UNIVERSITY OF LEEDS

VALUATION OF TRAVEL TIME SAVINGS FOR BUSINESS TRAVELLERS

Annexes to Main Report

Prepared for the Department for Transport

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ANNEX 1: TECHNICAL ANNEX ON THE HENSHER EQUATION

A1.1 Introduction

According to conventional theory, savings in business travel time may derive benefits to the employer and employee, in the following ways.

From the point of view of the employer:

a) The time saving may be used to undertake more productive work at home or at the normal place of work.

From the point of view of the employee:

b) The time saving may be devoted to additional leisure time at home.
c) The time saving may be devoted to additional work time at the regular place of work.
d) The time saving may permit a later departure for the business trip, or an earlier arrival home, possibly leading to reduced fatigue.

A number of approaches have been adopted for the estimating the potential benefits listed above, the predominant ones being the so-called ‘cost saving’ and ‘Hensher’ approaches. The cost saving approach focuses upon the benefit source a) above, and is underpinned by the following five assumptions (Mackie et al., 2003):

i. Competitive conditions in the goods and labour markets
ii. No indivisibilities in the use of time for production
iii. All released time goes into work, not leisure
iv. Travel time is 0% productive in terms of work
v. The employee’s disutility of travel during work time is equal to their disutility of working

If these assumptions hold, then cost savings arise from the direct compensation/reward to the employee, plus any additional costs of employing staff. On this basis, the cost saving approach is often referred to as ‘wage plus’, and the value of business travel time savings ($VBTTS$) is formalised:

$$VBTTS = w + c \tag{1}$$

where:

w is the gross wage
c is the non-wage cost of employing labour

In contrast to the cost saving approach, the Hensher approach considers benefit sources a) to d), and thus combines the perspectives of the employer and the employee. Whereas Hensher (1977) was responsible for the intuition behind the approach, Fowkes et al. (1986) were responsible for its 'codification', as follows:

$$VBTTS = \left[(1 - r - pq) MPL + MPF \right] + \left\{ (1 - r) VW + rVL \right\} \tag{2}$$

where:

- r is the proportion of travel time saved that is used for leisure
- p is the proportion of travel time saved that is at the expense of work done while travelling
- q is the relative productivity of work done while travelling relative to at the workplace
- MPL is the marginal product of labour[1]
- MPF is the extra output due to reduced (travel) fatigue
- VW is the value to the employee of work time at the workplace relative to travel time
- VL is the value to the employee of leisure time relative to travel time
- $[\cdot]$ is the portion of $VBTTS$ that is associated with the employer
- $\{\cdot\}$ is the portion of $VBTTS$ that is associated with the employee

Whilst the Hensher equation has found conceptual appeal, practical implementation of the complete framework has proved difficult. Consensus seems to be that the MPF and VW terms are especially difficult to estimate (see the discussion in Mackie et al. (2003), for example), and it is not unusual to drop these from consideration. Various authors have asserted that VL is simply the non-work $VTTS$ and can thus be populated using standard values. Of particular relevance to the current discussion is the situation where the Hensher and traditional cost-saving approaches arrive at the same estimate of $VBTTS$; according to Mackie et al., this is where $r = p = 0$, and $VW = MPF = MPL = 0$. In a similar vein, a number of studies have implemented restricted versions of the Hensher approach. A notable example is the AHCG (1994) study, which assumed $MPF = 0$ and $VP = VW = VL$ (i.e. work and leisure are valued equally), thereby deriving the identity:

$$VBTTS = \left[(1 - r - pq) MPL \right] + VP \tag{3}$$

The identity (3) has also been implemented in several subsequent studies, such as Algers et al. (1995) and the most recent Dutch study (not yet released/published). In the subsequent discussion, we shall question the validity of (3).

---

[1] To be more precise, this term should be interpreted as the marginal *revenue* product of labour.

A1.2 Previous Literature

Despite the attention that it has received, it is notable that Hensher never offered a formal derivation of (2) from first principles. Furthermore, Fowkes et al.'s (1986) codification of the Hensher equation entailed a formal statement of (2) rather than derivation from first principles. Working Paper 3 from the 1987 UK national non-work VTTS study (MVA, ITS & TSU, 1987) contributed a different piece of the jigsaw, by defining an economic problem apparently underpinning the Hensher equation (p72), but did not proceed to solve the problem. This gap in the literature motivated the recent contributions of Karlström et al. (2007) and Kato (2012). Karlström et al.'s derivation claims to 'come close' to deriving the Hensher equation, whilst Kato claims to derive it exactly.

Karlström et al. (2007) generalised Hensher by distinguishing between short distance and long distance trips; the latter were defined as trips where it would not be feasible to return to the office at the end of the day after completion of the business trip. They further distinguished between private and social valuations of travel time savings, where social valuations account for the incidence of tax. Kato (2012) adopted Karlström et al.'s definition of short and long distance trips, but proposed a different definition of the objective function, as the conflation of welfare accruing to the employee and employer. By contrast, Karlström et al.'s objective function was defined in terms of the employee's welfare only, with the employer's interests represented only as a constraint.

Despite being the more faithful to (2), Kato derivation is complicated, and involves several superfluous terms (for example, the contribution to the employee's utility from leisure travel is irrelevant to the derivation of $VBTTS$). Moreover, the key transition (from his equation (26) to (27)), and the interpretation of the resulting terms that give rise to the Hensher equation, are (arguably) not as clear as they might be. The contribution of the subsequent discussion will be to draw upon both Karlström et al. and Kato, but present a simpler derivation of the Hensher equation (2) from first principles. This will serve to clarify the interpretation of the terms within (2), and expose several assumptions and properties.

A1.3 Defining the Objective Problem Behind the Hensher Equation

In what follows, we shall outline an optimisation problem wherein:

- The problem is defined in terms of the joint interests of the employer and employee.
- More specifically, the objective statement is one of maximising welfare, where welfare is additive in profit generated by the employer (converted into utility units) and the utility of the employee, subject to a time resource constraint.

More formally:

$$\underset{T_w,T_l,X,t_w}{\text{Max}}\ W = \lambda\left(PX - wT_w\right) + U$$
$$\text{s.t.} \qquad (4)$$
$$T = T_w + r^* t_w + \left(1 - r^*\right)T_l \qquad (\mu)$$

where:

$$X = X\left[T_w + \left\{r^*\left(p^* q\right) - \left(1 - r^*\right)\left(1 - p^* q\right)\right\} t_w\right]$$
$$U = U\left[\left\{T_w + r^* t_w\right\}, \left\langle T_l - r^* t_w\right\rangle, t_w\right]$$

and:

W is social welfare

λ is the marginal utility of income

P is the sales revenue per unit of goods produced

X is the quantity of goods produced

$X[\cdot]$ is the production function of the producer/employer

w is the wage rate

T_w is the quantity of 'contracted' work time

$U[\cdot]$ is the utility function of the employee

T is the total time devoted to 'contracted' work, leisure and business travel (i.e. 24 in any one day)

t_w is the quantity of business travel time, which could straddle 'contracted' work and leisure time

T_l is the quantity of leisure time, given the work contract

μ is the marginal utility of time (and the Lagrange multiplier in (4))

r^* is the proportion of business travel time that takes place in leisure time; this should be distinguished from the r term in (2) which relates to travel time saving specifically

p^* is the proportion of business travel time that is productive; this should be distinguished from the p term in (2) which relates to travel time saving specifically

q is as defined in (2)

It is important to understand the salient features of the objective problem, as follows:

- **With reference to the profit function**, we assume that revenue is generated through the sale of goods, and that costs are incurred through the employment of labour. For simplicity, we further assume that the non-wage costs of employing labour are zero (i.e. with reference to (1), we assume that $c = 0$), and omit explicit consideration of tax (i.e. implicitly we assume that the taxation regime is neutral between employer and employee). Both issues can be introduced into the analysis, but with a modest increase in complexity.

- **With reference to the X function**, production depends solely upon the time contributed by the labour input, adjusted for the productivity of the time. Productive time could, conceivably, include not only 'contracted' work time, but also a proportion of leisure time, hence the notion of 'effective' work (and leisure) time.

- **With reference to the U function**, utility depends solely upon the quantities of 'effective' work time, 'effective' leisure time and business travel time (but not the consumption of goods; see subsequent comment on page 6).

- **With reference to the μ constraint**, the time resource constraint is ostensibly the sum of 'contracted' work and leisure time, but entails three key propositions concerning business travel time, namely that:
  - Business travel time may straddle 'contracted' work and leisure time (hence the r^* term, and the notion of 'effective' work time)
  - Business travel time may - to some extent - be unproductive (hence the p^* and q terms)
  - Although business travel time may straddle 'contracted' work and leisure time, p^* and q remain constant. This gives rise to the implicit assumption that the productivity of business travel is constant, irrespective of whether it is undertaken during 'contracted' work or leisure time. For a practical illustration of the objective problem (4), see Figures 1 and 2.

- In contrast to conventional work-leisure optimisation problems such as Becker (1965) and Oort (1969), it is notable that (2) omits a budget constraint. This reflects the following considerations:

  - It is assumed that the employer and employee face a common marginal utility of income.
  - It is assumed that the labour costs incurred by the employer in the course of production straightforwardly transfer to the wage-related income of the employee.
  - It is assumed that non-wage income to the employee is zero.
  - Since labour costs already feature in the objective statement, and we have assumed zero non-wage income, there is no need to also include a budget constraint[2].

[2] In the vein of Karlström et al. (2007), an alternative (but equivalent) way of specifying the problem (4) is to include a budget constraint, but represent the objective statement entirely in terms of the employee, as:

- Note furthermore that wage-related income refers to contracted work time T_w only; in effect, no wages are paid or received for business travel that takes place during leisure time $r^* t_w$. In section 4, we will relax this assumption.

Given these features, it is important to consider what forms of employment are compatible with the objective problem (2). Our conclusion, consistent with both Kato (2010) and Bates' (2013) assessment of Karlström et al. (2007), is that the Hensher equation is most applicable to the case of self-employment. That is to say, self-employment would justify:

- The notion of a joint welfare function, combining the perspectives of the employer and employee (who in this case would be one-and-the-same).

- The proposition that labour costs (income) should be represented in either the objective statement or the cost (budget) constraint, but not both.

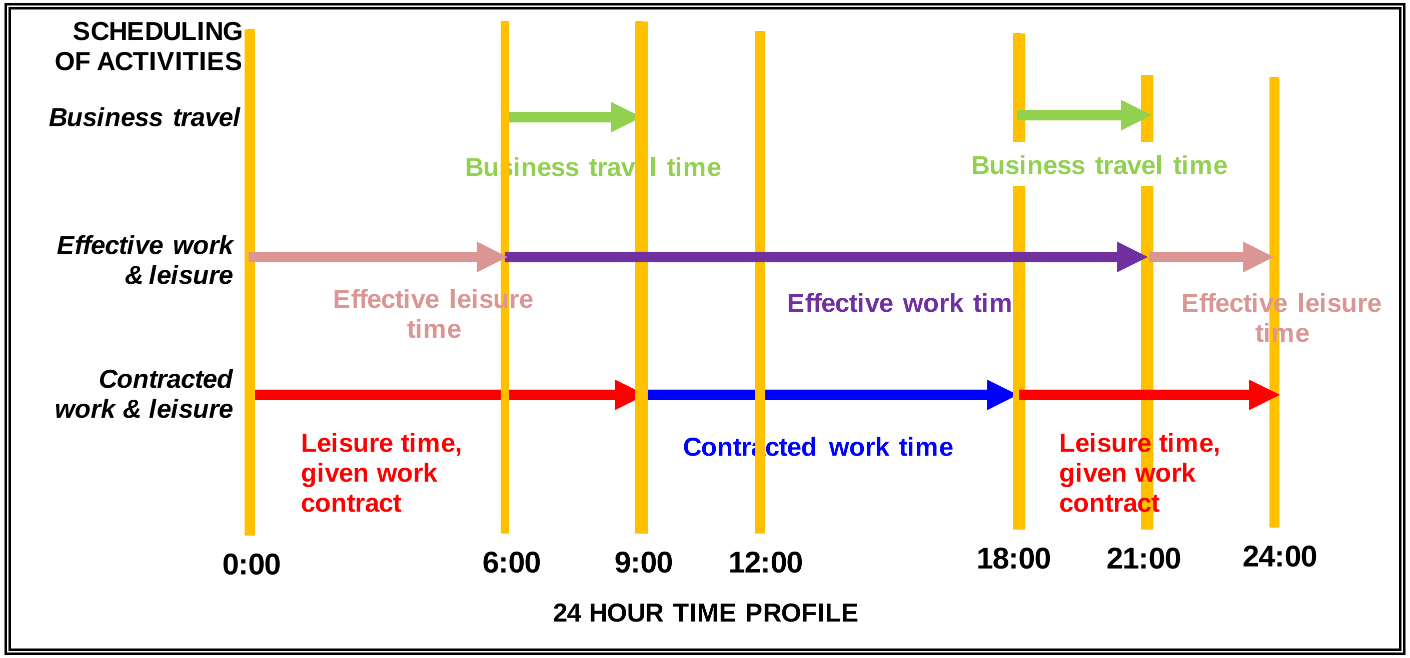
The Hensher equation might also be appropriate for representing some forms of co-operative or barter economy, but is less appropriate for economies that embody some degree of competitive behaviour between employer and employee.

$$\begin{aligned} &\underset{X,T_w,T_l,t_w}{\text{Max}}\ W = U \\ &\text{s.t.} \\ &PX = wT_w \qquad (\lambda) \\ &T = T_w + r^* t_w + (1-r^*)T_l \qquad (\mu) \end{aligned} \tag{f1}$$

This problem yields exactly the same Lagrangian function as (4), specifically:

$$L = U + \lambda(PX - wT_w) + \mu\left(T - T_w - r^* t_w - (1-r^*)T_l\right) \tag{f2}$$

Figure 1: Schematic diagram illustrating the workings of the Hensher



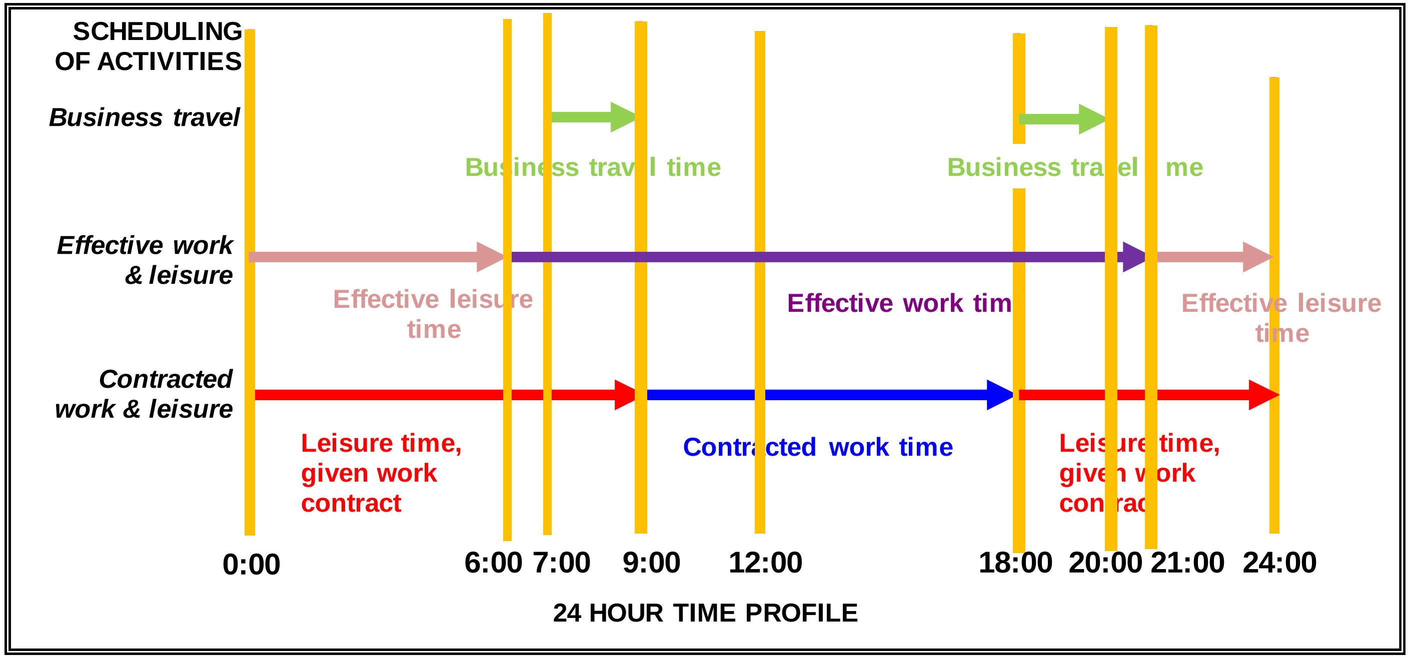
Example:

Consider an employee whose **contracted work time** is 9 hours per day, which is usually scheduled between 9:00 and 18:00. For expositional simplicity, we shall assume that no lunch break is taken (but such breaks could be admitted without substantive complication). Given the work contract of 9 hours, **leisure time** accounts for the residual time of 15 (i.e. 24-9) hours per day.

On a particular working day, the employee is required to travel to London to meet a client. In practice, this entails a 3 hour journey at each end of the day, giving total **business travel time** of 6 hours. Once in London however, the employee is expected to perform the normal contracted work time (e.g. he/she is expected to undertake a full schedule of meetings, thereby maximising the benefit of the journey), such that **effective work time** is 15 hours, and **effective leisure time** is 9 hours.

Since business travel is, in this case, undertaken outside of contracted work time, the proportion of business travel time that takes place in leisure time is 1 (i.e. r*=1).

Figure 2: Schematic diagram illustrating the workings of the Hensher equation



Example:

Now suppose that travel time to London is reduced by 1 hour in each direction.

In terms of the Hensher equation, we are interested in the allocation of the 2 hour saving in total business travel time, which could be:

1) Retained for work at home or at the normal workplace, such that **effective work time** is the same as Figure 1 (possibly to the benefit of the employee if working at home or the normal workplace is preferred to travel, and possibly to the benefit of the employer if productivity is enhanced). This is the outcome shown in Figure 2 above.
2) Returned to leisure, such that effective leisure time increases by 2 hours, as compared with Figure 1 (again to the benefit of the employee, but to the loss of the employer as productive output is reduced).
3) Split between work and leisure, such that the final outcome is intermediate between 1) and 2).

A1.4 Solving the Objective Problem

Having outlined the objective problem of interest, we will now proceed to solve it. In solving (4), it is appropriate to first solve for 'contracted' work time T_w, since this will determine the productive capacity of the firm, as well as the leisure time available to the employee.

$$\frac{\partial W}{\partial T_w} = \lambda P \frac{\partial X}{\partial T_w} + \frac{\partial U}{\partial \{\cdot\}} \frac{\partial \{\cdot\}}{\partial T_w} - \lambda w - \mu \tag{5}$$

In practice, T_w will be determined by the employee's supply of hours (and thus the interaction between work, leisure and consumption) and the employer's demand for hours (and thus the firm's planning decisions regarding the volume of production), as follows.

$$\frac{\partial W}{\partial T_l} = \frac{\partial U}{\partial \langle\cdot\rangle} \frac{\partial \langle\cdot\rangle}{\partial T_l} - \left(1 - r^*\right)\mu \tag{6}$$

$$\frac{\partial W}{\partial X} = \lambda P \tag{7}$$

The final first order condition relates to travel time specifically:

$$\frac{\partial W}{\partial t_w} = \lambda P \frac{\partial X}{\partial \{\cdot\}} \frac{\partial \{\cdot\}}{\partial t_w} + \frac{\partial U}{\partial \langle\cdot\rangle} \frac{\partial \langle\cdot\rangle}{\partial t_w} + \frac{\partial U}{\partial \{\cdot\}} \frac{\partial \{\cdot\}}{\partial t_w} + \frac{\partial U}{\partial t_w} - r^* \mu \tag{8}$$

In principle, the value of business travel time ($VBTT$) is given by:

$$VBTT = \frac{\partial W}{\partial t_w} \Big/ \lambda \tag{9}$$

As we shall demonstrate, the Hensher equation arises from a distinct focus on the value of *transferring* business travel time t_w (which may be less than fully productive, and potentially overlaps into leisure time, i.e. $r^* t_w$) into 'contracted' (and fully productive) work time T_w. Drawing upon (5) and (8) in particular, we can derive the Hensher equation as follows:

$$
\begin{aligned}
VBTTS &= \frac{1}{\lambda}\left(\frac{\partial W}{\partial T_w} - \frac{\partial W}{\partial t_w}\right) \\
&= P\frac{\partial X}{\partial[\cdot]}\left(\frac{\partial[\cdot]}{\partial T_w} - \frac{\partial[\cdot]}{\partial t_w}\right) - w \\
&+ \frac{1}{\lambda}\left(\frac{\partial U}{\partial\{\cdot\}}\left(\frac{\partial\{\cdot\}}{\partial T_w} - \frac{\partial\{\cdot\}}{\partial t_w}\right) - \frac{\partial U}{\partial\langle\cdot\rangle}\frac{\partial\langle\cdot\rangle}{\partial t_w}\right) \\
&- \frac{1}{\lambda}\frac{\partial U}{\partial t_w} \\
&- \frac{\mu}{\lambda}\left(1 - r^*\right)
\end{aligned}
\tag{10}
$$

This derivation of $VBTTS$ clarifies the interpretation of some of the terms in (2), which might be re-labelled as follows:

$$
\begin{aligned}
VBTTS &= \frac{1}{\lambda}\left(\frac{\partial W}{\partial T_w} - \frac{\partial W}{\partial t_w}\right) \\
&= \overbrace{P\frac{\partial X}{\partial[\cdot]}}^{MPL}\left(\frac{\partial[\cdot]}{\partial T_w} - \frac{\partial[\cdot]}{\partial t_w}\right) - w \\
&+ \overbrace{\frac{1}{\lambda}\frac{\partial U}{\partial\{\cdot\}}}^{VW}\left(\frac{\partial\{\cdot\}}{\partial T_w} - \frac{\partial\{\cdot\}}{\partial t_w}\right) - \overbrace{\frac{1}{\lambda}\frac{\partial U}{\partial\langle\cdot\rangle}}^{VL}\frac{\partial\langle\cdot\rangle}{\partial t_w} \\
&- \overbrace{\frac{1}{\lambda}\frac{\partial U}{\partial t_w}}^{Vot_w} \\
&- \overbrace{\frac{\mu}{\lambda}}^{VoT}\left(1 - r^*\right)
\end{aligned}
\tag{11}
$$

where:

MPL is the marginal product of labour[3]

VW is the value of 'effective' work time to the employee (we shall explain the terminology used in subsequent discussion)

VL is the value of 'effective' leisure time to the employee

Vot_w is the value of business travel time to the employee (this replaces the MPF term in (2); again we shall explain this subsequently)

VoT is the value of time as a resource

---

[3] In common with footnote 1, this term should, more precisely, be interpreted as the marginal *revenue* product, but we have used the notation *MPL* in order maintain consistency with (2).

Continuing with our derivation:

$$
\begin{aligned}
VBTTS &= P\frac{\partial X}{\partial[\cdot]}\left(1-\left\{r^{*}\left(p^{*}q\right)-\left(1-r^{*}\right)\left(1-p^{*}q\right)\right\}\right)-w \\
&+\frac{1}{\lambda}\left(\frac{\partial U}{\partial\{\cdot\}}\left(1-r^{*}\right)+\frac{\partial U}{\partial\langle\cdot\rangle}r^{*}\right) \\
&-\frac{1}{\lambda}\frac{\partial U}{\partial t_w} \\
&-\frac{\mu}{\lambda}\left(1-r^{*}\right)
\end{aligned} \tag{12}
$$

If, as is commonly assumed, $MPL = w$ then we can achieve further simplification:

$$
\begin{aligned}
VBTTS &= P\frac{\partial X}{\partial[\cdot]}\left(1-p^{*}q-r^{*}\right) \\
&+\frac{1}{\lambda}\left(\frac{\partial U}{\partial\{\cdot\}}\left(1-r^{*}\right)+\frac{\partial U}{\partial\langle\cdot\rangle}r^{*}\right) \\
&-\frac{1}{\lambda}\frac{\partial U}{\partial t_w} \\
&-\frac{\mu}{\lambda}\left(1-r^{*}\right)
\end{aligned} \tag{13}
$$

where we would expect, a priori, $\partial U/\partial\{\cdot\},\partial U/\partial\langle\cdot\rangle>0$, and $\partial U/\partial t_w<0$.

In this way, we derive the identity (13), which basically reproduces (2), but calls for us to reinterpret some of the terms of (2), as follows:

- **With regards to work time**, we should distinguish between the value of 'contracted' work time $\left(\partial U/\partial T_w\right)/\lambda$) to the employee and the value of 'effective' work time $\left(\partial U/\partial\{\cdot\}\right)/\lambda$ to the employee, where the latter includes business travel undertaken during leisure time (e.g. Figure 1 entails 'contracted' work time of 9 hours per day plus 6 hours of business travel time). Given this distinction, two clarifications are appropriate. First, the VW term in (2), which Fowkes et al. (1986) interpreted as 'the value to the employee of work time at the workplace relative to travel time', is better interpreted as the value of 'effective' work time. Second, the factor $\left(1-r^{*}\right)$ represents the proportion of business travel time that falls within 'contracted' work time. Moreover, the term $VW\left(1-r^{*}\right)$ as a whole represents the value to the employee of transferring business travel time to 'contracted' work time (e.g. outcome 1 in Figure 2).

- **With regards to leisure time**, and in a similar vein to the discussion above, the VL term in (2) is better interpreted as the value of 'effective' leisure time to the employee, and not 'the value to the employee of leisure time relative to travel time' (Fowkes et al., 1986). The factor r^* represents the proportion of business travel time that, given the work contract, falls within leisure time. Moreover, the term $VL \cdot r^*$ as a whole represents the value to the employee of transferring business travel time to leisure time (e.g. outcome 2 in Figure 2).

- More importantly - aside from the above clarifications - Fowkes et al. correctly interpreted $VW \cdot \left(1-r^*\right)+VL \cdot r^*$ as the value of business travel time savings to the employee, accounting for the possibility that such savings could be allocated to work or leisure.

