The spatial effects of domestic aviation deregulation: A comparative study of Australian and Brazilian seat capacity, 1986-2010

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Keywords: air transport policy volatility; spatial effects of aviation deregulation; Australia; Brazil; Theil's entropy

***Research Highlights**

Spatial distribution of Australian and Brazilian air transport seat capacity examined.
Generalised entropy indices used to measure the geography of seat capacity.
Evidence of a correlation between air transport policy volatility and spatiality.
Following deregulation, denser network developed among a smaller number of airports.

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Abstract

The aim of this paper is to examine the link between the volatility of aviation policy and the spatial evolution of air transport supply. We focus on the domestic aviation sector of two comparative cases – Australia and Brazil – each of which represents a large continental country with contrasting levels of policy volatility. We apply generalized entropy indices to measure the changing spatiality of air transport seat capacity over a 25-year period (1986-2010). We find evidence of a correlation between air transport policy volatility and spatiality. Using the generalized entropy indices, the study finds that the spatial evolution of Brazilian air transport capacity is governed by variations among very large airports, which are often subject to policy and regulatory intervention. Thus, policy volatility directly influences the spatiality of Brazilian air transport seat capacity. In contrast, the distributional pattern of Australian airports was relatively stable and characterised by gradual and consolidative changes, including evidence of strict airport hierarchy over the period examined. The Australian evidence is that relative dispersion occurred among large airports whereas relative concentration occurred among smaller airports. This supports extant findings in the research literature that deregulation promotes denser aviation networks among a smaller number of airports.

Keywords: air transport policy volatility; spatial effects of aviation deregulation; Australia; Brazil; Theil's entropy

1. Introduction

The study of the causes and consequences of the geographic unevenness of air transport has been one of key research agendas of transport geographers with interests in air transport. Knowledge about the spatiality of air transport is important for understanding the pattern of transport access and mobility, including the understanding and management of its practical implications. Furthermore, information about the spatiality of airline networks is relevant for understanding airline behavior and the types of products and services that they offer (Reynold-Feighan 2011). Information on the patterns of concentration and dispersal is important for gauging an airport's exposure to risk in its investment strategies as well as in assessing the geographic distribution of environmental externalities (Reynolds-Feighan 1998). Thus, the analysis of changing spatial patterns may reveal opportunities and threats for future investments into airport infrastructure (Suau-Sanchez and Burghouwt 2011). Moreover, given the socioeconomic significance of tourism in both Brazil and Australia, the spatial pattern of air transport can partly determine patterns of tourist dispersal by shaping the spatial behaviors of tourists and the spatial evolution of domestic tourism (Oppermann 1992, Mings and McHugh 1992, Koo *et al*. 2010a).

Hub-spoke network, which is often identified with but is not always caused by deregulation, is a key agent of concentration and uneven geographical dispersal (see, for example, Bowen 2011). Air transport dispersal appears to be driven by forces such as airport congestion, the point-to-point network model and to a certain extent, the product strategy of aircraft manufacturers (Derudder and Witlox 2009). Wide-ranging approaches have been used to measure and explain the concentration and dispersal of air transport traffic, its capacity and its policies, including accessibility (Chou 1993), the core-periphery model (Goetz and Sutton

1997), low-cost airline networks (Reynolds-Feighan 2001, Dobruszkes 2006), regional development (Papatheodorou and Arvanitis 2009), airport hierarchy (Thompson 2002) and impacts on tourism (Costa *et al*., 2010), among other approaches. Research in this domain encompasses, to a varying degree, the cause-effect relations between aviation policy and the spatial evolution of air transport.

Differential experiences across geographic contexts are expected as the political and operating environments vary for airlines in different countries, as do their country-specific aviation policies (e.g., Huber 2009, Shaw *et al*. 2009). As Graham (1999) argued, global and local forces interact to produce not only international similarities but also context-specific regional particularities, including the substantially different physical and human geographies of countries. Regional particularities can influence the spatial effects of policies as well as the policies themselves.

In Europe, for example, the link between the pattern of concentration and deregulation is less obvious than in the United States, where a high level of concentration existed prior to the onset of liberalization packages (Burghouwt *et al*. 2003). Australia did not experience the large-scale hub development and market entry or exit that occurred in the United States and Europe. Instead, Australia more closely mirrors the case of Canada, which, as shown by Small (1993), experienced relatively weak development of its major hub-spoke operations while the incumbents dominated on a few high-density routes. However, as Small (1993) argued, Canada, following US domestic aviation policy, has experienced ‘competitive weakness’ due to the joint effects of its proximity to the United States and its comparatively small domestic market. In China, economic reform involved a very different approach whereby airline consolidation was directly influenced by the state, which intended to create three approximately equal-sized carriers and to establish a market environment that is conducive to greater competition (Shaw *et al*. 2009). Thus, given each country's distinct characteristics in terms of the location, concentration and dispersal of its population and various socioeconomic factors, the spatial effects of deregulation vary substantially across large geographical countries.

While deregulation policy is formulated and implemented differentially in various countries, some countries appear to have substantially more volatile policy dynamics than others. For example, Hooper (1998) shows that in India, the rapid changes in the aviation sector following deregulation placed policymakers in a 'reactive position'. This, in turn, created the need for continuous intervention following the initial phase of deregulation, producing an environment with policy-induced volatility and uncertainty within which private airlines must operate. In the 1990s, the Indian government often changed its regulatory guidelines at short notice with respect to certain decisions, e.g., those regarding foreign investment in domestic airlines (Hooper 1998). This behavior may be symptomatic of a developing nation lacking the resources for the extensive evaluation of policy as well as the subsequent monitoring and supervision required during its implementation (Hooper 1998, Fayed and Westlake 2002). Coupled with issues such as low air traffic density, infrastructure shortages, governmental financial constraints and private investments (Fayed and Westlake 2002), one may expect greater policy uncertainty and volatility in developing nations.

In the context of the spatial effects of air transport deregulation, the recognition of policy volatility raises the following question: if deregulation (aviation policy) has certain spatial effects, does the volatility in policy also cause volatility in spatial effects? The aim of this paper is to test whether there is a significant correlation between the policy dynamics and the spatial evolution of air transport supply. In the absence of an experimental design, our study focuses on two comparative time-series cases, each representing contrasting levels of policy volatility. In so doing, we discuss the advantage of using generalized entropy indices as primary tools of analysis – tools that are often overlooked in favor of the commonly used Gini index. Additionally, the paper adds to the existing body of research by introducing Australia and Brazil as comparative cases – two neglected regions in the study of the spatial effects of deregulation.

This paper is organized as follows. First, a brief overview of Australian and Brazilian domestic aviation is provided. Then, the method of analysis is introduced with a discussion on the advantages and limitations of the common Gini and generalized entropy indices. The presentation of results and discussion follow before we conclude.

