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Public Service Obligation (PSO) Funding for Public Transport: Analysis of Performance Measurement

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Summary

Expenditure and Overview

- PSO subvention payments subsidise the provision of public transport in Ireland. The three main PSO providers are Iarnród Éireann, Dublin Bus, and Bus Éireann.
- Expenditure on PSO subvention **increased by 12% per year on average over the last three years to a total of €285 million** in 2018. This follows reductions in PSO funding from of a high of €308.6 million in 2008 to €209.7 million in 2015.
- On the output side, for the three main PSO operators, **passenger journey numbers and vehicle kilometres have increased by 12.3% and 11.9% respectively** in the three years 2015-17.

Analysis of Performance Monitoring

- The NTA manage an **obligation based** performance monitoring framework which focuses on **operational performance.** Based on data availability this paper reviews three central areas of performance measurement:

Reliability	The extent to which scheduled services operate
Punctuality	The extent to which services are on time
Service Quality	A measurement of service quality through customers experience

The following key points are of note:

- **Steps have been taken recently to improve the measurement of performance on bus services** through the use of automated vehicle location (AVL) data, although currently this is in use only for low frequency services (since mid-2017).
- Available data indicates that bus services in 2017 were operating **at or above target for reliability but that there were lower levels of performance for punctuality on low frequency services**.
- The current **definition used in punctuality measurement is noted as being** between -1 to +6 minutes of scheduled time for bus services and within 10 minutes for most rail services.
- Data on customer satisfaction is now being collected by the NTA rather than by operators for bus services; 2017 initial data suggests some performance areas of consideration.
- Current monitoring includes analysis **of scheme output**s (operational efficiency and effectiveness). Evaluation of broader **social and environmental impacts** (such as accessibility and 'emissions saved' estimations) require additional data gathering and use of specific modelling tools.

Next Steps and Areas for Consideration

- While cost and efficiency analysis is central to Public Expenditure Management, so too is analysis of provision output and impacts. There are a number of areas for consideration for DTTaS and the NTA to ensure that sufficient information is collected and provided to understand both scheme performance and the quality of the services being operated:
  - The trend towards NTA management of monitoring tasks and **roll out of more advanced methods to capture data centrally** on performance should be continued and standardised across all service types and operators where possible/relevant.
  - **Consideration could be given to broader scheme performance reporting in conjunction with the performance monitoring framework that is in place**. This could include wider measures of performance such as **social and environmental impacts**, and standardised reporting on **efficiency indicators** (e.g. cost per km or cost per passenger).

1. Introduction

The provision of effective and efficient public transport is a critical element in a well-functioning transport system. As well as the economic benefits associated with more efficient transportation, the positive effects of public transport also extend to social and environmental benefits, such as regional and social inclusion, higher air quality, increased health, and reduced greenhouse gas emissions and congestion. The overarching goal of public subvention of public transport is to realise the positive effects of public transport beyond the level which would be permitted though solely market based allocation. This paper analyses the main stream of funding provided to public transport services in Ireland, with a focus on performance monitoring. These services are funded through public service obligation (PSO) payments with the objective of ensuring that services which are financially unviable but socially beneficial may be provided.

This paper has been published as part of the 2018 Spending Review. The Spending Review process is a periodic, systematic evaluation of Government expenditure, focused on examining spending in relation to sustainability, efficiency, effectiveness and impact. This work builds on a previous paper[1], published as part of Spending Review 2017, which provided an analysis of the scheme in relation to trends analysis and efficiency indicators, across operators and over time. The primary objective of this paper is to provide an overview analysis of the PSO scheme for public transport, in relation to effectiveness and performance monitoring. The structure of this paper is as follows:

- Section two provides a brief overview of expenditure and usage trends and scheme rationale.
- Section three provides an overview of monitoring frameworks for public transport performance.
- Section four analyses both the current performance evaluation procedures which are in place for public transport, and the available performance data, focusing on three of the main areas.
- Section five considers further monitoring areas for consideration under PSO aims, and
- Section six concludes.

[1] O'Callaghan, D. (2017) Public Service Obligation (PSO) Funding for Public Transport

2. Context

The Public Service Obligation scheme for public transport is the scheme through which the operating costs of providing those socially necessary but financially unviable transport services in Ireland are subsidised by the State. The PSO subsidy is Exchequer funded, paid through the Department of Transport, Tourism and Sport (DTTaS) to the National Transport Authority (NTA), who negotiate and manage the contracts with the transport operators. Three main operators account for around 95% of the scheme expenditure and provide the large bulk of PSO services[2]; these are Iarnród Éireann/Irish Rail (IÉ), Bus Éireann (BÉ) and Dublin Bus (DB). Iarnród Éireann operate rail travel in Ireland, such as the intercity services, commuter and regional services and the DART service. Dublin Bus operate scheduled urban bus services in the greater Dublin area, and Bus Éireann operate a country-wide bus service, including Commuter bus services into Dublin, regional services, city services including in Cork, Galway and Limerick, and school transport services, among others. In addition a number of rural "Local Link" bus services are funded by the NTA through the PSO subsidy. The PSO subsidy represents one of multiple operator revenue streams; other sources include State funding through the Free Travel Scheme[3] and school transport funding provided to Bus Éireann by the Department of Education and Skills – as well as fare revenue and independent sources such as advertising revenue.

With regard to PSO expenditure[4], the last three years have seen renewed growth with an average increase of 12% per year to €285m in 2018, **currently at its highest level in nominal terms with the exception of the period between 2007 and 2009**. Expenditure on public transport provision has varied considerably in recent years. The dominant trend is characterised by a steady increase in expenditure up to 2008, followed by a sharp decline after the crisis up to 2015. The cyclical nature of the spending can be considered both within the context of overall reductions in public expenditure after 2008, and the positive link between public transport demand and economic activity i.e. as economic activity declined over the crisis period, fewer individuals were commuting for work as employment levels fell and fewer shoppers, tourists and recreational travellers availed of services as general demand fell. These effects are illustrated in Figure 2 below.

Passenger numbers on the three main operators experienced a large drop off in the wake of the economic crisis but since 2013 there has been renewed growth with an average yearly increase of 4.6% to 213 million. As mentioned above, one of the chief drivers of public transport demand is economic activity, explaining the general trajectories. It should also be noted that during the post-crisis period the portion of operator funding

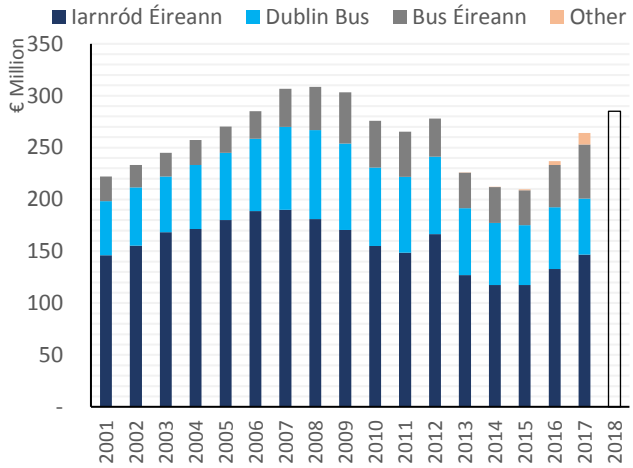
[2] A number of smaller bus operators provide services on specific routes under the PSO scheme. As part of the most recent direct reward renewal, under bus market opening, the NTA included a provision for 10% of bus services to be subject to competitive tendering process.

[3] The Free Travel Scheme is administered and funded by D/EASP. Funding to the three main operators under this scheme amounted to €47.8m in 2017. The total allocation for the Free Travel Scheme in 2018 is €90 million (CIE and non-CIE operators). While the level of funding was previously frozen at around €75 million from 2012. Further analysis of the scheme is outside the scope of this analysis.

[4] Excluding the Rural Transport Programme (RTP), and inclusive of non CIE operators. RTS amounted to almost €15m in 2017.

raised through customer fare generation has increased, reflecting a shift in the balance between subsidisation and fare generation to fund services. Total annual revenue across the three operators is now back to almost 2006 levels at €780m. Further detail on this is provided in last year's Spending Review analysis.

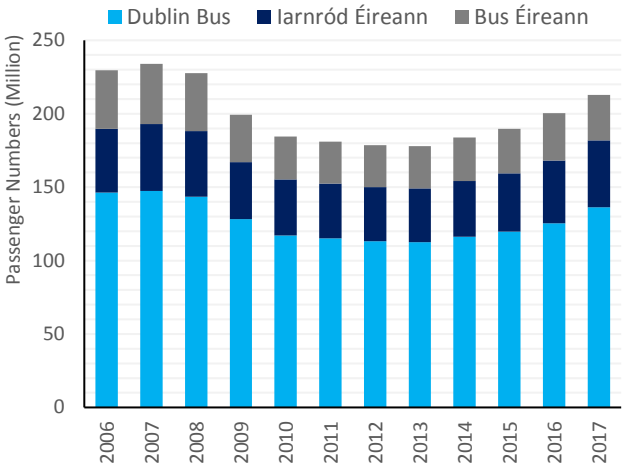
Figure 1: PSO Payments (2001-17)[5]



Source: DPER

Note: Final 2018 breakdown determined at year-end

Figure 2: Main Operator Passenger Numbers (2006-17)



Source: NTA

As laid out in last year's paper, the **rationale behind subsidising public transport is to provide transport services which are socially beneficial but financially unviable, availing of the social and economic benefits which accrue from a greater level of public transport provision than would be viable with services funded solely by fare revenue**. These benefits can be broken down into three groups:

i. Reducing the negative externalities of private car use, such as congestion and pollution;
ii. Availing of system economies of scale which come from having high rates of usage; and
iii. Promoting social inclusion and equity goals, in particular to marginalised and disadvantaged groups.

As the underpinning rationale describes the basic objectives of the scheme, understanding how well the scheme is performing against these goals is of key interest. Exploring potential avenues of generating evidence for these will be dealt with later in the paper.

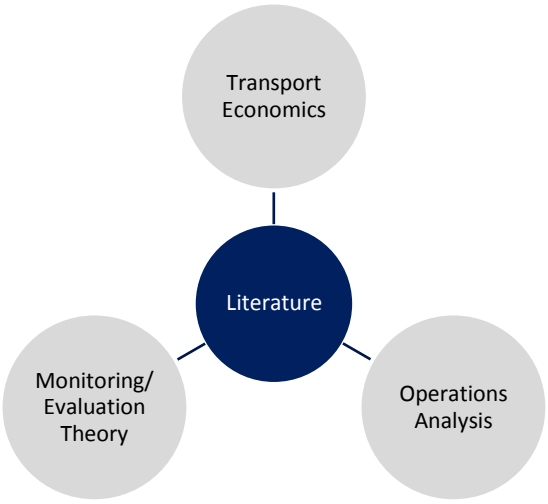
[5] Excluding the Rural Transport Programme

3. Overview of Monitoring Frameworks for Public Transportation

The purpose of this section is to provide a brief description of monitoring frameworks in the context of public transportation evaluation, and to briefly review some of the common approaches to public transport monitoring both in the academic literature, and in practice.

