average cost pricing allowing for a reasonable return on investment. Price competition was further stymied in many international markets in situations where bilateral air service agreements between countries forced the airlines (normally one, often state-owned, "flag carrier" from each nation) to pool their revenues.

Deregulation has resulted in extensive price competition as open markets have allowed open entry and exit and freedom in fare setting. The large number of privatizations in markets where state-owned flag carriers previously dominated and the removal of most subsidies has added a commercial incentive to the way airlines view fare setting. New technologies and managerial practices, partly emerging as the result of the new institutional environment, have allowed airlines to set fares more flexibly. The advent of computer reservations systems (CRS) has permitted airlines to price discriminate by separating potential traffic according to group characteristics.[1] Initially, CRS strategies were developed by carriers such as American Airlines in the United States as a means of influencing the advice rendered by travel agents to potential travelers. Now they are practiced through the airlines' own electronic booking systems or through consolidated systems such as Orbitz in the United States and Opodo in Europe.

The liberalization of aviation markets has brought with it a new form of competition, namely that offered by the no-frill (low-cost in the United States) carriers. While there has been cyclical volatility and individual carriers have differed in their financial performance, the global airline industry has not been profitable as a whole over the past 30 years. Even in good economic times the industry suffered from low operating margins.[2] A number of reasons have been posited for this, many based on the idea that the industry generically has suffered from high costs and that a "cleaning-out" process has been taking place. There is probably some truth in this, but equally in the United States, where deregulation took place in the 1970s, airlines still seldom make money despite significantly cutting costs.[3] Chapter 11 bankruptcies are commonplace; indeed many carriers have gone through the process multiple times.

While there have clearly been many less efficient airlines where significant cost cutting could enhance their relative positions in the marketplace, there also seem to be serious structural issues in providing a scheduled service in a competitive market. The main problem with airlines' finances may well be the lack of a "core" (Button 1996; Antoniou 1998). In other words, airlines have a committed cost when promising to deliver a service at a particular time and place in the future. These are not the traditional fixed costs of the type associated with manufacturing industry, but rather the commitment to have a plane, crew, fuel, and in-flight services available to provide this air transportation. In a competitive market with several airlines offering similar services in a narrow time frame, there is competition to fill their planes and fares drop to just cover short-run marginal costs. Because these costs are actually quite small, the result is that the fixed costs go largely unrecovered. To gain additional revenue, the airlines seek to segment customers. Frequent flyer loyalty programs separate regular from infrequent travelers and seek to commit them to the airline offering them. Another form of third-degree price discrimination is yield management by which travelers are separated by their willingness to book their seats at different times.[4] It is this topic, pricing down the temporal demand curve, which we focus on here.

"TEMPORAL-FARES-OFFERED" CURVES

Most of the analysis of airline markets, largely because of the questions that have been of interest, but also because of the limited availability of secondary-data on fares outside of the United States, has focused on changes in average fares (or "yields"). These studies are numerous and are not catalogued here but have covered such topics as differences in the fares between large markets such as the United States and Europe, the effects of liberalization of economic regulation on fare levels, and the impact of low-cost carriers such as Southwest Airlines in the United States and Ryanair in

Europe on the fare setting of the traditional, legacy carriers. What has not been explored so fully until recently is the nature of fare competition when carriers continually change their fares up to the point of take-off of a flight. They can do this because, while there is considerable competition in U.S. and European markets, and there is freedom of entry and exit, the situation still falls short of perfect competition.

The decision as to what fare to offer potential customers at various times is normally a static non-cooperative gaming problem for each seat.[5] The airline wants to extract as much revenue from each potential customer as possible and the customer seeks the lowest fare commensurate with the conditions attached to the ticket. In the past, airlines had considerable advantages in this game because they had more information (via their control over the CRS systems) than potential customers and could display it to the advantage of their services over those of rivals. This has now changed as airlines sell more tickets directly on-line and through Web-sites that allow customers to make decisions based on a variety of information sources. The airlines have more information in this world because they now also gather information about the fares being offered by rivals. Previously, only airlines with CRS systems hosting other carriers had this information.

This information about how fares for individual flights change over time until the time of take-off has begun to be examined in efforts to explore the nature of interactions between airlines in various market environments. The technique for data collection in the studies that have been conducted has been fairly standard. A future flight is selected and records of the fares offered at particular times are taken by consulting on-line booking services. This data can then be mapped to trace out the "temporal-fares-offered curve." This not only provides insights into how individual carriers adjust their fares over time but by looking at the profile of such curves for a number of competing services when they exist, it is then possible to examine the interactions between the fare setting of various carriers over time.

As in all types of data collection there are advantages and there are problems. The data to compile a temporal-fares-offered curve is readily available, cheap to collect, and reflects actual prices that are being offered in a market. It also is linked directly with the nature of the yield-management that virtually all airlines practice. But as a case study technique it suffers from the limitations of all case study work, and in particular the difficulty of moving from individual, micro cases to the macro-picture. As Lamnek (2005) argues, "The case study is a research approach, situated between concrete data taking techniques and methodologic paradigms. In particular there is the difficulty of moving from individual, micro cases ("critical instance cases") to the macro-picture and general conclusions."

There are also some technical problems both in the data collection and in its application. First, there is the problem of selecting representative services to study. Much depends on the issue under review, but no individual flight is representative. The number of bookings, which influences the price set for subsequent passengers, can fluctuate quite dramatically if, for example, a large group of people travel and book together, or if a particular flight corresponds to a unique activity such as a sporting or cultural event. There are also seasonal trends in air transportation markets that affect the aggregate demand for seats. None of the studies to date have looked at a sufficient number of individual flights to allow econometric analysis that can account for such external effects.