2. Domestic aviation in Australia and Brazil

Comparative analyses have been widely employed in air transport studies, addressing airlines (Barbot et al., 2008), airports (Nijkamp and Yim, 2001; Oum et al., 2003; Wang et al., 2004), networks (Reynolds-Feighan, 2010) or countries as a whole (Lohmann et al., 2009). The similarities and differences between Australia and Brazil provide an opportunity to explore the reality of domestic aviation in two similarly large countries with respect to their geographic size as measured by their surface areas. The World Economic Forum Tourism and Travel Report (2009) provides useful information to compare the two countries with respect to key air transport indicators (Table 1). Australia and Brazil are comparable in terms of their domestic available seat km (ASK), globally ranking fifth (1,388 million ASK per week) and sixth (1,354 million ASK per week), respectively, according to the 2009 World Economic Forum Tourism and Travel Report. Clearly, Brazil's domestic aviation has the potential to grow much larger than its current levels given that the population's propensity to fly increases as the level of income rises (with differences of 40 ranking points in 'departures per 1,000 population'). Brazil, compared to Australia, also ranks low on air transport infrastructure quality, which is a key policy-related air transport variable. Australia, in contrast, exhibits the characteristics of a developed economy given its high GDP per capita, a population with a relatively high propensity to fly and a higher ranking in air transport infrastructure quality, among other indicators. Most importantly, both nations commenced deregulation of the domestic aviation sector around the same time period (Australia in 1990 and Brazil in 1992), which is useful for comparative purposes. However, in the years following deregulation, the two regions developed very different domestic aviation policy trajectories. Table 2 provides a summary of the post-deregulation domestic aviation environment by discussing key criteria such as competition, price levels, safety and airport provision.

[insert Table 1 about here] (source: compiled from World Economic Forum 2009).

[insert Table 2 about here]

[insert Figure 1 about here] (source: processed from BITRE data)

3. Methodology

3.1 Generalised entropy

Against this background of information, this section introduces the generalized entropy indices used as tools to measure the spatial volatility of air transport seat capacity. If policy has direct effects on the spatiality of air transport supply, then there should be at least some correlation between policy volatility and spatial volatility. In other words, our chosen measurement tool should be capable of encapsulating changes in the spatial concentration and dispersal trends across the given number of airports over time.

'Ratio based' approaches are indicative but too restrictive because they ignore the distributional characteristics of the data. The Gini method is well understood, so its details are not replicated here (see, for example, Cowell 2011 and Dagum 1997). It is briefly noted that the Gini index is used widely in studying air transport's spatiality. The Herfindahl index, which is another common measurement device, has been found to be inferior to the Gini method in air transport applications (Reynolds-Feighan 1998). It has been argued that 'the Theil and Gini indices are considered superior statistics … allowing for comparison of traffic distributions over space and time by presenting an absolute measure of concentration based on the entire traffic distribution' (Reynolds-Feighan 1998: 250-251).

While the use of the Gini index is widely discussed, the key advantages of Theil's entropy index over the Gini index - often not acknowledged in studies of air transport geographies - are twofold: first, Theil's entropy is one of a family of 'generalized entropies,' and second, its decomposability is intuitive in its interpretation. The Gini index cannot be completely decomposed within or between group variations, whereas the Theil index and its variants – i.e., the generalized entropy index – can be. Instead, the Gini index decomposition generates an 'intensity of transvariation between subpopulations' in addition to allowing decomposition within and between group variations (Dagum 1997). There is one restrictive case where the Gini index is perfectly decomposable, but this case is rare (see, for example, Cowell 2011). However, it is unclear how the transvariation should be interpreted in air transport applications. The convenience of the Theil index is its ease of interpretation akin to ANOVA (decomposability), which generates important insights into the structure of spatial volatility. The Theil index also belongs to a family of entropy-based measures. This quality, as will be observed later, provides the analyst with ways to test the spatial concentration-dispersal characteristics of different parts of the distribution (e.g. among smaller or larger airports) by the control of the sensitivity parameter. Reynolds-Feighan (1998, 2001) and Derudder and Witlox (2009), for example, used these approaches to measure the concentration and dispersal of air transport traffic. However, in these studies, the aforementioned advantages of entropy-based measures were not explored in great depth. Instead, they were used as supplementary tools.

Theil index is of the form:

$$T = \frac{1}{n}\sum_{i=1}^{n}\frac{y_i}{y'}\left[\log\left(\frac{y_i}{y'}\right)\right] \qquad \text{equation (1)}$$

where y_i is seat capacity in *i*th airport and y' the average airport seat capacity. It is well-established that the Theil index can be decomposed into within-group (WG) and between-group (BG) component, akin to ANOVA:

$$T = \sum_{j=1}^{J} s_j T_j + \sum_{j=1}^{J} s_j \ln \frac{y'_j}{y'}$$

equation (2)

where y'_j is the average seat capacity in *j*th group of airports and y' the average airport seat capacity of the entire sample.   is airport *i*'s share of seat capacity and   is the Theil index for group *j*.

Generalised entropy (GE) is of the form (following Cowell 2011):

$$E_a = \frac{1}{a^2 - a}\left[\frac{1}{n}\sum_{i=1}^{n}\left[\frac{y_i}{y'}\right]^a - 1\right]$$

equation (3)

where y_i is seat capacity in *i*th airport and y' the average airport seat capacity. 'a' is a parameter that when equals to 1 it is equivalent to Theil (equation (1)) (Cowell 2011). When the identically weighted GE measures are applied to two test cases, more information can be earned on the characteristics and structure of spatial volatility by observing how they respond to different level of 'amplification'. Higher 'a' means that the entropy index will be more sensitive to the changes in airport capacity shares among large airports (high-end of the distribution), whereas lower alpha means that GE will be more sensitive to the changes in airport capacity shares among small airports (low-end of the distribution). Thus, through the control of weights we can examine the distributional characteristics in greater detail.

3.2 Data and airport grouping

Data were obtained from the OAG and the Bureau of Infrastructure, Transport and Regional Economics (BITRE) for Brazil and Australia, respectively, for the 25 years ranging from 1986 to 2010, inclusive. These are yearly uplift and discharge data for each airport in seat numbers. Aircraft information is not reported. The two countries share a similar number of airports with regular public transport services, although the actual numbers have fluctuated over the 25-year period (Figure 2). For the purpose of decomposition, it was necessary to group airports. With the aid of different variants of hierarchical cluster analysis and the authors' knowledge of domestic aviation in Australia and Brazil (for instance, as noted in Table 2, the state capitals in Brazil were subject to different regulatory barriers compared with all other airports), the airports were grouped based on yearly incoming domestic seat capacity. The Australian airports were grouped into four groups: group 1 consists of major international gateways; group 2 includes major domestic airports; group 3 includes large regional airports serving coastal towns and regional tourist centers; and group 4 comprises all other small airports. The Brazilian airports were grouped into three groups: group 1 includes the airports servicing the cities of São Paulo, Rio de Janeiro and Brasília; group 2 consists of all state capital city airports mutually exclusive from group 1; and group 3 comprises the remaining airports. The airports are listed in the Appendix.

[insert Figure 2 about here] (source: processed from BITRE and OAG data)

4. Results

4.1 Seat capacity

Seat capacity in the analyzed timeframe shows consistent patterns over time (Figure 3), despite small volatility during short periods of time. In Australia the 1990s were characterised by a gradual capacity growth, followed by a steep decline after the collapse of Ansett in 2001. Capacity recovered to levels prior to the collapse of Ansett by 2003, with Virgin Blue (in 2011 rebranded as Virgin Australia) and Jetstar adding significant domestic seat capacity, resulting in the acceleration of capacity growth. As for Brazil, the significant increase in capacity after 1998 was also followed by decreases in capacity between 2002-2004. Improved Brazilian GDP growth, a strong national currency, connectivity and the presence of an LCC in a particular route (Gol Airlines) with lower airfares had positive effects on demand increase (Bettini and Oliveira 2008). The excess capacity that existed in the early 2000s was adjusted in the 2002-2005 period as a result of code-sharing allowance between major airlines and the imposition of capacity restrictions in adjacent airports (particularly in the cases of Rio de Janeiro, São Paulo and Belo Horizonte, the largest multi-airport cities of Brazil). These majors contributed to load factor improvements. Both countries experienced the same underlying trend: an increase in domestic aviation demand and supply over time, although the growth curve proved more volatile for Brazil. It is worth noting that load factors (RPK/ASK) remain consistently high in Australian domestic aviation, fluctuating around 79% between 2000-2009 (Bureau of Infrastructure, Transport and Regional Economics). In the Brazilian domestic aviation market, the total load factor was 58% in 2000, reached a peak of 71% in 2006 and declined to 70% in 2010 (ANAC's annual reports).