The success of a public investment is typically determined by whether it has met its intended goals, and how efficiently it has done so, whereas private investment, in contrast, is typically measured through financial performance (i.e. profit levels). Evaluating performance within the public sector means observing how well it is working, or collecting and analysing data which will provide us with insights and answers to these questions, through a particular framework. Implementing and using monitoring frameworks for public programmes is an important process for several reasons, such as facilitating programme evaluation, understanding on-going performance levels and understanding the impacts of changing context.

Figure 3: Key Areas of PT Monitoring Literature



3.1 Overview of Literature

Much of the theoretical discourse on public transport monitoring and evaluation has taken place within the academic fields of transport economics, operations analysis, and monitoring and evaluation theory. Each of these areas has been developed from a particular perspective, guiding the approach they recommend.

Transport Economics

The work of transport economists in relation to monitoring generally considers the use of resources in return for private or social benefits, measured in monetary terms, through consumer surplus. In this regard **transport economics has tended to emphasise efficiency issues**. Evaluation and monitoring in the main stream of transport economics is built around the traditional welfarist, cost-benefit framework - quantifying inputs and outputs, and comparing them. As such, the recommended performance indicators arising from this focus tend to be around indicators such as the monetary cost per journey, the monetary cost per passenger kilometre, cost per vehicle service hour etc. These indicators are aimed at understanding different aspects of the fundamental input-output relationship. The main strengths of this approach is its comparative ease of implementation and its tangible and readily quantifiable metrics; the main shortcoming is that the methodology typically excludes performance analysis of other elements, such as accessibility, modal share or sustainability.

Operations Analysis

Operations Analysis, in contrast, is based on the systematic identification and examination of the elements and relationships which make up the local system, and unlike Transport Economics, does not develop its analysis within an economic or social framework. **In Operations Analysis, system performance is typically evaluated in terms of effectiveness** – how well the system is delivering on its intended objectives. This approach, who's practitioners commonly come from backgrounds in civil engineering or transport planning, places an emphasis on lower-level operational indicators, such as the vehicle occupancy rate, the headway (the average amount of time between two vehicle departures at a given stop) and correspondence of actual services to scheduled services. The main strength of an Operations Analysis approach is that it is not dependent on assumptions or complex theory to disentangle results. Given that it is essentially a highly developed system of transport benchmarking, it is also highly versatile and can used to analyse various parts of a public transport programme. It is also an effective method of evaluating the performance in relation to social outcomes.

Monitoring and Evaluation Theory

Monitoring and evaluation theory is a broad area which covers a wide number of practices and aspects. Monitoring is, in essence, collecting data on variables which are of interest. The key questions relating to monitoring may be: how much should be monitored, what should be monitored, and how to develop and choose indicators. Monitoring theory deals with questions such as categorising different types of variables which may be collected, and how best they can be managed given their (i) resolution (how frequently a sample is taken - every week, month, year etc.), (ii) latency (time before the information can affect policy) and (iii) diversity (types of information being collected (euros, kilometres, passengers, etc.)). Finally, the theory of change is a central area in monitoring and evaluation theory; this is a conceptual exercise where a programme planner defines programme objectives, and systematically maps out how those objectives will be achieved. A theory of change demonstrates the pathway of how to get from here to there (i.e. what is needed for goals to

Box 1: Essential Criteria for Performance Indicators

On the selection of Performance Indicators, Diana and Daraio (2010) propose six essential criteria:

1. Indicators should be strictly related to the objective of the evaluation exercise

2. The data needed to collect them should be available

3. Analytical procedures to compute them should fit the data (for example, adequately treating non-metric or qualitative information)

4. They should consider elements that can be directly or indirectly influenced by the subject on which the evaluation is carried (public transport operator, transit agency, policy maker), so that they are effectively responsive to those actions that can be taken by the subject itself

5. They should be robust, so that they can be used at different points in time to monitor trends, but also across different services to draw comparisons.

6. They should have some intuitive meaning and they should be easy to interpret; in particular they should be unambiguous, so that their variation in a given direction can be safely considered as good or bad.

be achieved). It requires underlying assumptions to be detailed out in a way that they can be tested and measured and puts the emphasis first on what the organization wants to achieve rather than on what the organization is doing. In short developing a theory of change forces the analyst to engage in the *how* of a programme, as opposed to the *what*.

3.2 Overview of International Practice

Comparing international practice of public transport monitoring is a challenging task for several reasons. Foremost is the lack of published material by operators and regulators, which can be confidential due to the commercial sensitivity of the information. Secondly, the institutional bodies who may be undertaking such monitoring can be difficult to discern. Thirdly, transport systems necessarily differ in terms of their makeup and objectives across different regions depending on policy, infrastructure, spatial issues, and market dynamics etc. making clear comparisons across countries difficult. Finally, language presents a major barrier to in depth research across a variety of countries. With those caveats in mind, the remainder of this section outlines some relevant information in relation to international practice, gathered from available information.

Singapore

Singapore, which has a population of 5.1m, has both rail and bus networks carrying an average of 5.4m passengers per day. The Public Transportation Council (PTC) which is responsible for delivering performance monitoring publishes internal monthly reports, and quarterly and annual public reports. Data gathering methods are based on smartcard feedback, trainload and revenue monitoring, customer surveys, automated incident tracking systems and cross validation between sources. Based on London's Quality Incentive Contract, Singapore's bus performance model imposes penalties or provides incentives to operators for increases/reductions of Excess Wait Time (EWT) beyond a certain route-specific baseline. Performance and standard measurements employed include tracking of reliability – headway adherence, bus breakdown and actual versus scheduled trips operated on each route, passenger loading and peak hour performance, accident rate, and modal integration. Availability and accessibility are reviewed both spatially (service coverage) and temporally (service hours/ average headways).

Table 1: Singapore Monitoring Areas

Category	Reported Areas Monitored
Productivity	Occupancy rate • Off peak and peak hour loading
Quality	Reliability • Headway adherence • Breakdown rate • Actual vs scheduled trips operated on each route
	Safety • Accident rate
	Availability • Service coverage (node distance to home/employment) • Temporal – maximum headways/service hours
	Integration • Integration between bus/rail

Source: GIZ, *Measuring Public Transport Performance*

Sydney

The public transport system of Sydney, Australia which handles 260 million passengers annually, bases its quality management on internal processes, financial performance, and customer satisfaction. The main monitoring body is the municipal New South Wales audit office, which produces internal weekly and monthly reports, and annual reports to State government. Complimentary reports which carry out in depth evaluations of areas such as punctuality are also produced periodically. Performance monitoring cover areas of reliability, mechanical failures, passenger safety, comfort, fleet age, staff training, and travel information.

Table 2: Sydney Monitoring Areas

Category	Reported Areas Monitored
Financial	Occupancy rate • Off peak and peak hour loading
Efficiency	• Average cost per journey • Cost per vehicle km
Quality	Reliability • Punctuality (by train line, peak/off-peak)
	Comfort • Fleet age • Vehicle load rates • Accident rate • Passenger information availability
	Availability • Disabled access

Sources: GIZ, *Ibid* & Audit Office of NSW *Report on Transport 2017*

London

London's public transport system, which is managed by the public authority, Transport for London (TfL), completed a daily average of 9.6m journeys in 2016. TfL publish quarterly and annual public reports which provide an in depth review of broad targets, financial and operational performance. Reports include detail on finance, operational trends, quality and service usage, on train, metro and bus transport. Punctuality is measured in Excess Waiting Time (EWT) which estimates delays multiplied by the number of people affected. Quality incentive provisions were introduced in 2001, which have delivered significant improvements in service quality and passenger numbers[6]; these offer both rewards and penalties to operators according to performance standards. Reliability incentives offer +10% to -15% adjustment in annual payment[7]. Operators are entitled to an automatic two year contract extension if they meet the 'reliability threshold' – a predefined standard of reliability performance.

[6] See Transport for London (2016)

[7] PSO contracts employ a potential 10% deduction for performance incentiviastion.

Table 3: London Monitoring Areas

Category	Reported Areas Monitored
Financial Trends	• Total income (composition & trend) • Total capital expenditure (composition & trend) • Operating costs (operator & trend) • Total costs (composition & trend)
Borrowing & cash	• Nominal value of borrowing (long/short term & trend) • Financing costs/total income • Cash balances
Operational trends	• Passenger journeys (operator & trend) • Yield per passenger journey • Operating cost per journey • Total cost per journey before financing
Quality/Reliability	• Underground Lost customer hours (Reason & trend) • Average bus excess wait time (trend) • Scheduled km operated %
Customer trends	• Reported satisfaction (operator & trend) • Recorded crime rate • Customer complaints • Website and social media engagement

Source: Transport for London Quarterly Performance Reports

Table 4 below is based on work produced by Steer Davies Gleave (SDG), analysing the effect of EU regulation 1370/2007 on public transport services. SDG attempted to formulate a set of performance indicators for public transport services in each EU state, and engaged with national transport authorities. The below table 4 serves as an indicator of the types of data which are actively being collected at the national level among EU member-states, and the types of performance monitoring and reporting which is possible.

Table 4: Transport Performance Indicators Reported based on Data Availability at the National Level for Europe

Performance Indicator	Austria/Vienna	Belgium	Bulgaria/Sofia	Croatia	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands*	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden
Total number of passengers transported																											
Total passenger km																											
Total vehicle km																											
Passenger-kilometres per vehicle-km																											
Vehicle km per staff member																											
Fare revenue per vehicle-km (€)																											
Operating cost per veh-km (€)																											
Proportion of total operating costs covered by fares																											
Proportion of total operating costs covered by subsidy																											
Operating speed (km/h)																											
Passenger satisfaction																											

Source: Steer Davies Gleave (2016)

* Lack of Netherlands data is due to the municipal-level management of public transport monitoring

Punctuality Performance Measurement

Internationally, the measurement of punctuality performance varies considerably, both in approach and parameter selection. The differences arise from three key variables: how data is collected, the indicator that is used, and how 'punctuality' is defined. Internationally there is a move toward automated forms of data collection based on GPS (AVL), a more robust and deeper source of data; the alternative is manual noting of the time vehicles commence or finish an operation, or surveying methods. Indicator type used varies internationally, and is partly dependant on data collection form; these are discussed in detail in Appendix 4. Finally the definition of punctuality is a question of the scale of the band around absolute punctuality – this may be a permitted amount of excess wait time or permitted time beyond a scheduled departure time (given as *i* in the table below) – depending on the type of indicator in use. A wider scale means more operations will be considered punctual without any change in actual performance.