Much of the work using the temporal-fares-offered curve approach is also comparative in its nature, looking at several suppliers of similar services, and this involves defining the boundaries of competition. Unless there are parallel runways, competing flights do not take off at exactly the same time and hence a "time-window" of competing services to the same destination has to be selected within which services offer reasonable competition with each other. They also have to be of similar service quality; travelers, for example, have a clear preference for a jet airliner service than a turbo-prop service. Added to this, in some cases airlines have similar services that effectively compete with each other – self-competition. For example, a passenger wishing to travel between A and B in the early morning on some future date may have the choice of, say, three services between 7:30 a.m. and 9:30 a m., two offered by airline X and one by airline Y.

There are also problems in deciding which fare to select when looking at a particular service. Normally a particular point of time is selected to collect a daily fare, but there may be several types of fare, each with different conditions attached to them. The standard practice is to take the cheapest fare available but this may mean that on any given day the fares selected may not be for an identical product if the terms of sale differ. The practice also says nothing about the spread of fares that are available for a particular flight at time the data are collected. Additionally, the fares that are selected may be sensitive to the time of day the snap-shot is taken.[6]

The approach takes no account of the use of frequent flyer "miles" to purchase tickets. While these may not affect many low-cost carriers, traditional legacy airlines and some low-cost airlines do have these programs and reserve various buckets of seats for such customers. This affects the number of seats available for normal sales; then traditionally carriers normally set aside about 2% to 3% of their seats for frequent flyer use but this various by route. The profile also only considers fares for those traveling on particular origin-destination pairs and assumes implicitly that their demand combined with seat availability influences the fares being set at any point in time. This is a reasonable approximation in the case of low-cost carriers that operate radial style networks with no on-line connections. It is much less valid for many legacy carriers operating hub-and-spoke networks and where much of the traffic involves combinations of flights. The availability of seats on any spoke, and thus likely fares offered at any time, in such networks depends both on the levels of direct traffic and hubbing traffic.

The interpretation of the temporal-fares-offered curve poses some problems because it does not actually say how many seats are sold at any price offered.[7] There is the implicit assumption that markets are clearing effectively each day and that the curve represents a series of equilibrium points at which the supply of seats offered at the revealed fare is equated with the demand at that price on the day the observation is taken. Given the lack of any information on quantity sold, this is perhaps the only assumption that can be made, but it does mean that the curve effectively is tracing out a pseudo-supply curve.

STUDIES TO DATE

Most of the analysis to date using temporal-fares-offered curves has focused on European air transportation markets, with a limited number of papers considering the U.S. situation. One possible reason for this is that with the 10% ticket sample available in the U.S. Department of Transportation, Data Bank 1A, analysts there have an alternative fares data source to explore and have not yet felt the need to gather extensive primary data. Another reason could be that the changes in regulatory regime have been more recent in Europe and more dramatic, involving not just the removal of economic controls over prices and market entry, but also ownership of many airlines. This provides a greater variety of market structures to be studied, at least in the short term.

Table 1 offers a brief listing of the characteristics of the main temporal-fares-offered curve studies and the main methods of statistical analysis that have been deployed. The questions that have been of interest have largely focused on the interplay in fare setting by airlines in different types of markets situations, especially when there is a low-cost carrier present. Questions of market dominance and its form are often implicit elements of the work.

Table 1: Studies Using Temporal-Fares-Offered Curves

Study	Market	Analysis Technique
Pels & Rietveld (2004)	London-Paris routes for legacy carriers	Statistical analysis of short-run airline responses to competitors' price changes. Partial analysis involving SUR estimation with regressions on lagged residuals
Pitfield (2005a)	Low-cost services from the UK	Cross correlation analysis, subject to a variety of lags. Series pre-whitened using ARIMA or Box-Jenkins to determine: - cross correlation functions (CCF) - autocorrelation functions (ACFs) - partial autocorrelation functions (PACFs)
Pitfield (2005b)	Low-cost services from the UK	ARIMA time series models, CCF, ACFs, PACFs.
Barbot (2006)	Low-cost services Paris to Milan	Ordinary least squares regression no lags introduced. Theoretical model based on Bertrand competition
Button & Vega (2006)	Low-cost carriers' internal service competition in the US	Graphical analysis using case studies
Button, Costa & Cruz (2007a)	Price leadership for routes from Portugal	Graphical analysis, comparative statistics
Button, Costa, Costa & Cruz (2007b)	Price leadership for routes from Portugal	Graphical analysis and Granger causality tests

The studies have all looked at daily movements in fares for a number of flights, although the periods over which fares are recorded vary.[8] The analyses offer graphs of the temporal changes in fares as take-off time approaches and several also involve the use of such techniques as Granger causality and ARIMA to look for linkages over time between the fare patterns of different carriers on a route, as well as more basic ordinary least squares estimations. These statistical techniques, however, have not proved to be reliable because of the nature of the data that often reveal a variable pattern of fares-offered over time. We thus focus the rest of the discussion on the types of pictures that can be seen in the graphics. It is appreciated that the material is in many ways ad hoc and the case may be seen as selective in terms of trying to support particular arguments, but in fact from the studies that have been completed to date the findings are quite robust.

WHAT DO TEMPORAL-FARES-OFFERED CURVES SHOW?

What follows is an extraction of fairly typical examples of what has been found to date in terms of developing temporal-fares-offered curves for a number of different situations.[9] The situations all concern routes in either the U.S. or Europe. There are differences in the details of the exact methods of data collection (e.g. in terms of the period prior to take-off that are used as the collection period), but most involve fairly well-established routes and well-established carriers that know how to play pricing games.[10] More details of the exact flights examined in each case study are given in the references cited.