[insert Figure 3 about here] (source: processed from BITRE and OAG data)

4.2 Gini and Theil

Concentration ratio shows that in Australia and Brazil seat capacity is concentrated (Figure 4). This is particularly the case in Australia where four airports, for most part of the period examined, account for more than three-quarters of total domestic seat capacity. There is clear evidence of increasing shares in the top 4 and capital cities over time, although this trend can be observed both before and after Australian deregulation in 1990. Brazilian deregulation in 1992 does not seem to have had much effect on the ratio, however, the concentration effect of 1998 deregulation can be seen.

For Australia, the Gini index shows a pattern of increasing concentration from 1990 onwards before stablising in the years following 1996 (Figure 5). Deregulation has forced the incumbent airlines to rationalise their networks, as well as to increase capacity on trunk routes in response to competition from the early entrants, whom have entered trunk routes (refer to Table 2). The combined effect has been growths in capacity especially among the major airports, increasing the Gini index. Brazilian airport capacity distribution is more volatile, especially in the decade following 2000; the value of the Gini dropped from the height of 0.79 (1999) to 0.71 (2005) before rapidly returning to 0.79 in 2008. This turbulence can be related to policy volatility, as detailed below:

- 2003-2004 (sharp decline in the Gini score and no capacity growth): The decline of the Gini score appears to be a result of re-regulation by the government, which implemented capacity control to limit route expansions, airline entry and fleet expansion of major airlines such as TAM and Varig. This is reflected in the slump in total domestic seat capacity in Brazil (Figure 3) during the same period. The Gini score decreased because the decline in capacity occurred among the largest airports.

- 2005-2007 (sharp increase in the Gini score and strong capacity growth): Slots were introduced at major airports following the establishment of the National Civil Aviation Agency (ANAC) in 2005. This had the effect of limiting rapid capacity growth in the largest airport, Congonhas, and it dispersed capacity to large yet predominantly international airports such as Galeão (Rio de Janeiro) and Guarulhos (São Paulo). As a result, the Gini score increased due to capacity growth occurring among large airports.
- 2008-2010 (stabilizing Gini score and strong capacity growth): At least two policy-induced changes appear to be responsible for the relative weakening of spatial concentration: (1) capacity control was relaxed and more competition was allowed, resulting in airlines such as Azul entering and operating out of under-utilized airports, such as Campinas (which serves São Paulo); and (2) after the two fatal accidents, long-distance flights (over 1,000 km) and connections were banned from Congonhas (São Paulo), which resulted in transit passengers been connected through other airports.

[insert Figure 4 about here] (source: processed from BITRE and OAG data)

[insert Figure 5 about here] (source: processed from BITRE and OAG data)

One interesting (and perhaps, in some sense, restrictive) characteristic about the Gini index is that the change in the score depends on the relative – and not absolute – position of the variables; the Gini will be most sensitive to a change in seat capacity occurring among the densest part of the distribution (Cowell 2011). Different from the Gini index, the Theil (equation 1) score changes by the same magnitude when the ratio of the seat shares is equal. The Gini and Theil (Figures 5 and 6, respectively) methods show similar results. Note that the Gini, in a discrete distribution, has a lower-upper bound of [0, (n-1)/n], whereas the Theil has [0, log(n)]. The considerable drop in concentration in 2003 in Brazil is due to re-regulation. The key difference in results between the Gini and Theil methods is that the Theil score for Australia shows signs of modest dispersion in the years following 2003, while the Gini score does not. The reason for the difference is that the Theil method places equal weight to two equal *ratios*, which means that a small change between small airports (airports with lower shares) are given the same weight as the same change between large airports as long as the ratios in the airport sizes are the same. There has been a disproportionate increase in the share of regional and secondary destinations with small airports in the post-2000 Australian domestic seat capacity growth linked to the sustained presence of the low-cost carriers (Koo *et al* 2010b). It is likely that the Theil is capturing some of these effects.

[insert Figure 6 about here] (source: processed from BITRE and OAG data)

More can be said about the spatial-structural variations in domestic aviation capacity using the generalized entropy indices in at least two interesting ways: (1) through experimentation with weights; and (2) through the analysis of sub-groups.

4.3 Generalized entropy indices

Entropy measures also allow analysts to change the weight (or the sensitivity parameter). By observing the effect of the changes in the weights, we can observe patterns that are otherwise difficult to encapsulate with other measurement tools. For instance, 'a' in equation (3) can be changed to help us gain a sense of where the concentration and dispersion (among airports of different sizes) have occurred. Specifically, as (equation 3) increases, the GE's sensitivity to the changes in 'top' (large airports) part of the distribution increases.

Australian GE(-1) shows consistent increases between 1986-2010 (Figure 7), while GE(2) shows, first an increase between 1986-1999, and then a decline between 2000-2006 (Figure 8). The GE(2) pattern over the entire period examined are similar to the Theil (GE(1)) albeit more amplified in its movements. The post-2000 patterns, in particular, are not recognized by the Gini, which remains relatively 'flat'. Putting these patterns together, we can conclude that Australian seat capacity has (1) increased in concentration in all parts of the distribution – small and large airports – until 1999, (2) began to disperse in the period following 1999 among large airports while increasing in concentration among smaller airports. The Australian results suggest a potential similarity to Europe's spatial evolution, whereby the density of air transport capacity (and traffic, as deduced from consistently high load factors) increases over time among smaller number of airports. This result is supported by the increasing level of concentration in the lower part of the distribution, while there is a concurrent dispersion among airports in the upper part of the distribution. Similarly, although lower in magnitude and volatility, it appears that the spatial evolution of Brazilian air transport capacity is governed by the 'top of the distribution'; that is, by variations among very large airports.

[insert Figure 7 about here] (source: processed from BITRE and OAG data)

[insert Figure 8 about here] (source: processed from BITRE and OAG data)

4.4 Decomposition

The results from the Theil decomposition method also show relevant structural variations. While the aggregated results do not reveal any major changes in the levels of concentration/dispersion, results that are divided by sub-groups do show considerable change in the level of concentration.

Generalized entropy decomposition is particularly useful for identifying the group that accounts for an inequality. Aviation policies, including airport slot controls, tariff restrictions, and traffic right allocations, are often applied discriminately across airports. In other words, some airports are subject to more restrictions than others, such as in the case for the major Brazilian airports, which are subject to greater capacity control and regulation than others. This means that it is important to observe how groups of airports contribute towards the overall level of spatial concentration and dispersion. The results in Figures 9 and 10 reveal that the airport hierarchy is cemented in Australia, which is made evident by the stability of the decomposed GE measurements over time. Between-group (BG) variation explains the majority of spatial volatility. The level of spatial concentration increased until 1996, then stabilized in the period between 1997 and 2001. In the decade following 2001, the shift towards dispersal appears to be due to the collapse of Ansett airlines and the proliferation of LCCs to second-tier airports.