- Comparing against (2), (13) includes an additional term, namely VoT. The role of the VoT term is to represent the benefit of relaxing the time constraint (μ) as travel time is saved, thereby permitting reassignment between work and leisure. The omission of the VoT term from (2) might thus give the impression that no account has been taken of the time constraint. However, this would be to overlook the role of the r term in (2), as distinct from r^* in (13), which represents the proportion of travel time *saved* that is used for leisure. That is to say, the VoT and r terms represent similar effects. We shall discuss the VoT term more fully in section 6 of this annex.

- Since (2) effectively represents the employer and employee as one-and-the-same, the MPF term in (2) can be attributed to either party. On this basis - but in contrast to Fowkes et al. - we reinterpret this term as the value of business travel time to the employee Vot_w (arguably, this is the more natural interpretation). Since we would expect $\partial U/\partial t_w < 0$, it should be the case that $MPF = -Vot_w$.

A1.5 Revealed Properties of the Hensher Equation

The above analysis has revealed a number of properties arising from (4) which can now be summarised:

- The Hensher equation is no different to the cost saving method in assuming that the marginal product of labour is equal to the wage rate, i.e. $MPL = w$.

- In perfect equilibrium, we would expect the marginal value of 'contracted' work and leisure time to be equal to the wage rate, i.e. $\left(\partial U/\partial T_w\right)/\lambda = \left(\partial U/\partial T_l\right)/\lambda = w$, but if $r^* > 0$ this precludes the possibility that $VW = VL$. Thus, by assuming the latter, AHCG (1994) effectively imposed a position of labour market disequilibrium.

- As noted in section 3 above, the Hensher equation implicitly assumes that business travel which takes place during leisure time is equally as productive as business travel that takes place during work time. If business travel during leisure is, in practice, less productive then $VBTTS$ will be understated (i.e. (13) will understate the benefits of transferring unproductive travel time to leisure). Taking the extreme case where business travel during leisure time is entirely unproductive, (13) becomes:

$$\begin{aligned} VBTTS &= P\frac{\partial X}{\partial[\cdot]}\left(1-p^{*}q-r^{*}+r^{*}p^{*}q\right) \\ &+\frac{1}{\lambda}\left(\frac{\partial U}{\partial\{\cdot\}}\left(1-r^{*}\right)+\frac{\partial U}{\partial\langle\cdot\rangle}r^{*}\right) \\ &-\frac{1}{\lambda}\frac{\partial U}{\partial t_w} \\ &-\frac{\mu}{\lambda}\left(1-r^{*}\right) \end{aligned} \tag{14}$$

The reality will perhaps fall somewhere between (13) and (14).

It has already been noted that the Hensher equation implies that no wages are paid or received for business travel that takes place during leisure time $r^{*}t_w$. If instead all 'effective' work time were fully remunerated, then $VBTTS$ should be revised upwards, as follows:

$$\begin{aligned} VBTTS &= P\frac{\partial X}{\partial[\cdot]}\left(1-p^{*}q\right) \\ &+\frac{1}{\lambda}\left(\frac{\partial U}{\partial\{\cdot\}}\left(1-r^{*}\right)+\frac{\partial U}{\partial\langle\cdot\rangle}r^{*}\right) \\ &-\frac{1}{\lambda}\frac{\partial U}{\partial t_w} \\ &-\frac{\mu}{\lambda}\left(1-r^{*}\right) \end{aligned} \tag{15}$$

Last but not least, a more fundamental issue is the nature of the production function, since the Hensher equation assumes that labour is the sole input to production, and that (apart from productivity issues) this input plays the same function whether at the regular place of work or travelling. If, in practice, the productive contribution of business travel is not simply one of labour input, but a broader one of generating and/or facilitating production (e.g. by visiting clients or suppliers), then there is a case for adjusting (13) along the lines:

$$
\begin{aligned}
VBTTS &= P\left(\frac{\partial X}{\partial[\cdot]}\left(1-p^{*}q-r^{*}\right)+\frac{\partial X}{\partial f\left(t_w\right)}\right) \\
&+\frac{1}{\lambda}\left(\frac{\partial U}{\partial\{\cdot\}}\left(1-r^{*}\right)+\frac{\partial U}{\partial\langle\cdot\rangle}r^{*}\right) \\
&-\frac{1}{\lambda}\frac{\partial U}{\partial t_w} \\
&-\frac{\mu}{\lambda}\left(1-r^{*}\right)
\end{aligned}
\tag{16}
$$

where $\partial X/\partial f\left(t_w\right)$ is the marginal product of business trips, and $f\left(t_w\right)$ is some function to be estimated. That is to say, savings in business travel time would allow more (or longer) business trips to be carried out, or allow more meetings to be conducted on a given business trip, thereby realising a potential benefit. Indeed, Kato (2010) formalises this proposition by specifying two productive functions within the objective problem, one where business travel has a negative impact on productive output (in the spirit of the Hensher equation), and a second where business travel has a positive impact on productive output.

A1.6 Special Cases of the Hensher Equation

Having derived the Hensher equation from first principles, let us now consider some special cases of the equation. We shall begin by considering the same four cases derived by Bates (2007), before considering other cases.

Case 1: Productive travel time is saved, and transferred to productive time in the workplace

This case simply amounts to imposing $r^{*}=0$ and $p^{*}=1$ on (12), as follows:

$$
\begin{aligned}
VBTTS &= P\frac{\partial X}{\partial[\cdot]}\left(2-q\right)-w \\
&+\frac{1}{\lambda}\frac{\partial U}{\partial\{\cdot\}} \\
&-\frac{1}{\lambda}\frac{\partial U}{\partial t_w} \\
&-\frac{\mu}{\lambda}\left(1-r^{*}\right)
\end{aligned}
\tag{17}
$$

If we further assume $MPL=w$, then (17) simplifies to:

$$VBTTS = P\frac{\partial X}{\partial[\cdot]}(1-q)$$
$$+\frac{1}{\lambda}\frac{\partial U}{\partial\{\cdot\}}$$
$$-\frac{1}{\lambda}\frac{\partial U}{\partial t_w} \tag{18}$$
$$-\frac{\mu}{\lambda}(1-r^*)$$

The above result replicates Bates' result for Case 1, with the exception that (18) includes the VoT term - namely the resource value of time - whilst Bates' result omits this term from consideration. The same qualification applies to Case 2-4 which follow. We shall consider the resource value of time in more detail in Case 6.

Case 2: Unproductive travel time is saved, and transferred to productive time in the workplace

This case simply amounts to imposing $r^* = 0$ and $p^* = 0$ on (12), thus:

$$VBTTS = P\frac{\partial X}{\partial[\cdot]}2-w$$
$$+\frac{1}{\lambda}\frac{\partial U}{\partial\{\cdot\}}$$
$$-\frac{1}{\lambda}\frac{\partial U}{\partial t_w} \tag{19}$$
$$-\frac{\mu}{\lambda}(1-r^*)$$

If we further assume $MPL = w$, then (19) simplifies to:

$$VBTTS = P\frac{\partial X}{\partial[\cdot]}$$
$$+\frac{1}{\lambda}\frac{\partial U}{\partial\{\cdot\}}$$
$$-\frac{1}{\lambda}\frac{\partial U}{\partial t_w} \tag{20}$$
$$-\frac{\mu}{\lambda}(1-r^*)$$

Case 3: Productive travel time is saved, and transferred to leisure time

This case simply amounts to imposing $r^* = 1$ and $p^* = 1$ (and again $MPL = w$) on (12), and yields the following:

$$\begin{aligned} VBTTS &= P\frac{\partial X}{\partial[\cdot]}\cdot -q \\ &+\frac{1}{\lambda}\frac{\partial U}{\partial\langle\cdot\rangle} \\ &-\frac{1}{\lambda}\frac{\partial U}{\partial t_w} \end{aligned} \tag{21}$$

Case 4: Unproductive travel time is saved, and transferred to leisure time

This case simply amounts to assuming $r^* = 1$ and $p^* = 0$ (and $MPL = w$) on (12), and yields:

$$\begin{aligned} VBTTS &= \frac{1}{\lambda}\frac{\partial U}{\partial\langle\cdot\rangle} \\ &-\frac{1}{\lambda}\frac{\partial U}{\partial t_w} \end{aligned} \tag{22}$$

Case 5: Cost saving approach

Further to the comment in section 1, if we assume $r^* = 0$, $p^* = 0$, $\partial U/\partial\{\cdot\} = 0$ and $\partial U/\partial t_w = 0$ (i.e. all business travel takes place during work time and is non-productive, and the marginal valuations of both work time and business travel time are zero), and also assume $MPL = w$ then - aside from the VoT term - (12) collapses to the 'cost saving' approach:

$$VBTTS = P\frac{\partial X}{\partial[\cdot]} - \frac{\mu}{\lambda} \tag{23}$$

Reflecting further, however, the five assumptions underpinning the cost saving approach detailed in section 1 (notably competitive conditions and no indivisibilities) effectively render the time resource constraint (and VoT term) redundant. Thus if these assumptions hold, (23) will in practice be equivalent to (1).

Case 6: Accounting for the resource value of time

In contrast to Case 5, the VoT term plays a substantive role in Cases 1 and 2. We shall therefore complete our analysis by considering the VoT term in more detail. Employing (5) and (6), we can derive the identity:

$$\frac{\partial W/T_w}{(\partial W/\partial X)/P} = \frac{\lambda P \dfrac{\partial X}{\partial T_w} + \dfrac{\partial U}{\partial\{\cdot\}}\dfrac{\partial\{\cdot\}}{\partial T_w} - \lambda w - \mu}{\lambda} \tag{24}$$

Simplifying and rearranging:

$$\frac{\mu}{\lambda} = P\frac{\partial X}{\partial T_w} + \frac{\dfrac{\partial U}{\partial\{\cdot\}}\dfrac{\partial\{\cdot\}}{\partial T_w}}{\lambda} - w - \frac{\partial W/T_w}{(\partial W/\partial X)/P} \tag{25}$$

Assuming $MPL = w$, (25) further simplifies to:

$$\frac{\mu}{\lambda} = \frac{\dfrac{\partial U}{\partial\{\cdot\}}\dfrac{\partial\{\cdot\}}{\partial T_w} - \partial W/T_w}{\lambda} \tag{26}$$

Finally, if we substitute for μ/λ in (12), then $VBTTS$ can be re-stated equivalently:

$$\begin{aligned}
VBTTS &= P\frac{\partial X}{\partial[\cdot]}\left(1 - p^{*}q - r^{*}\right) \\
&+ \frac{1}{\lambda}\left(\frac{\partial U}{\partial\{\cdot\}}\left(1 - r^{*}\right) + \frac{\partial U}{\partial\langle\cdot\rangle}r^{*}\right) \\
&- \frac{1}{\lambda}\frac{\partial U}{\partial t_w} \\
&- \left(\frac{\dfrac{\partial U}{\partial\{\cdot\}}\dfrac{\partial\{\cdot\}}{\partial T_w} - \partial W/T_w}{\lambda}\right)\left(1 - r^{*}\right)
\end{aligned} \tag{27}$$

Rationalising (26), intuition suggests that the value of 'contracted' work time to society must be at least as great as the value of 'contracted' work time to the employee; work would not otherwise take place. This implies that $\left(\left(\partial U/\partial\{\cdot\}\cdot\partial\{\cdot\}/\partial T_w\right) - \partial W/T_w\right) \leq 0$. In Cases 1 and 2, therefore, the VoT term potentially offers a positive contribution to $VBTTS$.

A1.7 Synthesis and Conclusions

Following a brief review of methods for estimating $VBTTS$, we have devoted particular attention to the Hensher equation, not least because it offers a general theoretical framework from which most of the competing methods can be derived or conceptualised. In particular, we derived the Hensher equation (2) from first principles, considered various special cases of the equation, and reconciled these special cases with similar work by Bates (2007). This exercise has given us reassurance that the Hensher equation can be rationalised in terms of the microeconomic theory of consumption and production, but has exposed a series of assumptions and properties, the appropriateness of which might be debated, namely:

i. Production is assumed to be a function of a single input - labour - which could include not only 'contracted' work time but also a proportion of leisure time.
ii. The marginal product of labour is assumed to be equal to the wage rate, but the employer does not pay for business travel time that takes place during leisure time (i.e. nil overtime payments are assumed).
iii. Business travel time that takes place during leisure time is assumed to be equally as productive as business travel time during 'contracted' work time.
iv. Utility to the employee is assumed to be a function of 'effective' work and leisure time, and business travel time. The MPF term in (2) can be otherwise interpreted as the value of business travel time to the employee Vot_w in (13). That is to say, it makes little practical difference whether the (negative) utility of travel per se is a burden to the employer or employee.
v. The VoT term in (13) is omitted from (2), but is instead proxied by the r term (as distinct from r^*).
vi. The Hensher equation takes no account of the potential for business travel to have a broader function of generating and facilitating economic activity.

Moreover, it is important to consider what forms of employment are compatible with the notion of a joint welfare function for the employer and employee, and the proposition that labour costs (income) should be represented in either the objective statement or the costs (budget) constraint, but not both. Our conclusion is that the Hensher equation is most applicable to self-employment, or economies that operate on a co-operative basis.

In principle, the above assumptions and properties can be relaxed, but this may have implications for estimates of $VBTTS$. Table A1.1 illustrates this, by comparing a 'base' specification of the Hensher equation with five variants, specifically:

- **Model 1**: this is taken to be the 'base', and restricts (13) to the case where the employee's value of business travel time is zero, and the time resource constraint is not binding, i.e. we assume $Vot_w = 0$ (or $MPF = 0$) and $VoT = 0$.

- **Model 2**: we adjust Model 1 such that business travel during leisure time is zero-productive, i.e. we assume $q = 0$ during leisure. This has the effect of increasing $VBTTS$ relative to the base, but typically not to the extent that it will exceed w.

- **Model 3**: we adjust Model 1 such that overtime is paid, i.e. we assume that labour costs equal $w\left(T_w + r^* t_w\right)$. $VBTTS$ increases relative to the base, but typically will be less than w.

- **Model 4**: Model 1 is adjusted such that the value of business travel time savings to the employee is admitted, i.e. we assume $Vot_w \neq 0$ (or $MPF \neq 0$). $VBTTS$ increases relative to the base, and could in some circumstances exceed w.

- **Model 5**: we adjust Model 1 such that the value of time as a resource is admitted, i.e. we assume $VoT \neq 0$. $VBTTS$ increases relative to the base, but typically will be less than w.

- **Model 6**: this is as Model 1, but admits the possibility that business trips have a productive benefit beyond the basic labour input, i.e. we assume $\partial X / \partial f\left(t_w\right) > 0$. Again $VBTTS$ increases relative to the base, and could possibly exceed w.

Although Models 2-6 outline cases where $VBTTS$ increases relative to Model 1, it is important to note that Models 2, 3 and 5 would still be expected to yield a $VBTTS$ less than the wage rate. By contrast, Models 4 and 6 could, in some circumstances, yield a $VBTTS$ above the wage rate.

Table A1.1: Variants of the Hensher equation, and impacts on VBTTS

Model	Description	Formula for $VBTTS$	$VBTTS$ relative to Base
1	Assume $Vot_w = 0$ (equivalent to $MPF = 0$) and $VoT = 0$	$VBTTS_1 = P\frac{\partial X}{\partial[\cdot]}\left(1-p^*q-r^*\right)+\frac{1}{\lambda}\left(\frac{\partial U}{\partial\{\cdot\}}\left(1-r^*\right)+\frac{\partial U}{\partial\langle\cdot\rangle}r^*\right)$	Base $= VBTTS_1$
2	Assume zero productivity (i.e. $p^*q = 0$) during leisure time	$VBTTS_2 = P\frac{\partial X}{\partial[\cdot]}\left(1-p^*q-r^*+r^*p^*q\right)+\frac{1}{\lambda}\left(\frac{\partial U}{\partial\{\cdot\}}\left(1-r^*\right)+\frac{\partial U}{\partial\langle\cdot\rangle}r^*\right)$	$VBTTS_2 > VBTTS_1$, but typically less than w
3	Assume overtime is paid, i.e. wage costs equal $w\left(T_w + r^*t_w\right)$	$VBTTS_3 = P\frac{\partial X}{\partial[\cdot]}\left(1-p^*q\right)+\frac{1}{\lambda}\left(\frac{\partial U}{\partial\{\cdot\}}\left(1-r^*\right)+\frac{\partial U}{\partial\langle\cdot\rangle}r^*\right)$	$VBTTS_3 > VBTTS_1$, but typically less than w
4	Assume $Vot_w \neq 0$ (or $MPF \neq 0$), implying that travel has a fatigue effect on the employee	$VBTTS_4 = P\frac{\partial X}{\partial[\cdot]}\left(1-p^*q-r^*\right)+\frac{1}{\lambda}\left(\frac{\partial U}{\partial\{\cdot\}}\left(1-r^*\right)+\frac{\partial U}{\partial\langle\cdot\rangle}r^*-\frac{\partial U}{\partial t_w}\right)$	$VBTTS_4 > VBTTS_1$, and possibly greater than w
5	Assume $VoT \neq 0$, implying that time savings allow reassignment of work and leisure time	$VBTTS_5 = P\frac{\partial X}{\partial[\cdot]}\left(1-p^*q-r^*\right)+\frac{1}{\lambda}\left(\frac{\partial U}{\partial\{\cdot\}}\left(1-r^*\right)+\frac{\partial U}{\partial\langle\cdot\rangle}r^*\right)-\frac{\mu}{\lambda}\left(1-r^*\right)$	$VBTTS_5 > VBTTS_1$, but typically less than w
6	Assume business trips generate business, i.e. $\partial X/\partial f\left(t_w\right) > 0$	$VBTTS_6 = P\left(\frac{\partial X}{\partial[\cdot]}\left(1-p^*q-r^*\right)+\frac{\partial X}{\partial f\left(t_w\right)}\right)+\frac{1}{\lambda}\left(\frac{\partial U}{\partial\{\cdot\}}\left(1-r^*\right)+\frac{\partial U}{\partial\langle\cdot\rangle}r^*\right)$	$VBTTS_6 > VBTTS_1$, and possibly greater than w

Annex 1 References

Accent & Hague Consulting Group (AHCG) (1999) The Value of Travel Time on UK Roads. Prepared for Department for Transport.

Bates, J. (2007) Business value of time and crowding – some thoughts. Private communication.

Bates, J. (2013) Assessment of 'Technical Annex on the Hensher Equation'. Private communication.

Becker, G.S. (1965) 'A theory of the allocation of time'. *The Economic Journal*, 75, pp493-517.

DeSerpa, A. (1971) 'A theory of the economics of time'. *The Economic Journal*, 81, pp828-846.

Forsyth, P.J. (1980) The value of time in an economy with taxation. Journal of Transport Economics and Policy, Vol. XIV, pp337-361.

Fowkes, T. (2001) Principles of valuing business travel time savings. Institute for Transport Studies, University of Leeds, Working Paper 562.

Fowkes, A.S., Marks, P. & Nash, C.A. (1986) The value of business travel time savings. Institute for Transport Studies, University of Leeds, Working Paper 214.

Hensher, D.A. (1977) Value of Business Travel Time. Pergamon Press, Oxford.

Karlström A., Eliasson J. & Levander A. (2007) On the theoretical valuation of marginal business travel time savings. European Transport Conference.

Kato, H. (2012) On the value of business travel time savings: derivation of Hensher's formula. Working paper.

Mackie, P., Wardman, M., Fowkes, A.S., Whelan, G., Nellthorp, J. & Bates J.J. (2003) Values of travel time savings in the UK. Report to Department of Transport. Institute for Transport Studies, University of Leeds & John Bates Services, Leeds and Abingdon.

MVA, ITS & TSU (1987) Working Paper 3: Theoretical considerations. Report to the APM Division, Department of Transport.

Oort, O. (1969) The evaluation of travelling time. *Journal of Transport Economics and Policy*, 3, pp279-286.

ANNEX 2: CURRENT APPRAISAL PRACTICE

A2.1 Objectives

This note forms an annex to the main report to the Department for Transport on the valuation of travel time savings to business travellers. The purpose of this annex is to:

- Give some context to the current practice of valuing business travel time savings in the UK;
- Review international practices on valuing business travel time savings;
- Review the sources of wage data, working hours, etc. the Department uses for the calculation of business travel time savings.

A2.2 Structure of this annex

Following this short introductory section, the second section of this annex gives some context to business travel in GB in terms of its economic importance, how these trips are made (timing and mode) and who makes them (occupations and industries). The third section summarises the approach used in Britain to value business travel time savings and briefly introduces alternative approaches. In the fourth section practice across Europe and other countries with developed appraisal systems is compared, whilst in the fifth section the methodology and data used to implement the cost saving method to valuing business travel time savings in GB is critically reviewed. The final section presents a brief summary of the main points contained within this annex.

A2.3 Business Travel in Great Britain

For infrastructure projects with the objective of improving accessibility business travel time savings are important - travel time savings typically comprise the majority of the direct benefits of such projects. As business trips are valued on average at more than 4 times non-working time savings (DfT, 2012a), the value of business time savings is critical to the economic appraisal of such projects. For example time savings form half of all user benefits for the proposed London to West Midlands high speed rail line, and business time savings are almost three times those for non-work time savings (DfT, 2012b Table 10 p42).

Despite its economic importance business travel actually comprises a minority of trips made in Great Britain (GB). 8.5% of all trips made per year within GB and 8.8% of all miles travelled per year[4] are

[4]NTS 2010 Tables 0409 and 0410. Note that the National Travel Survey excludes professional driver mileage the UK NTS specifically excludes the following types of motorised trips as they are commercial rather than personal travel: trips made specifically to deliver/collect goods in the course of work; trips made by professional drivers or crew in the course of their work; trips made by taxi drivers if they are paid or charge a

made on employers' business. We can also see that there is a great deal of heterogeneity in who makes business related trips and when they are made. Cars and vans dominate the mode of travel for business travellers as is apparent in Table A2.1.

Table A2.1: Proportion of Business Trips by Mode (by Distance Travelled and by Trips Made)

	Walk	Bicycle	Car/ van driver	Car/ van pass	Motor-cycle	Other private[1]	Local bus	Rail[2]	Other public[3]	All modes
By distance	0.2%	0.2%	73.0%	8.2%	0.3%	0.6%	0.7%	11.5%	5.3%	100.0%
By trip	6.1%	1.4%	71.6%	7.9%	0.8%	0.5%	4.0%	6.5%	1.3%	100.0%

1 Mostly private hire bus (including school buses).

2 Surface rail and London underground.

3 Non-local bus, taxi/minicab and other public transport (air, ferries, light rail).

Source: NTS 2011 Tables 0409 and 0410

Most business trips (60%) start within the core of the working day (9am to 5pm), as can be seen in Table A2.2 though 21% start before 9am and 18% after 5pm. A greater proportion of business trips start outside the core working day when looking at rail as 33% of business trips start be*f*ore 9am, and 20% after 5pm.

There also exist differences between the types of workers who make business trips as is apparent in Table A2.3. Managerial and professional staff not only make more trips per person (averaging at more than 1 per week), but also travel the furthest. Whilst there is no NTS table to show it we would also hypothesise that such workers dominate travel by rail (for business purposes) – given the high wages of such travellers (DfT, 2012a) and their propensity to travel further (see Table A2.3).

We can also see in Table A2.4 that whilst travel is more evenly split between different industrial sectors (compared to occupations) employees in certain industries appear to travel further than others. These are employees in the high value service sector (financial and real estate) and those in construction and agriculture/fishing.

fare for making a trip; and trips made by professional driving instructors whilst teaching or driving their vehicles in the course of their work.

Table A2.2: Start Time of Trips (All Modes and Rail Only)

Start time		All modes	Rail
Before 9am	0000 - 0059	*0%*	*0%*
	0100 - 0159	*0%*	*0%*
	0200 - 0259	*0%*	*0%*
	0300 - 0359	*0%*	*0%*
	0400 - 0459	*0%*	*0%*
	0500 - 0559	*1%*	*2%*
	0600 - 0659	*3%*	*9%*
	0700 - 0759	*7%*	*13%*
	0800 - 0859	*10%*	*10%*
Between 9am and 5pm	0900 - 0959	*8%*	*6%*
	1000 - 1059	*7%*	*4%*
	1100 - 1159	*7%*	*4%*
	1200 - 1259	*7%*	*4%*
	1300 - 1359	*7%*	*5%*
	1400 - 1459	*7%*	*5%*
	1500 - 1559	*8%*	*7%*
	1600 - 1659	*9%*	*11%*
After 5pm	1700 - 1759	*8%*	*10%*
	1800 - 1859	*4%*	*5%*
	1900 - 1959	*2%*	*2%*
	2000 - 2059	*1%*	*1%*
	2100 - 2159	*1%*	*1%*
	2200 - 2259	*1%*	*1%*
	2300 - 2359	*1%*	*0%*
	All day	*100*	*100%*

Source: NTS 2011 Table 0503

Table A2.3: Business Travel by Socio-Economic Classification (All Modes)

NS-SEC	2010
Average number of trips (per person per year)	
Managerial and professional occupations	58
Intermediate occupations	38
Routine and manual occupations	20
Never worked and long-term unemployed occupations	2
Not classified[3]	26
All people (aged 16+)	**35**
Average distance travelled (miles per person per year)	
Managerial and professional occupations	1,516
Intermediate occupations	596
Routine and manual occupations	258
Never worked and long-term unemployed occupations	15
Not classified[3]	463
All people (aged 16+)	**729**

[1] Business purpose trip: personal trips in the course of work, including a trip in the course of work back to work. This includes all work trips by people with no usual place of work (e.g. site workers) and those who work at or from home.

[2] . = not applicable.

[3] Most of the people in the 'not classified' category are full-time students.

Source: NTS2010 Table 0708 (edited)

Table A2.4: Business Travel by Industry (All Modes)

Industry group	2008/09
Average number of trips (per person per year)	
Agriculture and fishing	88
Energy, water, mining etc.	34
Manufacturing	24
Construction	69
Distribution and hotels	16
Transport and communication	25
Financial and real estate	54
Public administration, education and health	50
Other service	57
All people (aged 16+)	**40**
Average distance travelled (miles per person per year)	
Agriculture and fishing	931
Energy, water, mining etc.	786
Manufacturing	717
Construction	1,586
Distribution and hotels	356
Transport and communication	836
Financial and real estate	1,349
Public administration, education and health	597
Other service	761
All people (aged 16+)	**780**

Note: Business purpose trip: personal trips in the course of work, including a trip in the course of work back to work. This includes all work trips by people with no usual place of work (e.g. site workers) and those who work at or from home.