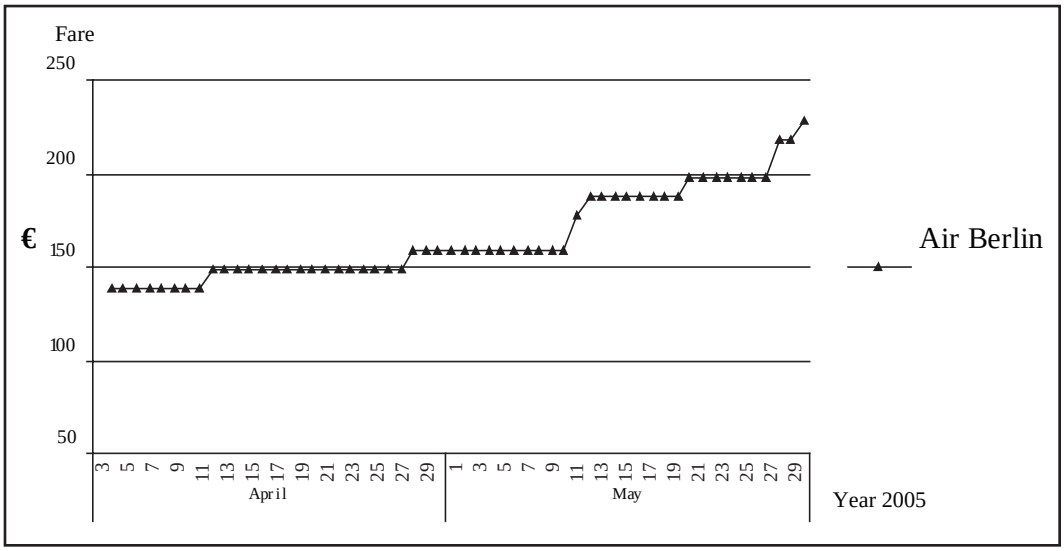
A variety of market structures have been examined in the studies surveyed. The competitive situation, however, where there are numerous carriers, is not illustrated in what follows. There are few cases where there are large numbers of carriers providing services on a single origin-destination (O-D) pair of cities. The few attempts to examine the temporal-fares-offered curves in such cases

reveal considerable volatility across the carriers in markets characterized by a multiplicity of airlines as each seeks a short-term advantage in the fare that it can charge. There is no major up-turn in the fares being offered during the final days prior to departure.

MONOPOLY MARKETS

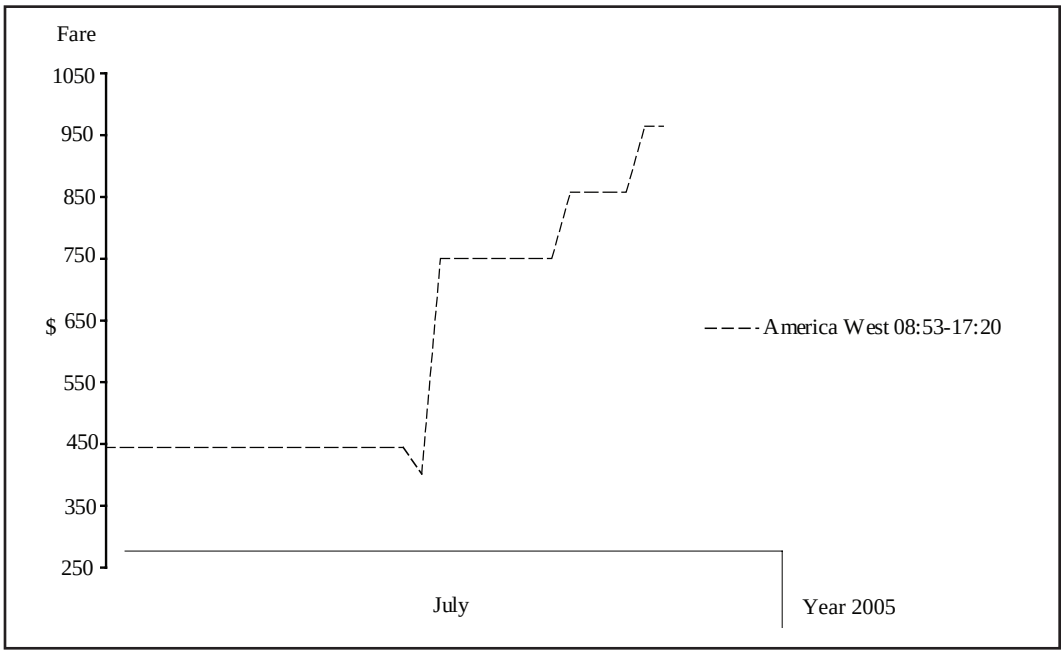
Legacy airlines have traditionally used fairly complex yield management programs (Smith 1992) whereas low-cost carriers take a somewhat simpler approach. The text-book model of how low-cost carriers change fares to the point of departure of any flight is one of gradual fare rises to the point of departure.[11] The carrier makes little or no money on early bookers – normally leisure travelers with a high fare elasticity of demand, but makes its profits on late booking business travelers with a low fare elasticity. This simple model of low-cost carrier fare setting would seem to be valid in both Europe (where fares are given in Euros, €, for Europe and dollars, $, for the U.S. services) and the United States when the carrier enjoys a monopoly position in the market (Figures 1 and 2).[12]

Figure 1: Temporal-Fares-Offered Curves for Return Services from Porto to Palma, Leaving May 30 and Returning June 5, 2005



Source: Button et al. (2007a)

Figure 2: Temporal-Fares-Offered Curves for Return Services from Phoenix to Des Moines, Leaving August, 1 and Returning August 5, 2005



Source: Button and Vega (2006)