[insert Figure 9 about here] (source: processed from BITRE and OAG data)

[insert Figure 10 about here] (source: processed from BITRE and OAG data)

The results for Brazil are different. First, within-group (WG) variation assumed a greater influence in Brazil than it did in Australia. This can be explained by the fact that the top five airports have undergone significant changes over time (policy-related volatility in seat capacity). Second, WG variation increased after 2005, contributing to the rapid concentration of air transport. WG variation increased in its influence from 27% to 33% between 2005 and 2010, while total concentration increased from 0.96 to 1.27. This increase in WG appears to be policy-related. WG variation increased due to the shift in capacity from Congonhas to other large airports such as Galeão and Guarulhos in response to several factors: (1) slots control; (2) regulatory change to introduce new competition in 2007, which opened up more entry into secondary airports that service large centers such as São Paulo; and (3) the banning of flights with distances over 1,000 km from Congonhas. The concerted outcome of these factors has been a dispersing capacity to other airports in the top five grouping.

Thus, in contrast to the Australian case, where WG variation is almost insignificant, the source of approximately one-third of the volatility of Brazilian domestic aviation capacity is the policy-induced reshuffling of capacity among the largest five airports. The remaining level of volatility can be accounted for by the growing gap between small and large airports. These results suggest that Brazilian domestic aviation is still undergoing major spatial restructuring in terms of its airport hierarchy. Deregulation has yet to fully consolidate an airport hierarchy, and this volatility is expected to continue as long as there is ongoing uncertainty in aviation policy dynamics. Aviation policy volatility appears to be related to specific changes in policy that pertain to the most significant domestic airport, Congonhas.

5. Conclusion

This paper found correlative evidence that policy volatility and the spatiality of air transport are closely linked. The Australian domestic aviation sector was deregulated in 1990 and since then, with the exception of the Ansett collapse in 2001, the sector has experienced ‘spatially stable’ growth. In contrast, rapid changes in the Brazilian aviation environment have partly resulted in the need for the government to re-intervene after deregulation. Such shifts in the aviation policy environment are not uncommon, with India having experienced similar uncertainty in air transport policy post-deregulation (Hooper, 1998). These uncertainties include volatility in policy dynamics, safety and infrastructure provision issues; many of these are can be associated with the development stage of a country.

Furthermore, the use of generalized entropy indices provided opportunities to explore structural variations in the spatial evolution of air transport capacity in ways that the Gini index could not. In particular, given the fact that aviation policies, including airport slot controls, tariff restrictions, and traffic right allocations, are route- and airport specific, tools to analytically trace how sub-groups of airports contribute towards the overall spatiality of domestic aviation were considered. Specifically, through the control of sensitivity parameter and decomposition, we have shown that the spatial evolution of Brazilian air transport capacity is governed by variations among very large airports, which are often subject to policy and regulatory intervention. Thus, policy volatility directly influences the spatiality of Brazilian air transport seat capacity. In contrast, the distributional pattern of Australian airports was relatively stable and characterised by gradual, and to an extent, predictable, changes. Furthermore, airport hierarchy appeared to have consolidated during the 25-year period in our analysis. The Australian evidence is that relative dispersion occurred among large airports whereas relative concentration occurred among smaller airports. This supports extant findings in the research literature that deregulation promotes denser aviation networks among a smaller number of airports.

We focused on correlative evidence indicating that policy volatility can be closely linked to spatial volatility. An evaluation of the appropriateness of different policy options is beyond this study. To do this, other factors must be considered; for instance, it may be desirable to protect national carriers from competition until a critical level of efficiency and competitive international networks have been established (Fayed and Westlake, 2002). Despite its effects on inconsistency and volatility of air services over the short-term, continuing policy and regulatory involvement may contribute towards securing consistent air services in the long run.

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Table1

Table 1 Key indicators: Australia and Brazil (source: compiled from World Economic Forum 2009).

	Australia	Brazil
Population (million)	20.6	191.3
GDP/Capita (US$)	36,225	9,703
Surface area (1,000 square km)	7,741	8,514
Quality of air transport infrastructure (world rank)	19th	101st
Airport density (airport per million people, world rank)	4th	78th
Departures per 1,000 population (world rank)	22nd	62nd
Government prioritization of travel and tourism industry (world rank)	19th	113th
Domestic ASK (world rank)	5th	6th

Table2

Table 2. Summary of post-deregulation domestic aviation environment: Australia and Brazil

	Australia	Brazil
Deregulation and re-regulation	In October 1990, the Australian government-enforced duopoly on inter-state domestic aviation terminated. Constraints were removed from control aircraft imports, the capacity allowed and supplied on trunk routes by airlines, the abolishment of the Independent Air Fares Committee in setting fare levels, and the entry/exit barriers to domestic trunk routes (BTCE 1991).	Regional services (excluding services between state capitals) were deregulated in 1992, followed by the deregulation of the main state capitals' domestic routes in 1998 (Williams, 2002). This was followed by re-regulation of the industry in 2003, including the granting of code-share rights between the two main carriers, as well as limits on frequency of air services and new aircraft import, in response to the airline financial crisis in 2002. All of this occurred before reverting to the pre-2003 deregulatory state in 2006 (Bettini and Oliveira, 2008).
Competition	<u>First wave of entry:</u> 1990-1993 (Compass I and Compass II entry and exit within one year of operation) <u>Duopoly:</u> 1994-1999 (Trans-Australian, acquired by Qantas in 1996, and Ansett). It is argued that despite the failure of two new entrants, their effect on competition perpetuated because it fostered greater competition between the two incumbents (Sinha 2001). <u>Second wave:</u> Impulse (1994-2000) and Virgin Blue (inaugurated in 2000) entered with a low-cost model. Impulse was absorbed by Qantas in 2000, while Virgin Blue was successful in cementing a position in the domestic aviation market, partly helped by the collapse of Ansett in 2001. <u>Third Wave:</u> three more carriers entered the market (OzJet, Jetstar and Tiger) of which Jetstar (in 2004, as a subsidiary of Qantas) and Tiger (in 2007) cemented positions in the domestic market alongside Qantas and Virgin Blue.	Transbrasil, Vasp and Varig exited the market, while Gol started operating following the deregulation. Gol bought the largest domestic airline, Varig, in 2007. The only incumbent airline to survive deregulation was TAM Airlines, which now dominates the domestic market in a duopoly with Gol/Varig. (In 2008, TAM and Gol/Varig accounted for approximately 92% of the domestic ASK.) The remaining airlines comprised several small- and medium-sized regional airlines as well as the two main low-cost carriers, Webjet and Azul.
Prices	Figure 1 illustrates the significant increase in levels of discounting over time (made evident by the decreasing discount ticket fare levels) and the widening gap between high and low fares. These are consistent with the post-deregulation effects observed in the U.S. (see, for	No comparative data exists in Brazil. However, it is known that the entry of new airlines (such as Gol, Webjet and Azul) has contributed to a decrease in airfares (Oliveira 2008). A study conducted by BNDES (2010) shows that the yield of Brazilian