A2.4 Measuring the Value of Business Travel Time Savings

A2.4.1 GB practice and the Cost Saving Method

The 1960s heralded the first UK applications of social cost benefit analysis to transport projects (Coburn et al., 1960; Foster and Beesley, 1963). By the 1970s transport cost benefit analysis theory had been developed to a satisfactory state of the art and was widely accepted (Dodgson, 1973, 1974; Harrison, 1974; Mohring, 1976; Leitch 1978). In these early studies business travel was valued using what has now been termed the cost saving method. Some fifty years later the cost saving method is still in use in the UK and, in fact, in much of the rest of the world where transport appraisal is actively practised. Eades (2000) sets out the approach used by the Department for Transport in deriving business values for travel time savings.

The cost saving method says that in a competitive labour and product market, firms hire labour to the point at which the value of the marginal product is equal to the wage rate. Thus the value of the time saving is equal to the marginal gross cost of labour including labour related overheads. To arrive at this conclusion a number of well documented assumptions are implied regarding the labour market and the allocation of time between work and leisure (Harrison, 1974). Specifically travel time is assumed to be unproductive, reductions in travel time are assumed to go into work not leisure, the labour and product markets are assumed to be competitive and there are no indivisibilities in the use of time for production.

A2.4.2 Alternative Valuation Approaches

Alternative approaches to valuing business travel time savings are discussed in detail in Annex 1 and also in Section 2 of the main report. They are: the Hensher model, the Modified Cost Saving Approach/Restricted Hensher Model, and Willingness to Pay.

A2.5 International Appraisal Practice

When looking at international appraisal practice it is important to recognise that in many countries no firm guidelines are provided. The requirement on the transport analyst is to use best practice methods. In a 2005 survey of appraisal practice in the EU plus Switzerland Odgaard, Kelly and Laird (2005) found that ‘national guideline values’ which are used in almost all appraisal circumstances only exist in 10 of the 27 countries surveyed. Seven of the 27 countries have no guideline values whatsoever and the remaining countries have guideline values but there is no requirement to use them. In fact for four of the latter group of countries the guideline values are only rarely used (Odgaard, Kelly and Laird, 2005 Table 5.1).

Looking at the ten EU countries where guideline values are provided and used in almost all circumstances, we find that three different valuation methods for business travel time savings are in use. As shown in Table 2.5, the cost saving method for valuing business travel time savings is the most popular method. Adjusted cost saving/restricted Hensher models have been estimated in Sweden (Algers, Hugosson and Lindqvist Dillen, 1995), and the Netherlands. (HCG, 1998). Norway used to use an adjusted cost saving/restructed Hensher method (Ramjerdi et al., 1997), but in 2010 reverted back to using a cost saving approach. Switzerland is unique in that it marks up the non-working time savings value (Bickel *et al.*, 2005 p118). The European Investment Bank (EIB, 2005) and the EC (Bickel et al., 2006) also advocate the cost saving method.

Table A2.5: Approaches to Estimating Business Values of Travel Time Savings (for Countries/Organisations with Guidelines for Appraisal).

Method	Countries	
Cost saving method	Europe:	Denmark, Finland, France, Germany, Ireland, Norway, UK, European Investment Bank, EC
	Non-Europe:	Australia, New Zealand, USA, World Bank
Adjusted cost saving/Restricted Hensher	Europe:	Sweden, Netherlands
	Non-Europe:	---
Hensher model	Europe:	---
	Non-Europe:	---
Willingness to pay	Europe:	---
	Non-Europe:	---
Other	Europe:	Switzerland
	Non-Europe:	

Source: Odgaard, Kelly and Laird (2005) updated to 2012 and to include Australia, New Zealand, Norway, USA, World Bank and EIB with authors' own work

Outside of Europe we find that the cost saving method also dominates. In the United States business values of time are based on wage rates with no mark up for labour related overheads (Belenky, 2011). In Australia the cost saving approach is also used (Austroads, 2011) as it is in New Zealand (Melsom, 2003). In New Zealand, occupations and industries are taken into account when calculating wage and non-wage costs by mode (BCHF, 2002 Chapter 8). The World Bank also advocates the cost saving method, though wage rates are adjusted for the shadow price of labour (Mackie, Nellthorp and Laird, 2005 TRN-15). No country that we have surveyed uses either a Hensher model or values derived from direct elicitation of willingness to pay by employers.

Figure A2.1: Valuation of Business Travel Time Savings in Scandinavian Appraisal Guidance

Current practice

Sweden and Norway have used the Hensher formula (or variants of it) since the mid 1990s, but have both recently changed to a (modified) cost savings approach. Denmark has always used a cost savings approach. Sweden changed to a pure cost savings approach in 2008, after using Hensher-type formulas since the early 1990s. As of 2012, a modified cost savings approach is used. Here the BVTTS for train is reduced by 15% to account for productive travel time. Norway changed to a pure cost savings approach in 2010, after using a Hensher-type formula since (at least) 1997. Sweden and Denmark do not differentiate the BVTTS with respect to mode or trip distance, whereas Norway has a higher BVTTS for air trips due to higher average wage rates for air travellers. In Sweden's case, it is acknowledged that the BVTTS should in principle be differentiated with respect to mode and travel distance due to wage rate differences, but the available data have been too unreliable for this.

Principles for "cost savings" calculations

All three countries use the wage rate plus overhead costs as an indicator for marginal labour productivity (MPL). The question whether wages are a good enough approximation of MPL arises regularly, but no specific alternative has been suggested.

Another discussion is how to define overhead costs. Sweden currently uses only indirect labour taxes (social security charges and the so-called "employer tax"), but no other overhead costs, such as costs for office rents, administrative support etc. The Danish and Norwegian practices seem to be the same, although this is not absolutely clear.

Motivations for adopting the modified cost saving method

In both Sweden and Norway, the crucial argument for abandoning the Hensher-type formula was that in the long run, it was expected that workers would not transfer saved time to leisure, but would instead transfer it to increased work. That is in the Hensher formula r was argued to be zero. The motivation for this has been that spending some time travelling outside normal working hours is part of the agreement between employer and employee. This argument has been supported by the observation that despite substantial increases in travel speeds over several decades, there are no indications that business travellers nowadays spend less of their leisure time on business trips (Metz, 2004); hence, there seems to be no indication that some of the travel time savings have been converted to leisure time.

The debates in both countries seem to acknowledge that it is not enough to try to measure how a travel time saving would be divided between the employer and employee in the very short-term, such as focusing on a particular trip. The attempts at doing this during the 1990s are hence now viewed as misdirected, and that an understanding of the r parameter needs to be based on the long-run effects.

Neither Denmark nor Norway adjusts the BVTTS for productivity during the trip, although the Norwegian debate acknowledges that this should be done in principle. During the period 2008-2012, Sweden likewise had no productivity adjustment, although this was based on the misunderstanding that consumer surplus could not be calculated when values of time were different on different modes. Once this misunderstanding was corrected, it was decided to adjust for productivity during the trip in the 2012 recommendations. However, the current Swedish recommendation of 15% productivity during train trips is rather arbitrary. During the decision process, two sources were used (Fickling et al. 2008) and Lyons et al. 2007). The 15% productivity figure does not directly relate to either of these studies.

The content of appraisal guidelines whilst interesting does not necessarily reflect the state of the art in valuation methods. This is because a pragmatic balance between data collection efforts and need often has to be struck during development of the guidelines. Issues of equity also influence the methods adopted and the level of disaggregation in the values. Furthermore guidelines also have to be developed for the full spectrum of potential stakeholders, and recognition therefore has to be made in the guidelines for the practical realities of the modelling and evaluation methods that will be employed. There have therefore been a plethora of studies that have examined willingness to pay by business travellers for travel time savings, often with a demand forecasting perspective, that are more sophisticated in their valuation methodology than the cost saving method (Shires and de Jong, 2009; Abrantes and Wardman, 2011; Hensher, 2011). Patterns and trends in these empirical studies of the value of business travel time savings are presented in Annex 2 of this study. However, given that ultimately we are interested in amending national appraisal guidelines we briefly case study Scandinavian practices where adjusted cost saving models/restricted Hensher models have been implemented, and recently altered (Sweden) and replaced by a cost saving approach in Norway. This is presented in Figure 1.

A2.6 Implementing the Cost Saving Method in Great Britain

With the cost saving method the value of the time saving is equal to the marginal gross cost of labour including labour related overheads. In essence the DfT's approach has been to:

- Use NTS data to derive distance weighted annual incomes by mode of travellers. As the NTS only collects banded income data – the mid-point of the income band is used.
- Calculate hourly incomes by dividing average annual incomes by 39.4 hours (which is the average working week sourced from the New Earnings Survey).
- Use the New Earnings Survey to estimate hourly wage rates for commercial vehicle drivers and occupants.
- Use the Labour Cost Survey to estimate average non-wage labour costs. On average non-wage labour costs form 21.2% of the wage. Uprate average hourly estimates by a factor of 1.212 to give estimates of the gross cost of labour plus labour related overheads.
- Adjust estimates to correct unity of account and price and value base.

The current values in webTAG unit 3.5.6 (DfT, 2012a) were derived from survey data in 1999/2000. They have been updated to 2010 prices and values by reflecting changes in GDP/capita and inflation. Since these values have been derived the New Earnings Survey has been superseded by the Annual Survey of Hours and Earnings (ASHE).

Effectively the approach is a two staged approach. The first stage estimates the hourly wage of travellers, and the second estimates the nonwage labour costs. We comment on these stages separately.

A2.6.1 Deriving the Hourly Wage

Over time the labour market alters and the way that different modes of transport are used by different sections of the business community may also change. Given that the current average modal business time saving values were derived from 1999 to 2001 NTS data, they are arguably getting to the point of requiring an update. Even if the existing approach is maintained, there is a need to update the current values using more recent travel survey data.

Given that the cost saving method requires an estimate of the hourly wage ideally a dataset that is robust in earned income data should be used. The NTS is not such a dataset. This is for three reasons. Firstly, the personal gross annual income reported in the NTS is from all sources (earnings, benefits, pensions, savings, self-employment, multiple jobs, etc.). Secondly, the survey does not record the number of hours worked by individuals thus one cannot obtain a robust estimate of an hourly wage rate. Finally, the income data is only banded. More appropriate datasets for deriving hourly incomes would be the Annual Survey of Hours and Earnings (ASHE) and the Labour Force Survey (LFS). These form the basis of ONS estimates of earnings. The challenge of course is to link these more robust estimates of hourly earnings to observed travel behaviour to derive distance weighted estimates of the value of business travel time savings by say, transport mode.

The current approach could bias the values. Firstly total annual income exceeds earned income. The Family Resources Survey (DWP, 2012 Table 2.3) indicates that earned income comprises on average about 85% of total income for households with a head of household aged between 25 and 59. That is using total income as an approximation to earned income overestimates earned income by about 18% (on average across the workforce). Secondly hours worked vary significantly by occupation. Managers and senior officials work about 15% more hours than the average worker[5,6]. As these occupations travel the most (see Section 2 of this report) then using average hours worked by the average worker risks introducing an upward bias to the estimated hourly wage rate of those travelling on employers' business. Furthermore, as travellers will self-select between modes any upward bias will vary between modes and will be largest for modes used by those who work the longest hours (i.e. modes preferred by managers, senior officials and professionals). Ultimately, how significant any biases are is an empirical question that needs further analysis before conclusions can be drawn.

An alternative approach to estimate the distance weighted hourly wage by mode would be to use each dataset to its full strength. Therefore the NTS would be used to describe the types of business travellers using each mode (in terms of distance weighted proportions by occupation and potentially

[5] Census 2001 Table CAS040

[6] Some of the additional hours worked by managers and senior officials will not be 'officially' contracted, but having an accurate understanding of their hours is essential to calculate their effective hourly wage.

industrial sectors[7]), and the LFS or ASHE would be used to derive hourly wage rates for each of these categories of business travellers. ASHE is a survey of employers and responses are based on documentary evidence, whereas responses in LFS are based on individual recollection, sometimes by proxy respondents and sometimes without reference to payslips. ASHE is therefore generally considered more reliable (Ormerod and Ritchie 2007). The ASHE sample is also considerably larger than LFS, although is not as representative of low-paid workers as LFS, does not include unpaid overtime hours, and does not cover self-employed, which the LFS does: we discuss the self-employed below. The LFS is therefore arguably the better dataset from which to derive hours worked, whilst ASHE, is considered the best dataset to describe earned income. Such an enhanced approach is similar to that used in New Zealand (BCHF, 2002 Chapter 8).

Ultimately the question of whether the existing methodology for calculating distance weighted average hourly earnings by mode is a good approximation to reality is an empirical question. We have raised a number of issues that would suggest that upward biases exist in the current methodology (i.e. the current values of work travel time savings are too high). However, how significant those biases are is an empirical question that needs further analysis before any conclusions can be drawn.

A2.6.2 Non-Wage Labour Costs

Our discussions with the ONS indicate the Labour Cost Survey is the most comprehensive dataset for non-wage labour costs in the UK. It is re-compiled every four years by the ONS as part of ongoing commitments to Eurostat. Partial annual updates are also made. The latest survey relates to 2008. A 2012 survey will also be undertaken, which should become available in 2014 once Eurostat has published it. The Labour Cost Survey is not a survey in the strictest sense, but is in fact an analysis of existing datasets – the main ones of which are ASHE, LFS and the Annual Business Inquiry (ABI). The main sources of non-wage labour costs are employers' national insurance and employers' pension contributions. Other non-wage labour costs are also estimated including paid annual leave, paid maternity/paternity leave, training costs, sick pay, benefits in kind, etc. Mark-up factors from employee wage costs to gross labour costs to the firm per hour of employment are available for the economy as a whole and by industrial sector.

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[7] The NTS contains National Statistics Socio-economic Classification (NS-SEC) data that gives broad occupational data. It also contains data on standard industrial sector (SIC). These are also contained in the LFS and ASHE. If disaggregating by mode, NS-SEC and SIC sample sizes are likely to be small giving imprecise estimates of both distance weighted proportions (from the NTS) and possibly earned income from the LFS or ASHE. Some aggregation of the NS-SEC categories and SICs will be necessary. Additionally it may be necessary to pool several years of the NTS data to obtain reliable estimates of mileage weighted proportions at whatever level of disaggregation NS-SEC/SIC is chosen. Another estimation issue that may arise is that if business related travel is a function of income rather than job function than an income/mileage distribution may arise within any specific NS-SEC/SIC sample segment. Arguably business travel should be a function of the job undertaken by the worker and not income – however there may be whether there is sufficient data in the NTS to identify job functions accurately enough and some correlations with income/wage may still be present.

The current non-wage labour costs are based on the 2000 Labour Cost Survey. The existing business values of time could therefore be updated to be consistent with the 2008 survey (the latest available survey). The proportion of non-wage costs varies by industry with skilled service sector industries incurring higher non-wage costs than agricultural, construction, manufacturing and low skilled service sector employment. As travel behaviour (distance travelled and mode choice) varies by income and job type there is therefore an argument that the non-wage mark-up should also be allowed to vary by mode. This would require an analysis of the NTS to indicate the industrial sectoral split by mode. Such an enhanced approach is similar to that used in New Zealand (BCHF, 2002 Chapter 8).

A2.6.3 Professional Drivers

Employed professional drivers would be treated the same as other employees in this revised methodology – in the sense that the ASHE or LFS would be used to derive their hourly wage..

A2.6.4 Long run marginal costs

From a cost benefit analysis perspective we are not, strictly speaking, interested in the marginal product of labour per se. This is because in response to changes in labour productivity the firm will re-balance factor inputs (other classic inputs being capital and land) to maximise profits. What we are primarily interested in therefore is how the long run marginal costs to the firm alter in response to changes in labour productivity. As far as we are aware there is no comprehensive evidence on this. For marginal changes in business travel time we would consider that short run responses, that is all inputs aside from labour being held constant, would be a suitable approximation.

A2.7 Summary

Business travel whilst forming only a small proportion of the trips made in the UK is a very important in economic terms. Business travel is also very heterogenous in terms of who makes the trips, when those trips are made and how they are made (mode). Importantly:

- 40% of business travellers start their journeys outside of the core working day (9am to 5pm);
- The number of and length of business trips increases with socio-economic status/occupation, and also by corollary with income; and
- Travel varies by industrial sector – albeit not as much as by occupation.

In terms of international appraisal practice the cost saving method dominates valuation methods used to derive values published in official guidance. The adjusted cost saving approach is used in the Netherlands and in Sweden.

Currently business values of time used for appraisal in Britain have been derived from the 1999/01 National Travel Survey (for annual incomes by mode) and the 2000 Labour Cost Survey (for average non-wage costs). The New Earnings Survey was used to derive hours worked and the hourly wage of commercial drivers. For a number of reasons these values are considered questionable. Firstly the data upon which they are based are old, and secondly the income data is based on the NTS rather than a combination of the ASHE and the LFS. The NTS does not give reliable hourly earned income data. A potentially more robust method to derive hourly wage plus non-wage costs for travellers by mode would be to use the NTS to describe who travels on which mode (in terms of occupation and industry) and other datasets – the Labour Cost Survey, the ASHE and the LFS – to give estimates of the hourly wage and hourly non-wage costs by occupation/industry. Such an approach would be similar to that adopted in New Zealand.

Annex 2 References

Abrantes, P.A.L. and Wardman, M.R. (2011) Meta-analysis of UK values of travel time: An update. *Transportation Research Part A* **45** 1–17.

Algers, S., Hugosson, B., Lindqvist Dillén, J. (1995) *1994 års tidsvärdestudie. Slutrapport, Del 1, Resultat*. Transek AB, Solna

Austroads (2011) *Updating Austroads RUE Unit Values and Related Methodologies.* Austroads Research Report AP-R373/11. Report dated February 2011. Sydney, Australia: AUSTROADS

Barrington, A. (1977) Valuing Time Savings in Developing Countries – A Comment. *Journal of Transport Economics and Policy*, **11**(2) pp195-201.

Beca Carter Hollings & Ferner Ltd (2002) *Review of Benefit Parameter Values for Economic Evaluation*. Report to Transfund New Zealand. Report dated: April 2002.

Belenky, P. (2011) The Value of Travel Time Savings: Departmental Guidance for Conducting Economic Evaluations. Revision 2. Memo dated 28 Sept 2011. Available online at:

Bickel, P., Burgess, A., Hunt, A., Laird, J., Lieb, C., Lindberg, G., Odgaard, T. (2005) *State-of-the-art in project assessment. HEATCO Deliverable 2*. HEATCO – Developing Harmonised European Approaches for Transport Costing and Project Assessment. Funded by the 6th Framework RTD Programme. IER Stuttgart, Germany. . Available online at: http://heatco.ier.uni-stuttgart.de/.

Bickel, P. *et al.* (2006) *Proposals for harmonised guideliens. HEATCO Deliverable 5*. HEATCO – Developing Harmonised European Approaches for Transport Costing and Project Assessment. Funded by the 6th Framework RTD Programme. IER Stuttgart, Germany. . Available online at: http://heatco.ier.uni-stuttgart.de/.

Coburn, T.M., Beesley, M.E. and Reynolds, D.J. (1960) The London-Birmingham Motorway. *Road Research Technical Paper 46*. London, HMSO.

Department for Transport (DfT) (2012a) *Values of time and operating costs, TAG Unit 3.5.6 August 2012*. London: Department for Transport. Available online at: <http://www.dft.gov.uk/webtag/> (Accessed 23rd August 2012).

Department for Transport (DfT) (2012b) *Economic Case for HS2: Updated appraisal of transport user benefits and wider economic benefits*. A report to Government by HS2 Ltd. January 2012. Available online at: < http://www.dft.gov.uk/publications/hs2-economic-case-appraisal-update/> (Accessed 26th October 2012).

Dodgson, J.S. (1973) External effects and secondary benefits in road investment appraisal. *Journal of Transport Economics and Policy*, **7** (2), pp 169-185.

Dodgson, J.S. (1974) Motorway Investment, Industrial Transport Costs and Sub-Regional Growth — a case study of the M62, *Regional Studies* **8** (1), pp 75-91

Eades, D. (2000, Unpublished) *Creating new values of working time (HEN2)*. Internal note to the Department for Transport. Note dated: April 2000.

European Investment Bank (2005) RailPAG: Rail Project Appraisal Guidelines. Brussels: EIB. Available online at: http://www.eib.org/infocentre/publications/all/railpag-railway-project-appraisal-guidelines.htm (Accessed 26th October 2012).

Fickling, R., Gunn, H., Kirby, H., Bradley, M., & Heywood, C. (2008). *The productive use of rail travel time and value of travel time saving for travellers in the course of work*. ETC Proceedings. Available online at: <http://www.etcproceedings.org/paper/the-productive-use-of-rail-travel-time-and-value-of-travel-time-saving-for-tra-1> (Accessed 26th October 2012).

Foster, C.D. and Beesley, M.E. (1963) Estimating the benefits of constructing an underground line in London. *Journal of the Royal Statistical Society, Series A,* **126** (1) pp 46-58.

Fowkes, A.S., Marks, P and Nash, C.A (1986) *The value of business travel time savings.* Institute for Transport Studies, University of Leeds, Working Paper 214.

Hague Consulting Group (HCG) (1998) *Value of Dutch Travel Time Savings in 1997.* Final report. A report for Rijkswaterstaat – AVV by Hague Consulting Group, The Hague, Netherlands.

Harrison, A.J. (1974) *The economics of transport appraisal*. Croom Helm, London.

Hensher, D.A. (1977) *Value of Business Travel Time*. Pergamon Press, Oxford.

Hensher, D.A. (2011) Valuation of travel time savings. In de Palma, A., R. Lindsey, E. Quinet, and R. Vickerman(eds) *A Handbook of Transport Economics*. Cheltenham: Edward Elgar pp135-159.

Howe, J. (1976) Valuing time in developing countries. *Journal of Transport Economics and Policy*, **10**(2) pp113-125.

Leitch, G. (1978) *Report of the Advisory Committee on Trunk Road Assessment. (ACTRA),* London, HMSO.

Lyons, G., Jain, J., & Holley, D. (2007). The use of travel time by rail passengers in Great Britain. *Transportation Research Part A: Policy and Practice*, **41**(1), 107-120. http://doi:10.1016/j.tra.2006.05.012

Mackie, P.J.; Nellthorp, J. and Laird, J.J. (2005) *Toolkit for the Economic Evaluation of Transport Projects.* Washington DC: World Bank: Available online at: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTTRANSPORT/EXTROADSHIGHWAYS/0,,contentMDK:20464962~pagePK:148956~piPK:216618~theSitePK:338661,00.html (accessed 26th September 2012).

Mackie, P.J., Jara-Diaz, S. and Fowkes, A.S. (2001) The value of travel time savings in evaluation *Transportation Research Part E **37*** pp91-106

Mackie, P.J., Wardman, M., Fowkes, A.S., Whelan, G.A., Nellthorp, J. and Bates, J. (2003) *Value of Travel Time Savings in the UK*. A report to the Department for Transport. Institute for Transport Studies, University of Leeds, UK.

Melsom, I. (2003, Unpublished) *Review of the Benefit Parameters Used in Transfund New Zealand's Project Evaluation Procedures*. Information Note, Transfund New Zealand. Note dated February 2003.

Metz, D.A. (2004) Travel time – variable or constant? *Journal of Transport Economics and Policy*, **38**(3), pp333-344

Odgaard, T., Kelly, C.E. and Laird, J.J. (2005) *Current practice in project appraisal in Europe – Analysis of country reports*. HEATCO Deliverable 1. HEATCO – Developing Harmonised European Approaches for Transport Costing and Project Assessment. Funded by the 6th Framework RTD Programme. IER Stuttgart, Germany. . Available online at: http://heatco.ier.uni-stuttgart.de/.

Ormerod, C. and Ritchie (2007) Linking ASHE and LFS: can the main earnings sources be reconciled? *Economic & Labour Market Review*, **1**(3) Office for National Statistics

Ramjerdi, F., Rand, L. Inger-Anne F. Sætermo, I-A.F. and Sælensminde, K. (1997) *The Norwegian Value of Time Study.* Transportøkonomisk Institutt (TOI), Oslo, Norway.

Shires, J.D. and de Jong, G.C. (2009) An international meta-analysis of values of travel time savings. *Evaluation and Program Planning* **32** pp 315–325.

ANNEX 3: REVIEW OF EVIDENCE ON BUSINESS TRAVEL TIME SAVINGS

A3.1 Introduction

A3.1.1 Aims

This review is primarily concerned with the empirics rather than the theory of estimating values of time for business travellers. We are here concerned with existing evidence, whether UK or elsewhere, regarding the value of business travel time savings (VBTTS), along with evidence on parameters that can be used to deduce business time valuations and methodologies for estimation. This review of empirical evidence has three central themes:

- The first addresses the major national value of time studies, insofar as they provide insights into business time valuations, and also other significant studies that we have identified. It focusses upon:

  Evidence on the p, q and r parameters that input to the Hensher equation
  Evidence obtained from RP and SP studies
  Implications for appraisal, and in particular challenges to the widely used cost saving approach
  Other insights and evidence

- The second theme is to cover empirical evidence more generally, with an emphasis on the insights provided by our own data sets, assembled for the UK and also Europe as a whole, as part of meta-analyses of valuations of travel time savings.

- The final theme considers other evidence that provides insights into the VBTTS. These include who pays for the time savings and to whom the benefit accrues, self-employed compared to employed business travellers, high speed rail evidence and methodological issues.

A3.1.2 Scope

This review focusses solely on briefcase travellers. This annex complements the material discussed in section 3.1 of the main report in providing more detail about the original studies. The key material and discussion from the main report that is not repeated here is cross-referenced. We generally here report values from studies in the original units they were estimated and have, as far as is practical, reproduced the questions that underpin the evidence on the Hensher parameters.

A3.1.3 Structure

The structure of this annex is as follows. Section 2 sets outs some definitions of terms relevant to the research findings reviewed in this annex. Section 3 adds detail to our review of major national value of time studies and other significant studies, contained in section 3.1.2 of the main report, with an emphasis on those that have sought to compare different approaches or have investigated the Hensher equation as a means of estimating the VBTTS. Other willingness to pay evidence, covered in section 3.1.3 of the main report, is here the focus of section 4. The remaining two sections point out what is covered in the main report in terms of its coverage of specific issues that arise from the review of many studies and its conclusions and recommendations.