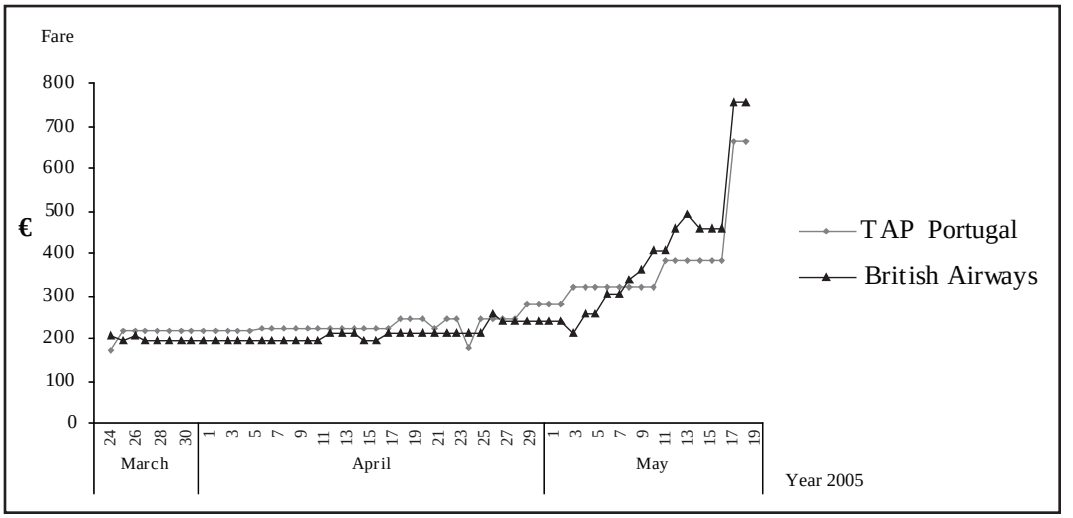
DUOPOLY INVOLVING LEGACY CARRIERS

Duopolies involving large, national airlines were a common feature of international aviation markets under traditional bilateral air service agreements. This pattern has largely evaporated where "Open Skies" policies have emerged in the context of U.S. international services, or where multilateral deregulation has occurred as with intra-European Union markets. In some cases, however, the original legacy-carriers have remained on these routes and examinations of these situations reflect the outcome of long-term games as players have gained information about each other's reaction functions.

Since Kessel's (1971) analysis of financial markets, there have been debates about the number of firms in a market required before pricing approaches the perfectly competitive market level. Kessel indicated that one or two competitors are adequate and subsequent analysis using game theory indicates that, under most assumptions, only three actors in a market are needed for prices to approach the perfectly competitive level.[13]

Figure 3 considers two European Legacy carriers – the UK airline British Airways and TAP, the Portuguese legacy carrier – serving the long established route of Lisbon to London. The data indicates that, while there is an upward movement in the price of seats available towards the time of the flight departures, the increase comes relatively late and after a period of fairly low and flat fares. The temporal-fares-offered curves for the two airlines also closely mirror one another. This inability to raise fares until relatively late suggests that there are competitive pressures at work despite the duopolistic nature of the market.

Figure 3: Temporal-Fares-Offered Curves for Return Services from Lisbon to London, Leaving May 19 and Returning May 25, 2005



Source: Button et al. (2007a)

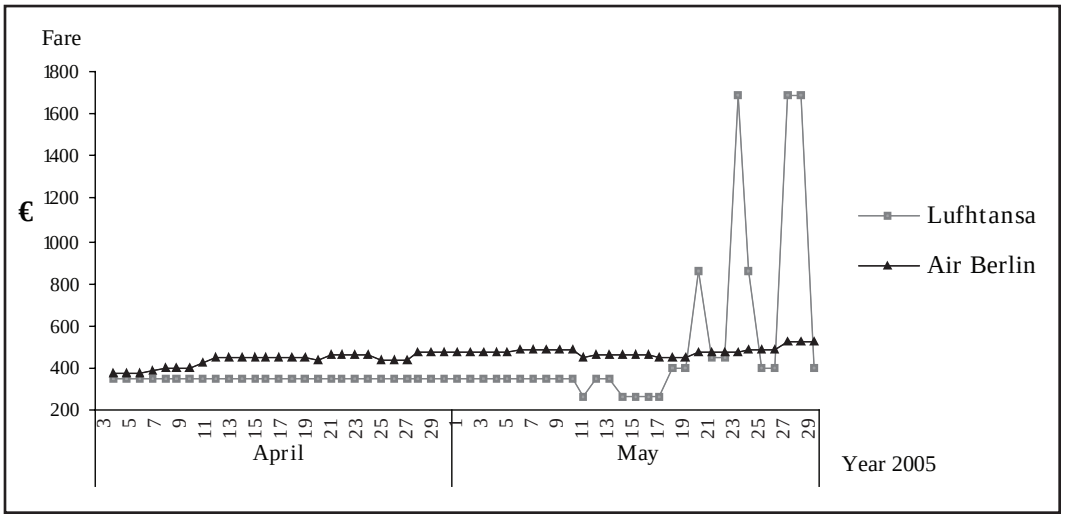
LOW-COST CARRIERS AND LEGACY CARRIERS

Work in the United States has shown the significant impact that the "Southwest effect" has had on fares in markets that this carrier has entered (Morrison 2001). It indicates that there is a degree of macro-level price leadership in markets where there are low-cost carriers with incumbent legacy operators forced to reduce their average fares when a low-cost airline enters a market. There may also be implications for fares on adjacent services operated from nearby airports.

There are a priori reasons to expect a degree of barometric price leadership, whereby price leader firms respond more quickly than rivals to changing cost and demand conditions. Low-cost carriers compete almost entirely in terms of fare rather than "service" attributes such as meals and multiple reservation channels. They thus have small margins and need to be nimble to survive; their fixed committed costs are lower. The analysis of this impact of low-cost airlines on fare setting has, however, been focused on average fares and not the dynamics of the path of how fares are set at the micro level.