	example, Borenstein and Rose, 1994). Forsyth (2001) has shown that Australian domestic airlines have improved in productivity during the 1990s and argued that the gains have been passed onto consumers, despite limited competition. While the same cannot be said for the years 2000-2010 due to data limitations, the combination of strong competition and the proliferation of low-cost carrier services (and the longevity of their presence in the market) may be indicative of improvements in airline efficiency.	airlines has decreased by nearly 50% since the major deregulation process in 1998 (from an average of R$0.48/pax-km, in 1997, to R$0.26/pax-km, in 2008), although it is still higher compared with the yield of other airlines around the world.
Airport policy	As part of a series of microeconomic reforms in many sectors of the economy, the Federal Airports Corporation (FAC) was established by the Australian federal government in 1988, administering 22 airports in Australia (Hooper et al., 2000). All major airports managed by the FAC were eventually privatized in 1997 and 1998; Sydney airport, in 2002 (Kain and Webb 2003). Pricing caps were removed on aeronautical charges in most airports in 2002, while pricing reforms also took place in the air traffic control and airspace management services provided by Airservices Australia, which involved shifts toward user-based and cost-reflective pricing strategies (Kain and Webb 2003).	The airports in Brazil are managed by Infraero, which controls 67 airports that handle approximately 95% of the passenger traffic, while CINDACTA (Center of Air Defense and Air Traffic Control) is responsible for air traffic management. Both services are centrally managed. In the case of Infraero, cross-subsidization between profitable and non-profitable airports is implemented. While there are wide variations in the efficiency across airports (Pacheco and Fernandes, 2003; Pacheco et al., 2006), it appears that two characteristics of the air transport system in Brazil -- its history of being underfunded and rigidly managed under a military control – are linked to the two major accidents that caused major disruptions between 2006 and 2008 (Costa et al., 2010; Lohmann and Trischler, 2012). Consequently, the civil aviation authority decentralized the traffic from the congested airports, particularly Congonhas, in addition to a work-to-rule tactic used by air traffic controllers who were blamed for the 2006 accident (Lohmann and Trischler, 2012).
Safety	Between 1999 and 2008, accidents (both fatal and non-fatal) fluctuated between 14.4 and 30.9 accidents per million departures, while the rate of fatal accidents ranged between zero and four per million departures. In this period, there were no occurrences of fatal accidents among high capacity regular public transport (defined as a capacity greater than 38 seats) or commercial air transport.	Contemporary Brazilian aviation is marred by two major accidents. In October 2006, a mid-air collision between a Gol Boeing and an executive jet killed all 154 passengers and crew on-board Gol Airlines B737. In July 2007, an A320 from TAM slipped off the Congonhas' airport runway in São Paulo and crashed into a building, killing 200 people. These resulted in 'crisis-level' cancellations and congestions between 2006-2008.

Figure1

Figure 1. Domestic airfares in Australia 1992 – 2010 (source: compiled from BITRE 2012)

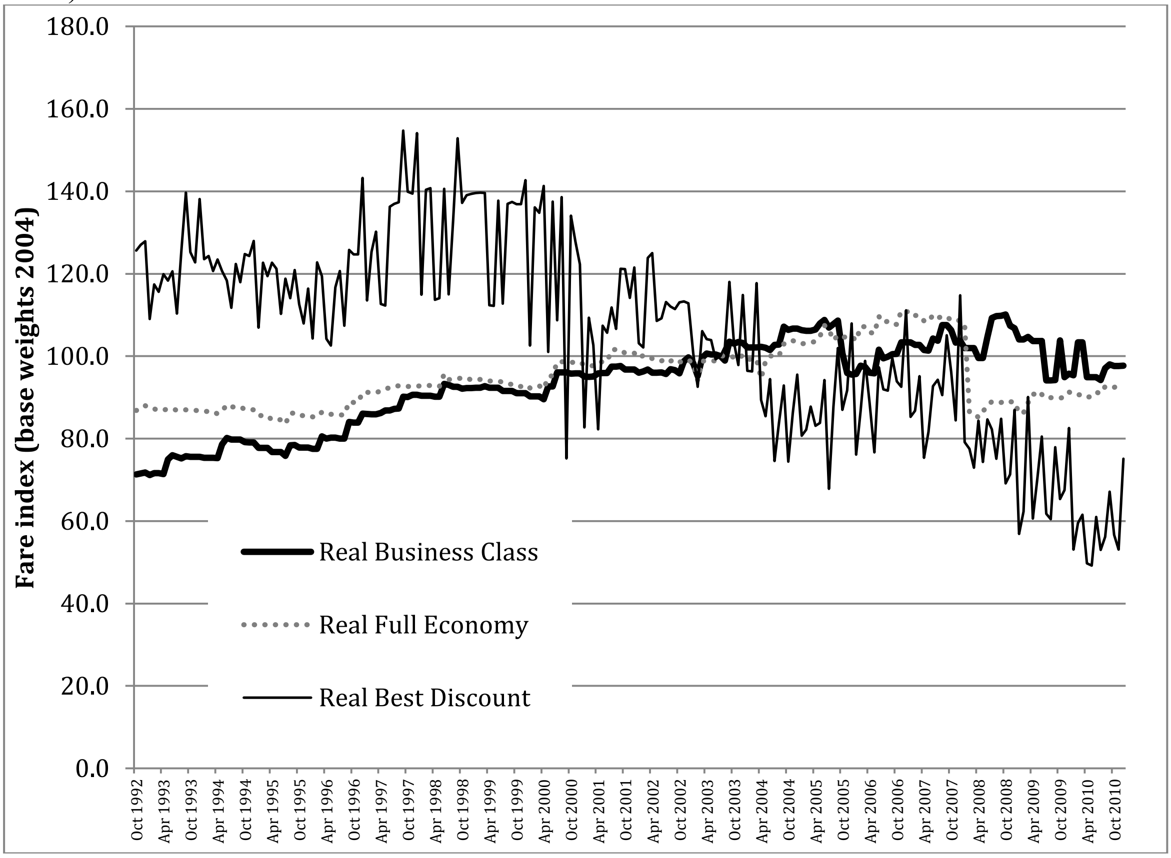

Figure2

Figure 2 Number of airports served with scheduled services (more than 10,000 seats per annum) (source: processed from BITRE and OAG data)

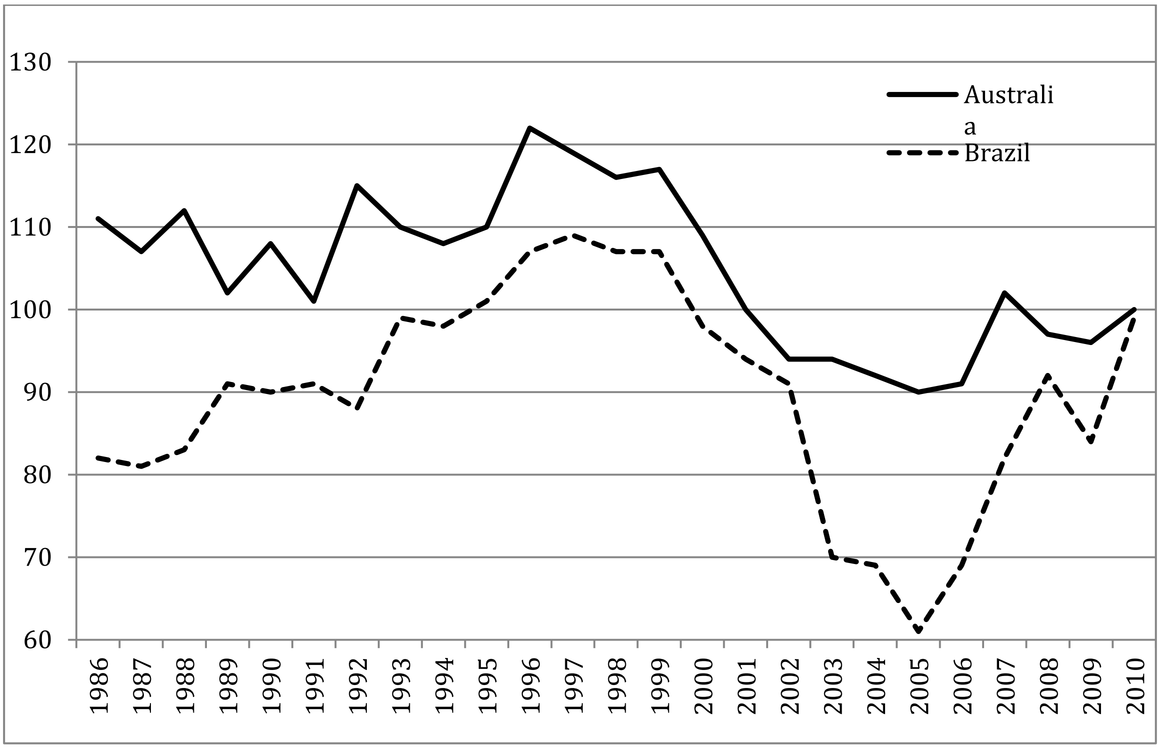

Figure3

Figure 3 Number of incoming seats over time (1986-2010) (source: processed from BITRE and OAG data)