Table 5: 2010 Comparison of Urban Bus Operators Service Punctuality Indicators

Bus Operator	Indicator Type	Definition of Punctuality (i + minutes)
Barcelona TMB	Wait Assessment.	i-1 to i+3
Brussels STIB	Wait Assessment.	i to i+2
Dublin Bus	None. Measures on time terminal departures.	NA
Los Angeles LACMTA	None. Measures route time performance.	NA
Lisbon Carris	Service regularity.	i-20% to i+20%
London Buses	Excess Wait Time.	EWT: 0.5 - 2
Milan ATM	Wait Assessment.	i-3 to i+3
Montreal STM	None, measures en route on time performance	NA
New York NYCT	Wait Assessment.	i to i+3 (peak), i to i+5 (off-peak)
Paris RATP	Wait Assessment.	i to i+2
Singapore SMRT	Wait Assessment.	i-5 to i+5
Sydney Buses	None, measures on time terminal departures.	NA
Vancouver CMBC	Wait Assessment / Service regularity.	i-2 to i+4, i-20% to i+20%

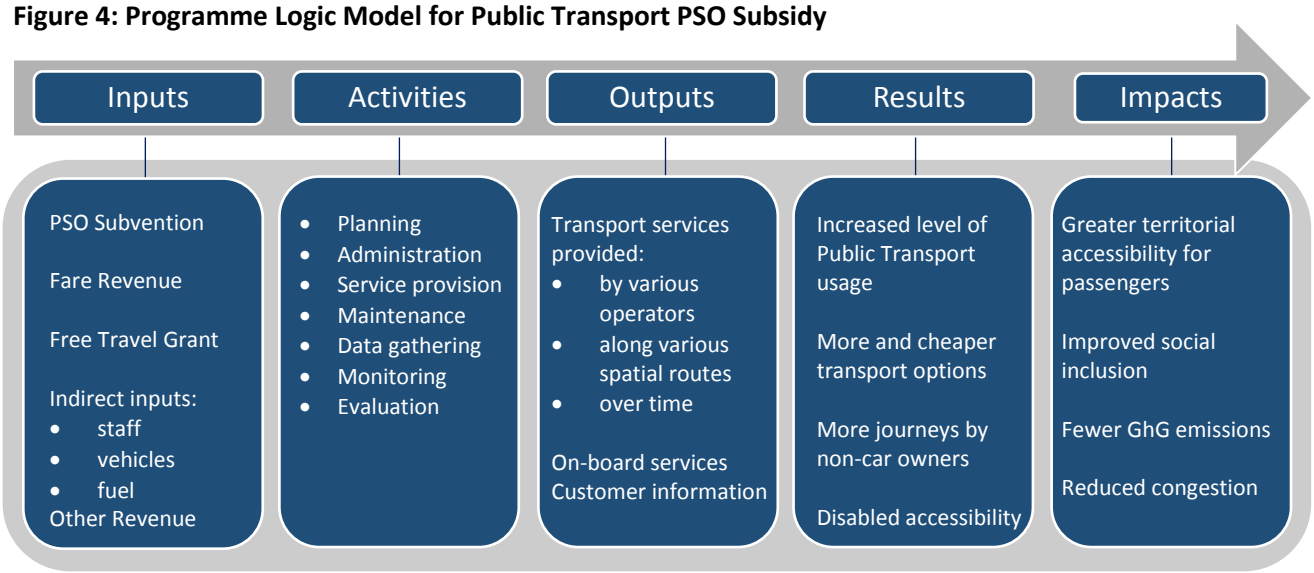
Source: Trompet, M. (2010)

The above table illustrates at stop punctuality performance methodologies for bus operators involved in the International Bus Benchmarking Group in 2010. "i" refers to the scheduled time of departure from a given stop. As Dublin Bus has only introduced AVL data collection in mid-2017 it is considered as having no punctuality performance monitoring in this study. Indicator types and definitions are discussed more in depth in Appendix 4. Because punctuality performance is highly technical and universal, a deeper analysis here was possible; other areas of performance with greater variation prohibit easy cross comparison for reasons discussed in the opening of this subsection, 3.2.

3.3 Programme Logic Model

A useful tool for both programme planning and programme evaluation is the explicit conceptualisation of programme logic and components. One approach to this is the Programme Logic Model (PLM). PLM is a framework which analyses a programme in terms of chronological events, represented as a causal chain beginning with inputs. As shown in Figure 4, PSO scheme elements can be broken down into *Inputs*, *Activities*, *Outputs*, *Results* and *Impacts*.

Figure 4: Programme Logic Model for Public Transport PSO Subsidy



3.4 Summary

Based on a review of the literature and practice, it is found that, while there is overlap in international approaches to public transport monitoring, there is no universal set of indicators which can capture all avenues of PT programme performance. Instead, indicators must be chosen to fit both the specific programme and the context within which the services are provided. What follows is a short analysis of the categories, or groupings frequently used to organise sets of indicators; the most frequently used metrics and indicators in PT monitoring are listed.

Publications on PT performance organise indicators and data into categories in order to assist structure and ease of understanding and digesting the material. The traditional organisation of performance indicators is into the categories of effectiveness and efficiency, however this is not universal. In respect to the most common effectiveness/efficiency paradigm, efficiency indicators analyse levels of output (e.g. passenger journeys/vehicle kilometres) in relation to input (e.g. subsidy/total revenue). Effectiveness indicators analyse how well the programme is achieving an objective, for example reducing congestion or providing access to low-cost transport. Other publications arrange reporting according to different category paradigms, for example context/supply/demand/financial. Context indicators provide background on contributing elements which may affect the scheme, such as population density, modal share, or rail network length. Supply and

demand each capture elements of effectiveness and efficiency, orientated to provision and consumption of services respectively. Financial indicators may refer to cost indicators, such as labour cost per journey – or metrics such as total expenditure or total revenue. Differences in terminology, rather than differences in meaning can often give the false perception of conceptually different frameworks; productivity, efficiency and supply categories for example will often contain the same types of indicators. Increasingly, publications employ a 'quality' category which considers the qualitative aspects of service delivery, such as comfort or punctuality/reliability. We find that the most useful and straightforward type of categorisation is the *effectiveness and efficiency* paradigm along with a *quality* aspect. As pointed out by Allen and Di Cesare (1976), these three groupings roughly correspond to the specific interests of the three main stakeholders in PT provision: funding bodies who sponsor the programme in order to realise broad objectives (effectiveness), operators concerned with efficiency and proper system functioning (efficiency), and customers concerned with quality and experience of public services (quality).

Table 6: Commonly used/cited Public Transport Monitoring Indicators

	Common Data Captured →	**Common Indicators**
Efficiency	Examples: • Total Expenditure (labour, fuel, admin etc.) • Total Revenue (fare, subsidy, fine etc.) • Vehicle km travelled • Passenger km travelled • Number of passenger journeys • Staff Numbers • Vehicle fleet size	Examples: • Subsidy/Cost per journey/passenger km • Average fare per journey/passenger km • Distance travelled per employment hour • Fuel consumption per km • Average seat occupancy rate • Daily passenger journeys per vehicle/per hour of vehicle operation
Effectiveness (goals contingent)	Examples: • Route and network information • Travel survey– mode use/distance/profile • Vehicle emissions and speeds • Spatial information on population/economy • Node locations – routes and PT types served • Fare price information	Examples: • Measures of integration between routes • PSO journeys/km as a % of total travelled • Estimated emissions saved (behavioural) • Estimated impact on air quality/ noise pollution • Accessibility assessments – average distance to node etc. • Accessibility measures by demographic • Catchment area/Percent of people or jobs served
Quality	Examples: • Passenger satisfaction surveys • Average vehicle speed • Scheduled/actual vehicle departure time • Services/KM operated • Number/types of accidents • Customer information availability • Frequency rates at different stops • Vehicle age • Performance across various dimensions for competing modes • Frequency & operating hours	Examples: • Number & cause of passenger complaints • Average journey satisfaction score • Number of accidents • Average excess wait time • % services punctual (at stop – AVL info) • % of services/KM operated • Relative mode performance indicator • % of the day services are in operation • Urban/rural travel time comparison

Sources: Various

4. Analysis of Performance Monitoring Framework and Performance Data

This section provides an analysis of PSO performance monitoring and historical data, focusing on operational effectiveness and service delivery. We first outline the existing performance monitoring framework for PSO services; secondly a high level overview of output and efficiency indicators is provided for context. Thirdly, given available data, an analysis of operational performance is provided. We focus on measurement indicators relating to the three primary areas of effectiveness:

The analysis which follows is high-level and should be interpreted as such. The areas under review are highly complex and subject to a wide range of influencing factors; a detailed investigation from an operational perspective would require a finer analysis by route and specific time frames as well as an analysis of determining factors.

4.1 PSO Contracts and Monitoring Framework

PSO operator contracts are either directly awarded (the NTA awarding a subvention contract to a publically owned body) or allocated through tendering (transport operators, private or public may bid on a contract for specific routes). The obligations which operators must meet as part of the contract (service frequency/quality etc.) are set out and agreed upon at the tender or award stage of the contract process. Under agreements, operators are obligated to meet certain service provision requirements, such as running scheduled services, achieving a certain level of punctuality, and ensuring information availability and a positive journey experience. To ensure obligations are met, operators are also contractually bound to collect "all such performance information as may be required by the [NTA]" for the purposes of monitoring and performance incentiviastion. Most available data is self-reported by operators. **Under the 2009-14 PSO direct award contracts, performance data submitted to the NTA was self-reported**. **The 2014-19 contracts provided that monitoring may be conducted directly by the NTA.** As of mid-2017, with the rollout of bus AVL systems on board Dublin Bus and Bus Éireann vehicles, the NTA has begun carrying out monitoring functions on some areas of performance as captured in the new data management process – namely *KM Operated* and *Punctuality*.

Operator performance reports are completed on a quarterly basis, and reviewed and published by the NTA. **Certain obligations, such as reliability and punctuality are enforced through incentivised payment mechanisms**; 10% of compensation due to operators is retained by the NTA on a quarterly basis, and released

to the operator when compliance with obligations is demonstrated via quarterly performance reporting. Where evidence of adherence to obligation standards cannot be demonstrated, that portion of revenue is withheld. Table 7 provides a synopsis of the information captured under the current monitoring framework.

Table 7: Summary of Operator Monitoring and Reporting Area Obligations

PSO Reporting Obligations	
Reliability/Punctuality	**Customer Information**
% arriving at stop within -1 to +6 mins of schedule* % departing terminus no later than 5 mins of schedule† Services operated (%) Vehicles in service (%)‡ Driver duties operated (%)‡ Scheduled km operated (%)	Timetable info online Destination info on vehicles Telephone info line (opening hours/answer time) Service info available via text or web Timetable info available at stops Complaints recording by category & response times Online fare and network info
Service Quality	**Efficiency**
Correct bus type for route Cleanliness (% compliance) Interaction with staff (% compliance) Driving style On board heating and lighting Operation of centre doors (where fitted) Wheelchair access to all vehicles (compliance) Average vehicle age	Implementation progress of cost and efficiency plans Revenue protection activities/fare evasion rate **Environmental** Complaints regarding noise/emission standards operator remedial action Reporting on bio-fuel targets ‘
Other Reporting Requirements	
Passenger journeys Payments received Costs incurred	Capital expenditure Staff numbers Network operations (accidents occurred, environmental reports, fleet age etc.)