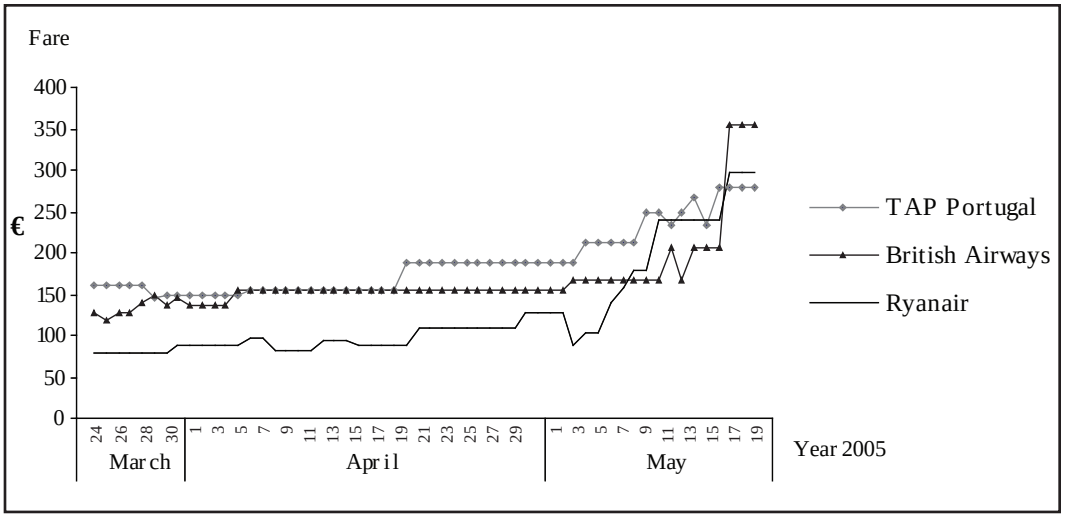
The evidence on price leadership looking at temporal-fares-offered curves is not very strong. Figures 4 and 5 take two European routes as illustrative of this and there are clear indications of different carriers changing their fares at different times and, on occasions, in different directions. This conclusion from a simple visual examination of the fares-offered path is supported by more rigorous analysis using Granger causality and other tests.[14]

Figure 4: Temporal-Fares-Offered Curves for Return Services from Porto to Frankfurt, Leaving May 30 and Returning June 5, 2005



Source: Button et al. (2007a)

Figure 5: Temporal-Fares-Offered Curves for Return Services from Porto to London, Leaving May 19 and Returning May 25, 2005



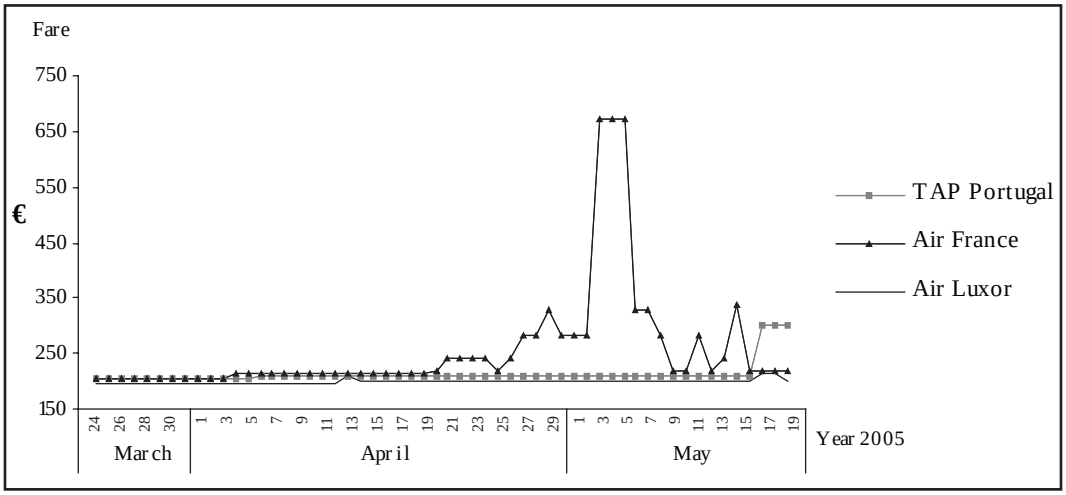
Source: Button et al. (2007a)

REGIONAL LOW-COST CARRIERS AND LEGACY CARRIERS

The business models now deployed in the aviation market are diverse and the simple legacy/low-cost carriers dichotomy only considers the extremes. In some markets there are carriers that are somewhere in between low-cost airlines and the legacy carriers and serve significant regional markets. Button et al. (2007a), for example, looked at the role of Air Luxor in a number of European markets that were also served by legacy airlines (Figures 6 and 7). In addition to the inability of the carriers in these markets with three suppliers to raise prices more generally as take-off time

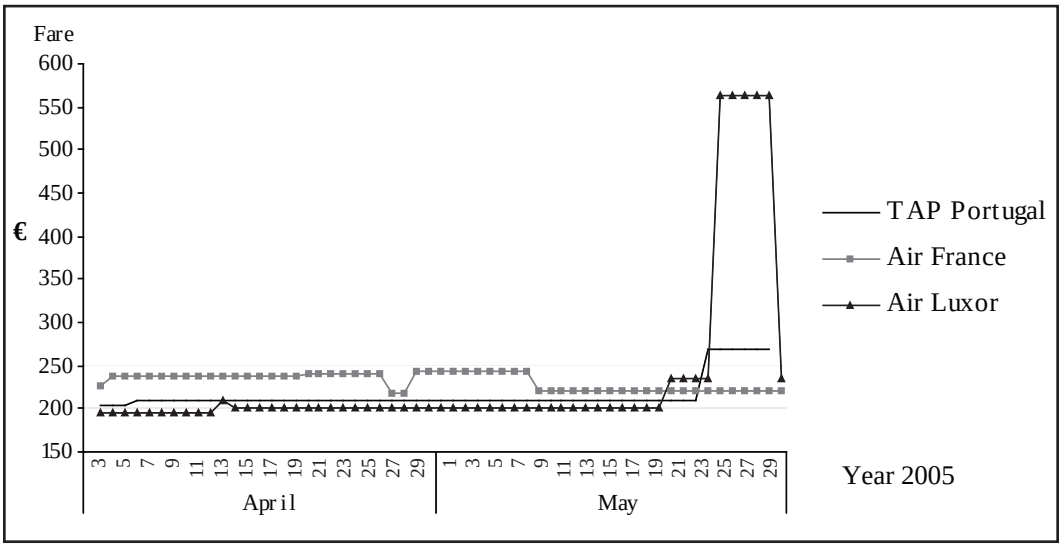
approaches, the behavior of the regional carrier seems not to have any pricing effects on the legacy carriers that serve the same Portuguese markets.[15]