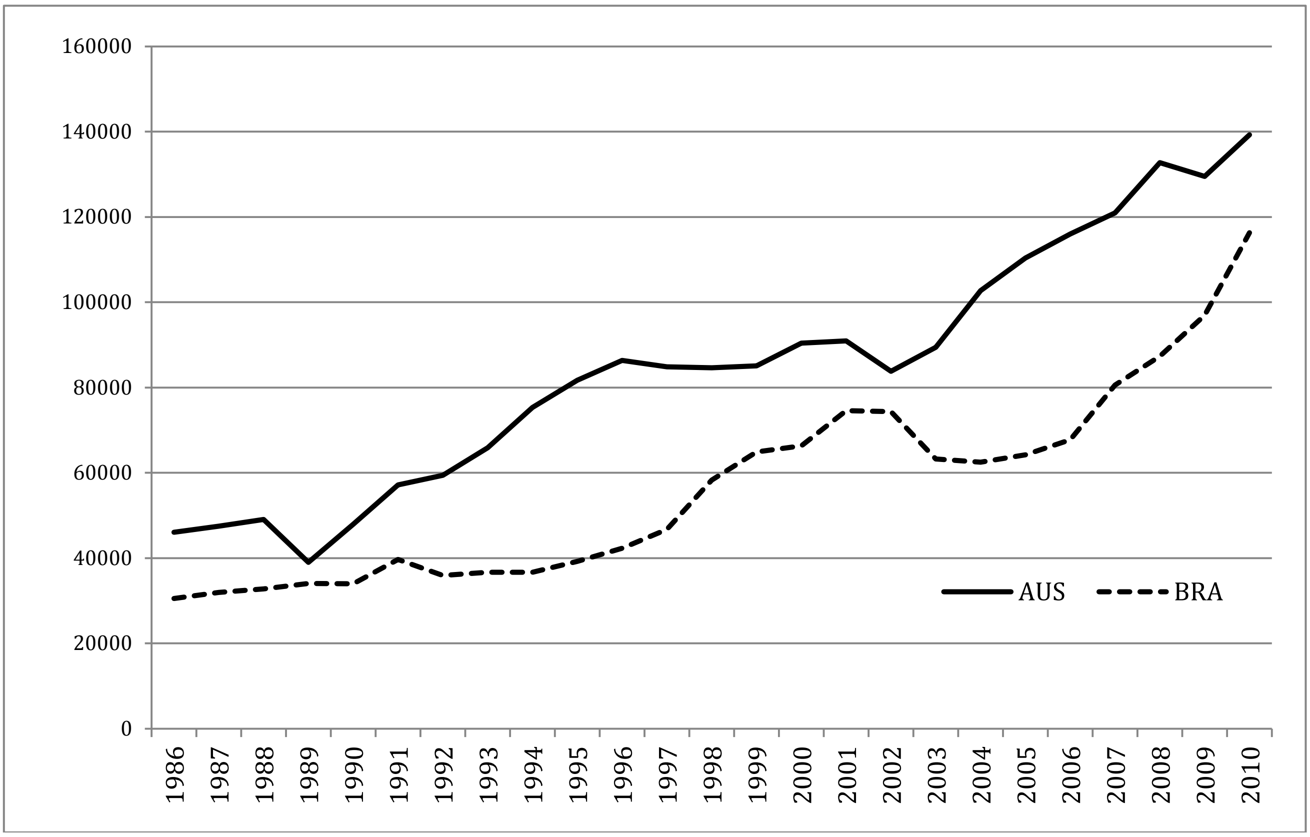

Figure4

Figure 4 Concentration ratio approach (1986-2010) (source: processed from BITRE and OAG data)

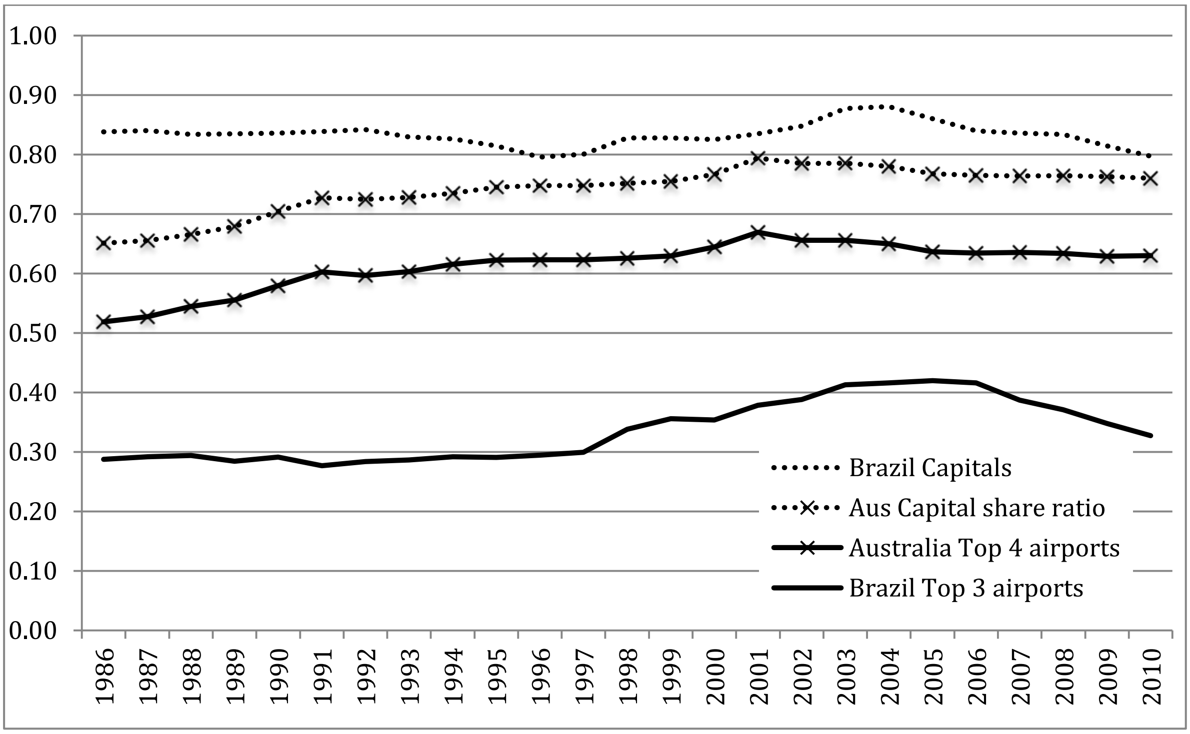

Figure5

Figure 5 Gini indices (1986-2010) (source: processed from BITRE and OAG data)