Source: NTA

* Low frequency bus only; † DART, Commuter Rail and High Frequency Bus;
‡ Discontinued for bus use since 2017; ‘ Discontinued

While highly functional, **the current framework enables assessment of operator, rather than scheme performance**. This is understandable given the framework's development and primary use in assessing performance obligations. Section 5 discusses further monitoring areas which may be developed to assess and monitor broader scheme impacts.

4.2 Overview of Output and Costs and Efficiency

This section provides a brief overview analysis of costs output and trends for the three main operators. As previously stated, an analysis of this area was covered in detail in the 2017 Spending Review paper. The purpose of this section is to briefly update the key indicators and analyse any change in the most recent year.

Overview of Output & Costs

The most basic output indicators are passenger journeys and service kilometres completed. As shown on page 5, Figure 2, total passenger journeys by operator are continuing to increase. Over the last three years total passenger journeys has grown by 12.3% across the three operators, driven by IÉ (14.8%) and DB (13.7%) with BÉ growing 3.1%. Both vehicle kilometres and seat kilometres (vehicle KM * vehicle capacity) have remained relatively static, with the exception of a dip in 2015 with BÉ vehicle KM as shown below in figures 5 and 6.

Figure 5: Total Seat Kilometres (2006-17)

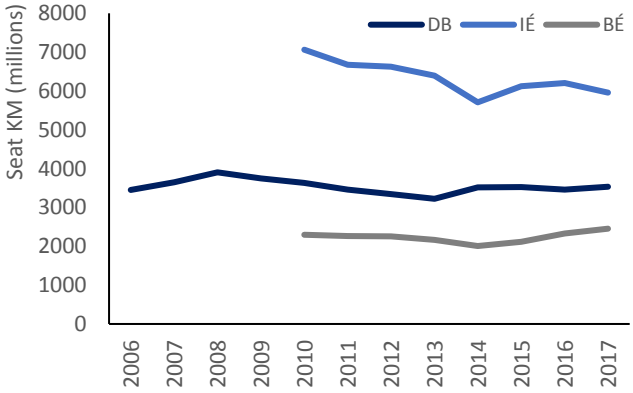
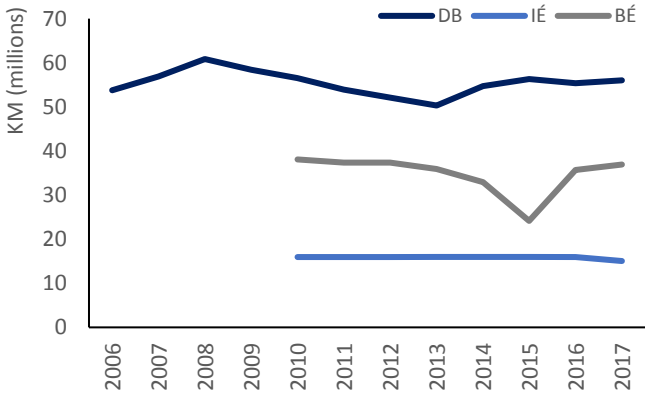


Figure 6: Total Vehicle Kilometres (2006-17)

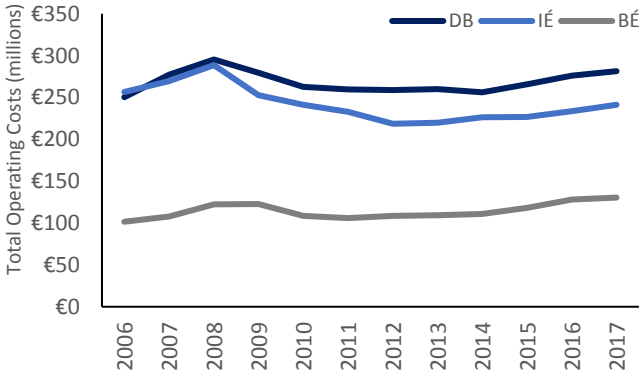


Source: NTA *Note KM data for IÉ and BÉ available only from 2010

While Vehicle KM and Seat KM are useful output monitors, a notable data gap for bus services is Passenger Kilometres (distance travelled by passengers). While collection of this data may not be feasible in the immediate term, moves towards collection of passenger KM would greatly benefit further analysis, particularly in the areas of efficiency and emissions analysis, as well as aiding operational analysis and planning.[8]

Figure 7 illustrates Total Operator Costs for the three operators. These costs are predominantly composed of payroll expenses and general operation costs such as materials and services. The three operators have generally followed a similar trend, peaking in 2008 and gradually increasing from around 2012 onwards. Both reduction and increase were driven primarily by falling materials

Figure 7: Total Operating Costs (2006-17)



Source: NTA

[8] Analytical methods on Leap card data may offer potential avenues for estimations of passenger KM, such as those put forward by Arnone, M. et al (2016), Li, D. et al (2011) and others.

etc. costs. While payroll costs reduced less sharply in the crisis period, downward pressure persisted for longer so that comparatively modest growth only returned in 2015.

Box 2: Key points of last year's PSO analysis

Last year's Spending Review provided an analysis of input, output and efficiency for the PSO scheme, notably:

- Analysis of fare-paying passenger numbers, and Free Travel Scheme user numbers.
- Analysis of gross revenue, revenue sources and average revenue per passenger.
- Analysis of total costs by operator, costs types, fuel expenditure and staff numbers.
- Indicator analysis of PSO per passenger and per seat kilometre.
- Indicator analysis of operating cost per passenger journey and per seat kilometre.

Overview of Efficiency

As discussed in section three, efficiency indicators indicate value for money, or the relationship between input and output. These can be captured using different metrics such as cost per journey, cost per passenger, cost per vehicle km etc. This subsection briefly reviews two efficiency indicators: Operating Cost, and PSO Subvention[9]. Each is given in terms of *average per journey* and *average per seat kilometre*. The purpose of this breakdown is to allow for meaningful comparison across operators; bus services will generally run shorter routes carrying fewer people, whereas trains have high passenger capacity and are disproportionately used for longer distance journeys.

Figures 8 and 9 below illustrate the Operating Cost trends over time. As can be seen in Figure 8, the main cost increases per journey occurred from 2006-09, with an increase of 20.7% across operators. In contrast, following 2009 costs per journey have reduced by 8% across operators. In the same period however, per seat km costs have increased by 13%. This is due to the fact that passenger journeys have increased faster than vehicle kilometres – reflecting the link between economic activity and nature of transport as a derived demand.

Figures 10 and 11 below provide the average PSO subvention per journey. As indicated in Figure 10, subvention per non-FTS journey has increased since 2006, by around 7%. Up to 2011 subvention was rising in tandem with overall subvention (Figure 1). The main driver of the overall increase was the increase in Bus Éireann PSO provision per journey, which more than doubled over this period. In contrast PSO per Passenger for Iarnród Éireann, which fell by 26%. While subvention per journey is highest for IÉ (Figure 10), Figure 11 illustrates that operators are subsidised more equally in terms of seat kilometre. The discrepancy here is again due to the disproportionate use of rail for longer distance travel. Further analysis could examine subvention between

[9] Appendix 2.1 and 2.2 give the same breakdown for Operator Total Revenue.

different rail services (intercity/ commuter/DART), as well as subvention per passenger kilometre when that metric is available.

Figure 8: Operating Costs per Passenger Journey

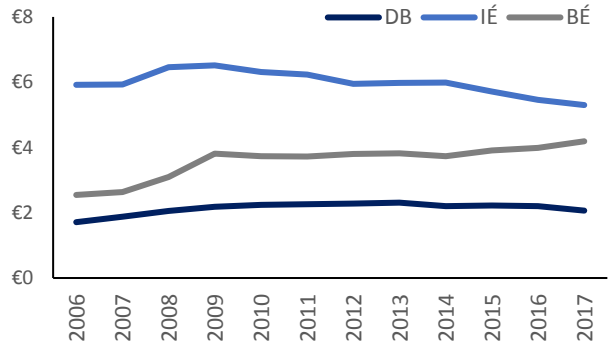
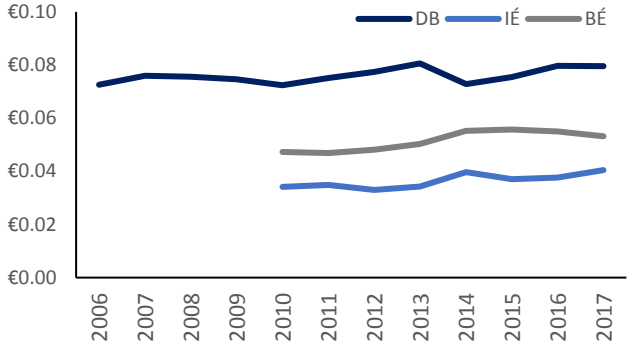


Figure 9: Operating Costs per Seat Kilometre



Source: NTA

Figure 10: PSO Subvention Passenger Journey (Excl. FTS)

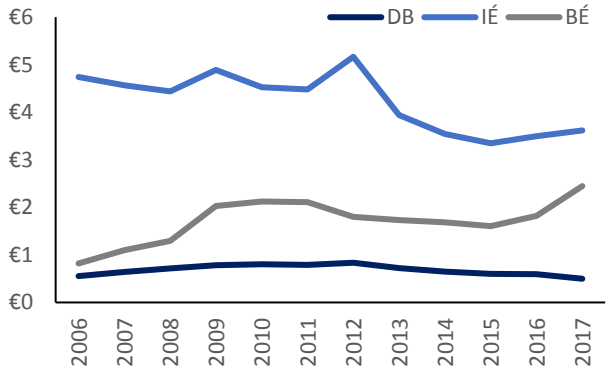
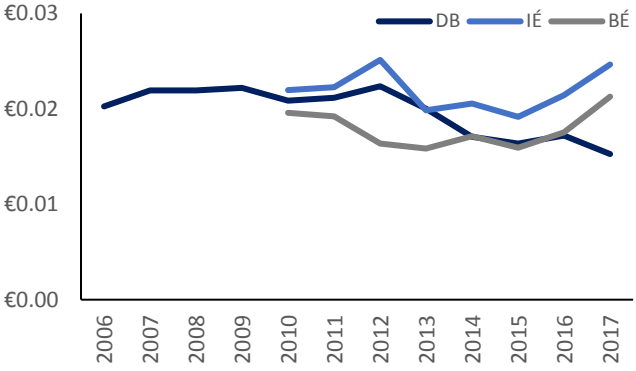


Figure 11: PSO Subvention per Seat Kilometre



Source: NTA

Note: Figure 10 Passenger Journeys exclude Free Travel Scheme user journeys

4.3 Reliability

Overview of Indicator

Reliability captures whether services scheduled are actually operated. Whether a service operates reliably is a key determinant of public transport demand, which in turn determines the modal share of PT and therefore the extent of the positive impacts derived from public transport subsidisation. While transport services operate in a complex and logistically challenging environment, fulfilling commitments to operate services as promised is key to maintaining public confidence and providing a functioning PT system. As highlighted earlier, there are several potential indicators to assess reliability, generally percentage measures of scheduled commitments delivered.