Figure 6: Temporal-Fares-Offered Curves for Return Services from Lisbon to Paris, Leaving May 19 and Returning May 25, 2005



Source: Button et al. (2007a)

Figure 7: Temporal-Fares-Offered Curves for Return Services from Porto to Paris, Leaving May 30 and Returning June 5, 2005



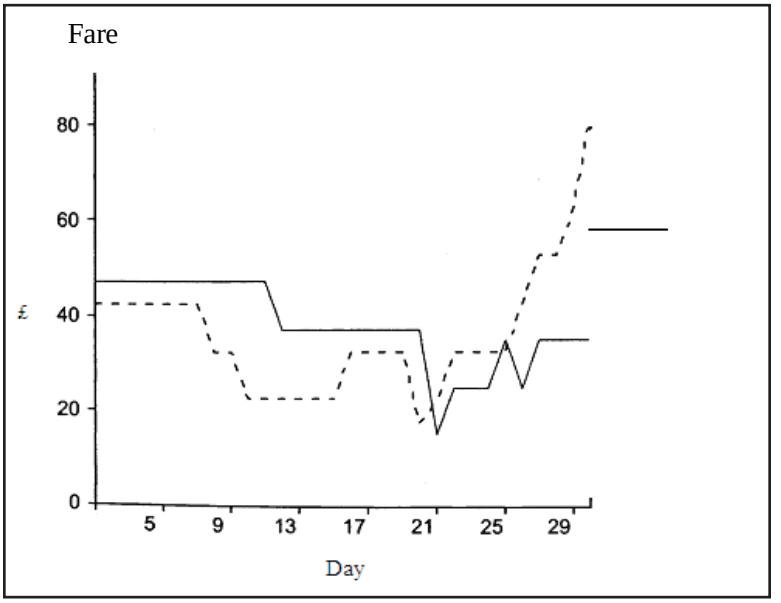
Source: Button et al. (2007a)

COMPETITION BETWEEN LOW-COST CARRIERS

The most successful low-cost carriers, especially in Europe, tend to operate from second tier airports to keep costs down. This strategy also enables them to largely avoid competition with each other. The plethora of ex-military airfields in Europe, for example, makes this possible and Ryanair has adopted such airports for many of their services. As the demand for air travel grows and as some of

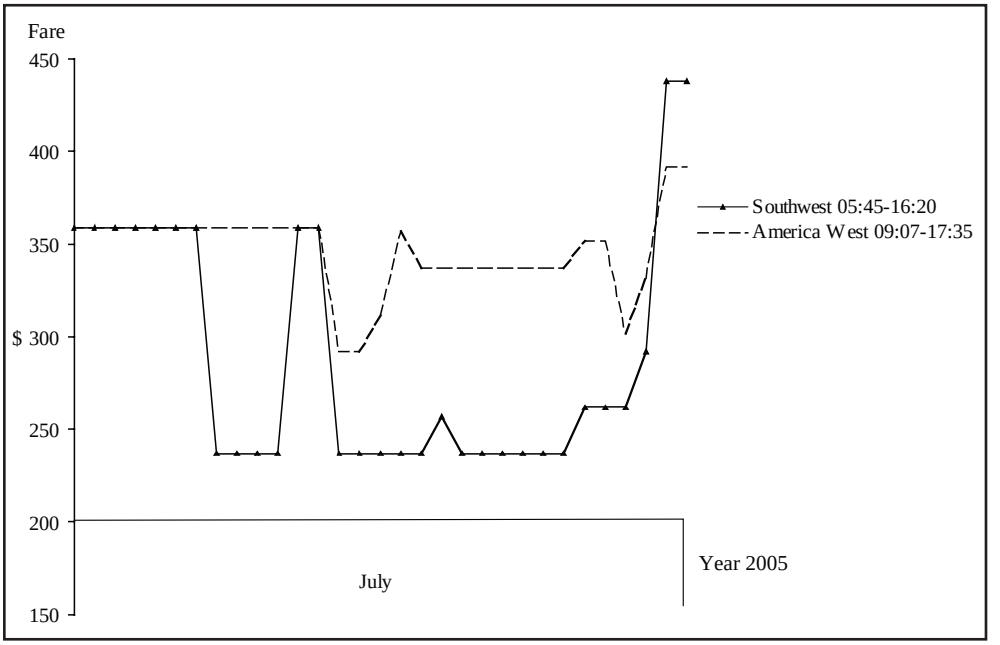
the legacy carriers retrench into longer-haul operations the role of the low-cost carriers is growing (Button 2004). Inevitably, there is an increasing overlap in their activities and competition between them is emerging.