A3.2 Definitions

The most common alternative to the Cost Savings Approach to the estimation of VBTTS is the Hensher Equation. This is gives a comprehensive conceptual framework for valuing VBTTS, which has found intuitive, if not practical, favour. The equation is given by the following:

$$VBTTS = \left[(1 - r - pq)MPL + MPF\right] + \left\{(1 - r)VW + rVL\right\} \qquad (1)$$

where:

r is the proportion of travel time saved that is used for leisure
p is the proportion of travel time saved that is at the expense of work done while travelling
q is the relative productivity of work done while travelling relative to at the workplace
MPL is the marginal product of labour, as in the cost savings approach
MPF is the extra output due to reduced (travel) fatigue
VW is the value to the employee of work time at the workplace relative to travel time
VL is the value to the employee of leisure time relative to travel time
[] is the portion of VBTTS that is associated with the employer
{} is the portion of VBTTS that is associated with the employee

Whilst the Hensher equation has conceptual appeal, practical implementation of the complete framework is difficult. The MPF and VW terms are especially difficult to estimate, and it is not unusual to drop these from consideration; we shall follow that convention here in what is often termed the Modified Cost Saving Approach:

$$VBTTS = \left[(1 - r - pq)MPL\right] + rVL \qquad (2)$$

Another important definitional point, first raised by Fowkes et al. (1986) is what p and r cover. These two parameters were defined above but two related terms have been widely used. These are what Fowkes et al. (1986) term:

p* which is the average amount of time spent working during a journey
r* which is the proportion of total travel time which occurs in leisure time

A3.3 Review of National Value of Time and Other Significant Studies

There have been a number of significant studies that have explored and estimated VBTTS. This review is not restricted to UK evidence but takes a broader perspective given that many of the issues addressed, even if not the absolute VBTTSs themselves, are transferable across contexts.

For the studies identified and reviewed below, we summarise the key findings and, where appropriate and possible, provide comments on those findings. We have generally attempted to record the precise questions asked since these are important in interpreting the results as well as providing an account of each study.

The main issues arising from each study are:

- the evidence on the p, q and r parameters
- how any estimated values relate to labour costs and how they vary by method and
- methodological issues and particular insights into business valuations

Hensher (1977)

This is the pioneering piece of work that first empirically challenged the convention of valuing business travel time savings at the gross wage rate. Note, however, that it was first codified by Fowkes et al. (1986) based on the concepts elucidated by Hensher (1977).

With regard to the productive use of time, Hensher asked:

During this last domestic/international business air journey, what percentage of the travel time do you estimate you devoted to work (i.e. writing, reading, thinking, discussing work matters) on each of the following stages of your journey

To the airport on your outward trip
During the flight in the aircraft on your outward trip
From the airport on your outward trip
To the airport on your return trip
During the flight in the aircraft on your return trip
From the airport on your return trip

If some time was devoted to work, they were then asked:

How effective do you think the time spent working during this journey was by comparison with the equivalent time spent working in your office

with the response required as a percentage.

The mean proportions of time spent working (p*) for the various categories of trip stage and type of flight are set out below in Table A3.1. The proportions are larger for domestic (Dom) than the very much longer international (Int) journeys and tend to be larger for the outward journey. They do indicate quite modest amounts of travel time spent working, with the least on access on the outward leg and egress on the return leg where car is most likely to dominate.

Table A3.1: Mean Proportions of Time Spent Working (Hensher, 1977)

OUTWARD TRIP					RETURN TRIP				
Access		Flight		Egress	Access	Flight		Egress	
Dom	Int	Dom	Int	Dom	Dom	Dom	Int	Dom	Int
17.4	9.6	44.8	23.1	48.1	32.9	27.0	14.5	27.0	8.2

The equivalent effectiveness of time spent working during a business air journey was 61% for domestic travel and 51% for international travel. Given that overall p and also q are relatively low, the impact of productivity on the valuations is relatively low.

Time savings devoted to leisure are proxied by the amount of business travel time spent in own time (r*). The proportion of travel that was undertaken in the employee's own time is reported in Table A3.2.

Table A3.2: Mean Proportions of Travel Time in Own Time (Hensher, 1977)

OUTWARD TRIP					RETURN TRIP				
Access		Flight		Egress	Access	Flight		Egress	
Dom	Int	Dom	Int	Dom	Dom	Dom	Int	Dom	Int
62%	16%	46%	8%	45%	31%	64%	55%	72%	54%

In general, a significant amount of travel is done in the employee's own time and, perhaps surprisingly, it is greater for domestic than international trips.

When the productivity and leisure time effects are both allowed for, the value of business travel times savings for domestic and international travellers are 68% and 30% of the average gross salary cost respectively. Removing the productivity effect would yield figures of 85% and 33% respectively[8].

[8] Our understanding is that Hensher assumed VW to be the same as VL (Hensher, 2011) whereas it is more likely that business travellers are indifferent between travelling (working or not) and working in the office which is VW of zero (Fowkes et al., 1986)

As part of a survey of employers, they were asked to imagine a situation where an employee could save time by an unspecified new means at the egress end of a domestic air journey and what monetary outlay ranging from $1 to $20 (12 different levels) would be permitted. The implied value, in 1973 prices, was $4.36 per hour, implicitly for domestic trips. The conventional marginal productivity approach would imply a valuation of $5.10 per hour for domestic journeys.

Hensher noted that individuals are likely to exaggerate the amount of time spent working and the relative productivity of time spent working while travelling relative to at work so as not to appear lazy.

UK National Value of Time Study (MVA et al., 1987)

This was the first of the so-called national value of time studies. Whilst its scope was broad, the remit was primarily private travel and the business travel element was largely left to a parallel research council funded project that is discussed below. Employers' business trips were considered, but only using SP methods and with uncertainty as to what extent they reflected employer sanctioned or personal willingness to pay. Unfortunately, the self-employed sample was too small to enable a distinction to be made. Nonetheless, the study made a number of useful comments on business time valuations.

It conceded, in 1987, that the possible shortcomings of the assumptions underpinning the cost saving approach have been "well-rehearsed". It went on to state, "On the other hand, there are a number of empirical questions which are in principle capable of resolution. For instance, what values of time do individuals travelling in the course of work reveal on the basis of their travel choices. And what use is likely to be made of time savings".

The report distinguishes between those for whom travel is the nature of their job, such as professional drivers, and briefcase travellers. In the former case, it is argued that in the short run not all time savings can be converted into extra output due to scheduling inflexibilities and even in the longer run some of the time saved might accrue to leisure as a result of collective bargaining. In such cases, non-work valuations would be applicable for the relevant proportion of time saved. To the extent that the time saving is converted into a wage increase in the longer run, this would lead to some reduction in the demand for labour and hence enforced leisure time and hence a leisure value of time would be appropriate.

Thus whilst the study recognises that even for professional drivers the wage rate related price can overstate the benefits of the time savings, "the difficulty with this argument is the paucity of empirical data on which to judge the extent of any such adjustment. It is for that reason of practicability, rather than anything else, that the implicit assumption is made that all working time saving is converted into extra productive employment".

For briefcase travellers, the vulnerability of the argument is accepted. It is stated that "Where neither the total job content or the required hours of work are clearly specified, and where the travel mode used may permit some work to be undertaken during the journey, the convention based on the marginal productivity theory might appear to break down completely". Some business travel time, particularly for longer distance trips, is done in the employee's own time where the opportunity cost to the employer is zero but there is a benefit to the employee of a time saving that should be accounted for.

The study suggests that an appropriate means of estimating their valuations is through the time-cost trade-off choices they make when making business trips.

UK Business Travel Study: Fowkes et al. (1986)

This SERC funded study into business travel time values paralleled the first UK national value of time study, where non-business travel was predominant. It did not examine commercial vehicles but was confined to briefcase travellers.

The study was both theoretical and empirical. It appraises the traditional cost saving approach and considers the implications for other estimation methods. It made use of two surveys of long distance business travellers and one survey of employers, being novel in its use of SP methods in this market to complement RP based approaches. It was one of the first surveys of employers and remains one of the few.

It pointed out that Hensher (1977) departed from the conventional wage rate approach by recognising that business travel might occur in what is leisure time, work might be undertaken during the journey and the employee might not be indifferent between working in the office and travelling.

The study also identified two studies conducted in the UK in the early 1970s that estimated business valuations from RP data on the choices between air and rail that found values somewhat lower than the wage rate. It stated that "since revealed preferences are the product of both the constraints on choice imposed by company travel policy and the preferences of travellers themselves, it is difficult to interpret such results". They may be the joint outcome of employers' and employees' preferences to save time. As such, they might be expected to drive behaviour and hence be appropriate for forecasting, but they do not necessarily reflect the sum of the employer's and employee's valuations to save time.

As a result of these findings, it was recognised that investigations of both the willingness to pay of employers and of employees would be necessary but "even this is far from straightforward" because there are difficulties in identifying within organisations those who can speak authoritatively about company decision making whilst for employees it is necessary to create a situation where they will incur the costs and receive the benefits of a faster journey.

This study pointed out that Hensher (1977) had specified the productivity element in terms of the proportion of the overall time spent working, which they termed p*, rather than the proportion of the time saved that would have been spent working, which is p. If the work can be done even with the time savings, which is possible where p* is not equal to one, it is likely that p will lie between zero and p*. It also pointed out that instead of specifying r as the proportion of time saved that would be devoted to leisure they used the proportion of total travel time which occurs in leisure time, termed r*. They state that “Since for some people travel time savings will be replaced by extra work on other days, we would suggest that, on average, the appropriate value of r lies between zero and r*. Whilst a recurring theme in the literature, we do not feel that the failure to distinguish r and r* is a serious one but p and p* could well be somewhat different.

The study covered four methods of valuing business travel time:

- Wage rate approach
- Employer’s Stated Preference
- Revealed Preference
- Synthetic Approach using p, q, r and employees’ valuations and the Hensher equation

Three surveys were used as the basis for the value of time calculations, all covering long distance trips which were defined as those over 50 miles.

- Telephone survey of 311 organisations, split between the South East and North East of England and focussing on their travel policies
- A self-completion questionnaire distributed amongst employees of the employers contacted who agreed to participate. This collected RP and SP data for 442 travellers (and was termed the ORGN sample)
- A very similar self-completion questionnaire of 411 rail travellers on the East Coast Main Line (and was termed the ECML sample)

Employers’ Survey

Employers were asked how employees would make a day return trip between London and Newcastle and then the following question:

> *Now suppose a first class (only) premium accelerated rail service between London and Newcastle was introduced, saving one hours travel time. Would senior staff be allowed to use the service if the extra cost was £5 ……. was £20 …… was £50? And what about other staff?*

In terms of current SP methodology this is a crude approach, but it is nonetheless pioneering. The value of time was deduced from the cumulative frequency of responses by interpolation. The results showed that:

- Time savings of what were termed senior staff were valued around 2½ times more highly than for other staff.

- The implied valuations varied by industry type, size of organisation and the cost of the mode used.
- The values were positively correlated with incomes.

For senior staff, the companies were, on average, prepared to pay more than the gross labour costs but broadly similar to the wage rate for other staff. The authors speculate that the former could reflect the employer's valuation of the disutility incurred by its staff in making business trips. On average, the employer's valuation was £12 per hour.

Employees' Stated Preference

Long distance business travellers were asked to consider a hypothetical 300 mile each way round trip. The available options were air, first class rail, standard class rail and car, defined in terms of return cost, departure time from home and arrival time back at home. A fixed lump sum of £100 would be given by their employer for travel expenses with the respondent paying or keeping the difference on the actual cost. The four alternatives were ranked in order of preference, and 12 such rankings were presented.

As far as we are aware, this was the first study to aim to estimate employees' personal values for time savings incurred during a business trip. It was found that the values increased strongly with income and that values of time savings for journeys starting very early in the morning were somewhat larger. The average values, at around £7 per hour, are slightly over half the employers' average valuation of around £12 per hour.

Employees' Revealed Preference

The employees' survey also asked for RP information for their actual and best alternative mode. This allowed models to be developed explaining the choice between car and rail and between air and rail.

Only around a third faced a time-cost trade-off essential for precise value of time estimation. This, combined with the small sample sizes of 234 for the car and rail model and 130 for the air and rail model, meant the time and cost estimates are not precisely estimated. Nonetheless, the values of time averaged around £13 per hour, not dissimilar to the employer based values. It is clearly higher than the SP values since the latter reflected a valuation based on personal rather than company willingness to pay

Synthetic Approach

The study evaluated a modified Hensher approach, with the marginal product of labour amended by the (1-r-pq) term and the inclusion of VL. Compared to the full Hensher approach, VW was assumed zero and MPF was also assumed zero or else is included within employees' SP valuations.

Using the terminology set out above, the business travellers were asked to record a log of their most recent long distance business trip, and to indicate how much time they spent working on the trip (p*) and their normal hours of work and salary from which r* and MP were calculated.
The figures in Table A3.3 below unsurprisingly indicate that rail is the most productive mode and car the least. Relative productivity is similar between work and travelling for all modes. The larger r* values for rail and air might be because, once access and egress are accounted for, these journeys take longer and hence incur more out of hours travel.

Table A3.3: Hensher Parameter Estimates (Fowkes et al. 1986)

Parameter	Car	Rail	Air
p*	0.03	0.20	0.14
q	1.01	0.95	0.99
r*	0.32	0.42	0.42

Implications for Appraisal

Table A3.4 below sets out the values of time, in £ per hour, from the different methods considered in this study. Whilst the relationships apparent between mode and valuation for the employers' stated preference and the revealed preference conflict with each other, the exploratory nature of this pioneering study and the precision with which the values are estimated should be borne in mind. However, the results do show a reasonably high degree of similarity across methods. Fowkes (2001) stated that, "Nevertheless, it is easy to see why Table 1 [of their report] was not thought to give any great support to calls for a move away from the current approach towards use of the Hensher formula".

Table A3.4: Fowkes et al. (1986) UK Business VoT Study (£/hr 1985 prices)

Method	Car	Rail	Air
Wage Rate Approach	10.3	9.8	11.9
Employers' Stated Preference[1]	12.0	12.0	12.0
Revealed Preference	14.1	12.6	11.5
Synthetic (Hensher)			
r = r* p = 0	10.4	10.1	10.0
r = r* p = p*	10.1	7.7	8.3

Note: We have averaged over the ECML and ORGN samples. [1] This is the overall SP figure reported in the paper.

The personal valuation of business travel time savings, where a strong income effect was apparent, was between 6.11 and 6.21 times larger than the official equity values of time for non-work journeys. The ratio is over 4 even for the lowest income group of business travellers.

This was, at least in the UK context, a pioneering study and the conclusions are worth recounting, particularly since its findings influenced the Department for Transport's retention of the cost saving method.

Whilst we find good reason to suppose that much of the time savings in our sample will be devoted to leisure, we still find that these time savings are valued highly by employers and employees alike. Perhaps this is not surprising; the reason why we expect time savings to be used for leisure is that they accrue on (often extremely) unsocial hours.

For evaluation purposes, the issue is less clear cut. The value of time savings has been shown for our samples to vary significantly according to the valuation methodology adopted. Although we do not possess sufficient evidence with which to decide unequivocally on the most appropriate to use, we believe that the lowest value that it would be reasonable to contemplate are those which assume that all time savings would be devoted to leisure activities but that any work undertaken en route would still be done, and which use employees' stated preference values adjusted for equity considerations. This gives values in the range of 40-57% of the wage rate approach value. Only a modest use of time savings for work purposes is needed to obtain values close to the wage rate approach value; for instance assuming that the proportion of time savings devoted to work equals the proportion of travel time in normal working hours will do this.

In short, although we find no empirical support for the assumptions upon which the present valuation conventions are based, our empirical work suggests these conventions yield values which are approximately correct.

This study did not claim to provide representative values of time. What it did aim to do and achieve was to compare different methods of estimating the values of time. However, the relationships apparent do not necessarily apply to shorter distance trips whilst it is possible that the relationship between the values might have varied over time either with methodological advances or, more significantly, with changes in the characteristics of business travel.

UK 1994 Study (Hague Consulting Group et al. 1999)

Unlike the 1987 national value of time report, an explicit objective of this national study was to derive values of time for work as well as non-work time. Business travel is covered in four aspects:

- Explicit consideration of the application of the Hensher approach to business travellers;
- The main car users' value of time experiments, which covered employer's business trips;
- A repeat of the 1987 study's analysis of urban car users' route choices in Newcastle but including business travel in the RP element;
- A study of the SP choices of freight operators[9].

[9] Although this was not restricted to the value of time but will also cover operating costs and the value of the commodity. We do not cover this aspect of the study here.

p, q and r evidence

The value to the employer of changes in travel time for the employee (EVoT) was specified as:

EVoT = W(a-bc)

where W is the wage rate inclusive of overheads, a is the fraction of the time variation that impacts on time spent working, often referred to as 1–r where r is the proportion of travel time saved that is used for leisure, b was specified as the fraction of travel time already spent doing some work, which is p*, and c is the productivity of work during travel relative to work done elsewhere which is typically referred to as q.

The questions specifically asked of business travellers relating to the formula above were:

Suppose that the business trip that you were making when you received this questionnaire had taken 15 minutes longer as a result of congestion on the roads. Would that extra time have been paid by your employer or would it have mostly come out of your own time?

and

Did you use any of the time during that trip to do work which you otherwise would have done elsewhere; for example preparing for a meeting, conversations on a portable telephone etc.? If so, about how much time?

Approximately how long would that same work have taken you if you had done it at your office or at home?

The averages for a, b and c across the entire business travel sample were 0.537, 0.043 and 1.02. Not surprisingly, b (p) is low for car given the limited opportunities to work during a car journey, particularly in 1994. The value of r (1-a) seems high given that many trips would have been made in normal work hours.

The variations in p*, q and r across a number of dimensions are given below. P* is higher for motorways and lower for delivery/pickup, as expected, but the effect is slight and there is hardly any variation across categories. Similarly, q is closely centred around one.

There is more variation in r with it higher for journeys made after 1600, as might be expected, whilst those attending a seminar which presumably takes up the whole day as well as those attending a meeting would be more likely to incur the extra travel time in their own time. The high figure for self-employed could be because there is little point paying themselves extra as a result of a delay. There is a slight but not convincing effect of the expected form from journey duration.

Table A3.5: p, q and r values (HCG et al. 1999)

	p*	q	R
Before 10	0.03	1.08	0.42
10:00 to 16:00	0.05	1.01	0.44
After 16:00	0.05	1.01	0.61
10-30 mins	0.03	1.11	0.47
31-60 mins	0.04	1.01	0.41
61-120 Mins	0.05	1.00	0.43
> 120 mins	0.05	1.01	0.54
Self Employed	0.03	0.96	0.81
Employed	0.04	1.02	0.36
Meeting	0.06	1.00	0.51
Visit Client	0.05	1.04	0.44
Visit Branch Office	0.04	1.00	0.40
Attend Seminar	0.03	0.78	0.66
Delivery/pickup	0.01	0.98	0.45
Other Purpose	0.02	1.05	0.47
Motorway	0.06	0.98	0.46
Trunk	0.04	1.06	0.46
Urban	0.02	0.99	0.47
Time Save to Employer	0.05	1.05	0.00
Time Save to Self	0.03	0.97	1.00

Given a gross wage rate of around £18.5 per hour, the average employer value of time is just over £9 per hour . However, as was pointed out, the various components of the Hensher formula are not independent; for example, those with higher salaries are more likely to work while travelling. Adopting a sample enumeration approach, based on each individual's wage rate, and their own a, b and c, the average is a little lower at £8.8 per hour.

<u>Employer's Business Trips SP</u>

There were two SP exercises relating to business (and indeed other) travel. The first, termed SP1, offered trade-offs between time and cost and was intended to obtain a personal value of time for journeys made on company business. The respondents were told:

> *If you did not actually pay for the journey yourself, please assume that you would receive a fixed amount of reimbursement equal to the current journey cost, so that any additional or saved costs would go to you*[10]*.*

[10] Note that four of the twelve questionnaires (TA, TC, MB, MD) deliberately did not include this text.

The second SP exercise relating to business travel, termed SP3[11], offered choices between an untolled A road option and a tolled urban road, trunk road and motorway. Business travellers were told:

> *If you think that an employer would reimburse the toll cost then this should be taken into account when making your choice*

The statement about a fixed reimbursement had no significant effect on the cost coefficient in the business model. Those who were reimbursed had a lower cost coefficient but surprisingly it would not be zero but rather only 20 to 30% less. It was concluded that, "Overall, the effect of cost reimbursement is not as strong as one might expect". Whilst it was claimed that, "all respondents behaved to some extent as if the SP cost changes would come out of /go into their own pocket" there is nonetheless an element of uncertainty as to what the valuations represent.

In distinguishing additionally between whether it was the employer's or the respondent's time, and relative to a base of respondent's time and money, business travellers for whom it was their own time and their employer's money had a 26% higher value, reflecting the slight effect above of reimbursement. When it was the employer's time, the value was 11% lower when it was the respondent's money and 11% larger when it was the employer's money. This indicates that the respondent places slightly less importance the employer's time than their own time which is to be expected if the respondent is primarily taking their own preferences rather than the company's into account. The variations do seem slight and again raise concerns about the interpretation of the SP results.

Turning to the tolled road SP exercise (SP3) for business travellers, the reimbursement was based on the question, "if you were to travel on a tolled motorway/trunk road/urban road who would pay the toll costs". It was found that the toll coefficient would not be zero even for those who had all the toll reimbursed. Tests were conducted for strategic bias against tolling but this had little effect on the non route constant terms.

The values from the SP1 and SP3 exercises are reported in Table A3.6 for all three purposes. Despite one exercise relating to tolls and the other to other car costs, which might be seen as causing a difference due protest against tolls, we see little difference between the commuting and other values for the two exercises. We might then conclude that there are other factors causing a difference between the two results. Note that SP3 does not have car passengers, and for business travellers in SP1 these had higher values. This would account for some of the difference.

[11] There was a second SP exercise but it did not relate to business travellers. Hence the second SP exercise for business travellers was the third SP exercise (SP3) offered.

Table A3.6: SP1 and SP3 valuations from HCG et al. (1999) - £ per hour

	Business	Commute	Other
SP1	7.3	3.2	2.6
SP3	4.8	3.2	3.5

Note: Reproduced from Table 104

However, it is a little concerning that the SP3 exercise, which aims to provide business valuations more in line with the employers, yields lower business valuations than the SP1 valuations which are intended to be personal values.

<u>Repeat Newcastle Study</u>

Unlike the original study, business travellers were here asked for RP information in addition to conducting the SP exercise. And two SP exercises were used; one was an exact repeat of the Newcastle route choice SP exercise (SP1) whilst the other was a simple time and toll trade-off (SP2). Business travellers were told to bear in mind company policy on cost reimbursement when answering the SP exercises.

The results for the three sets of data are presented below, split by journey purpose. As expected, the 95% confidence intervals, expressed as a proportion of the central estimate, are much tighter for the SP data given their larger samples. We observe the business SP values to be larger than the non-business values. However, this can hardly be taken to indicate that respondents have followed the instructions on reimbursement since we would have reasonably expected much higher multiples than apparent here. The study mean labour cost is 30.9 pence per minute, and is only a little lower for shorter distance trips.

Table A3.7: Valuations (£ per hour) from Repeat Newcastle Study (from HCG et al. (1999)

		Business	Commute	Other
RP	Value	6.8	2.4	5.7
	95% CI	±89%	±39%	±73%
	Obs	189	453	222
SP1	Value	3.6	2.3	2.2
	95% CI	±20%	±12%	±20%
	Obs	1070	2834	1528
SP2	Value	2.6	1.4	2.0
	95% CI	±12%	±8%	±9%
	Obs	1583	3721	1661

Note: For reference we provide the cost saving value of time of £18.5 per hour

Whilst the RP business values are somewhat larger than the corresponding SP values, they are not high and very much less than the wage rate. In any event, the RP values are also higher than the SP values for other trips, and thus there could well be reasons other than cost reimbursement and company policy issues that are leading to a discrepancy. We would have to conclude that neither the RP nor SP values support the cost savings approach but equally admit that there are some uncertainties as to what the SP values represent and recognise the imprecision of the RP estimates.

Implications for Appraisal

The employer value was derived using the modified cost saving approach of 14.7 pence per minute, to which is added the employee value of 6.7 pence per minute. The latter was based on SP1 for those who used their own time and money. Note, however, that the measure of p used (p*) was the average amount of time spent working rather than the amount of time spent working that would be lost as a result of the time saving. More importantly, the value of 6.7 pence per minute should have been weighted by r, which on average is 0.463. Thus the total value of time would have been 17.8 pence per minute of which 3.10 is the employee's value. This is 58% of the average gross wage rate in the sample obtained.

Commercial vehicles were also covered. SP methods were used to get employer's value of time saved. The study concluded that, "as with the Hensher approach for working time, we would recommend adding the personal VOT of the driver and any accompanying staff"

Netherlands' Experience

The Mott MacDonald (2009a) study identifies the Dutch National Model (LMS) as containing time and cost effects estimated directly to mode and destination choices. Apparently these models have not been used in evaluation, with the reason given being that due to the log-cost specification the value of time is not constant with journey duration. Notably, Mott Macdonald et al. (2009a) state that, with respect to the business time valuation, "the results obtained may have been similar to the wage rate at the time" whilst recognising that "trends in societal time use and technology could change this in future".

The Dutch national value of time studies of the 1980s and 1990s (Hague Consulting Group, 1990a; Hague Consulting Group, 1998) indicate that business travellers work during their journey and, particularly for rail, the amount of time spent working has increased over time. The results of a more recent Dutch national study are soon to be published and this will presumably provide more insights into inter-temporal variations in the Hensher parameters.

The Dutch 1988 value of time study (Hague Consulting Group, 1990a) used travel demand survey data covering mode and destination choice, including longer distance travel, to develop Revealed Preference models. Whilst the business values for car driver were 76% higher than for commuting and over 5 times leisure, with respective figures of 64% and 3.3 times for train passengers, the standard errors for the business values exceeded the central estimates.

Whilst imprecisely estimated, the business values are in line with the wage rate. The report states that, "….. Revealed Preference values …… should in principle reflect the valuation of the employer as well". The SP results were claimed to relate to individuals' personal valuations, since business travellers were instructed to consider the SP alternatives as if they were making the exact same journey but in their own leisure time and at their own expense. Noticeably, the RP and SP values for car and train and commuting and other were similar but the SP values were 42% and 39% lower for car and train business travellers respectively.