Current Status/Method

PSO operators are obliged to report on reliability performance; the process for collecting data has recently been enhanced. Under the PSO monitoring framework operators report on the following reliability dimensions:

- Vehicle Kilometres Operated – the actual distance travelled by services in relation to the distance which would be travelled if all services operated as planned.

- Services operated – the number of services which went ahead as planned (i.e. the inverse of the number of services cancelled).
- Driver's duties operated - the proportion of scheduled driver duties carried out as rostered.
- Vehicles in service – the actual number of vehicles in service at peak and off-peak times in relation to the number of vehicles required to be in service.[10]

Appendix 1 provides a more detailed account of the methodological approach to data collection and reporting in relation to these four metrics. For bus operations, since mid-2017 the measurement of Kilometres Operated is carried out using Automated Vehicle Location (AVL), replacing less robust methods previously in place. Rail services use the real-time TOPS system, managed by IÉ record reliability information. TOPS records services cancelled; the length of these services (in kilometres) is then calculated and deducted from the expected level of kilometres operated.

Analysis of Available Data

AVL data available from mid-2017 onwards indicates that Dublin Bus and Bus Éireann have operated above target for the percentage of scheduled kilometres operated in 2017. Older, self-reported data indicates that operators have generally tended to meet reliability targets. As shown in Figure 12 Dublin Bus have achieved 95%-96% of scheduled kilometres in 20017, in line with the target of 95%. Figure 13 illustrates that Bus Éireann improved reliability performance over the latter half of 2017, from around 90% to 95%. While the BÉ target over this period was set at 85%, that has increased to 95% as of 2018. As outlined, IÉ use an alternative methodology for gathering reliability data, which is self-reported. Appendices 3.1 to 3.4 illustrate operator performance in completing scheduled kilometres going back to 2010, as per self-reported operator data collection; as depicted, under those methods of reporting operators appear to consistently operate the required amount of scheduled kilometres to meet obligations.

Figure 12: Dublin Bus % Scheduled KM Operated (2017) as per AVL

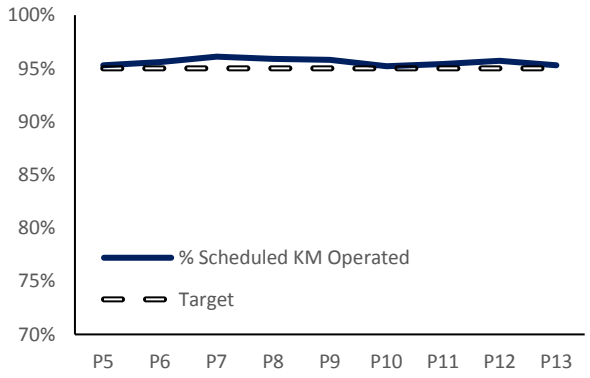
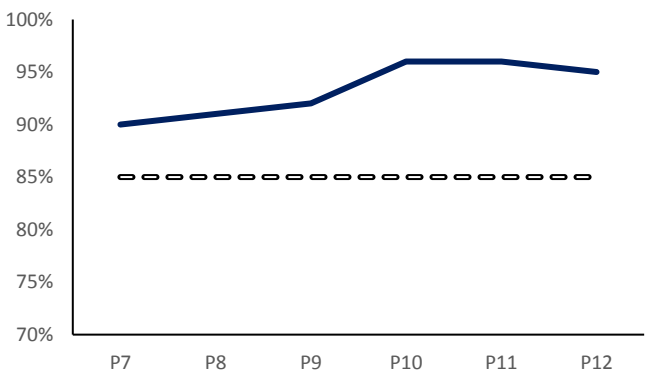


Figure 13: Bus Éireann % Scheduled KM Operated (2017) as per AVL



Source: NTA. Note: 85% target for Bus Éireann is listed as interim target increasing to 95%

[10] Drivers' duties operated and Vehicles in Service have been discontinued for bus services since mid-2017 with the introduction of AVL performance monitoring. This will likely extend to rail services with IÉ incorporation of AVL.

The other measures of reliability under the PSO framework have generally followed similar trends above target, across operators with some fluctuation. More detail on these can be found in Appendix 3.

Discussion

The measurement of reliability through the metrics discussed offers a robust framework of monitoring in this specific area. As discussed, reliability performance is of direct relevance to the regulator from a contractual and operational perspective. While important to the *objectives* of the PSO scheme, it is of indirect importance. Reliability, which is affected by organisational efficiency and the level of investment partly determines the modal share of public transport. The modal share (the degree to which public transport is used) in turn determines the scheme's success in realising economic, social and environmental objectives.

A point of relevance to be considered is the issue of assessment methodology. As discussed, the rollout of AVL for reliability measurement has enabled a more robust system of monitoring due to conclusive data collection and shift of monitoring duties from operators to the NTA, ensuring impartiality. While this is a positive transition steps should be taken to ensure that this is done in a consistent fashion across modes where possible. Secondly it should be ensured that Data Management Systems are designed and organised so as to maximise ease of querying and drawing data down for future analysis.[11]

4.4 Punctuality

Overview of Indicator

Service punctuality is frequently sighted as the most important contributor to overall customer satisfaction with public transport services. The high value placed by customers on punctuality makes it a significant determinant of the overall social, economic and environmental impact of the PSO scheme. For these reasons transport operators and authorities should aim to optimise service punctuality. As illustrated below, and laid out in more detail in appendix 4, there are a number of potential measures of punctuality performance, the selection of which can have a significant effect on the derived result.

Current Status/Method

The recent rollout of AVL technology on board bus services has also greatly benefitted the measurement of punctuality. It is noted that across the services the measurement of punctuality is -1 to +6 mins on bus, and within 5 and 10 minutes on rail. The previous data collection method used for punctuality performance monitoring of PSO bus services was measurement of vehicle departing time from the route initiating point, or terminus. The deployment of AVL technology now permits measurement of departure time from each stop. This is currently in place for low frequency services and the previous method is still being utilised for high

[11] A more versatile and accessible presentation of performance information could also be considered.

frequency services – however a transition to AVL monitoring for all bus services is due to take place in coming months. On rail services, the data collection method is managed by Iarnród Éireann and involves the use of IÉ's Train Operations Performance System (TOPS) which automatically calculates the actual figures based on arrival time at destination. The timings of each train are tracked and recorded and the system automatically calculates the number of journeys operated in the appropriate time frame. **It should be noted that the performance system is managed and implemented by Iarnród Éireann which is in contrast to the AVL system for bus services where the data is generated and supplied to the NTA.**

The current method of measurement is percentage of services leaving within a given number of minutes of the scheduled time. As described in Appendix 4 part 3, this method (the proportion of services departing within a given time band of scheduled) has several benefits; however it is sensitive to the specification of the permitted band. As highlighted at the end of section 3.2 (the review of international practice) there is significant variation in the setting of punctuality bands internationally.[12] **The use of Excess Wait Time (EWT) as a punctuality performance indicator is to be rolled out for high frequency bus services this year.**

Analysis of Available Data

Available data based on automated vehicle location (AVL), indicates that Dublin Bus operated its low frequency services either at or above target in 2017 while Bus Éireann's punctuality performance for low frequency services fell below target over the period. As noted, data collection of punctuality information for low frequency services has recently changed with the adaption of AVL technology. While previous measures considered only the departure time of vehicles from the terminus, the new method permits comparison between scheduled and actual arrival time at stops/stations. Figures 14 to 17 illustrate bus punctuality performance, historically using the previous methodology (Figures 14 and 16) and for 2017 using the AVL methodology (Figures 15 and 17). For 2017 Dublin Bus were operating at between 56% and 65% and Bus Éireann were operating at between 49% and 55% punctuality. The effect of the new methodology on performance results is clear.

[12] The NTA have specified the given bands for bus operators to mirror those of bus operators in the UK, outside of London. While this is enables quick comparison between operators in the UK and Ireland, the nature of AVL data permits reviewing punctuality under various assumptions – meaning, with some analytical manipulation, Irish data should be universally comparable irrespective of designated bands.

Figure 14: DB % departure from terminus within -1 to +5 minutes after scheduled

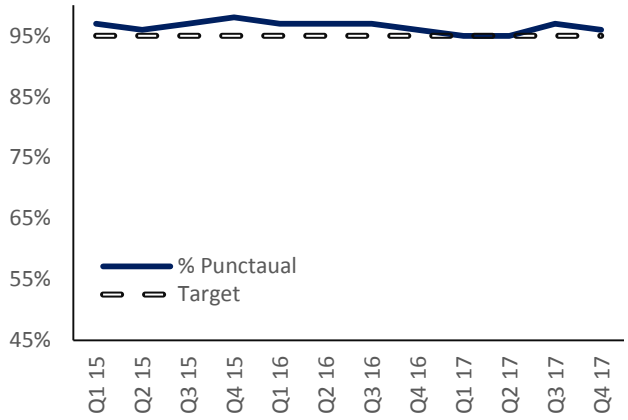
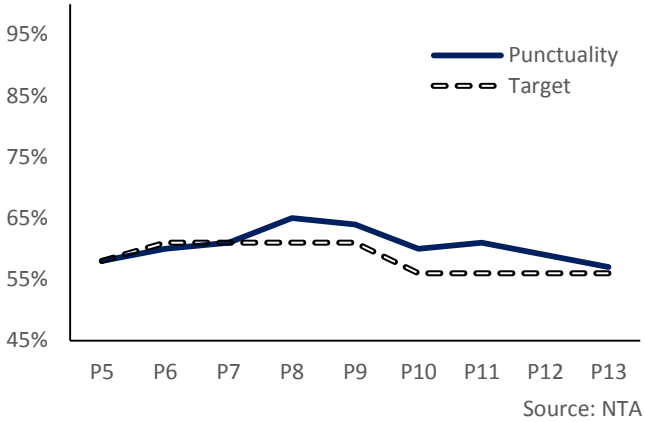


Figure 15: DB % departure from each stop within -1 to +6 minutes after scheduled (AVL)



Source: NTA

Figure 16: BÉ % departure from terminus within -1 to +(5/6) minutes after scheduled