Figure 8: Temporal-Fares-Offered Curves for Services from Nottingham to Malaga, 2003



Source: Pitfield (2005b)

Figure 9: Temporal-Fares-Offered Curves for Return Services from Phoenix to Kansas City, Leaving August 1 and Returning August 5, 2005



Source: Button and Vega (2006)

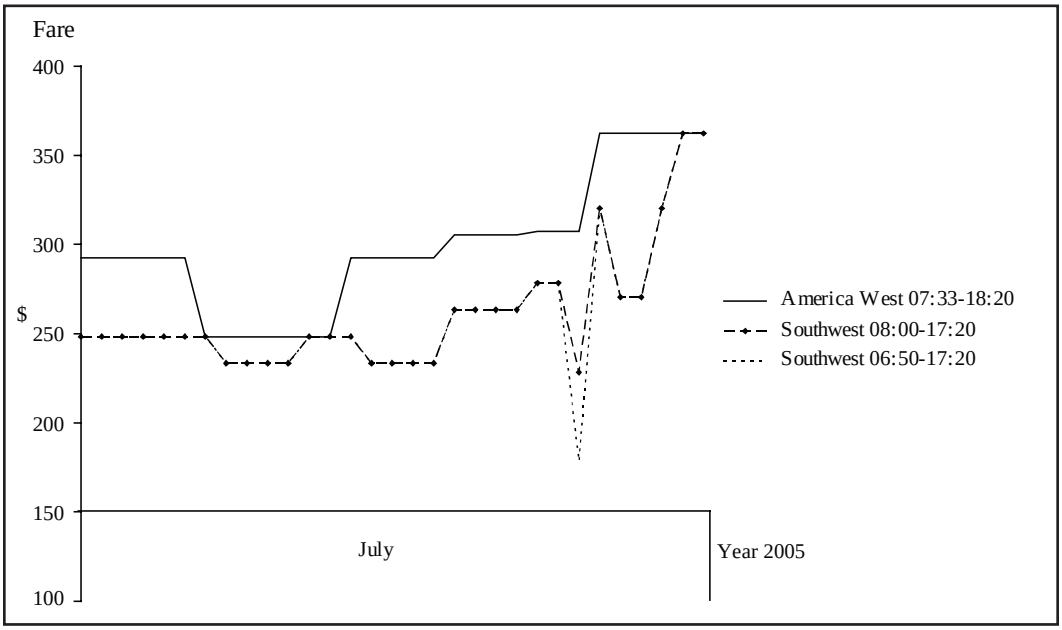
The standard picture of a simple yield management strategy of gradually increasing fares to the time of the flight, found for monopoly low-cost carriers (Figures 1 and 2), begins to change as other low-cost carriers compete on the same routes. As seen in Figure 8 that involves a European market, and Figure 9 that addresses a US market, there appears to be evidence of game playing between the carriers with fares hardly rising at all in the lead-up to departure. This is very much in line with what would be expected as a "core" disintegrates as competition takes place when there are fixed-schedule commitments.

INTERNAL COMPETITION BETWEEN AIR SERVICES

Airlines generally offer a number of flights to particular destinations on any day and these effectively compete with each other. A potential passenger, for example, not finding a seat at an acceptable fare on airline A at the preferred travel time may elect for a second choice time at an acceptable fare on this carrier rather than travel on airline B at the preferred time. Frequent flyer effects may come into play in making this decision, but there may also be other attributes of airline A that give it an advantage over airline B. It would seem logical in these circumstances for airline A to treat its flights as in competition with one another as seats fill on one to raise fares on that flight while offering lower fares on the other service. The fact that airline A has two alternative flights with the ability to manipulate the fares offered on each over time should afford it an advantage over a competitor such as B that only has one flight. There are, of course difficulties in defining the time windows in which this type of effect may be anticipated and there may be secondary considerations, such as the type of aircraft used on the services offered by airline A.

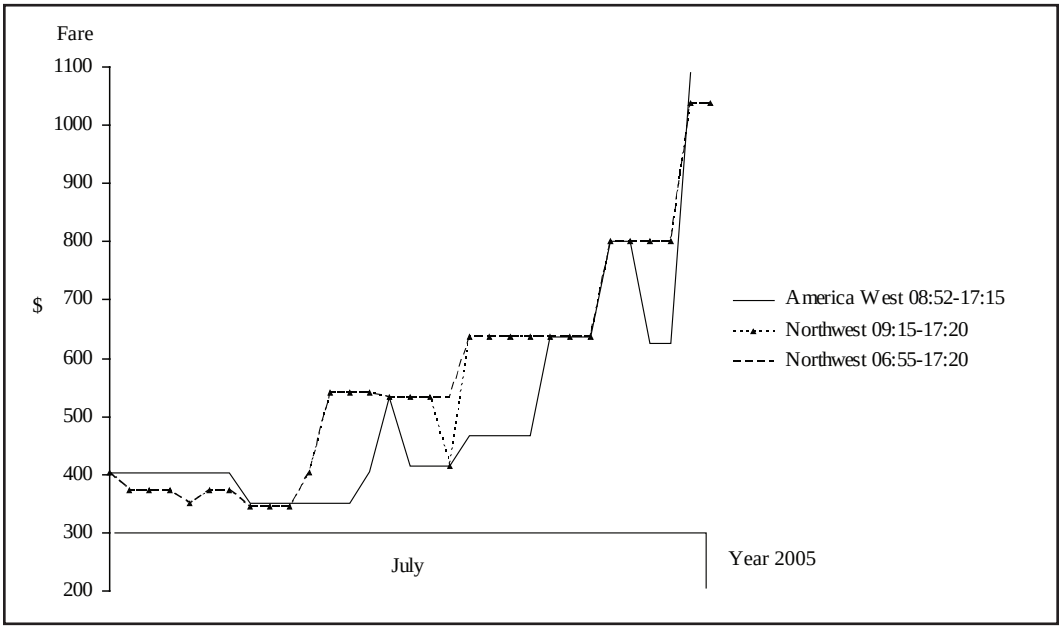
Figures 10 and 11 provide examples of two markets in the United States where an airline does offer flights in close temporal proximity with one another and where there is a competitor. In both cases, Southwest in Figure 10 and Northwest in Figure 11, the multi-flight airline neither appears to develop a gaming advantage nor sees its services as competitive with each other. It simply sets fares along the same temporal-fares-offered time pattern for both flights. Why this is so can only be a subject of conjecture; it may be simply inertia on the part of the airline with multiple services but it may also reflect a desire not to bombard potential customers with excessive information.