The business valuations were intended to reflect VL and can be compared with the private leisure valuations. The ratios were 1.91 to 2.44 for car, depending on the type of time, 1.75 for train and 1.83 for bus/tram. These presumably reflect the larger incomes of business travellers.

In further analysis of the SP experiments offered on public transport users (Hague Consulting Group, 1990b), the cost coefficient for business travellers was found to be 37% smaller where the employer reimbursed some or all of the cost. This is surprising given respondents were told to assume that they would pay for all costs directly so that the values reflect travellers' personal valuations. It is concluded that, "the results above indicate that this approach has not been entirely successful".

The 1988 Dutch study was extended by making use of questions asked in the survey and relevant to the Hensher approach (Bradley and Gunn, 1991). This included the p, q and r terms. The relevant questions (for car) asked were:

Did you do some work during this car trip which you would otherwise have had to do in the office? If yes, how long was it in total?

How many minutes would the work in Q13a (above) have taken in the office?

Suppose your travel time is 20 minutes less than your current one, how would you allocate this 20 minutes time saving?

Table A3.8: 1988 Dutch Study – Implications of Modified Hensher Equation

Mode	MPL	Employer	Employee	Total	%MPL
Car	44.69	30.4	21.2	37.6	84%
Train	36.52	15.7	14.0	23.1	63%
Bus	28.46	11.8	11.3	17.2	60%

Note: Values in Dfl per hour in 1991 prices. The employee value has here been weighted by r and, unlike the report, is that which enters the total value reported here.

For car, train and bus business travellers, r was on average 0.34, 0.53 and 0.48. The corresponding figures for p were 0.02, 0.11 and 0.03 respectively and for q were 0.90, 0.89 and 0.93 respectively. Note however, p was not the amount of saved time that would have been spent working but the amount of time spent working (p*). The implied values using the modified cost savings approach are set out in Table A3.8. For all modes, the value of time is less than the wage rate (MPL). As would be expected, the reduction is larger for public transport modes where the opportunity to work is greater.

The repeat Dutch study, conducted in 1997 (Hague Consulting Group, 1998), followed the same approach for business travel of using SP to estimate employee valuations and using a modified cost saving approach to deduce employer valuations. Summary statistics relating to the business value of time are provided in Table A3.9.

For car, train and bus business travellers, r was on average 0.45, 0.63 and 0.65. The corresponding figures for p* were 0.04, 0.16 and 0.03 respectively and for q were 0.90, 0.89 and 0.93 respectively. The q values on average varied very little between 1988 and 1997 whilst it is only for rail that we see sizeable increases in the amount of working while travelling.

As a result of these changes to p* and particularly r, the employers' value of time for all modes fell quite appreciably between 1988 and 1997. The employers' values for car, train and bus were 26.2, 11.7 and 12.2 in 1997, with the 1988 study providing values of 28.6, 25.1 and 27.4 in 1997 prices. Increases in the productive use of time can creditably be related to the greater use of laptop and mobile phones but it is unclear why the proportion of travel time saved converted into leisure should increase. Indeed, given many journeys would be made in normal hours, it is surprising the the r values are so large. In reality, travellers might not be allowed to convert time savings into leisure at the rate they perceive and report.

Table A3.9: 1997 Dutch Study – Implications of Modified Hensher Equation

Mode	MPL	Employer	Employee	Total	%MPL
Car	50.97	26.2	23.9	37.0	73%
Train	51.41	11.7	19.2	23.8	46%
Bus	37.57	12.2	11.6	19.7	52%

Note: Values in Dfl per hour in 1997 prices. The employee value has here been weighted by r and, unlike the report, is that which enters the total value reported here.

Swedish Experience

The Swedish 1995 study (Algers et al., 1995) contained a section aiming at measuring the Hensher parameters. The relevant questions posed to business travellers were:

Did you work during the trip?

The proportions working during the trip were 48% for car, 25% for air and 56% for train. Unsurprisingly the figure for rail is large but that for car is also high. These respondents were asked:

In that case how much? (percent of total in-vehicle time)

The proportion of the total in-vehicle time spent working (p*) was 30% for car, 50% for air and 50% for train. The relative productivity question took the form:

How long time would these tasks have taken at your normal workplace?

The mean for those working during the trip was that they were 93% as efficient as at the office. Travellers were next asked:

If you hadn't had the possibility to do these tasks during the trip, how much of it (in %) would you have done during: a) normal working hours; b) overtime; c) leisure time; d) not at all.

50% would have done the work during normal hours and for 6% it would have been overtime. It would have been done in leisure time for 36% and not at all for 8%. This was followed by:

If the value of working time at your normal working place is 100%, how high would you value your working time on the train?

The mean value was 65%, with 17% stating between 0 and 33%, 31% stating between 33% and 66% and 52% stating between 67% and 100%. Business travellers were then asked:

If the travel time of this trip had been shorter, how much of this time had you spent working and how much would have been leisure time?

This question was asked in two versions, one where the travel time reduction meant that the traveller would start later and one version where the traveller would arrive earlier. On average, 30% of the time would be used for work. Table A3.10 summarises the results for the Hensher parameters split by mode.

As tends to be the case across studies, the relative productivity of work done while travelling and at the office (q) is close to one overall. However, as can be seen, there are several cases where q is somewhat over 1 and this is not plausible. This is something the study wrestled with, including distinguishing between relative productivity, whether the activities would have been undertaken outside of travelling and the value of the activities being undertaken, as addressed by two of the questions above. Whilst it did appear that the activities would have been undertaken, it was concluded that they had only two thirds of the value[12].

The p* values are generally low, with a greater tendency to work on public transport modes, as expected, whilst the higher r values for rail and air and indeed long distance bus may well reflect the longer duration of these journeys and hence a greater likelihood that travel is undertaken in personal time or in unsocial hours. Nonetheless, concerns were raised about the high values of r, and it was concluded that the total amount of work should not fall after a time saving, thereby setting 1-r to the maximum of 1-r or pq).

[12] The study therefore weighted q values by 0.65. It also assigned the same value to VW as VL. In our calculations later, we have for consistency with other studies used the reported q values, set VW to zero and weight VL by r.

Table A3.10: Swedish Value of Time Study p, q and r values (Algers et al., 1995)

Mode	p*	q	R
Car	0.14	1.01	0.54
Car Self Employed	0.10	1.20	0.66
Air	0.13	0.97	0.84
Air Self Employed	0.11	1.02	0.85
Train Inter	0.28	1.03	0.78
Train Self Employed	0.23	1.08	0.75
X2000	0.28	1.04	0.79
Train Regional	0.18	1.15	0.82
Bus Inter Urban	0.13	0.93	0.85
Bus Regional	0.17	1.26	0.86
Comp Car	0.19	1.11	0.47

In order to estimate the private value of time VL, travellers were subject to an SP experiment where changes in travel costs were to be covered with the traveller's own money. A special study, similar to the main study, was also carried out on self-employed travellers. Presumably, for them the 'company's' value of time would be completely internalized. Nonetheless the results were not markedly different from those in the main study.

Finally, an SP study where the respondents were told to choose "according to company guidelines and rules" was carried out. This gave considerably higher valuations, especially for air and train trips. Table A3.11 summarises four estimates of the business value of travel time savings: the Hensher equation with the original parameters and with VW set to VL, the Hensher equation with the original parameters and VW set to zero, which are obviously lower and indeed somewhat so, figures which set revised values for q (q=0.65, (1-r)>pq for each individual) given concerns about the q and r values, which leads to higher than original values, and the 'company guidelines' WTP choice experiment.

Table A3.11: Swedish National Study: Various Values of Business Travel Time (Algers et al., 1995)

	Original	VW = 0	Revised	WTP
Car	145	118	167	150
Air	122	107	141	223
Train	100	70	134	201

The original values are pretty much between the VW=0 and revised values, but the WTP values for rail and air are very much higher. These values offset the higher p values for train that lead to its otherwise relatively low values. Whilst the WTP values for rail and air might be regarded to be too high, around twice as high as those of the Hensher equation with the original parameters, we can point out that the car WTP values are reasonably in line with the other Hensher figures and we might expect air and train business travellers to have relatively high values because of more senior positions, longer journey length, travel at inconvenient times and relatively high productivity at the destination.

Norwegian Experience

The Norwegian 1997 study (Ramjerdi et al., 1997) was similar in many ways to the Swedish 1995 study. A number of questions aimed to estimate the Hensher parameters, and the survey also contained a choice experiment where changes in travel costs were covered with the respondent's own money to capture VL. The p, q and r questions are reproduced below.

How much of the travel time is within your normal working hours?

Do you get any compensation for travel time outside normal working hours?

Permissible responses were wage, wage and overtime, half wage, can get time back through rescheduling other work, no and don't know.

Did you work during the trip (e.g. made a call, read, write)?

If the traveller replied yes, then they were asked:

How much time did you work? and
How long would the same task have taken at your normal workplace?

Note that, in Fowkes et al. (1986) terminology, these questions elicit p* and r*. The table below summarises results for inter-urban and urban travel respectively. It is not clear why the q values are so low and out of line with values typically obtained of around 1.0. The r values tend to be large for the inter-urban modes, presumably because of the prevalence of travel outside of normal working hours due to the distances involved. The figure falls noticeably for urban trips. Productivity levels also seem atypically low when compared with other studies, but this might also be a function of travelling in personal time. The study offers little by way of explanation for some surprising values, particularly for q which are out of line with the evidence from other studies.

Table A3.12: Norwegian Value of Time Study p, q and r values (Ramjerdi et al., 1997)

	p*	q	r*
Inter-Urban Car	0.03	0.32	0.57
Inter-Urban Air	0.07	0.28	0.64
Inter-Urban Train	0.18	0.39	0.72
Inter-Urban Bus	0.06	0.20	0.74
Inter-Urban Ferry	0.03	0.19	0.63
Urban Car	0.21	0.02	0.39
Urban Public Transport	0.30	0.07	0.43

The SP exercise clearly stated that the respondent would directly incur or benefit from any cost variations but it did not state what the time savings would be spent on. The authors segmented the models according to the proportion of the time (r) that would be used for leisure. For car, bus, train and air, the values of time were between 18% and 58% lower when r exceeded 90% than when it was less than 10%. This suggests that care needs to be taken in specifying what the time saved would be used for.

The implied values of time using the Hensher approach are set out in Table A3.13. In the 'Full Hensher' equation, VW is set equal to VL. This seems difficult to justify, as argued by Fowkes (2001) and the very much higher values are unwarranted. The 'Modified Hensher' approach sets VW to zero. In both cases, MPF is assumed zero. The modified Hensher approach generally provides values less than the cost savings approach although notably air users are assigned higher values presumably due to their high values of VL.

Table A3.13: Norwegian National Study: Various Values of Business Time (Ramjerdi et al., 1997)

	MP	Full Hensher	Modified Hensher	VL/Leisure VoT
Inter-Urban Car	185	259 (140%)	181 (98%)	2.15
Inter-Urban Air	201	379 (189%)	267 (133%)	2.02
Inter-Urban Train	153	148 (97%)	116 (76%)	2.19
Inter-Urban Bus	132	90 (68%)	75 (57%)	1.23
Inter-Urban Ferry	161	172 (106%)	130 (81%)	1.23
Urban Car	170	190 (112%)	137 (81%)	2.23
Urban Public Transport	131	152 (116%)	106 (81%)	2.76

New Zealand Study

A major New Zealand value of time study was reported by Beca Carter Hollings and Ferner et al. (2002), and a part of this covered the estimation of the p, q and r values through telephone surveys of 600 business travellers, including professional drivers.

<u>p, q and r evidence</u>

The use of a telephone survey contrasts with intercept surveys (for instance, on train or at service stations) in two important respects. Firstly, we can be sure the questions are answered after the journey has been completed. Secondly, the farther in the past was the actual trip then the greater the potential problem of recall.

The questions asks in investigating p, q and r are set out below.

> *I am now going to ask you about some activities that people do while travelling. Please tell me if you did any of these as part of your job (that is not for personal reasons) on that specific trip*

Permissible responses were use a phone, reading, use a computer, dictation, discuss work/business with travelling companions or none of these. This was followed by:

Did you do anything else while you were travelling that was part of your job? (not including driving for professional drivers).

If the answer was yes, then the respondent stated what the activity was.

The interview then proceeded to determine how much time during the course of the journey was spent on each activity separately.

You said your trip took ….. hours ….. minutes. How much of the travelling time did you spend (talking on the phone/reading/using a computer/dictating/talking to travelling companions) to do with your job.

This p* question was followed up with questions on relative productivity:

If you hadn't spent time (activity description) while travelling, when would you have done it?

Permissible responses were: in other time at work; while travelling to/from work; during personal time (outside work hours but not while commuting), would not have done it at all; and other. This was followed by:

Would (activity description) have taken longer, about the same time or less time if you had done it (at work, in own time etc)

The response categories were about the same, more time and less time, and the latter two were followed up with questions on the amount of time more or less. The next question related to what they would do with any saved time:

Now, with the same trip in mind, I want you to imagine that recent improvements to the (road and traffic system/bus service/rail service) meant that you knew you would save some travelling time on this trip. Do you think that you would have used that time for more time working/ more personal time/ some of each)?

Followed with:

How much if each? (¼ work ¾ other, ½ work ½ other, ¾ work ¼ other)

The final question relating to the Hensher equation was:

You said you spent (hours, minutes) (activity) during your (hours/minutes) trip. If the (road and traffic system/bus services/rail service) improvements meant that your journey was shorter, would it have reduced the time you spent on any of these activities.

If the answer was yes, then they were asked:

If your journey had been, say, 5 minutes shorter how much less time would you have spent on (activity)

Hence questions on p and p* were asked alongside q and r.

Almost 60% of trips involved no work activity while travelling and p* was on average 0.22 but with a strong negative correlation with distance. The relative productivity of activities in travel compared to elsewhere slightly exceeds one, with travel based activities around 7% more productive on average. However, a cap of one was applied, so that working while travelling could not be more productive than elsewhere for any individual, whereupon the central estimate for q was 0.93.

The proportion of time saved that would be devoted to leisure is around 28%, with relatively little variation across occupations. However, the response categories were crude. The mean reduction in time spent on work activities for those working during the journey was only 7%, implying a value of p overall of 0.028. This is not surprising given the dominance of car.

VL was not estimated in this study and instead the behavioural value for all non-work travel was used instead. The latter can be expected to understate VL, not least because business travellers have higher incomes.

As a result of applying a modified Hensher correction, that is ignoring MPF and setting VW to zero[13], the car driver kilometre weighted business valuation falls by 18%. The adjustments are small because the scope for working during the course of a car journey is relatively limited, and the time savings would not be predominantly at the expense of working while travelling. The reduction for PT users is 24%.

Switzerland Value of Time Study

As part of this study, which primarily addressed private travel, a small sample of 62 answered questions relating to the Hensher parameters. 16 of these would not work during a business journey and 19 stated that any time saved would not be used for work.

The questions were:

Do you work during your business trips? (i.e. telephone, read, write, discussion with colleagues or clients etc.)

Responses were never or normally. If the answer was normally then the amount of time was established. This was followed with a question relating to q:

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[13] Note that VL was correctly weighted by r

How long would this work take at your workplace?

which could be the same time or X minutes on average shorter or longer. As for r, respondents were asked:

Imagine that improvements in travel conditions were to reduce the journey by 15 minutes. How would you use this time?

Responses distinguished between work time (at workplace, with clients etc), own time and a mixture of the two. A similar question was asked relating to p:

Imagine that improvements in travel conditions were to reduce the journey by 15 minutes. How long would you then work during the journey?

Permissible answers were the same time, X minutes less or not at all.

The mean level of working while travelling across the sample was 64% whilst relative productivity (q) was 98%. The proportion of saved time that would be used for work was 49%.

The study concluded that "Based on these average figures we obtain a business VTTS of 21.35CHF/h (compared to a wage rate of 66.49 CHF/h). This seems implausible in relation to other references, both in the level and in its relationship to other purposes". It is because the employer's value is negative given that pq is large relative to 1-r. Essentially the time is being transferred from working while travelling to leisure and hence is a loss to the employer. We can note three things. Firstly, it is not p but p* which is measured; and if the work is so important it may still be done after time savings occur whereby p will be much small than p*. Secondly, the figure of p* is very large relative to evidence from other studies. Finally, the sample is small.

We have included this Swiss study for completeness but little emphasis should be placed upon it, as far as business travel is concerned, given the small sample and strange results. Nonetheless, it does point to some 'unsavoury' implications when pq is large relative to 1-r.

UK Rail Travel Time Productivity

This Study of the Productive Use of Rail Travel (SPURT) is reported in Mott MacDonald et al. (2009a, 2009b). It is one of the first, and certainly the most comprehensive, examinations in the UK of the amount of time spent working on trains by business travellers and the activity consequences of time savings.

The study is useful for several purposes. Firstly, in estimating p, q and r values, and working through the implications for business valuations of time savings in the rail market. Secondly, in inspecting how these parameters might vary across a range of situations. Thirdly, in undertaking SP research to obtain personal valuations of time savings for those undertaking business travel including crowding and other benefits. Finally, it provided a review of some important studies.

p, q and r Evidence

A sample of 1660 valid and checked questionnaires were obtained from on-train surveys conducted in Spring 2008. Respondents were asked to complete the questionnaire "towards the end of the train journey you are making" to be returned by mail. A very creditable response rate of 35% was achieved.

Respondents were asked:

> *Could you please estimate the amount of time you spent on this train doing each of the following activities?*

Permissible responses were settling down, work activities related to employment, personal activities, and preparing to disembark. Responses could be in minutes or proportion of overall journey. This was followed by:

> *Which, if any, of the following work activities related to your employment did you do on this train?*

Response categories were none, prepare for a meeting, make or receive business calls/texts, talk to colleagues, use laptop, use PDA/Blackberry and other work related to employment.

Respondents were then asked to indicate on a 'timeline' when they undertook work related activities during the course of the journey. This seems to be a novel and well worthwhile feature of the study.

With regard to the relative productivity of working while travelling and in the usual work environment, the respondent was asked:

> *Approximately how long would the work-related activity have taken you if you had done it at your normal place of work?*

Permissible responses were about the same time, more time and less time. In the latter two cases, the respondent was invited to state how many more or less minutes. Whilst it is possible that some things can be done more productively while travelling, say because there are fewer disturbances, this is offset by the range and value of activities that can be done in the normal workplace being higher.

There were then a set of questions relating to how journey time variations, which varied from 10 minutes for the shorter journeys through 15 minutes to 20 minutes for the longest, would impact on work undertaken. Two questions related separately to a shorter and a longer journey.

> *Suppose this rail journey was scheduled to last 10/15/20 minutes longer (shorter) how long would you have spent undertaking work-related activity on train?*

The answers could be the same or more or less time with the amount specified. Following on from this was a question on the use of the time saved. This was:

> *If this train was scheduled to arrive at your destination station 10 minutes later (earlier), would you have spent the additional time working on the train (do you think you would have worked or not in the 10 minutes saved time)?*

For earlier arrivals, permissible responses were not worked, worked in usual workplace, worked in other workplace, worked at home, worked elsewhere (e.g., café, hotel), and other. For later arrivals, the responses were spend all of the additional time working on train, spend some of the additional time working on the train, spend none of the additional time working on the train and don't know.

Other questions related to levels of crowding, and its impact on productivity, presence of facilities to support working while travelling and detailed activities undertaken during the journey.

Around 80% of rail business travellers in Spring 2008 are now working during a train journey, with 82% working on the outward leg and 77% on the return journey. This is contrasted with an estimate of 52% from the National Passenger Survey (NPS) of 2004, and is facilitated by more power points on trains and more Wi-Fi connectivity. This was over a period of only 3½ years and is therefore a large increase. The NPS did not reveal the actual amount of time spent working. Although not undertaken on a comparable basis, it was estimated that 30% of journey time was spent working in 2004 increasing to reported levels of 57% in 2008.

Across both directions of travel, on average business travellers spent 46% of travel time working in 2008, which represents p*, and this contrasts with a value for p of 0.41. However, the latter does vary across time bands. This value of p is high compared to other evidence and presumably a contributory factor is that it is the most recent rail evidence and we would expect p to increase over time.

A key issue is how productive this is relative to work done in the office environment. It was found that there was little difference, with train time having 97% of the productivity of work-place time. This falls to 89% in crowded conditions where 90% or more of seats are occupied but hardly varies at all with journey length. The credibility of these results can be questioned.

Of the time that is saved after an earlier arrival, on average 48% of that time would be spent working off-train, although this varies by factors such as journey length and direction of travel. This r value of

0.52 is high. However, it would be difficult argue that the main reason is because of the long distance involved since only 19% of journeys exceeded 90 minutes.

Explaining travel behaviour[14]

There are quite a number of studies that provide estimates of p, q and r but there has been little research conducted into how the parameters vary across different circumstances.

A novel feature of this study was that the questions set out above were subject to an extensive amount of segmentation by relevant factors, although without conducting the detailed empirical analysis to systematically explain and quantify how these figures vary across individuals, travel conditions and journey characteristics so as to have predictive models of time use.

Although the vast majority of the data covers trips of less than 90 minutes, it is interesting to observe how the various parameters vary with journey length. These are reported in Table A3.14 below.

Table A3.14: Hensher Parameter Variation by Journey Length

	p	p*	q	r
< 45m	0.60	0.41	0.98	0.48
45-89m	0.35	0.49	0.97	0.51
90-149m	0.28	0.49	0.98	0.56
150m+	0.22	0.49	0.96	0.65

The relative productivity varies little with distance, unsurprisingly, whilst we might expect r to increase with distance as more trips are then made out of normal office hours. The average level of productivity (p*) varies little when we might have expected some downturn for longer distances although it is not surprising that it is lowest for short distance journeys. In contrast, p quite clearly decreases with journey duration. This seems realistic; there will be less pressure on working time on longer journeys and hence the amount of productive effort foregone will be less.

The type of activities and amount of productive time (p*) undertaken during a train journey varied, generally in an expected manner, with a range of factors, such as direction of travel, occupation, flow type, crowding and on-board facilities all having a bearing. Interactions between variables were apparent whilst there were variations in effect between the proportion working and the proportion of time spent working. The timing of work undertaken peaks earlier in the journey, and this is a possible explanation of why p is less than p*. Perhaps surprisingly, there was little difference between first and standard class in the propensity to work on the outward leg, although a 10 percentage point difference was apparent on the return leg.

[14] The discussion below is based on our understanding of the significant amount of outputs from this important study. However, the discussion is often detailed and in some cases not easy to follow or interpret.

Less attention was paid to variations in p, q and r, with the distance segmentation reported above being the most significant analysis and there being no clear effect from the amount of time saved on p. The exception to this was crowding levels where a number of segmentations were presented.

Crowding is potentially a key issue and as far as we are aware, this study provides the first insights into how crowding impacts on the Hensher parameters, although there is a considerable amount of evidence on how crowding impacts on valuations (Wardman and Whelan, 2011). Unfortunately though, and as also applies to the examination of distance effects, the analysis of the crowding issues was hindered by small samples in the more crowded categories.

It was only at load factors over 90% with some standing that the relative productivity is impacted. At that level q falls from around 1 to around 0.9. We can but speculate that it will be somewhat lower when standing is involved but further research is required on this issue, not least because one could imagine that crowding would have a larger impact than this study revealed.

Even if we accept that q does not vary greatly with load factor providing if it is possible to be seated, we would expect the ability (or indeed willingness) to work during the journey to fall with the load factor. The results with regard to crowding and productivity are not conclusive, but it appears that at 75%-90% load factor 50% of the journey was spent working (i.e. $p^* = 0.5$). At load factors over 90% (without standing) it was 38%. For passengers who are forced to stand, the evidence denotes that p might be halved.

The level of crowding, in terms of proportion of seats occupied, did not greatly affect whether work was undertaken during the course of a journey. It was only when the conditions on the departing train involved (a few) people standing that there was a significant drop-off in the proportion working during the journey. When related to the proportion of the journey the respondent was seated, the results are limited by the ability of most to be able to sit for most of the journey. The study states, "the conclusion remains that work activity is affected by whether one can sit all the time or not, but further insights are desirable" and "the effect of crowding, and/or seating availability, needs therefore to be explored further".

The dominance of short business journeys might be seen as something of a weakness since they can be expected to be somewhat different in nature, as we have to some extent seen. In addition, a very useful addition to the literature would have been a model that explains how p, q and r vary over different travel and personal circumstances.

<u>SP Research</u>

An SP exercise was used in which business travellers had the opportunity to trade-off their own money against time variations and also crowding levels and the quality of mobile phone reception. However, the crowding variable denoted the proportion of seats taken (25%, 50%, 75%, 100%) but did not indicate whether the respondent would get a seat or not.

The manner in which the personal payment was introduced was that the company would provide an allowance of £15 for the journey. Any increase in the SP exercise on a £15 fare would have to be paid by the respondent, but conversely if the fare was less than £15 they could keep the difference. This is now the standard approach for estimating VL. The value of time that emerged varied with model specification.

This study also provides estimates of how VL varies with crowding levels, with a fairly strong effect on VL from crowding above the 75% occupancy level. This is consistent with other crowding evidence that load factor seems to have an effect at this sort of level prior to standing occurring (Wardman and Whelan, 2011). However it only examined crowding up to a level of 100% of seats taken. Even then it is unclear at that level whether the respondent would have got a seat or had to stand; the difference in valuation between the two can be expected to be large.

An effect related to clear mobile reception was also detected but presumably this is not a significant issue going forward.

Appraisal Consequences

The consequences for appraisal values of time under various scenarios for the sample obtained were calculated (Mott Macdonald et al., 2009b). Four scenarios are reproduced below:

Scenario 1: The cost saving approach;
Scenario 2: Consider working time lost on the train but assumes all time saved is converted to work time (r=0);
Scenario 3: For home based trips, this takes into account leisure time increases in addition to working time lost but assumes all time saved is converted to work time for other trips;
Scenario 4: This is the short run modified cost saving approach, with levels of on-train working and proportions of time saved as in the SPURT survey.

The train user business valuations, in £ per hour 2008 prices and income, under each scenario reproduced in Table A3.15.

Table A3.15: Train User Valuations (£ per Hour) from SPURT (Mott MacDonald et al., 2009b)

Scenario	Employer VoT	Employee VoT	Total VoT
1	39.09	0	39.09
2	25.11	0	25.11
3	10.89	7.07	17.96
4	4.69	17.80	22.49

Note: Fowkes (2001) has pointed out that many studies incorrectly do not apply the r weight to VL, effectively treating VW as VL. If r is applied to VL, then the total value of time falls to 13.76 in scenario 4.