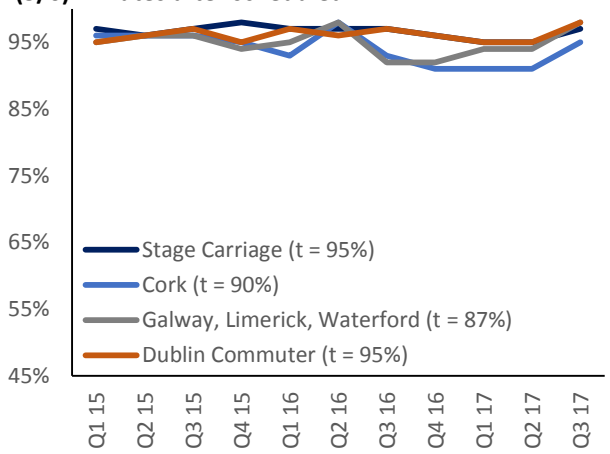
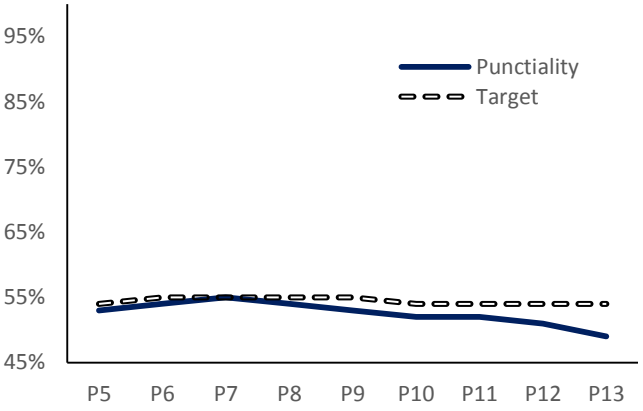


Figure 17: BÉ % departure from each stop within -1 to +6 minutes after scheduled (AVL)

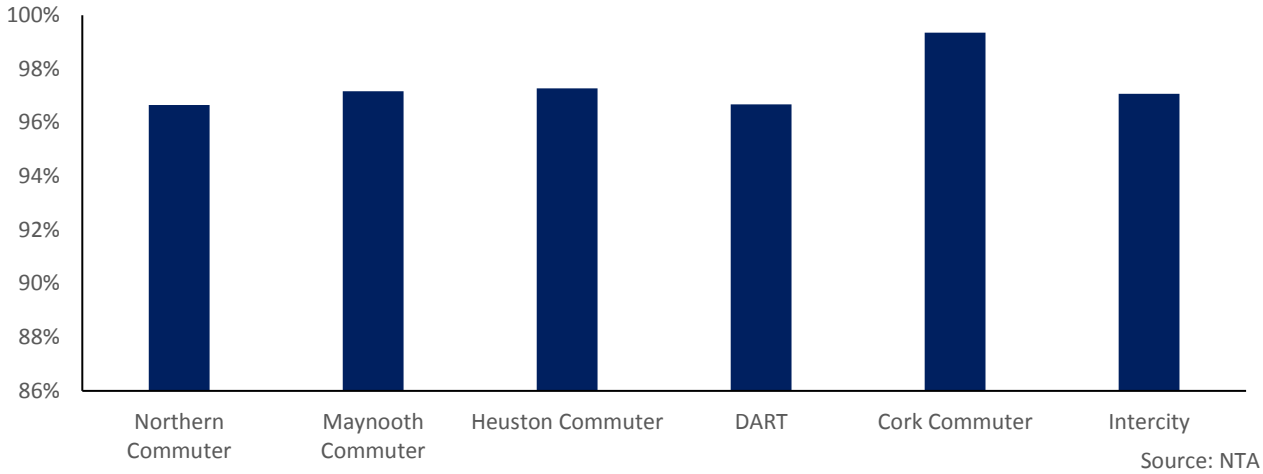


Source: NTA

Figure 18 illustrates the average punctuality results for Iarnród Éireann between 2015 and Q2 2017. It should be noted that this metric is not currently calculated using AVL technology; in contrast to bus operations it is operator reported by IÉ to the NTA, using the TOPS system. As detailed the average punctuality level within the relevant time band (within 10 minutes with the exception of off-peak services on the DART and the Maynooth, Northern and Heuston commuter services) is around 97% across the different service types with the Cork Commuter service scoring slightly higher. It should also be noted that this data is reported excluding any delays caused by external factors (force majeure), such as delays as a result of traffic accidents, or especially severe weather conditions. When such delays are included, data for Q1 and Q2 2017[13] indicates that punctuality rates are lower with DART AM and PM peaks at 86.3% and 76.3% respectively compared to 98.5% and 97.9% without such delays.

[13] https://www.nationaltransport.ie/wp-content/uploads/2017/11/Q2_2017_Iarnrod_Eireann_Performance_Report.pdf

Figure 18: Iarnród Éireann Average Punctuality 2015-17



Source: NTA

Discussion

Punctuality performance is affected by a number of factors which are at least partially under operator control; these include: alighting time (time taken by passengers to board and exit vehicles), dwell time (time the vehicle is stopped), effectiveness of vehicle maintenance and management, driving style, timetable and route planning. However, punctuality is also affected by external factors beyond operator control such as congestion and incidents such as accidents or obstacles preventing passage, as well as performance of the transport system as a whole. A major determinant of both speed and punctuality on PT services is the quality of the infrastructure, in particular with regard to rail.[14] Considering these factors, it should be noted that changes in recent years have been made to reduce the effects of these factors, such as the purchase of vehicles with additional doors to improve exit time, and implementation of smart ticketing, reducing the time needed to pay fares in many cases.

In terms of the performance indicator methodology, as discussed earlier, terminus departing time is a weaker approach than punctuality at each stop as it fails to capture the effects of most factors affecting punctuality; moreover terminus departure time is of indirect significance to public transport users in relation to at-stop time. In this respect **the move to AVL based punctuality monitoring is a positive development in bus performance monitoring**. Rollout of a similar measurement for high frequency bus services[15] and for train services, for the purposes of performance monitoring should be considered.

There are a number of potential methodologies which may be used to assess punctuality using AVL data. As noted, the methodologies to be implemented are: the percentage of services departing from each stop within a specified period of the scheduled time (for train and low frequency bus routes) and use of Excess Wait Time (EWT) for high frequency routes. Potential methodologies are described in more detail in Appendix 4.

[14] This is of significance for PSO as Iarnród Éireann manage rail infrastructure as well as service provision.
[15] This is planned to be implemented in the near future.

4.5 Customer Experience

Overview of Indicator

Measurements of customer experience relate to the stated view of users to understand the extent to which they are satisfied with the service. As previously discussed, customer experience is an area of performance monitoring given increasing consideration is recent years. Efforts to increase the modal share of public transport have placed greater emphasis on all aspects of the user experience. Potential customer experience indicators are listed in Table 6 in the quality section.

Current Status/Method

Methods of analysing customer experience have been recently changed to refocus on measurement led by the NTA rather than by operators. Current PSO monitoring within the contractual arrangements covers a variety of areas relating to customer experience. These can be broken into three sections: information availability, complaint reporting (number of complaints per 100,000 passengers) and quality of experience (cleanliness/staff helpfulness/ticketing ease).

Complaint reporting is included in the quarterly reports – the number of complaints per 100,000 passengers by complaint category is captured. In addition, mystery shopper reporting is undertaken to measure a number of aspects related to quality. While these reports were typically commissioned by the operators, the NTA has recently moved to carrying out this task itself for bus services and has implemented a revised methodology and categorization. The measures focus on bus vehicle performance, bus equipment performance, bus driver performance, customer information performance, customer care performance, cleanliness performance and stop maintenance performance. This enhances the level of oversight within the process.

These measures are supplemented outside of obligation reporting by more in depth customer surveys and safety reports. In addition, the NTA introduced Customer Satisfaction Research in 2017. In this research a survey was carried out on 2,516 customers across each of the modes of transport (Dublin Bus, Luas, Iarnród Éireann, DART, Bus Éireann and private coaches). The survey represents the first time customer satisfaction has been measured in a unified and comparative way across public transport modes.

Analysis of Available Data

Available data across each of the modes provides a general overview of quality from the perspective of the end user; data since mid-2017 indicates that there is a variance in the performance of operators.

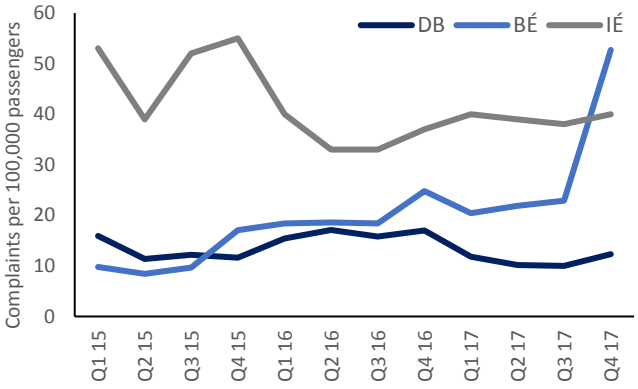
Based on a Bus Éireann commissioned mystery shop, over the past four years BÉ has consistently met obligations in keeping comprehensive and up to date timetable information published online, service information available on website, fare change information published on website, in advance of changes and network change information published on website in advance of changes. Based on a Dublin Bus

commissioned mystery shop, over the past two years DB has consistently met obligations in keeping comprehensive and up to date timetable information published online, destination scrolls information on board busses, telephone information available and answered within one minute, real-time on street information at stops with those facilities, 24 hour service information available online and via text, and fare and network information up to date and available in advance of changes.

Mystery shop analysis conducted directly by the NTA indicates that in 2017 targets for Dublin Bus were met in all periods for the relevant indictors with the exception of bus vehicle performance and bus equipment performance which were only fully met in two of the four quarters. For Bus Éireann, the performance target was met for all quarters for bus equipment performance only with bus driver performance being met in two quarters, customer information performance and cleanliness performance were met in one quarter while customer care performance was not met in any quarter.

The number of customer complaints can also serve as an illustration of overall customer satisfaction. As given in the Figure 19, there is considerable variation in the level of complaints both for each operator and over time. The recent upward spike in BÉ complaint levels is due to issues surrounding driver availability to operate services following strike resolution.

Figure 19: Customer Complaints per 100,000 Journeys for PSO Operators



Source: NTA

The 2017 survey of public transport customers indicated that there was variance in the level of satisfaction by public transport mode. The survey methodology consisted of 2,516 face to face interviews with customers over the age of sixteen. Table 8 shows that the proportion of customers reporting that they were very satisfied was highest on Dublin Bus and lowest on Irish Rail/DART. In terms of the analysis behind these trends the report lists that the main reasons for satisfaction were overall service and convenience whereas timing (i.e. punctuality) is the main source of dissatisfaction.