Figure 10: Temporal-Fares-Offered Curves for Return Services from Phoenix to Sacramento, Leaving August 1 and Returning August 5, 2005



Source: Button and Vega (2006).

Figure 11: Temporal-Fares-Offered Curves for Return Services from Phoenix to Minneapolis, Leaving August 1 and Returning August 5, 2005



Source: Button and Vega (2006)

CONCLUSIONS

Yield management, the practice of dynamic third-degree price discrimination by time of ticket purchase, is a common phenomenon in deregulated air transportation markets. There have been few studies, however, that have examined the exact form this price discrimination takes in different competitive environments. Data are scarce commodities but in this case, useful data are relatively easy and inexpensive to collect. The quality of the data, however, is far from ideal and there are problems, for example, involving market definition, the appropriate fares to be considered, and the frequency with which sampling should take place. Establishing temporal-fares-offered curves can, however, offer some insights into the ways airlines market their services and the implications of market structures on their ability to influence fares. This is important in situations where there are fixed, schedule-committed costs to recover.

The overall conclusion from the body of academic work that has been completed to date in the United States and Europe using this type of data is that no single temporal pattern to fare setting exists. But rather, the forms of temporal-fares-offered curve are highly sensitive to the details of the prevailing market structure. The number of airlines is, for instance, relevant to the fare path, as is the nature of the business models the airlines employ. These patterns are quite robust, but not all that surprising and largely conform to a priori expectations derived from standard industrial organization theory. Where there is some divergence with what one may expect is in terms of price leadership. One would anticipate when looking at imperfect markets over time that some dominant actor would emerge but this does not consistently seem to occur in the cases examined.

Endnotes

*Earlier versions of this paper were presented at the 48th Annual Transportation Research Forum, Boston, the 9th NECTAR conference Porto, and the 11th World Conference on Transport Research, Berkeley. The authors are grateful for comments received at these meetings.

1. There had been some degree of price discrimination in airline markets, particularly in Europe, prior to deregulation because of the presence of charter operations. Many of these were linked to the activities of scheduled carriers that practiced second-degree price discrimination by offering blocks of discounted seats to consolidations and inclusive tour operators.

2. While the airlines have not on average made a viable return, other elements up the value chain, such as airports, global distribution systems, and airframe manufacturers have (Button 2004).

3. For example, the major U.S. airlines lost $7.6 billion in 2004 and $5.7 billion in 2005, and forecasts for 2007 by the U.S. Air Transport Association suggest only a 2.7% operating margin is likely in 2007 even though many airlines are enjoying record load factors.

4. Strictly, the airlines do not change the fares that they offer but rather they vary the number (or "buckets") of seats at any given fare that are available at any one time.

5. While the process may be dynamic, the sale of any single seat is a once-for-all transaction and thus a static game.

6. There is a further potential problem with tracing out the temporal-fares-offer curve in that it is assumed that the overall effective demand in the market remains constant over the period leading up to take-off. A sudden rise in demand in the overall market could push up the fares-offered curve after that point.

7. Some airlines or travel websites do post information about remaining seats on a flight but this does not indicate the fares at which previous sales were made.

8. What has not yet been done is a more intensive study of the period immediately before a flight using, for example, hourly observations or even periods of shorter duration. Because tickets sold in this period generally generate a higher yield, one would anticipate that airlines would be particularly thoughtful in their setting.

9. The paper by Button et al. (2007b) also indicates that examination of the same service over an extended period generates broadly similar temporal-fares-offered curves.

10. Some studies have look at reported fares at particular points on the temporal-fares-offered curves; e.g. Bilotkach (2007) is only concerned with fares very close to the point of take-off. This "snap-shot" type of work is not considered here and does not really address the issue of short-term fare fluctuations as take-off is approached.

11. The typical image of the yield management policy of low-cost carriers can be summarized as, "Revenue management on individual flights is quite ingenious. Passengers who are able to book long in advance or will accept less popular travel days are offered ticket prices that are little more expensive than local train fares. On the other hand, anyone who books only a short time ahead or wishes to fly at certain times that are much in demand pays an almost normal ticket price" (Thomalla 2002).

12. In some cases when a flight is full prior to take-off, a low-cost monopoly carrier may add an additional flight scheduled at about the same time. This results is a sort of scalloped temporal-fares-offered curve with seats offered on the additional flight being at fares somewhat below that of the original flight but then rising until take-off (Button et al. 2007a).

13. This type of work focuses on actual competitors being in a market and does not take any account of the role that potential competition (a contestable market) may play. The latter appears to have some influence but not to be as potent as actual competition (Morrison and Winston 1987).

14. These features can only be taken as indicative of a lack of barometric price leadership. Such leadership can be consistent with occasional switching between firms in the role of price leader; occasional and sometimes substantial time lags in the price response of follower firms; and occasional rejection by the rest of the market of price changes initiated by the price leader. Other models characterize price leadership in terms of industries where the distribution of firm sizes is highly skewed, resulting in a dominant firm that exists alongside a competitive fringe of much smaller firms, typically supplying a relatively standardized product. These latter forms of price leadership in aviation have not been explored using temporal-fares-offered curves.

15. There are some significant "bumps" in the temporal-fares-offered curve, a feature sometimes observed in other market forms. This may be a function of the airlines' computer software automatically overreacting to a large number of sales at some previous price and then correcting. It may also reflect an airline gathering information by testing the market with higher fares and then dropping them quickly if sales did not materialize. The data offer no guidelines as to which is the case.

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