Departing from the conventional wisdom leads to a large reduction in the business travel value of time. The main effect is from allowing for the time spent working on train that would be lost which reduces the value of time by 36%. When the transfer to leisure time is taken account for home based trips, and the employee's valuation included, the reduction is 55%. In scenario 4, which represents the modified cost saving approach the business valuation would be reduced by 43%, increasing to a massive 65% when r is applied to VL.

The study made a number of useful recommendations for further work, notably extending to other modes, on-going monitoring, more focus on what it termed inter-metropolitan trips, and behavioural modelling to determine how the ability to work productively influences the demand for rail travel.

Summary of p, q and r values

A detailed summary is provided in section 3.1.2 of the main report which is not repeated here. In particular, it contains:

- Table A3.2 (Summary of p, q and r evidence)
- Table A3.3 (Impact of Modified Cost Savings on Cost Saving Value of Time)
- Table A3.4 (Comparison of Valuations)
- Table A3.5 (Within Study Comparison of WTP and Modified Cost Saving Methods)

Section 3.1.5 arrives at representative figures for p, q and r based on the evidence reviewed.

A3.4 Willingness to Pay Evidence

We have also examined a large amount of willingness to pay evidence, and in particular the extent to which it aligns with the values implied by the conventional Cost Saving Approach. We cover three separate sets of evidence:

- A data set covering UK and mainland European values of time assembled as part of a recent meta-analysis (Wardman et al., 2012)[15];
- Some evidence from a recent large scale study in Japan;
- Evidence from high speed rail studies as it relates to business travel.

[15] Whilst this data set covers out-of-vehicle time, reliability terms and departure time shifts, it does not cover crowding values. We therefore cover these in the next section.

This data is in large part separate from the willingness to pay evidence discussed in section A3.3. Whilst the evidence in section A3.3 covers business values from UK and European studies, it was generally based around the estimation of vL, whereas the evidence covered here contains much more business travel evidence and it covers high speed rail.

A3.4.1 Review of European WTP Evidence

We have at our disposal some data sets that have been assembled for the purposes of meta-analysis. These are:

- A data set covering 3109 monetary valuations from 389 studies across 26 European countries from 1960 to 2011. The UK provides 1862 valuations (60%) across 233 studies. These money values are largely made up of IVT (60%) but walk and headway each provide 10% whilst the remaining cover reliability variables, wait time, departure time shift and congested travel time.

- Related to this data, we have time multipliers for 1389 observations from 244 studies. Of these, 63% are for the UK. These provide for a more controlled assessment of time multipliers, since they all reflect 'within study' variations, than comparing money valuations of various attributes with money values of IVT.

We must though bear in mind that these data sets contain a relatively small proportion of business values: the former contains 14% of business valuations whereas the latter contains 9%. Nonetheless, there is sufficient data to be able to conduct meaningful analysis.

Our UK data does not include SP studies, as far as we are aware, where the value of time on business travel was explicitly a personal valuation (VL); that is, where the respondent was told that they would personally incur any cost increases in return for times savings or receive cost reductions after a time loss when undertaking a business trip.

In the other European studies, where personal values have been estimated they have been used to calculate Hensher type business values. The latter are contained in our data set, and can be separately identified.

Our SP values are certainly not explicitly personal values, but are derived from SP exercises offered to those making business trips. We therefore contend that there is a degree of ambiguity as to what they represent. Our impression is that most studies have taken a quite 'cavalier attitude' and do not specify what the respondent should assume in terms of company policy and who pays. It would have been a large task to go back to each study and determine this information, and in some cases the studies do not report the questionnaire. The values are therefore dependent upon how respondents interpreted the SP exercises presented to them.

The sorts of insights that analysis of our meta-data sets can provide are:

- To what extent are the estimated WTP business values of time in line with labour costs, given the cost savings approach is an appropriate benchmark?

- Given that the modified cost saving approach would lead us to expect rail values of time to be lower than car, all else equal, is there any WTP empirical support for this?

- A related point is the modified cost saving approach might lead us to expect a falling valuation over time, as the opportunities for productive use of travel time increase.

- We might expect RP valuations to exceed SP valuations, on the grounds that the latter do not fully represent company policy. Is this apparent in the WTP evidence and, if so, how do the latter compare with values obtained by other means?

- Given SP evidence now dominates, but without the resource to investigate what each SP exercise might have been valuing in terms of personal or company values, is there evidence to indicate that SP based valuations vary according to relevant indicators such as whether the purpose of the study was forecasting or the choice context was a real one?

- To what extent are the relationships between estimated business valuations and distance, mode and other relevant variables consistent with the different approaches to business time valuation?

- In the cost saving approach, time is time. Is there evidence to indicate that, for business travel, different aspects of time such as walking, waiting and in-vehicle attract different weights?

Section 3.1.3 of the main report contains a detailed account of our analysis of the assembled value of time evidence for the UK and mainland Europe. We therefore do not repeat it here.

A3.4.2 Recent Japanese Evidence

A major three year value of time study has recently been completed in Japan, covering RP analysis of motorists' route choices, SP analysis and a meta-analysis of a large number of Japanese values of time. It did not major on business travel value of time but nonetheless it provides some insights.

The RP analysis was based on the 2005 Road Traffic Census and examined motorists' choices between ordinary roads and an alternative that included ordinary roads and a tolled expressway (Kato et al, 2013). Short distance, intra-zonal, journeys were removed as were trips where the time expressway option was more than 70 minutes quicker or greater than 20 minutes slower. It was observed that in such circumstances there was little variation in the choice rate whereas between these points the expressway option was observed to increase its share as the journey time difference increased.

Separate models were estimated for business travel, commuting and other, and Table A3.15 reports the values of time.

As would be expected with such large sample sizes, the coefficient estimates were precisely estimated, with t ratios over 25. The value of time per person for business travel is not far short of the average wage rate, which at the time was 37.2 yen per minute, but note that the distance elasticity was estimated to be 0.77 which is very large and would imply implausible variations in the value of time for even relatively small changes in distance.

Table A3.15: Japanese Values of Time (Yen per Minute)

	Sample	VoT
Commuting	82068	24.5
Business	12328	33.9
Other	51621	21.0

Kato and Tanishita (2013) report a meta-analysis of 261 Japanese values of time obtained from 68 papers between 1979 and 2003. The business values average 158 yen per minute in 2000 prices from 15 observations, contrasting with 40.9 for home to work from 40 observations and 55.8 for leisure from 30 observations. Note that the business values are largely inter-urban and hence a distance effect may have influenced the results, as implied by the elasticity of 0.77 above, whilst all 15 values were from RP studies[16] which might also lead to higher values. Indeed, removing the air studies, with average values of 177 yen per minute, leaves an average value somewhat lower of 83 yen per minute but still larger than the then average wage of 30 yen per minute.

The meta-model itself obtained a very low income elasticity of 0.31 and therefore we do not regard it to be a reliable means of predicting absolute values of time for business travel or indeed other forms of travel. Notably the meta-model found that RP values were over 30% larger than SP values, in line with previous UK meta-analysis evidence, whilst inter-urban trips were 50% larger backing up the distance effect above. These findings might partly explain why the business values reported in this study were so large.

SP surveys were conducted in 2010 and based upon motorists' route choices. The results based on a web survey obtained very high values for commuting (87.4) and very low for business (11.1). The paper based questionnaire seems to have obtained more reliable evidence, with a business value of 51.9 yen per minute, falling to 45.5 when estimated to combined RP and SP data. The official business value of time in 2008, based on the wage rate, was 44.0 yen per minute.

[16] 5 are route choice, 8 are mode choice and 1 is destination choice. Air travel is the focus of 3 route choice and all of the mode choice studies and these can be expected to be large values.

This Japanese evidence would, if anything, support the valuation of business travel time savings in the conventional manner in line with the wage rate.

A3.4.3 High Speed Rail Evidence

Whilst this scoping study is not primarily concerned with rail, this aspect of it relates to briefcase travellers and rail is an important mode for this market segment. Given this, and that high speed rail projects are of interest because they offer large time savings, we here cover the WTP evidence that relates to high speed rail of which we are aware. This evidence is summarised in Table A3.18.

There is some evidence from Eurostar (Wardman and Murphy, 1999) but it might be regarded to be a different market to domestic UK travel and it certainly generated yields very much higher values than the potential High Speed rail studies in Britain as is apparent in Table A3.18 below.

At about the same time, and for a similar market, Halcrow Fox (1998) used SP methods to examine preferences towards a high speed link between Heathrow and Paris. For point-to-point business travellers, and in 2010 prices and income, the value of time was estimated at £68 per hour. This is 45% higher than the official value for rail. However, the sample relates to air travellers, for whom income levels will be relatively high.

Steer Davies Gleave (2009) undertook SP exercises in the context of a new high speed line between London and Scotland. One related to the choice between car, air and rail whilst another examined the choice of access mode. The estimated values are reproduced in Table A3.16.

The high speed values are lower presumably due to a comfort effect, in that time spent in the proposed high speed train incurs less disutility than time spent in a conventional train. Having said that, we cannot be certain that this is not the result of strategic bias in favour of a new high speed service, although it is commendable that mode specific valuations have been explored rather than imputing all the quality benefit of high speed as a fixed amount regardless of distance as would be the case if the conventional approach of specifying alternative specific constants had been pursued.
The estimated car users' values are somewhat less than the official values of £34 per hour. Similarly, the estimated air and rail users' values are somewhat less than the £47 per hour for rail travellers in Webtag.

Table A3.16: In-Vehicle Time Values (Steer Davies Gleave, 2009)

	Air and Rail Users		Car Users	
	Business	Leisure	Business	Leisure
Rail	39.6	25.2	24.0	20.0
High Speed Rail	30.2	23.3	19.0	15.0
Air	36.1	35.3		
Car			23.0	11.0

Note: Values in £ per hour. January 2009 Prices and Incomes

These business values are low compared to official recommendations. Note that the business values are not much larger than the leisure values, although they are themselves large relative to official values. It may be that the business values reflect personal rather than company willingness to pay; the ratios would not be out of line with the VL values relative to personal leisure values reported above.

The estimated access time values are reported in Table A3.17. These were obtained from a separate SP exercise related to access mode choice.

Table A3.17: Access Time Values (Steer Davies Gleave, 2009)

Rail Users		Car Users		Air Users	
Business	Leisure	Business	Leisure	Business	Leisure
18.0	12.0	29.0	12.0	35.0	18.0

Note: Values in £ per hour. January 2009 Prices and Incomes

For car users, the values of access time for business travellers are higher than the values of IVT, although not by the customary amount and a premium of around 30% might seem appropriate. For air users, it would seem that access time is valued more or less in line with IVT. In contrast, rail users' access time on business trips is valued somewhat less than the value of IVT. Whilst access time multipliers significantly in excess of one are not consistent with the cost savings approach, this evidence taken as a whole is not inconsistent with the cost saving approach.

The Atkins (2002) high speed line study for SRA used SP mode choice exercises amongst rail, air and car users, covering high speed rail journey times. The values of time were £37.0 per hour for air travel and high speed rail and £30.7 per hour for car and conventional rail. These are broadly in line with official values at the time of £26.4 per hour for car and £37.0 for rail.

Burge et al. (2010) undertook an SP mode choice exercise to complement the long distance model (LDM) estimated to NTS data. The SP exercise covered car, air, existing rail and a new high speed rail service with the travel attributes being in-vehicle time, cost, access and egress time, service frequency, rail interchange, airport waiting time, rail crowding and percentage of trips on time.

The form of the cost parameter means that the value of time increases with cost, and is largest for those modes with the highest costs. This restricts the usefulness of the value of time results since the value of time increases as costs increase! However, the model finds little variation in the time coefficients across air, rail and car. Access and egress has a 40% premium on rail and air time whilst waiting at the airport is values slightly less than in-vehicle time.

Recent reworking of the Long Distance Model SP data (Bates, 2012) obtained a mean value of time for business travel of £56.76 per hour, although with considerable variation around this depending upon model specification. The LDM itself provides a value for rail at its mean cost of £55.20. These contrast with webTAG values of £34.12 for all users, being 65% larger. However, a more appropriate denominator is some kind of average of £33.74 for car drivers and £47.18 for rail. If we take a simple average, given that air users will also have large values, then we have a value of £40.5 per hour. The estimated value is therefore 40% larger than labour cost. The Bates (2012) reworking provides a value for leisure travel of £21.30 per hour and access and egress multipliers in the range 1.2 to 1.4.

González-Savignat (2004a) offered SP exercises to current air users between Madrid and Barcelona to examine the propensity to switch to a high speed rail option. The value of time for business travellers was 55€ per hour although the value of access time was somewhat less at 22€ per hour with the value of leisure time not much less than the business value at 37€ per hour. Our estimate of the labour costs at the time is 10€ per hour but this is not specific to air travellers who may well have higher incomes.

In a related study (González-Savignat 2004b), but instead focussing on car users between Madrid and Barcelona and their propensity to switch to high speed rail, business travellers were estimated to have a value of time of 12.4€ per hour for short journeys (Madrid or Barcelona to Zaragoza) and 11.5€ per hour for the longer distance trips. Relative to our estimate of 10€ per hour for gross labour costs, the values here seem reasonable.

Wardman et al. (1992) used an SP choice exercise to examine business travellers' choices between air and rail for journeys between Edinburgh and London. The SP exercise specifically reinforced the point that the respondent was to bear in mind company travel policy when answering the SP questions. What emerged was a value of time of £30 per hour. This is high even given that 80% of the sample were current air users.

The study speculated that because the fares offered were less than the current air fares, which all the air users were authorised to purchase, then there is no constraint from company policy for at least 80% of the sample. It is then hardly surprising if the sensitivity to cost is low and the value of time is high.

A large scale SP survey was undertaken in Australia in 1987 that examined the potential for a very fast train alongside air, coach, car and the current train service (Gunn et al., 1992). Updated to 2010 prices and incomes, the values of time obtained for car were AUD95.6 per hour and AUD44.4 per hour for business and non-business respectively. The corresponding figures for air were AUD105.0 per hour and AUD40.8 per hour. The official value, based on the gross wage rate, is AUD42.2 per hour. These values clearly exceed the official values. It is not beyond belief that values have been influenced by strategic bias, to the extent that travellers would like to influence policy regarding a new high speed rail service.

In a study of high speed rail between Sydney and Canberra, the so-called Speedrail project, our understanding is that the SP based values, in 2010 prices and income, were

- Sydney-Canberra market, business: AUD78.5 per hours
- Sydney-Canberra market, non-business: AUD16.2 per hour

- Intermediate markets, business: AUD31 per hour
- Intermediate markets, non-business: AUD17.5 per hour

What is interesting here is not only that there are differences in WTP values by flow, but that the relativities between business and leisure are far different at 4.8 for the Sydney to Canberra market but only 1.8 for the intermediate markets. The values for the Sydney to Canberra market somewhat exceed the wage rate.

Table A3.18: Summary of High Speed Rail Evidence

Study	%MPL	OVT/IVT	Business/ Leisure	SP Instruction	Comment
Bates (2012)	1.4	1.2-1.4	2.66		Removes log cost of Burge et al. (2010) and easier to interpret.
SDG (2009)	0.8 0.6 0.8 0.7 0.6 0.7	0.88 & 0.45 1.16 & 0.59 0.97 & 0.50 1.21 1.53 1.26	1.57 1.29 1.03 1.20 1.27 2.09	No specific	Air and Rail Users: Rail Air and Rail Users: HSR Air and Rail Users: Air Car Users: Rail Car Users: HSR Car Users: Car Rail MPL value used for air
González-Savignat (2004a)	5.0	0.4	1.49	Unknown	Air Users. Wage rate figure expected to be too low for air users.
González-Savignat (2004b)	1.2 1.1	- -	1.75 1.74	Unknown	Short Long Car Users
Wardman et al. (1992)	1.4	-	-	Consider company policy	Rail user official value used for MPL
Atkins (2002)	1.4 & 1.0[1] 1.2 & 0.8[1] 1.2 & 0.8[1] 1.4 & 1.0[1]	1.08 1.30 1.30 1.08	1.80 2.02 2.02 1.80	No specific	Air Car Rail HSR
Wardman and Murphy (1999)	1.58 3.18	0.73 0.81	2.39 1.82	Consider company policy	Rail Users Air Users Official value for rail users
Halcrow Fox (1998)	1.45	n.a.	-	No specific	Air users. Rail user valuation used as base
Gunn et al. (1992)	2.49 2.27	- -	- -	No specific	Air Car
Speedrail	1.86 0.74	- -	4.8 1.8	Unknown	Sydney-Canberra Intermediate
Yao and Morikawa (2005)	2.39 2.31	0.77 0.80	2.79 2.69	Unknown	Rail and Air Car and Bus Japanese evidence

Note: [1] First figure is Car MPL denominator and second is rail MPL denominator. This is the same as Table 3.13 in the main report.

Outwater et al. (2010) examined demand for high speed rail in California, offering an SP choice exercise that covered car, air and rail and another exercise dealing with access and egress mode choice. The business model reported also contains commuters but, given the distances involved, there will be few of the latter. The implied value of time in the main mode choice model was $63.64 per hour, nearly 3½ times larger than the $18.45 per hour for recreation and other trips. In the access mode choice model, the values were $48 and $15 per hour respectively, a ratio only slightly less than for main mode choice.

Yao and Morikawa (2005) examined high speed rail in Japan. Their mode choice model covered rail, air, bus and car and was estimated jointly to RP and SP data. The business model estimated to nearly 19,000 observations recovered very similar values of time for rail and air and for car and bus of 107.0 and 103.3 yen per minute in 2000 prices. Access time was valued slightly less at 82.6 yen per minute. In contrast, the value for non-business trips was 38.4 yen per minute across all modes.

The evidence from this raft of high speed rail studies is that the values implied by the cost saving approach are broadly supported. It would be difficult to make a case in favour of the Hensher approach, with its typically lower values for rail, on the basis of these findings. Having said that, the sort of business travellers involved are likely to be more senior and to be travelling long distances and these would tend to inflate the values although not necessarily their relationship to MPL. The large time savings on offer might also have a bearing but the studies provide little insight into how the unit value of time varies with the size of the time saving.

A3.5 Specific Issues and Insights

In reviewing studies that have addressed the valuation of business travel time savings, we can draw out some common threads over and above the p, q and r parameters and relationships between different valuation methods covered in the previous sections. Other, more specific, insights have been provided by these studies whilst it is useful to draw somewhat disparate insights together to inform our review.

The specific issues we here examine are:

- Who pays for the time saving and who benefits
- Self-Employed and Employees
- SP and company policy
- Distance Effects
- Crowding, Comfort and Soft Factors
- RP and SP

These issues are discussed in detail in section 3.1.4 of the main report.

A3.6 Conclusions

The evidence we have reviewed does not tell an entirely consistent story. On the one hand, the Hensher equation would imply in some cases, and particularly for rail, significant reductions on the value of time of the traditional cost savings approach. On the other hand, the WTP evidence is more in line with the values of the costs savings approach whilst multiplier evidence would indicate that some premium should be attached to out-of-vehicle time and crowding.

Section 3 of the main report draws together the evidence and hence we do not repeat it here. In section 3.1.5 it provides:

- A summary of the Hensher equation evidence
- A summary of the WTP evidence
- A summary of the insights evidence
- A summary of the empirical support for and challenges to valuation methodologies

It also sets out:

- Recommendations for further Hensher equation research
- Recommendations for further WTP research

Annex 3 References

Accent Marketing and Research, Hague Consulting Group and Steer Davies Gleave (1989) InterCity Business Travel Price Elasticity Research. Prepared for InterCity Marketing Planning Manager, British Railways Board.

Algers, S., Dillen, J.L. and Widlert, S. (1995) The National Swedish Value of Time Study. Proceedings of Seminar F, PTRC Summer Annual Meeting.

Atkins (2002) High Speed Line Study: Stated Preference and Revealed Preference Surveys. Prepared for Strategic Rail Authority

Bates, J. (2012) A Short Analysis of the Long Distance Model's Stated Preference Data. 14th August 2012.

Beca Carter Hollings and Ferner, Steer Davies Gleave, Forsyte Research and Brown Copeland and Co. (2002) Project Evaluation Benefit Parameter Values. Prepared for Transfund New Zealand.

Bradley, M. and Gunn, H.F. (1991) Further Application and Validation of the Netherlands Value of Travel Time Study.

Burge, P., Rohr, C and Kim, C.W. (2010) Modelling Choices for Long Distance Travellers in the UK: An SP Analysis of Mode Choice. Paper presented at European Transport Conference, Glasgow.

Fowkes, A.S., Marks, P. and Nash, C.A. (1986) The Value of Business Travel Time Savings. Working Paper 214, Institute for Transport Studies, University of Leeds.

Fowkes, A.S. (2001) Principles of Valuing Business Travel Time Savings. Working Paper 562, Institute for Transport Studies, University of Leeds.

González-Savignat, M. (2004a) Competition in Air Transport: The Case of the High Speed Train. Journal of Transport Economics and Policy 38 (1), pp.77-108.

González-Savignat, M. (2004b) Will the High Speed Train Compete Against the Private Vehicle? Transport Reviews 24 (3), pp.293-316.

Gunn, H.F., Bradley, M.A. and Hensher, D.A. (1992) High Speed Rail Market Projection: Survey Design and Analysis. Transportation 19, pp.117-139.

Hague Consulting Group, Accent Marketing and Research and Department of Environment Transport and Regions (1999) The Value of Travel Time on UK Roads. The Hague.

Hague Consulting Group (1990a) The Netherlands' Value of Time Study: Final Report. Prepared for Dienst Verkeerskunde Rijkswaterstaat.

Hague Consulting Group (1990b) Further Analyses of the Netherlands Value of Time Study. Public Transport Survey Data. Final Report to Ministerie Van Verkeer en Waterstaat.

Hague Consulting Group (1998) Value of Dutch Travel Time Savings in 1997. Final Report to Rijkswaterstaat – AVV.

Halcrow Fox (1998) Project Isambard Demand and Revenue Study. Final Report to British Airways.

Hensher, D.A. (1977) Value of Business Travel Time. Pergamon Press

Hensher, D. A. (2011) 'Valuation of Travel Time Savings' in Handbook in Transport Economics, ed. Andre de Palma, Robin Lindsey, Emile Quinet, Roger Vickerman, Edward Elgar Publisher, London, United Kingdom, pp. 135-59.

Kato, H., Oda, T. and Sakashita, A. (2013) Valuation of Travel Time Saving with Revealed Preference Data in Japan: Further Analysis Paper to be presented at 13th WCTR Conference, Rio de Janeiro.

Kato. H. and Tanishita, M. (2013) A Meta-Analysis of the Value of Travel Time Savings: Evidence from Japanese Passenger Travel. Paper to be presented at Annual Transportation Research Board Conference, Washington.

Mott MacDonald, Hugh Gunn Associates, TRI Napier University, Accent and Mark Bradley Research and Consulting (2009a) Productive Use of Rail Travel Time and the Valuation of Travel Time Savings for Rail Business Travellers. Final Report to the Department for Transport.

Mott MacDonald, Hugh Gunn Associates, TRI Napier University, Accent and Mark Bradley Research and Consulting (2009b) Value of Working Time and Travel Time Savings: Long Run Implications Report. Prepared for the Department for Transport.

MVA Consultancy, Institute for Transport Studies University of Leeds, Transport Studies Unit University of Oxford (1987) The Value of Travel Time Savings. Policy Journals, Newbury, Berks.

Outwater, M., Tierney, K., Bradley, M., Sall, E., Kuppam, A. and Modugula, V. (2010) California Statewide Model for High Speed Rail. Journal of Choice Modelling 3(1), pp.58-83.

Ramjerdi, F., Rand, L., Sætermo, I.A. and Sælensminde, K. (1997) The Norwegian Value of time Study Part 1. TØI Report 379. Report to Ministry of Transport and Communications, The Norwegian Railways, the Norwegian Public Road Administration and the Norwegian civil Aviation Administration.

Steer Davies Gleave (2009) New Line Programme: Demand and Revenue Modelling Report. Prepared for Network Rail, London.

Wardman, M., Holden, D and Fowkes, A.S. (1992) An Analysis of the Mode Choice Behaviour of Business Travellers between Edinburgh and London. Technical Note 304, Institute for Transport Studies, University of Leeds.

Wardman, M., Chintakayala, P., de Jong, G. and Ferrer, D. (2012) European Wide Meta-Analysis of Values of Travel Time. Report to European Investment Bank

Wardman, M. and Whelan, G.A. (2011) 20 Years of Rail Crowding Valuation Studies: Evidence and Lessons from British Experience. Transport Reviews *31* (3), pp.379-398.

Wardman, M. and Murphy, P. (1999) Eurostar Demand Forecasting Research. Technical Note 425, Institute for Transport Studies, University of Leeds.

Yao, E. and Morikawa, T. (2005) A Study of an Integrated Intercity Travel Demand Model. Transportation Research Part A, 39, pp. 367-381.

ANNEX 4: TRAVEL TIME USE – AN EXAMINATION OF EXISTING EVIDENCE

A4.1 Context

This is a contribution to the Institute for Transport Studies (University of Leeds) 2012 study for the Department for Transport (DfT) entitled "Valuation of Travel Time Savings for Business Travellers". It is based on the assembly of a set of 66 potentially relevant articles and close review of around a third of these. The full bibliography is attached. The purpose was to identify and examine existing evidence on how people use and interpret their travel time, particularly in the context of business travel. Views expressed in interpreting the evidence are those of the author.

A4.2 Introduction

The orthodox wage-rate approach in economic appraisal has, at its heart a key assumption regarding business travel time. "*Time spent travelling during the working day is a cost to the employer's business. It is assumed that savings in travel time convert non-productive time to productive use and that, in a free labour market, the value of an individual's working time to the economy is reflected in the wage rate paid*" (DfT, 2012a). This has been a source of academic provocation which has contributed to a growing number of pieces of work in both transport studies and mobilities research in the social sciences concerned with people's use of and opinions regarding their travel time use. The implication of the assumption is that all business travel time is wasted time. Academic studies have set about gaining empirical insights into how travel time is used with, in part, an aim to refute this implication. Of course the appraisal of travel time focuses on travel time *saved* not upon travel time *used*. It has been argued that productive use of *a proportion* travel time does not necessarily compromise the validity of the assumption above *unless* the saved time would otherwise have been used productively within the journey.