Table 8: Overall Satisfaction by Mode, 2017

	All	Dublin Bus	Bus Éireann	Private Coach	Irish Rail	DART	Luas
Very Satisfied	47%	54%	40%	44%	39%	31%	42%
Fairly Satisfied	44%	38%	45%	45%	52%	53%	57%
Very or Fairly Dissatisfied	4%	5%	7%	1%	3%	7%	0%

Source: NTA, Customer Satisfaction Survey 2017. Note: Excludes neither and may not sum due to rounding

Discussion

The analysis provided in the results section illustrates information on elements of customer experience across the operators. The analysis has detailed steps that have recently been taken to centralise the process of collecting information in this area across bus services. In terms of next steps it is important that data and information is collected across all operators in a consistent fashion were possible/feasible. Data on customer performance collected directly by the NTA is only available from 2017 onwards and as such it is not possible to analyse trends in performance over time. Available data does indicate lower performance levels for customer experience on Bus Éireann services compared to Dublin Bus. In addition, the first unified customer survey indicates that customer satisfaction varies across modes with indications that satisfaction levels are higher on Dublin Bus services than on Irish Rail or Bus Éireann. As the survey has only been produced for one year it is not possible to look at trends over time. The recent progress in improving the analysis of this area should be continued with a focus on ensuring consistency across all modes and ensuring that consistent data is available over time to enable assessment and evaluation.

5. Wider Performance Measurement and Data Availability

The analysis above has highlighted relevant information with regard to three areas: reliability, punctuality and customer satisfaction. As outlined, the monitoring framework for PSO services is derived from contractual obligations in managing the PSO programme. As such the requirements are centred on operational performance and customer experience. While these are two very important areas of consideration and facilitate the implementation of the NTA's performance management, there are a number for other areas of interest in terms of the evaluation and monitoring of the scheme mainly relating to the effectiveness of the scheme in realising broader environmental, social and economic benefits of the scheme. In addition, the collection, monitoring and reporting of data relevant to performance could be expanded beyond the measures included in the performance element of the PSO contracts.

a) Public Transport Usage

A key high-level performance indicator for the PSO scheme is the degree of PSO transport usage relative to other forms of transport.[16] While many variables impact the modal share of public transport beyond how effectively the scheme is operated[17], the modal share of PT is central to the scheme's objectives of reducing the negative externalities associated with private car use and encouraging modal shift. Tracking of the modal share in relation to investment in public transport operation should be considered for ongoing reporting in

[16] The modal share of PT in 2016 was 5.5%, down from 5.8% in 2014 (DTTaS, 2017).

[17] These include economic activity, the relative attractiveness of public transport to the end-user, and the quality and reach of public transport infrastructure.

relation to PSO monitoring. Deeper analysis could estimate the counterfactual of PSO provision in terms of increased congestion and lost time, fewer journeys, and fewer private cars consumed.

b) Environmental Effectiveness

An environmental effectiveness performance analysis of the PSO scheme would estimate the net emissions saved as a result of the services. A transport model would be necessary to develop the counterfactual, which may be feasible given existing modelling capacity in the Irish transport agencies. Regular data reporting and benchmarking of statistics such as emissions per km by operator, emissions per journey etc. would facilitate understanding of the impact effectiveness of the PSO. Under current PSO arrangements, emissions and noise information is reported to the NTA, however the data could not be made available for this analysis.

c) Accessibility

Monitoring of territorial accessibility performance in relation to social inclusion would be valuable in assessing the impact of the PSO. This would require use of a geographic model which incorporates demographic information, establishing accessibility through transit. A number of methodologies have been used.[18] This would consider location data of transport routes, service frequency, service user cost, enriched by socio-economic information such as sex, employment, car ownership status etc. An accessibility indicator may be developed which is related to actual travel patterns – establishing the service extent of meeting travel demands to different consumer categories, based on background information. This could be updated and regularly published along with NTA reports.

While not considered here, it should be noted that the D/EASP is transitioning from paper to e-card travel passes for individuals in receipt of free travel. This is important from a data collection perspective as updated cards across the full population recipients would enable much more robust analysis of accessibility, and the overall performance of the free travel scheme.

Broader Measurement and Reporting – While the NTA has a performance management system in place to facilitate the operation of the PSO contracts, consideration could be given as to whether the wider collection and reporting of performance information would be possible to enhance the level of detail with regard to performance. For example, and as highlighted earlier, more detailed measures of punctuality (such as excess delay[19]) could be reported in addition to the specific performance measures related to the contracts.

[18] Examples of academic work include Bhat, C.R. et al (2005) and Bajada, T. et al (2016). For an in depth review of policy practitioner work see Boisjoly, G. and El-Geneidy, A., (2017).
[19] See appendix for further detail on measurement

In terms of management and coordination of the monitoring processes, there has been a gradual move away from operator management and towards the NTA conducting main monitoring tasks. This is a positive development, partially enabled by advances in the monitoring methods, which should continue.

6. Conclusion

- Expenditure on PSO public transport services has increased by 12% per year on average over the last three years to a total of €285 million in 2018, roughly equal to 2006 levels.
- For the three main PSO operators, passenger journey numbers and vehicle kilometres have increased by 12.3% and 11.9% respectively in the three years 2015-17.
- The performance framework for the PSO scheme, which is managed by the NTA, is focused on the monitoring of operator obligations (such as running services and meeting punctuality). While this is important, the framework as a whole omits;
    - Analysis of PSO in improving accessibility and social inclusion at the national at regional levels
    - Analysis of the environmental impact of the PSO scheme – in particular in reducing greenhouse emissions from transport by diverting passengers from private car use.
- Based on data availability this paper reviews three central areas of performance currently in place for public transport at a high level. It found:
    - Steps have been taken recently to improve the measurement of performance on bus services through the use of automated vehicle location (AVL) data although currently is in use only for low frequency services (since mid-2017).
    - Available data indicates that bus services in 2017 were operating at or above target for reliability but that there are lower levels of performance for punctuality on some low frequency BÉ services.
    - Data on customer satisfaction is now being collected by the NTA rather than by operators for bus services and available initial data suggests some issues with performance in 2017.
- Current monitoring includes analysis of scheme outputs (operational efficiency and effectiveness). Evaluation of broader social and environmental impacts (such as accessibility and 'emissions saved' estimations) require additional data gathering and use of specific modelling tools
- While cost and efficiency analysis is central to Public Expenditure Management, so too is analysis of provision output and impacts. There are a number of areas for consideration for DTTaS and the NTA to ensure that sufficient information is collected and provided to understand both scheme performance and the quality of the services being operated.
- The trend towards NTA management of monitoring tasks and roll out of more advanced methods to capture data centrally on performance should be continued and standardised across all service types and operators where possible/relevant.

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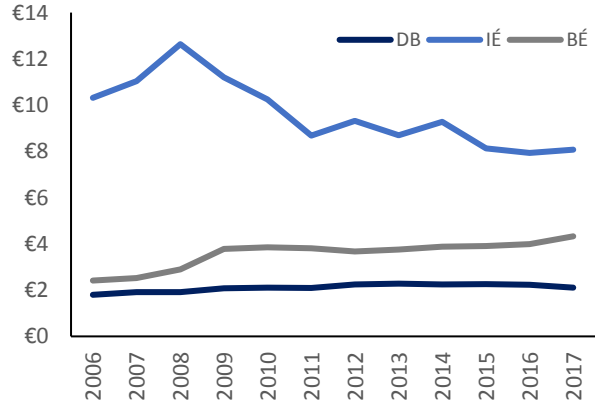
Appendix

Appendix 1: Methodology for Performance Measurement

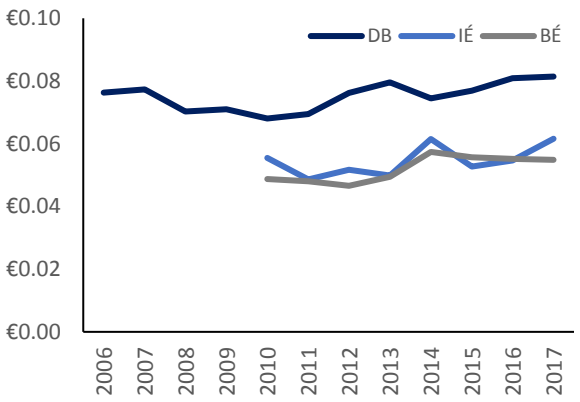
Operator	Detail
Reliability – Services Operated	
Iarnród Éireann	"Scheduled Services Operated" measure for InterCity, Regional, DART & Commuter. The target (99%) is defined by the NTA and is based upon number of actual services operated against planned services operated. TOPS automatically records all services operated and cancellations to generate the appropriate percentage figures.
Dublin Bus	A random sample of trips are selected by the External Auditor for each depot to examine. The sample sized is of such a size to ensure statistical significance. Each of the above trips are checked on the AVL system for compliance (operation / punctuality) by Operations Manager (or a person delegated to Operations Manager). Where a trip is not found to have operated on the AVL system, further verification using ticket machine data is needed. If the trip is found from ticket machine records, the trip is deemed to have operated and is included in Section 1.7 as operating. However, ticket machine data cannot be conclusive regarding punctuality, so this record is excluded from Section 1.8.
Bus Éireann	"Planned Services are taken from the Microbus system. Service Failures are maintained by each Area by product, by day and by time period. Each period this data is collated and uploaded to SAP BI. Percentage of Services Operated is calculated as: (Planned Services - Service Failures)/Planned Services"
Reliability – Scheduled Kilometres Operated	
Iarnród Éireann	"Passenger Service Train KMs" measure for all IÉ routes, and then grouped as InterCity, Regional, DART & Commuter. The target (98%) is defined by the NTA. IÉ is expected to operate a pre-determined number of train KMs per year which is then divided by period. TOPS records all train cancellations per period, quarter or YTD which are then inputted into Excel to calculate the Km distance for each cancellation. This figure is then deducted from the expected Kms to be operated in the reporting timeframe to automatically generate the percentage figures.
Dublin Bus	The scheduled kilometres for each bus route are calculated using the route length and route frequency. Any additional kilometres operated are added and kilometres not operated are subtracted to give a figure for kilometres operated. The % scheduled km operated is the km not operated figure given as a percentage of the kilometres operated.
Bus Éireann	"Scheduled Kilometres are taken from the Microbus system. Estimated Kilometres lost are maintained by each Area by product, by day and by time period. Each period this data is collated and uploaded to SAP BI. Percentage of Scheduled Kilometres operated is calculated as: (Scheduled Kilometres - Estimated Kilometres lost)/Scheduled Kilometres"

Punctuality – Services within X Mins	
Iarnród Éireann	"Punctuality" measure for all IÉ routes, and then grouped as InterCity, Regional, DART & Commuter. The measure and target are defined by the NTA and vary by route. Our Train Operations Performance System (TOPS) automatically calculates the actual figures based on arrival time at destination. The timings of each train are tracked via a unique head-code (train ID) and recorded by way of track circuit detection. Each route has a corresponding route in TOPS. TOPS automatically calculates the number of journeys operated in the appropriate time frame (by period, by quarter and by year to date (YTD)), calculates the number of occurrences within the defined measure (eg. InterCity is 10 minutes), adjusts it by removing force majeure / third party delay incidents to produce the final actual reporting figure.
Dublin Bus	Previous methodology: 'a random sample of trips are selected by the External Auditor for each depot to examine. The sample sized is of such a size to ensure statistic significance. Each of the above trips are checked on the AVL system for compliance (operation / punctuality) by Operations Manager (or a person delegated to Operations Manager). Where a trip is not found to have operated on the AVL system, further verification using ticket machine data is needed. If the trip is found from ticket machine records, the trip is deemed to have operated and is included in scheduled kms operated as operating. However, ticket machine data cannot be conclusive regarding punctuality, so this record is excluded from punctuality measure'. Note, this methodology was updated in 2017 to the AVL system described below for Bus Éireann.
Bus Éireann	Punctuality figures are taken from AVL System. For punctuality, the evaluation establishes the percentage of trips whose schedule deviation lies within the given tolerance range.