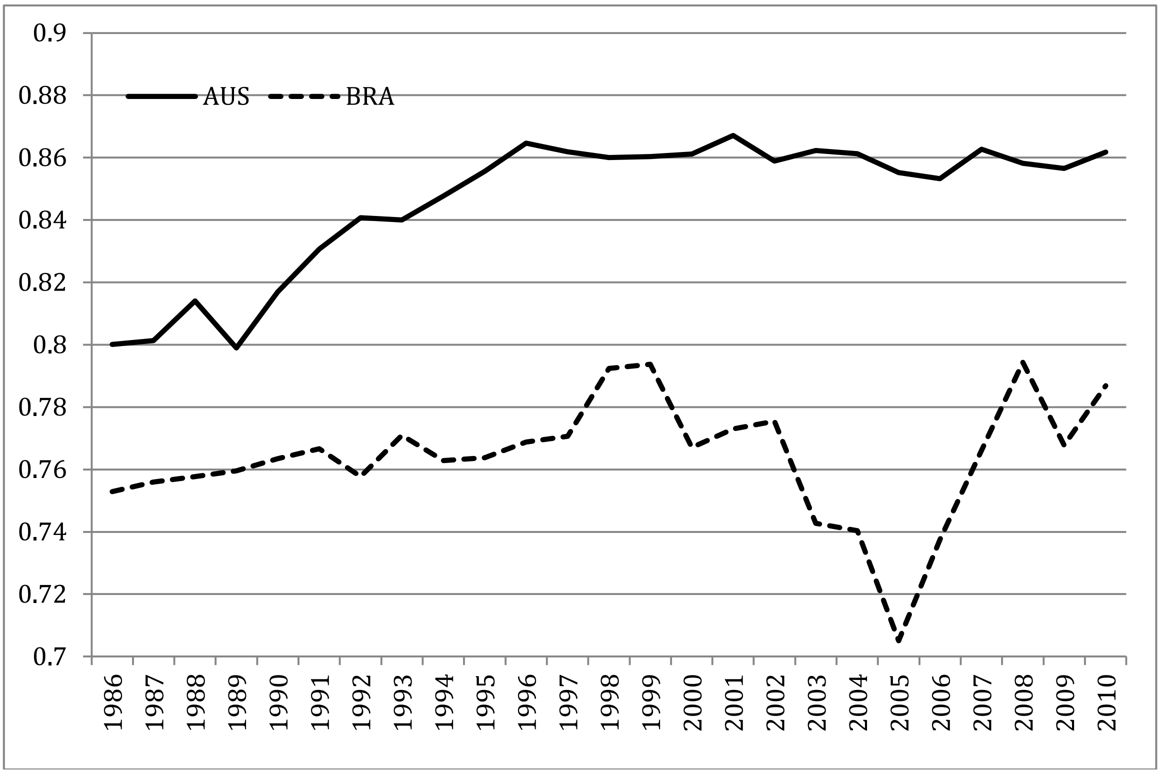

Figure6

Figure 6 Theil index (GE1) (source: processed from BITRE and OAG data)

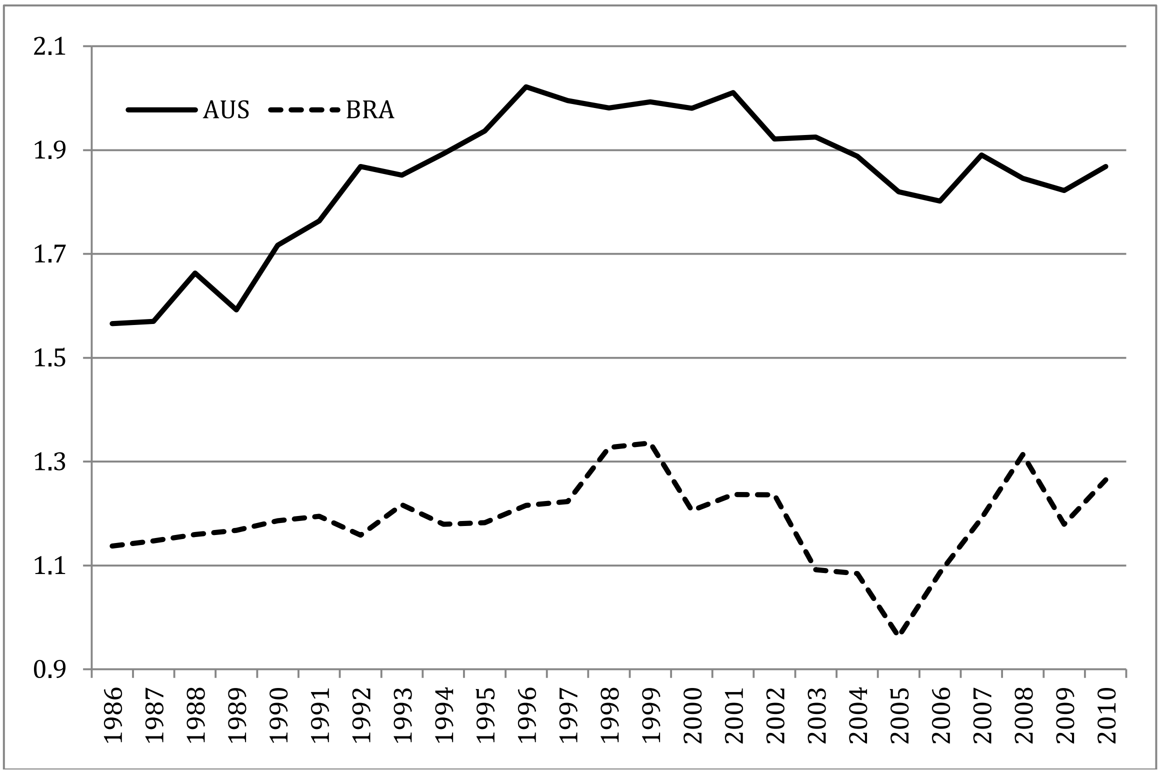

Figure7

Figure 7 Generalised entropy (GE -1)

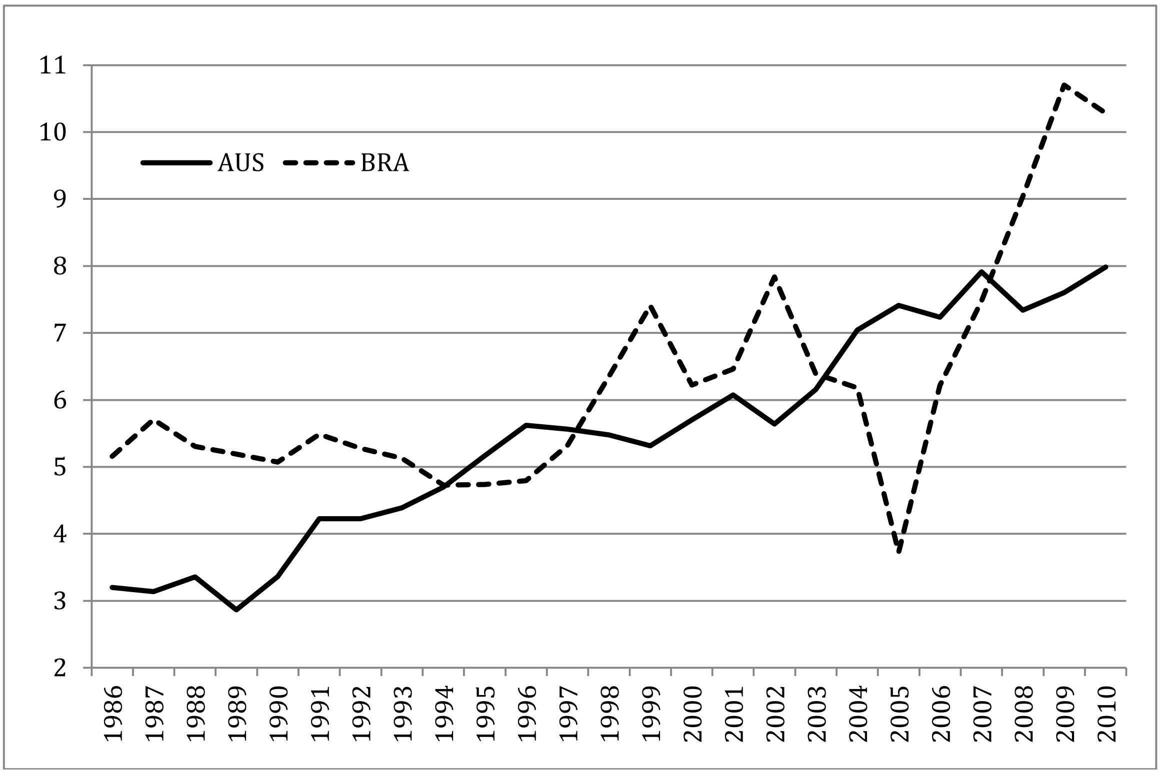

Figure8

Figure 8 Generalised entropy (GE 2)