In 2005 a conceptual paper by Lyons and Urry was published which examined travel time use in the information age and potential implications for economic appraisal. This has become a point of reference for many subsequent articles with over 170 citations – reflective of the scale of interest in the topic of travel time use in recent years. Empirical studies of travel time use, employing a range of methodologies, can be found for the UK, Netherlands, Sweden, Norway, USA, Japan and New Zealand. These have variously considered specific modes or journey purposes. Some have involved observational methodologies while others have employed self-reporting. There are in-depth qualitative studies which seek to elicit greater insight into the meaning of travel time use for individuals. There are few studies which specifically concern themselves with trying to examine notions of productivity in relation to travel time use and those which touch upon this have not done so in a way that would align with the parameters in the Hensher equation[17]. However, there are also insights in the literature concerning the changing nature of work in the knowledge economy which raise if not answer some wider questions about how travel time and travel time savings are treated in relation to ownership of time and productivity of time.

A4.3 Empirical Insights into Travel Time Use

It is important to stress that, especially for information workers, the forms of communication and ways of equipping oneself and undertaking work are changing over time. It is therefore important to be aware that cross sectional empirical insights at a point in time may not hold true over time.

Not all studies in the literature have sought to focus (solely) upon business travel or have predominantly considered what have been referred to as 'briefcase' travellers. It is appropriate to summarise empirical insights according to mode of travel. The literature has predominantly concerned itself with public transport and rail in particular but t here are also some helpful studies addressing car travel.

Time Use During Rail Travel

On two occasions in 2004 and 2010, questions on travel time use have been included in the National (Rail) Passengers Survey for Great Britain. This survey instrument has the advantage that it captures passengers' views about the specific train journey they were on when receiving the questionnaire. It also has a limitation in terms of the scope of questions able to be asked – all being closed questions with pre-defined response options. The questions have addressed: (i) what rail passengers do with their time on the train; (ii) how worthwhile they consider this time to be; (iii) how they equip themselves for using their time; and (iv) the extent to which they plan in advance how to use the time on the train. The response sample sizes for the 2004 and 2010 surveys were 26,221 and 27,556 respectively (however, the comparative analysis between the two surveys (see below) used sample sizes of 22,866 and 19,715 respectively).

Key findings for 2004 were as follows (Lyons et al., 2007): 55% of business travellers spend some of their time on the train working/studying on their outbound journey (for 35% it is the activity they spend most time on); the figures are 48% and 27% respectively for the return journey. They are more likely to be reading for leisure on the return journey. Meanwhile, 13% of commuters indicate working/studying as the activity they spend most time on (around 28% spend some time working/studying). Journey duration has an effect on what people do with their time, with window

[17] See Section 2.4 and Annex 1 for a fuller discussion of the Hensher equation. He proposed a formula for calculating the value of business travel time savings which attempts to account for the following: the proportion of travel time saved at the expense of work done while travelling (p); the productivity of work done while travelling relative to at the workplace (q); and the proportion of travel time saved used for leisure (r).

gazing/people watching showing a marked increase for journeys of less than 15 minutes in duration. Only 2% of respondents indicated spending most of their time being bored and 1% spent most of their time being anxious. Business travellers' aligned as follows with one of these three statements: "I made very worthwhile use of my time on this train today" – 27%; "I made some use of my time on this train today" – 58%; and "My time spent on this train today is wasted time" – 13% (2% not answered). While not specific to business travellers, travellers overall reflected on the role of mobile technologies in their travel time experience: *"[o]ver a fifth of rail passengers, to whom the question applied, considered having electronic devices with them made the time on the train a lot better. However, nearly half of all passengers, 46%, considered electronic devices had not made the travel time any better*". There was a marked difference in opinion by respondent age, with a declining proportion indicating 'a lot better' with increasing age. The results of this survey underlined the heterogeneity of travel time use and experience with, for example, distinct differences in 'time worth' assessments for given types of main time use. Unfortunately questions relating to the effect of mobile technologies on travel time experience were not included in the 2010 survey. The 2004 survey predates the launch in the UK of the first iPhone in 2007, the Kindle in 2009 and the iPad in 2010.

In 2010 a core subset of questions on time use were repeated, enabling what appears to be the first case of longitudinal comparison of travel time use (Lyons et al., forthcoming; Susilo et al., 2012). The comparative analysis reveals a broad consistency overall over the six years in terms of the most popular activities – reading for leisure, window gazing/people watching and working/studying. There are two key findings in terms of change. There has been an overall upward move in terms of positively viewing time 'worth'. "*There has been a 37% reduction over six years in the proportion of business travellers indicating that their time on the train was wasted*". 34% of business travellers in 2010 considered they had made very worthwhile use of their time on the train compared to 28% in 2004. The other key change relates to the increasing availability and use of mobile technologies – here applying to all passengers. "*Taking netbooks and laptops together then the proportion of people with such a device has increased by 77% in six years from 7% in 2004 to 13% in 2010. The proportion of travellers who have and use a laptop computer has increased by 60%. The proportion of people with a mobile phone has only increased modestly over the six years. However, a much higher proportion of those who have a phone with them are now using it* [for any purpose] *during the journey – 54% compared to 36% for 2004. The proportion of people who have a music player, and the proportion who have one and use it, have doubled in six years*". The National (Rail) Passengers Survey between 2004 and 2010 also revealed an overall increase in the proportion of travellers who were very/fairly satisfied with the punctuality/reliability of their train and who rated the train very good or good in terms of there being sufficient room for all the passengers to sit/stand. Perceptions of level of service and the uptake of mobile technologies then have increased in tandem with an overall increase in the sense of travel time being worthwhile. Advance planning of how an individual is going to use their time on the train seems significant – for all rail travellers, individuals who have planned a lot in advance are three times more likely to consider their time use very worthwhile compared to those who have not planned at all and seven times less likely to consider their time has been wasted.

Drawing upon the question design used in the National (Rail) Passengers Survey in Great Britain, Gripsrud and Hjorthol (2012) examined responses from 1,196 rail travellers in Norway in 2008. The study revealed that "*a high proportion of ordinary commuters and business people work on board while travelling by train, i.e. 35% of commuters and 43% of business people".* It is found that 27% of commuters responding to the survey indicate having travel time approved of as working hours by their employer. The figure is 53% for business travellers. In this Norwegian study it was found that *"[a]bout 40% of commuters and business travellers take a laptop on board the train, and, in total, 25% use it".* These figures are considerably higher than those for the 2004 GB study, though noting above the changes in the GB context revealed by later 2010 data. In the Norwegian study, *"[m]ore than half of all commuters and 41% of business travellers state that use of an electronic device during the journey makes the trip more worthwhile than it would otherwise be*". It was also found that the majority stated "*that the use of ICT while travelling by train made the time pass more quickly, and about one third of the commuters and business travellers are claiming that they made good use of the time on board*". Only 10% of respondents in this survey indicated that their travel time was wasted – lower than the findings for the GB study 4 years earlier.

A study called 'Survey on the Productive Use of Rail Travel-time ' (SPURT) has examined productive use of rail travel time for business travellers and the value of time savings. The findings were first made available as Fickling et al. (2008) and subsequently as a published report (Mott MacDonald et al. 2009). The study undertook its own empirical work but first reviewed other key studies. This included work based on the National Rail Passengers' Survey data from 2004 by TRi Napier for Virgin Trains which applied an analytical technique to estimate activity durations. It was found that "for journeys in the 1-3 hour range, 30% of the journey time (across all business travellers) was spent working (43% for those business travellers who did some work)". SPURT secured responses to a questionnaire including a revealed preference section, a stated intentions section, a set of stated preference games and some socio-economic questions. The survey found that "*around 80% of the business rail travellers reported undertaking work during their journey. The longer the journey, the higher the percentage of travellers working*". The study team, in drawing comparison between the 2008 data and the 2004 data from the National Rail Passengers' Survey, found that "*the proportion of business travellers who spend some time working/studying as 52% in Autumn 2004, 79% in Spring 2008 Whilst a like-for-like comparison of the percentage of time they spend working/studying has not yet been undertaken, the two surveys yield estimates of 43% in 2004 (for 1h-3h journeys), and 57% in 2008, again suggestive of a strong upward trend*" (Fickling et al., 2008). The study also examined crowding and found that while there was some impact on productivity even in crowded conditions productivity could remain high. The '*Average* [weighted] *minutes change in the amount of working time needed if the work was done at the office*' was -1 when 25 % of the seats on the train were occupied compared to -5.6 when '*90% of seats occupied a few people standing*' (Fickling et al., 2008). 87% of the journeys in the survey response sample were 45 minutes or longer in duration; 40% were 90 minutes or longer (DfT, 2009).

The most recent UK data in relation to rail travel comes from the April 2012 omnibus survey commissioned by the DfT (DfT, 2012b). This study estimated from its results that just over a quarter of the public had used a long distance train service (a journey of over 50 miles) in the previous twelve months. Those respondents who had undertaken a long distance train journey were asked, for their last such journey, to recall how they had spent their time. It was found that *"[t]he most popular ways that users had passed time on their last long distance train journey included reading books, magazines and newspapers (69 per cent); looking at the view (47 per cent); sending texts, making calls or sending emails for personal reasons (38 per cent); eating or drinking (38 per cent), and using electronic devices to watch films, listen to music, play games or use the internet (37 per cent). A majority (40 per cent) of users said they had spent most time reading*." 11% spent most time doing work for their job (including work text/calls/emails) – 20% spent some time doing this. These figures are comparable to (though slightly lower than) those from the 2004 and 2010 National Rail Passenger Surveys' results.

Work by Russell et al. in New Zealand employed a structured observation approach (812 passengers) to examine what people do on trains and buses (Russell et al., 2011). It was found that "*nearly two thirds of passengers observed spent some of their travel time looking ahead or out of the window (65.3%)*". This study also reflected on methodological issues and drew comparison with other studies including an observational survey of 161 Bay Area Rapid Transport System users in San Francisco (Timmermans and Van der Waerden, 2008) and an observational survey of 84 train users in the Tokyo Metropolitan Region (Ohmori and Harata, 2008). The San Francisco study observed few people doing more than one thing during their journey and with doing nothing being the case for 64% of observed travellers. The study in Japan focused on a short distance train which departed from Machida at 6.30am and arrived at Shinjuku at 7.04am. It found sleeping to be the most observed activity (67% of observed passengers) followed by 62% observed reading. 17% were observed doing nothing. Authors for all three studies note limitations in the observation approach to studying travel time use. Russell et al. caution against the assumption that just because someone appears to be doing nothing they are in fact doing so, suggesting that in fact they could be 'doing something' – "thinking, planning, remembering, praying, daydreaming".

A further observational study has concerned London Underground users (Gamberini et al., 2012). It confined itself to the observation of seated passengers with 1,722 passengers and 1,965 occurrences of coded activities observed. The authors note official data which indicates the average time spent in a single underground car to be 12.7 minutes. 26% of observed activities concerned technology use, 22% talking with other passengers and 18% reading a book or paper. Men were statistically more likely than women to be using at least one technology device. As with the national rail insights where journeys of less than 15 minutes have a stronger likelihood of 'passive' activities such as window gazing being dominant, passive activities are also common on the Underground when people are travelling for only two stops. However, "*[f]or people leaving at the fourth, fifth, or sixth stop after they got on the train, passive occupations were not the most common activity*". The study also drew attention to findings from a recent Which? report revealing that "*the majority of mobile phone owners would welcome mobile coverage as they travelled on the London Underground*" with "*approximately one third of respondents stat[ing] that they would use it to do work during their trips*".

Time Use by Car Drivers

By comparison to public transport, fewer studies have examined travel time use by car drivers, yet this is important given the assumptions in the absence of data that such time use would be less worthwhile or productive than that by train in particular because of the constraints to multitasking of the driving task itself.

Eric Laurier has been noted as one of the pioneers of in-depth work into the use of the car as a mobile office or place for activity (Laurier et al., 2008). However, the study that perhaps has most salience for considering business travel time and value of time savings is one by Hislop (2012). He undertook a survey of business travellers at a motorway service station (149 responses) and a set of 15 follow-up interviews. The survey evidence concerned individuals for whom journeys "*were intrinsic to their work, and involved travelling between diverse locations during the working day*". Nearly a third of respondents regularly (2-3 times per week) used their car for work-related purposes and over half used their phone while driving either 'quite a lot' or 'a great deal'. Hislop suggests that drivers use their phones extensively whilst being aware of the distraction they cause because "*they felt under pressure both to make use of their driving time productively, and to deal with calls regarded as urgent or necessary*". He also found that "*a number of interviewees argued that driving time could be used for thinking about work*". The study also explored drivers' use of service stations finding that "*business travellers often utilized much of their time spent in their cars when parked to communicate with remote people such as clients, or colleagues*". Car environments were seen as "*relatively private spaces over which drivers had a reasonable level of control*". At the same time lack of space could inhibit ability to work prompting advice to car manufacturers about how design could improve in terms of facilitating use of a vehicle as a working environment.

A second study merits brief review for the principal reason of highlighting how change has occurred over time in relation to mobile technologies and forms of communication. A 1994 study looked at a sample of 90 business people "*stopping at roadside restaurants and service areas*" (Eost and Flyte, 1998). Implicit in the reporting was that activities undertaken in the car were referring to those done while the car was stationary and the principal focus was on paperwork as the medium. The following extracts from the paper itself reflect how 18 years ago, mobile technologies were different in their nature, availability and use. "*Of the 70 people who used a telephone to keep in touch the most commonly used type of telephone was a fixed car telephone (39%), with analogue cell telephones the next largest category (28%). Two of the case study respondents were expected by their company to keep in touch using public telephones, as were 18% of those in the interview survey*". "*Fifteen interview survey respondents had a computer in their car... [d]ata were usually sent to or from the office only once a day or less*". "*The number of people using an in-car computer was small, although it is likely to rise as more and more companies utilise computers in their business dealings*". "*Compared with office environments the use of computers for word processing in the mobile environment was hardly ever mentioned*".

Time use by pedestrians

A study by Middleton (2009) provides a reminder that while receiving less attention in the literature, walking too can be a mode where travel time use has positive connotations for work productivity. The study examined walking in London using a mixed method approach including a postal survey, walking diaries and in-depth interviews. The author observes that "*for many residents, walking is a significant part of their day-to-day working life – they work whilst they walk*". To illustrate this observation the following quote from a participant is offered:

> "*The next few minutes are lost to me. I must have walked past the theatre but didn't notice as my brain has switched to thinking about brochure spreads and advertisements. It's amazing how I suddenly start conceiving ideas about work whilst walking along even without realizing it. Since I get paid to think, I wonder if I should be paid for my walking. But then again, I also get paid to be in by 9!!'*"

Multi-Modal Studies

Two studies examine travel time use across public and private transport modes. Ettema et al. (2010) secured 662 responses to an activity-travel-communication diary in the Netherlands with the sample skewed towards highly-educated professionals. It was found that "*with increasing travel time the share of travellers not engaging in any activity during travel becomes smaller, both for car and for train. For train, the share working during the trip increases from 5.6% for trips under 30 minutes to 42.3% for trips longer than 90 minutes*". Further, it was noted that "*travel mode is the major predictor of working while travelling. Working on the move hardly happens for car drivers and passengers, although it happens to some extent (4.9%) on trips longer than 60 minutes*".

O'Fallon and Wallis (2012) have surveyed 512 Auckland and Wellington metropolitan area residents in terms of "*the 'utility' of travel time when commuting to work on tertiary study*". The study explored people's estimated commute times against their stipulated ideal commute times. "*The median existing or estimated commute time (EC) for all commuters was 20 minutes. The median ideal commute time (IC) of 10 minutes identified by our sample meant that 68% of respondents spent more time commuting each day than they would have liked to"*. In relation to the statement 'I enjoy the time I spend commuting to work', 35% of those driving a car most frequently for commuting strongly agreed or agreed; the figures were 68% for walk/cycle and 35% for public transport. Considering estimated commuting time to work/study in relation to the statement, the proportions agreeing or strongly agreeing were as follows: 0-9 mins – 58%; 10-19 mins – 47%; 20-29 mins – 39%; 30-39 mins – 32%; 40+ mins – 24%. In other words, 'enjoyment' of the commute diminishes with commute duration. It was also found that those who enjoyed their jobs were more likely to enjoy their commute. The study found that "[a]bout one-fifth reported doing work or study activity, namely reading/writing/typing/thinking, while commuting... One-third (33%) of commuters were contented with their time spent commuting, enjoying it and finding it a useful transition between home and work."

Understanding Business Travel Time

Gustavson (2012) undertook 12 semi-structured interviews with travel managers in Sweden followed by interviews with 22 employees in relation to their business travel (across modes - it was noted that *'[r]elatively few travellers in the study made business trips by car*'). He found that employers do not tend to have explicit expectations about work during travel time – however, expectations were instead about "*getting one's work done in a satisfactory way*". The study revealed that "*although travellers often appreciate having good working conditions while travelling, the first priority for many frequent travellers is to minimize time spent away from home and family, rather than to make productive use of their travel time*". In this regard there were strategies to replace physical meetings with virtual equivalents or to combine meetings associated with a given journey. The author identified four different attitudes to travel time and working time:

1. Travel as any other working time – mobile workers whose work goes with them and is done wherever they are including travelling.

2. Travel on long distance journeys as a special kind of working time – "*an opportunity to perform work tasks that demand undisturbed and uninterrupted time and are therefore difficult to do at one's regular workplace*".

3. Travel as inappropriate for or a poor second for undertaking work – leading to no work being done or done with limited efficiency.

4. Travel as valuable 'time out' – "*time that travellers use for relaxation and restoration*".

Holley et al. (2008) provide an examination of time for work which is specifically oriented towards questioning the wage-rate approach in economic appraisal. This is a theoretical paper informed by UK empirical evidence from a national rail passenger survey and from an in-depth case study of a knowledge worker. The paper, in reflecting on current approaches to economic appraisal of transport schemes notes a further assumption beyond those often recognised, namely "that it is possible to clearly distinguish between what constitutes productive or unproductive use of time and in turn assign corresponding economic values". It points out that Taylorism and Fordism[18] provide the roots to the current economic appraisal approach – with the notion that business travel time is 'employer owned' time and leisure and commute travel time is 'owned' by the individual. The authors argue that the knowledge economy has brought a "*reduced (and reducing) dominance of the*

[18] "*In 1911 Taylor first published The Principles of Scientific Management (1911/1972) which introduced the idea of breaking manual labour into its component parts (or motions) in order to remove those which were not necessary and rearrange the remaining components so that they were conducted in a more efficient manner and achieved greater productivity. It also resulted in a complete removal of workers' autonomy. A similar approach was taken by Henry Ford for car production lines a few years later. A dominance of these work practices would aid in the justification of transport appraisal's approach*." (Holley et al., 2008).

clock-controlled industrialized time and a resurgence of the pre-industrial task-oriented concept of time". They go on to suggest that "*a strict adherence to the task-oriented concept of time would imply that the 'ownership' of the time is determined by the activity consuming that time. Time spent conducting non-work activities while travelling is not automatically a cost to the employer that needs to be reduced*". Over and above adding evidence concerning productive use of travel time, this paper puts forward further challenges "*to the current understanding of business travel time informing UK transport appraisal*":

1. Why does the purpose of a journey define what constitutes time use within it and related saved time? In a task-oriented knowledge economy, ownership of time is more sophisticated than this.

2. "*the possibility that business travel time serves a similar function to traditional work breaks – providing anti-activity time which can assist productivity at other time periods and assist creativity by providing 'incubation' time*".

A4.4 A Conceptualisation of Travel Time Productivity

Reference was made at the start of this review to a paper by Lyons and Urry (2005). The literature above has tended to be 'in search of positive utility of travel time'. Lyons and Urry recognised that not all travel experience is positive and put forward a conceptualisation of travel time productivity. This postulates that across all travellers and journeys for a given mode a distribution of levels of productivity of time use must exist and that these distributions would vary across modes. To be of practical value this would require calibration with empirical data. Nonetheless, the conceptualisation (reproduced below) illustrates what might be seen as the full array of productivity consequences of time invested in travel. This extends beyond the two apparent bounds of 'unproductive' and ''fully' productive' to include 'counter-productive' ("*time use that not only achieves no benefit in itself but also has an adverse effect on time use beyond the journey (e.g. a stressful commute journey affects an individual's level of productivity once they reach work)*") and ''ultra' productive' ("*the use of time on the journey has been more beneficial than had that time been used otherwise (e.g. getting more work done because of the lack of interruptions which tend to disrupt thinking in the office)*").

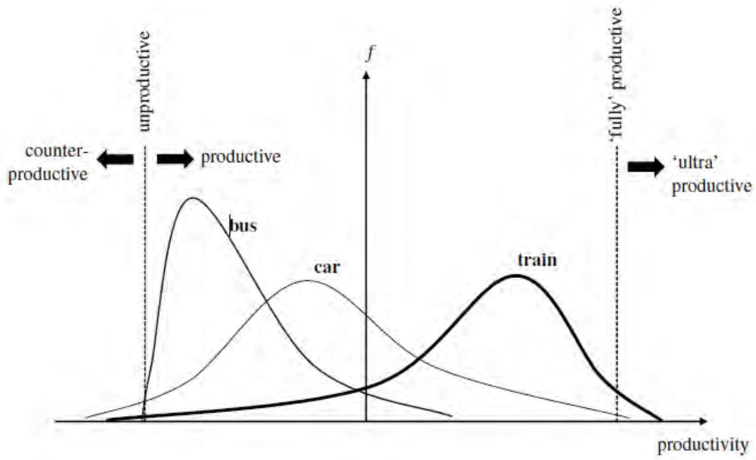

Figure reproduced from Lyons and Urry (2005) – "*illustrative frequency* [f] *distributions of 'productivity' of travel time by mode*"

A4.5 Reflections on the Literature Examined

A number of key summarising points can be made from this examination of available literature on travel time use:

1. Methodological approaches to gaining insights into travel time use are varied and studies often appear to face significant constraints in terms of balancing breadth and depth of coverage. Observing or recording *what* people do with their time falls short of understanding *why* they use the time in the way that they do and *how* this time use finds its place in their overall time use.

2. The evidence as gathered is limited in terms of attempts to distinguish between different types of business travel and is likely to have an implicit focus upon or leaning of emphasis towards 'briefcase travellers'. It is important to recognise this potential 'evidence gap'. It should certainly not be assumed in the absence of evidence that productive travel time use is less prevalent within business travel beyond the bounds of briefcase travellers.

3. There are clear modal differences in relation to productive use of travel time. While the assumption that rail holds more prospect than car for productivity is likely to be robust, the car environment nevertheless has prospect for worthwhile time use and indeed this may be increasing over time.

4. Attempts to judge any sense of relative productivity of time use between travel and non-travel are especially scarce in studies of time use which are often not principally concerned with consequences for economic appraisal.

5. However, there are qualitative insights to suggest that the full span of the conceptualised distributions depicted by Lyons and Urry (2005) occur in practice. In other words for some the

6. There is recognition of the permeability between work and non-work time or indeed the drift towards unbounded work and non-work time such that individuals are incorporating their travel time use into a wider blend of daily time use that is geared towards meeting work, social and personal goals. There is clear evidence for example that some people use some of their commute time for work activity and some people use some of their work-related travel time for personal activities.

7. Evidence for rail suggests that *change over time* is occurring in terms of ways of working and communicating in the knowledge economy and a reducing distinction between the key facilities for work in 'the office' or 'on the move'. For both rail and car (and likely all modes), technologies are evolving that appear to increase the versatility of and support of work and personal activities that can be undertaken during travel. Evidence is now available that highlights change over a six-year period. With scheme appraisal potentially covering ten times longer into the future, change could be dramatic and unpredictable and not necessarily in one direction.

8. Observation or self-completion questionnaires are likely to massively over-simplify how activities relate to an individual's overall productivity in their employment role. To fulfil, for example, a knowledge worker' role is likely to involve a blend of reflecting, thinking, planning, reading, writing, typing, talking and so on. There is evidence to suggest that with suitable advance planning, individuals are able to align the travel environment and time with appropriate elements of this blend to good effect.

9. While there are clearly some journeys for which the experience for the traveller does not offer much if any positive utility, the evidence points towards an appreciable existence of positive utility within travel across modes. It is contestable whether notions of proportions of a journey which are either productive or not productive are too reductionist, added to then by notions of determining the relative productivity of productive time on the move compared to that outside of travel.

10. It seems clear that there is significant heterogeneity of travel time experience and utility across people, modes and specific journey contexts. In some respects this heterogeneity is accommodated within the wage rate approach which has its focus upon the average or aggregate picture. However, the evidence on travel time use in particular highlights how time use varies with journey duration which in turn will have consequences for the (subjective) utility the time is judged to offer. This may be difficult to accommodate in any approach to economic appraisal unless some forms of disaggregation of travel circumstances are introduced and treated separately. Such disaggregations may relate, for example, to journey duration.

There is evidence then to suggest a strong presence of travel time use activities that derive personal or work benefits. The extent to which this positive utility prevails is likely to vary by context. At the same time there is some evidence to support the view that mobile technologies and changing ways and norms of working are contributing to increasing the propensity for travel time to be used in ways that derive benefit to the individual in either their work or personal lives. The emerging evidence also underlines the sophistication of how society and the individuals within it choreograph activity participation in time and space. Such sophistication may defy any attempt to adequately reflect it through metrication and measurement as is implied by the thinking embodied within the Hensher formula. Productivity eludes being commoditised in blocks of time where it can be judged for different spatial contexts as being 'more' or 'less' productive. Such a reductionist way of thinking may well be perilous and far from 'future proof' as we move ever further from the Fordist/Taylorist approaches to work.

Annex 4 References

DfT (2009). Productive Use of Rail Travel Time and the Valuation of Travel Time Savings for Rail Business Travellers - Final Report.

DfT (2012a). *Values of Time and Vehicle Operating Costs*. TAG Unit 3.5.6. Department for Transport, August.

DfT (2012b). Public attitudes towards train services: results from the April 2012 Opinions Survey. Department for Transport.

Eost, C. and Galer Flyte, M. (1998). An investigation into the use of the car as a mobile office. *Applied Ergonomics*, 29(5), 383-388.

Fickling, R., H. Gunn, et al. (2008). The productive use of rail travel time and value of travel time saving for travellers in the course of work. *Proc. European Transport Conference*, Association for European Transport. Leeuwenhorst Conference Centre, The Netherlands.

Gamberini, L., Spagnolli, A., Miotto, A., Ferrari, E., Corradi, N. and Furlan, S. (2012). Passengers' activities during short trips on the London Underground. *Transportation*.