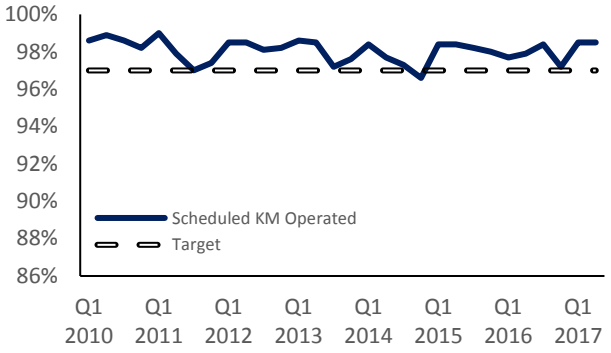
Appendix 2.1: Total Revenue per Passenger (2006-17)



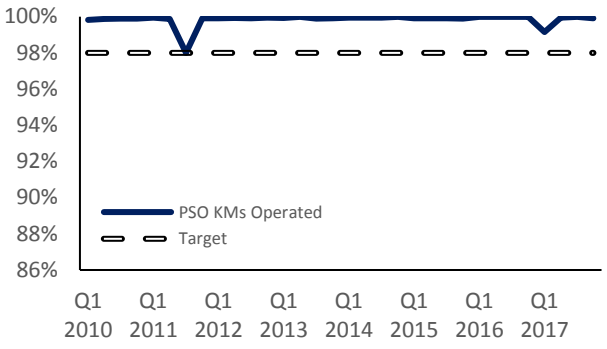
Appendix 2.2: Total Revenue per Seat KM (2006-17)



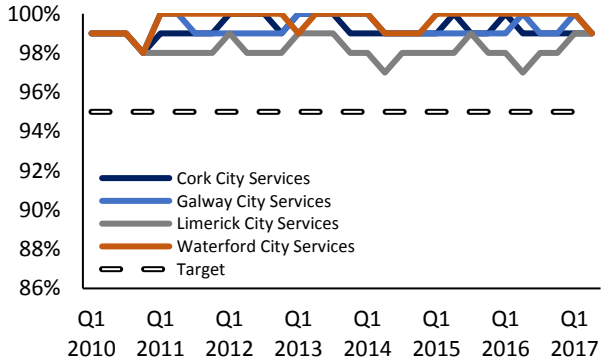
Appendix 3.1: Dublin Bus % Scheduled KM Operated



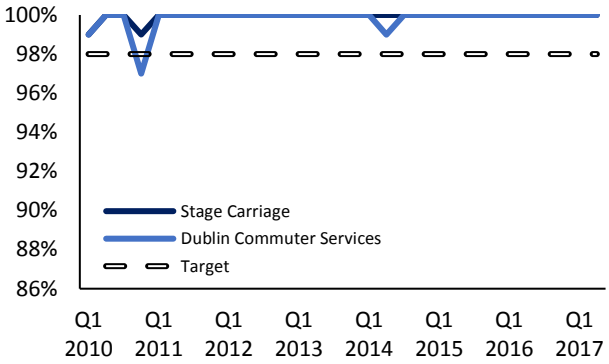
Appendix 3.2: Iarnród Éireann % Scheduled KM



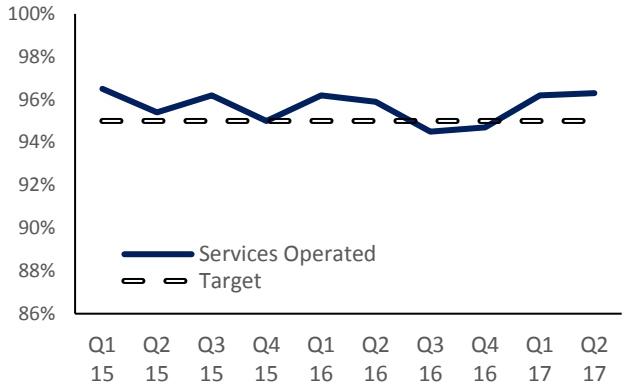
Appendix 3.3: Bus Éireann % Scheduled KM Operated (Services with target = 95%)



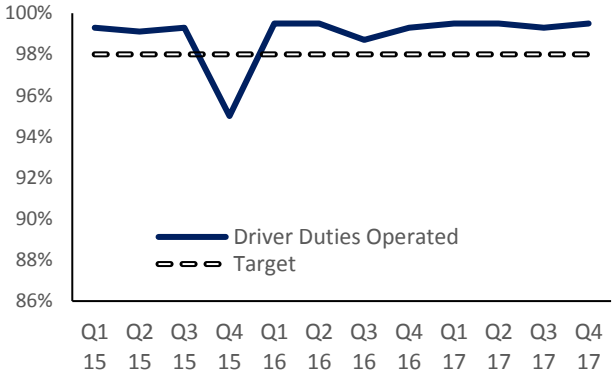
Appendix 3.4: Bus Éireann % Scheduled KM Operated (Services with target = 98%)



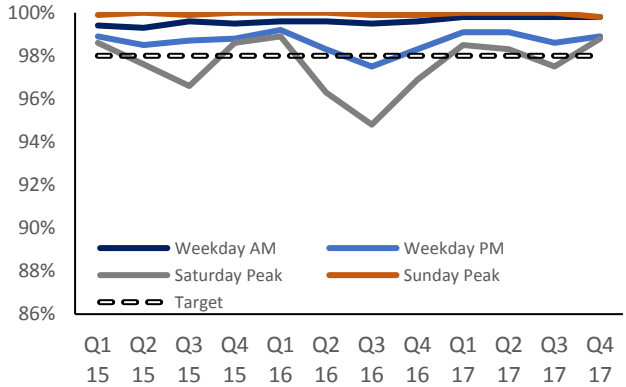
Appendix 3.5: Dublin Bus Services Operated as % of scheduled



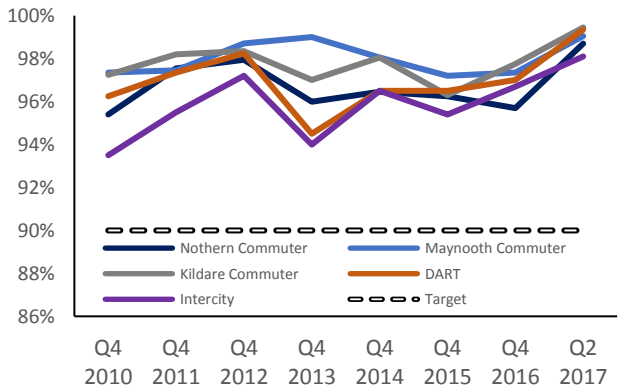
Appendix 3.6: Dublin Bus % Scheduled Driver Duties Operated



Appendix 3.7: Dublin Bus % Scheduled Vehicles in Service



Appendix 3.7: Dublin Bus % Scheduled Vehicles in Service



Note: Results are average of AM and PM peak

Appendix 4: Measures of Punctuality Performance

The structure of the punctuality performance indicator employed will have a significant impact on performance results, the differences between measures should therefore be understood by performance assessors. The four most common measures of punctuality (using AVL data) identified here are: excess wait time (EWT), standard deviation and regularity within absolute band (current PSO punctuality measurement) and regularity within relative band.

1. Excess wait time is based on capturing the degree of punctuality from the perspective of the transport user. It provides a measure of perceived regularity by estimating the additional amount of time (beyond scheduled) that passengers would expect to wait, based on the previous performance. It is calculated as the difference between Scheduled Wait Time (SWT) and Actual Wait Time (AWT), formally given as the difference between:

$$\left(SWT = \frac{\sum_{i=1}^{N} SHW^2}{2 * \sum_{i=1}^{N} SHW}\right) - \left(AWT = \frac{\sum_{i=1}^{N} AHW^2}{2 * \sum_{i=1}^{N} AHW}\right)$$

   where SHW and AHW refer to scheduled and actual headway respectively; i.e. the scheduled time between bus departures at a stop, and the actual times. The advantages of EWT is that it provides an objective measurement of punctuality, it is intuitive to understand, it considers all of the data and it focuses on the customer perspective. However it is not directly suitable to routes with irregular headways (vehicle departures occur at irregular intervals) as this can skew results, and is only suitable to be measured over long periods.

2. The second measure identified uses the standard statistical measurement of standard deviation, an assessment of the variance or spread of a population. This measures how much of the observed data lies within one deviation of the mean. It follows standard measurement as:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(AHW_i - SHW_i)^2}$$

   While this measure is statistically robust in that it provides an objective measurement which considers all of the data, and is expressed in minutes, it is relatively less intuitive to interpret, depends on assumptions about the data distribution and is strongly affected by large data gaps.

3. The final two measures are measurements of the proportion of actual departures within a given time band. The first is an absolute band, e.g. -1 to +5 minutes (this type is used for punctuality measurement under current PSO contracts); and the second is time band determined relative to the headway, e.g. +20% of the headway (i.e. if the scheduled headway is 20mins, the indicator would capture the proportion of busses departing within 4mins after scheduled departure time). While these measures

are very intuitive to understand, and simple to calculate due to the designation of bands, they are not objective. [20]

Appendix 5: Research Quality Assurance Process

Quality assurance process

To ensure accuracy and methodological rigour, the author engaged in the following quality assurance process.

- ☑ Internal/Departmental
  - ☑ Line management
  - ☑ Spending Review Steering group
  - ☑ Other divisions/sections
  - ☐ Peer review (IGEES network, seminars, conferences etc.)
- ☑ External
  - ☑ Other Government Department
  - ☑ Steering group
  - ☐ Quality Assurance Group (QAG)
  - ☑ Peer review (IGEES network, seminars, conferences etc.)
  - ☐ External expert(s)
- ☐ Other (relevant details)

[20] See Trompet, M (2010).