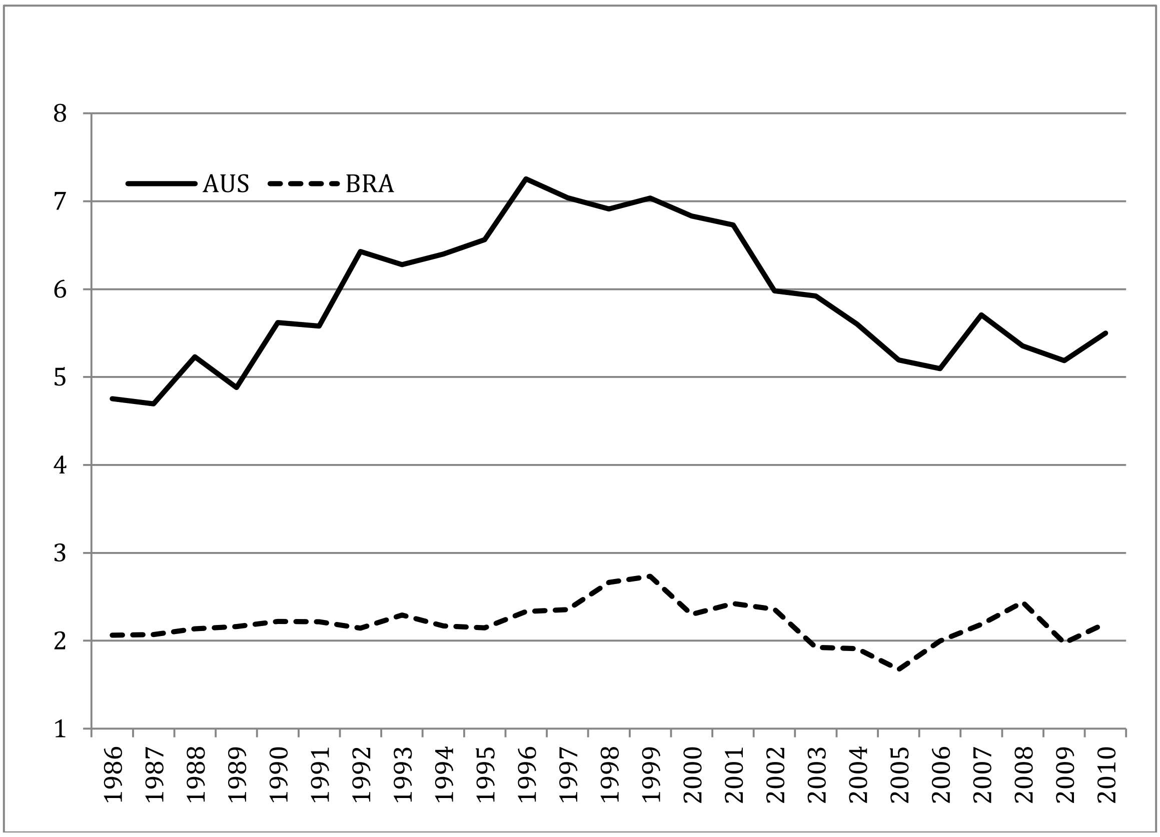

Figure9

Figure 9 Theil decomposition Australia

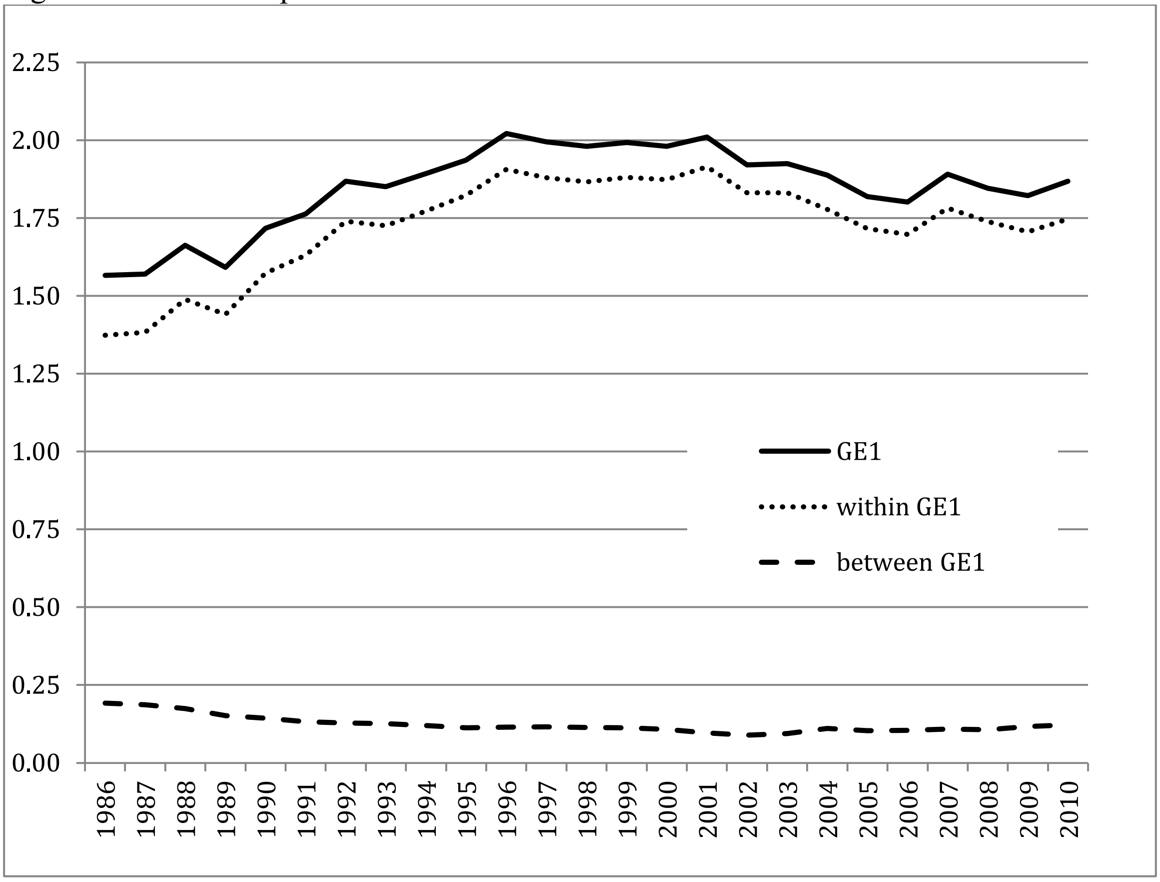

Figure10

Figure 10 Theil decomposition Brazil