Gripsrud, M. and Hjorthol, R. (2012). Working on the train: from 'dead time' to productive and vital time. *Transportation*, 39, 941–956.

Gustafson, P. (2012). Travel time and working time: What business travellers do when they travel, and why. *Time & Society*, 21(2), 203–222.

Hislop, D. (2012). Driving, Communicating and Working: Understanding the Work-related Communication Behaviours of Business Travellers on Work-related Car Journeys, *Mobilities*.

Holley, D., Jain, J. and Lyons, G. (2008). Understanding Business Travel Time Use and its Place in the Working Day. *Time & Society*, 17 (1), 27-46.

Laurier, E., Lorimer, H., Brown, B., Jones, O., Johlin, O., Noble, A., Perry, M., Pica, D., Sormani, P., Strebel, I., Swan, L., Taylor, A.S., Watts, L, and Weilenmann, A. (2008). Driving and 'Passengering': Notes on the Ordinary Organization of Car Travel, *Mobilities*, 3:1, 1-23.

Lyons, G. and Urry, J. (2005). Travel time use in the information age. *Transportation Research*, 39(A), 257-276.

Lyons, G., Jain, J. and Holley, D. (2007). The use of travel time by rail passengers in Great Britain. *Transportation Research,* 41(A), 107-120.

Lyons, G., Jain, J., Susilo, Y. and Atkins, S. (n.d.). Comparing rail passengers' travel time use in Great Britain between 2004 and 2010. Forthcoming in *Mobilities*.

Middleton, J. (2009). `Stepping in time': walking, time, and space in the city. *Environment and Planning A*, 41, 1943-1961.

Mott MacDonald, Hugh Gunn Associates, TRI Napier University, Accent and Mark Bradley Research and Consulting (2009) Productive Use of Rail Travel Time and the Valuation of Travel Time Savings for Rail Business Travellers. Final Report to the Department for Transport.

O'Fallon, C. and Wallis, I. (2012). A wider look at how travellers value the quality and quantity of travel time. NZ Transport Agency research report 469.

Ohmori, N. and N. Harata (2008). How different are activities while commuting by train? A case in Tokyo. *Tijdschrift voor economische en sociale geografie; Royal Dutch Geographical Society*, 99(5): 547-561.

Russell, M., R. Price, et al. (2011). What do passengers do during travel time? Structured observations on buses and trains. *Journal of Public Transportation*, 14(3), 123-146.

Susilo, Y., Lyons, G., Jain, J. and Atkins, S. (2012). Rail Passengers' Time Use and Utility Assessment: 2010 findings from Great Britain with multivariate analysis. Proc. 91st Annual Meeting of the Transportation Research Board, Washington, D.C., January. And forthcoming in *Transportation Research Record*.

Timmermans, H. and Van der Waerden, P. (2008). Synchronicity of Activity Engagement and Travel in Time and Space - Descriptors and Correlates of Field Observations. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2054, Transportation Research Board of the National Academies, Washington, D.C., 1–9.

ANNEX 5: LABOUR MARKET CONDITIONS AND IMPLICATIONS FOR THE VALUATION OF BUSINESS TRAVEL TIME SAVINGS

A5.1 Introduction

A5.1.1 Objectives

This note forms an annex to the main report to the Department for Transport on the valuation of travel time savings to business travellers. The purpose of the annex is to review UK labour market conditions and their implications on the valuation of the business value of time for use in cost benefit analysis. The issue of the use of time whilst travelling (i.e. the productivity of travel time) is discussed in a different working report (Annexes 3 and 4).

Such a review is necessary as the different valuation methods: cost saving method; adjusted cost saving method; Hensher model; etc. (see Chapter 2 of main report for brief descriptions of the different methods) require competitive labour and product markets to give robust valuations. By assuming a competitive labour market the marginal product of labour can be taken to be the observed wage rate plus non-wage costs. Historically this has been taken to be quite a reasonable assumption in developed economies. For developing or emerging economies this condition has long been recognised as being inappropriate. If markets are not competitive either the wage plus non-wage costs may differ from the marginal product of labour or the resource value of labour released into the labour market will not equal its marginal product.

Given this, transport appraisals in developing countries use shadow prices for labour when it is clear that markets are not competitive (Howe, 1976; Barrington, 1977; Mackie, Nellthorp and Laird, 2005 TRN-15). The assumption that markets approximate competitive conditions in developed countries is now also challenged, when compared to the situation forty or fifty years ago when the cost saving method was introduced. They are challenged on a number of fronts. Firstly, the Department for Transport as part of its wider impacts guidance, has acknowledged that the product market is sufficiently different from competitive conditions to warrant including product market surpluses in the cost benefit analysis (DfT, 2012b). Secondly, the recent economic downturn has once again put the spotlight on high unemployment levels as being indicative of structural unemployment and a market failure in the labour market. Furthermore, the concept of competitive labour market conditions for all sections of the workforce is being challenged (Manning, 2003). The question that this annex therefore aims to address is whether it is necessary to adjust the market wage (i.e. shadow price labour in some form) when estimating the business value of travel time savings.

A5.1.2 Structure of Annex

For completeness of discussion we present in this report all relevant market failures that affect or potentially can affect the labour market, and discuss their implications for valuing business travel time savings. Following this short introductory section, the second section discusses the implications of labour taxes (i.e. income tax), whilst the third section discusses the implications of structural unemployment. Imperfect competition in the goods market and in the labour market are discussed in sections four and five respectively, whilst section 6 contains a discussion regarding the impact of increased flexible working on whether time savings are transferred to additional work or leisure. The final section summarises the main points and identifies areas of further research, the implications of the different labour market conditions for the different valuation methods and the implications for appraisal.

A5.2 Income Tax

Income taxes distort the labour market by driving a wedge between the wage faced by employers and that received by employees. This restricts employment to levels below that associated with fully competitive conditions. This distortion generates welfare benefits (equivalent to the increased tax take) additional to user benefits when employment expands or wages increase (e.g. through agglomeration impacts) (DfT, 2005; Venables, 2007; DfT, 2012b). Departmental guidance recognises these additional welfare benefits.

From a business VTTS perspective income tax in an otherwise competitive economy does not prevent the gross of tax wage equalling the marginal product of labour. In a competitive economy the presence of an income tax therefore means that the gross of tax wage can be used as a basis to derive the marginal product of labour for workers.

A5.3 Structural Unemployment / Excess Labour Supply

If there is an excess supply of labour, that is some form of market failure is preventing the wage rate falling and the labour market clearing, then the wage will not be a good reflection of the social value of reducing employment or increasing employment (Boardman *et al.*, 2011 Chapter 4, Haveman and Farrow, 2011). This is important if valuing the business travel time savings using the cost saving approach, the Hensher model or variants of them. This is because an implicit assumption of these models is that labour if released into the labour market will be able to find work at their existing marginal product – which if there is structural unemployment will not occur. In such situations the shadow price of labour could be used instead of the wage rate to reflect the social value of business time savings.

The shadow pricing of labour due to unemployment is well established aspect of cost benefit analysis. Certain texts on the matter suggests that when unemployment levels are below 5%

frictional unemployment dominates and the opportunity cost of labour is the wage (see e.g. Boardman et al. 2011 pp.105-108). When it is higher than 5% the opportunity cost is less than the wage and some form of shadow pricing is needed. As can be seen from Table A5.1 unemployment levels exceed 5% in 84% of local authorities in Great Britain and exceed 10% in 17% of local authorities.

Table A5.1: Unemployment Levels in GB (2011-12) at a Local Authority Level

Unemployment rate	**Local authorities in GB**	
	Number	**Percentage**
Unemployment greater than 10%	69	17%
Unemployment greater than 7.5% and up to or equal to 10%	94	23%
Unemployment greater than 5% and up to or equal to 7.5%	178	44%
Unemployment greater than 3% and up to or equal to 5%	65	16%
Unemployment greater than 0% and up to or equal to 3%	0	0%
Total	406	100%

Source: ONS annual population survey [Apr 2011-Mar 2012] accessed via www.nomisweb.co.uk (Oct 5th 2012)

Note: Numbers and % are for those aged 16 and over. % is a proportion of economically active. Figures and percentages are modelled based.

Obviously the rate of unemployment varies geographically, but it also varies systematically in other ways: for example by gender, age and skill level. Additionally it will vary temporally, as ideally the rate of unemployment will return to pre-2008 levels at some point in the future.

To understand whether shadow pricing labour for unemployment is empirically relevant to the valuation of business travel time savings we need a comparison between the skill levels of the unemployed and business travellers. This comparison needs to relate to the area in which the business travellers originate/reside. The market wage would only be adjusted to a shadow price if the unemployed and business travellers are substitutable. For this study such information is not available. We would however conjecture that for modes of travel that cater for mobile high skilled workers (e.g. rail travel) that the skills of the unemployed cannot be substituted for such workers. Adjusting the business value of time for modes such as rail is not therefore likely to be empirically relevant. In contrast, where a reasonable percentage of business travel is be undertaken by low and medium skilled workers (e.g. those in administration or construction sectors in an urban area) then the skills of the unemployed and some ‘business’ travellers might be considered substitutable. Further research however would be needed to confirm this conjecture.

Shadow pricing labour for unemployment may have implications in other aspects of appraisal that include a labour component. These are as follows:

- Capital costs;
- Operating costs both of public transport services and cars (non-fuel element);
- Wider impacts (agglomeration and move to more productive jobs).

At this point in time it is unclear how empirically relevant to a cost benefit analysis shadow pricing labour for unemployment would be nor how onerous the task would be to shadow price labour for unemployment effects. Further research on this topic is required before such conclusions can be drawn.

A5.4 Imperfectly Competitive Markets

A5.4.1 Imperfect Goods/Product Market

A competitive goods/product market is a necessary condition for the cost saving method, for the Hensher model and its variants. There are two relevant goods/product market failures: indirect taxation and imperfect competition arising through for example product differentiation or geographic monopolies. Appraisal methods account for both of these market failures in that any surpluses additional to user benefits are estimated in the cost benefit analysis (DfT, 2011; 2012b). The average rate of indirect taxation in the economy is 19.0% (DfT, 2012a), whilst marginal costs are taken to be 20% lower than shop prices (DfT, 2005 p49). The evidence reviewed by DfT (2005) however shows that this 'average' mark-up disguises tremendous variability by industry with a range in the mark-up from 0% to mark-ups in excess of 40% in some sectors.

There is also ample evidence at an international level that perfect competition does not prevail. For example for 10 EU countries Badinger (2007) estimates markup factors of price above marginal costs of approximately 1.3 for manufacturing and construction and 1.37 for services for the late 1990s. Christopoulou and Vermeulen (2008) also find evidence that rejects the perfect competition hypothesis with price-marginal cost factors of 1.37 in 8 Euro area countries and 1.31 in the US. They also find that the price-marginal cost margins are not uniform with significant variation by industry and country lying behind these headline numbers.

In both situations the market failure reduces output below that which would occur under competitive conditions. Employment levels are therefore lower in the presence of either indirect taxes or imperfect competition than they would be under perfect competition. Whilst the firm is a wage taker (and the labour supply curve it faces is perfectly elastic) these market failures can operate at an economy wide level. As the labour supply curve for the economy as a whole is elastic there then exists a gap between the wage and the marginal product of labour (with a competitive labour market). This is because the firm equates the wage to the marginal revenue product of labour. Therefore with an imperfectly competitive goods market and a competitive labour market the value of marginal product of labour is greater than the wage. The situation of an imperfectly competitive labour market is discussed below.

A5.4.2 Imperfect Labour Markets

Whilst the pervasive view is that labour markets in developed economies are competitive[19], this view faces a number of challenges (Manning, 2011). One of the central criticisms is that the competitive labour market model regards firms as wage takers, where if the wage rate was lowered by 1 penny the firm would lose all its employees. This is clearly a simplification. Other characteristics of labour markets that can be taken to be symptomatic of the presence of imperfections include firms attitudes to general training (i.e. transferable between firms) and recruitment costs, job search costs of employees as well as differences in pay and conditions between public and private sector, union and non-unionised elements of the workforce.

From the perspective of transport policy cost benefit analysis, the issue is not what causes the imperfections but whether any market imperfection leads to the wage departing from the marginal product of labour. This is because we are interested in whether the market wage needs to be adjusted (i.e. shadow priced) in some way to reflect the actual marginal product.

In an imperfectly competitive labour market rents are derived from the employment relationship either by the employer or worker or both. If an employer gets rents the marginal product is above the wage, whilst if a worker gets the rents then the wage is a good indicator of the marginal product of labour. Manning (2011) in reviewing the evidence on the size of such rents in the labour market concludes that rents in the region of 15% to 30% are plausible. There is however a lot of variation and enormous uncertainty in these estimates. The limited evidence that does exist suggests that most of the rents are being accrued by workers – implying wages are close to marginal product.

Evidence that imperfect competition exists in the labour market can also be found through a joint transport sector labour market analysis. With imperfect competition in the labour market commuting costs will not be fully compensated if firms have more market power than workers. Manning (2003) shows that this is the case for the UK, whilst Rouwendal and Van Ommeren (2007) demonstrate that it is the case for the Netherlands. Whilst these averages suggest that on the whole labour markets are imperfectly competitive, arguably the level of competitiveness will vary with labour market segment. Mobile workers, typically high skilled and the primary wage earner in a household, arguably would face a competitive labour market as the household may move or migrate in response to their work. Workers in lower skilled occupations, women, ethnic minorities arguably face restricted geographic search areas and high mobility/migration costs (Madden, 1981, 1985; Zax, 1991; Ihlanfeldt, 1992; McQuaid, Greig and Adams, 2001) and therefore are more likely to face an imperfectly competitive labour market. Laird (2008) finds evidence for varying degrees of imperfect competition by labour market segment. Following the work of Manning and Rouwendal and Van Ommeren, in a Scottish context, Laird finds that the level of compensation for commuting costs

[19] A labour market can be competitive even when the product market is not competitive.

varies by labour market segment: urban/rural, gender and skill level. The implication is that the market wage is likely to be a good estimate of the marginal product for 'mobile' workers.

A5.4.3 Synthesis

The lack of evidence in this field makes it difficult to give recommendations on the size of any gap between the wage and the marginal product of labour for business travellers. On the basis of what evidence there is it would seem that the wage is a reasonable approximation for the marginal product of labour for business travellers, despite the prevalence of market imperfections. This is because firstly a lot of business travel is conducted by 'mobile' workers, and secondly that what evidence there is suggests the rents accrue to workers. That is there is no need to shadow price labour as a consequence of market imperfections - further research however may be needed to confirm this.

A5.4.4 Flexible Working

The cost saving approach was devised at a time when it could be argued there was a degree of rigidity in the labour market. So the distinction between employer's business time and non-working time was relatively clear cut. The modern service economy is no longer characterised by the formalised work contract. The 'white collar' and 'pink collar' worker now dominate the 'blue collar' worker in the workforce[20]. Simultaneously there has been an increase in a more flexible working environment: flexi-time, job-sharing, flexible working. Sunday working has also increased particularly in retail and entertainment. This is relevant to the context of business travel time savings because the value of business travel time savings will vary depending amongst other reasons upon the contractual arrangements the worker has with the employer (primarily whether they work paid or unpaid overtime) – see section 2 of the main report and Annex 1 for further discussion. The discussion contained in this section is complementary in many ways to that in Annex 4 on the use of travel time.

There has been notable shift to more flexible working over the years. The number of hours worked in a lifetime has decreased from 124,000 in 1856 to 69,000 in 1981 (Ausubel and Grübler, 1995). Average weekly hours of a manual worker have fallen from 53 hours in 1943 to 43.5 in 1987 (ONS, 2003). This trend has continued, with average hours worked having fallen by 4.7% since 1991 (ONS, 2011). The ONS attribute this latest decrease to a "mixture of structural changes in the economy, and more flexibility in the hours chosen by employees or offered by employers (including more part-time working)". Part-time working[21] is obviously a key component of flexible working, with part-

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[20] White collar workers work in offices typically at a desk; blue collar workers undertake manual work whether it is skilled or unskilled; whilst pink collar workers undertake work that involves customer interaction (e.g. entertainment and sales)

[21] There is no formal definition of part-time working in the UK. Workers are asked to categorise themselves as either part-time or full-time.

time workers form 27% of the UK workforce (ONS, 2011). The structural shift in the economy from manufacturing to service sector is one of the key reasons that more flexible working arrangements have been adopted. The service sector currently comprises 80% of employment in Britain compared to 68% in 1992, and in 2011 part-time workers comprised 31% of the service sector workforce compared to only 8% of the manufacturing workforce (ONS, 2011). There is no reason to expect a shift to more part-time work to halt. For example 49% of workers in the Netherlands are part-time (ONS, 2011).

Flexible working extends beyond working part-time. In 2003 some 6 million workers[22] (27% of women and 18% of men) it is estimated had working patterns that differed from the standard pattern (Hibbet and Meager, 2004)[23]. Such variability arises from flexitime, term-time working, annualised hours, job sharing, nine-day fortnights and zero hour contracts (see Table A5.2). Furthermore as can be seen from this table in the three years analysed there was a continuing trend towards increased variability in working patterns. In addition to these types of working patterns some 5% of the workforce also engage in telework[24] (White *et al.*, 2007). These workers typically are the higher income workers holding senior positions who use computers and telephones as part of their daily jobs. Such workers are typically judged on the outcomes they produce rather than the hours of work they give to the firm. The nature of teleworking also means that manual workers (blue collar) and customer focused workers (pink collar) typically do not telework.

Table A5.2: Variations in Working Patterns in Great Britain

Working patterns	Percent			
	Women		Men	
	2000	2003	2000	2003
Flexitime	11	12	8	9
Term-time working	7	8	1	1
annualised hours	4	5	4	5
Job sharing	1	2	~	~
Nine day fortnight	1	1	2	2
Zero hours	1	1	1	1
None of the above	75	73	84	82

Source: Hibbet and Meager (2003)

[22] Both part-time and full-time
[23] This includes part-time and full-time workers – though being part-time itself does not constitute flexible working.
[24] Telework is a work arrangement in which employees do not commute to a central place of work

The move away from the formalised working week in today's economy is also evident by the importance of weekend working (some 29% of workers usually work on Saturdays, whilst 21% usually work on Sundays) and by the fact that 35% of the workforce sometimes work either paid or unpaid overtime[25].

The evidence clearly points towards a very different labour market today than that of forty or fifty years ago. The structure of the economy has altered and with it the need for flexibility and variability in working patterns. The labour market however remains very heterogeneous. Whilst flexible working employees (i.e. those that work non-standard work patterns and part-time) are now a very significant component of the workforce, the majority of the workforce still do not have any flexibility in their work, and furthermore the majority of workers do not work overtime. Some groups of workers are judged on outputs, whilst others remain contracted to provide hours of work (albeit those hours may be subject to some form of flexible working). The latter distinction is what is most relevant to the valuation of business travel time savings. From a business value of travel time savings perspective different employment models are relevant to different workers and therefore business trips:

(i) Workers with fixed hours contracts with paid overtime. Here travelling time will displace time at the workplace no matter what time the trip occurs.

(ii) Workers with flexi-time contracts with ability to re-coup overtime through days off. Again travelling time will displace time at the workplace no matter what time the trip occurs.

(iii) Workers with contracts with unpaid overtime and the self-employed.
   a. Travelling during normal work hours. Here business travel would be expected to displace work.
   b. Travelling outside normal working hours. Here travelling for business may displace leisure time as well as work time. Employee would require compensation through the wage at a rate depending on how onerous the travelling is compared to leisure. A reduction in travelling time would lead in the long run to a reduction in the level of wage compensation required.

For workers with paid overtime or flexitime (i.e. (i) and (ii) above) business travel will only displace work activities. That is the r term in the Hensher formula will be zero or close to zero – though this should be tested empirically. For workers working unpaid overtime but who travel during normal work hours (i.e. (iii)a. above) business travel displaces work and leads to an increase in unpaid overtime. Travel time savings would therefore lead to a reduction in unpaid overtime. For workers who are not paid overtime and travel outside of normal working hours (i.e. (iii)b above) business travel could displace both work and leisure time. For these workers, (iii)a and (iii)b, the r term in the

[25] Source: Quarterly Labour Force Survey (April – June 2012). Accessed via the Economic and Social Data Service Nesstar Catalogue (accessed October 12 2012)

Hensher model will be greater than zero. Whilst undoubtedly these travellers comprise a minority of the workforce they are likely to be very relevant for certain policy interventions – particularly long distance rail interventions. This is because rail travellers are typically high skilled workers who are not paid overtime and the long distance element of the rail market can involve early departures and late returns home.

A5.5 Synthesis and Further Research

A5.5.1 Labour Market Conditions

Drawing this evidence together the following points emerge:

Income tax does not prevent the marginal product of labour elsewhere in the economy equalling the wage plus non-wage income.

Unemployment levels in the UK are currently at levels typically associated with structural unemployment, which some suggest may justify some form of shadow pricing of labour. This has implications to other aspects of cost benefit analysis (e.g. treatment of capital costs in particular) and also conflicts with current Treasury guidance. The shadow price of labour will also vary with the rate of unemployment – i.e. it will vary regionally.

How the wage differs from the marginal product of labour varies with the type of market failure. Goods and labour market imperfections would suggest the wage is lower than the marginal product. Contrastingly an excess supply of labour would suggest that the resource cost of labour is below the wage.

There is a lot of variability in the labour market. Some aspects of the labour market will be competitive whilst at the same time others will be experiencing imperfect competition. If these imperfections vary systematically with income, then because mode choice also varies systematically with income then any adjustments to the wage rate to reflect market imperfections may need to also vary by mode.

There is a growing body of evidence that both the goods and labour markets are imperfectly competitive in developed economies like the UK. The degree of imperfection in both the goods and labour markets appears to be empirically relevant. With respect to the goods market this is already recognised in DfT guidance. The difference between the wage and the marginal product due to imperfectly competitive markets is a function of market power and information asymmetries. We would therefore expect it to vary systematically by industry and occupation. Evidence to date suggests that workers seem to, on average, be exacting the majority of the rents. Therefore despite the markets being imperfectly competitive on average the wage may not differ too significantly from the marginal product of labour – though to a certain extent this is conjecture, as the evidence base is small.

With the shift to a more service based economy, flexible working in all its different forms is much more prevalent today than say forty years ago – when transport cost benefit analysis methods were developed. However, standard working patterns still dominant. Those working overtime are in a minority (although a sizeable minority), but because such workers may self select to certain modes of transport (e.g. rail) an explicit treatment of them in deriving business values of time is likely to be necessary.

A5.5.2 Valuation Methods

Aside from a direct elicitation of willingness to pay through either revealed or stated preferences, the other valuation methods typically build up a composite value of time from different components of work plus the value of transferring travel time to non-work activities. As the discussion in this report has solely concerned the adjustment to the wage to reflect the social value of transferring more time to work only those aspects of the Hensher model (and its variants) would need to be adjusted.

The willingness to pay (by employers) approach circumvents much of the discussion regarding imperfect goods and labour markets as well as the discussion regarding the transfer of time savings to either work or leisure activities.

A5.5.3 Further Research

In the short term (elapsed time less than 6 months) research could be conducted to examine the influence of shadow pricing labour for high unemployment on a cost benefit analysis. This would require analysis of regional labour markets, and a view on the longevity of the high unemployment levels we are currently seeing. A view on whether all parts of the labour market should be shadow priced needs to be made as well. A case may exist for shadow pricing low incomes and altering transport appraisal guidance to disaggregate by income rather than by mode. A key issue to note is that current Treasury guidance in the form of the Green Book does not permit the shadow pricing of labour.

Similarly in the short term (within 6 months) given differing working conditions we would expect that some elements of the labour market will transfer time savings to 'non-work' activities and others to increased work. This heterogeneity in the labour market needs to be taken account of in future surveys/research, as it appears to vary systematically with occupation, which is correlated with travel behaviour (e.g. mode choice) and income/wages. Key questions that need to be addressed in future work would include:

- Which sections of the labour market have flexibility to transfer travel time savings to leisure? What are their characteristics?

- How does the proportion of such travellers vary by mode, long and short distance, urban/inter-urban and time of day?

- Is there evidence that employers are willing to pay to save such employees travel time early in the morning or late at night (either revealed preference or stated preference)?

In the longer term (elapsed time 12 months plus) the Department could commission research to better identify the gap between the wage and the marginal product of labour, which would help implement the cost saving and Hensher methods (and their variants). Most of the problems related to the Hensher/cost-savings method arise because worker wages and costs are used as a proxy for the increased output obtained from marginal increases in available working time, but wages deviate from marginal product for all the reasons discussed.

An alternative potential approach which circumvents many of these problems is to obtain estimates of the productivity of work time directly using firm micro-data, with information on firm outputs and labour inputs. Better still is to link these data to worker level data with detail on worker characteristics wages and hours. Recent research in labour economics has developed methods for working with this type of linked employer-employee data (Abowd, and Kramarz 1999), and a growing body of literature provides empirical applications. Detailed firm/plant level data and individual worker data that can merged together by workplace identifiers is increasingly available, and the Annual Respondents Database (ARD) firm data and Annual Survey of Hours and Earnings provides the potential for this analysis for the UK.

Although not without its problems, both in terms of data set up and analysis, direct measurement of the marginal product of working hours from firm level data provides an alternative strategy which could be used to provide a point of comparison with wage-based estimates of the value of business travel time savings. The size of these datasets also allows scope for analysis by occupational, industrial and geographical groups to provide greater insights into the heterogeneity, both in marginal product of work time, and on the deviation between marginal product and wages. Some papers have already looked explicitly at the correspondence between wages and the marginal product of labour using these kinds of data, both in the US (Hellerstein, Neumark and Troske 1999) and for Britain (Galindo-Rueda and Haskel 2005, Haskel et al 2005) and provide potential prototypes.

A5.5.4 Implications for Appraisal

The implications of the observed heterogeneity in the labour market are reasonably large if they need to be taken account of fully. It is clear the value of travel time savings will vary by time of day (i.e. whether it is within or without the core business day) and by occupation of business traveller. The latter variation will lead to variations in values by (mode) and also most likely by short and long distance trips or correspondingly between urban and inter-urban trips. The former (variations by mode) are already reflected in appraisal practise, but the latter (variations by short/long distance) are not. Similarly variations by whether the trip occurs within or outside core business hours is not reflected in current guidance.

Annex 5 References

Abowd, J. M. and F. Kramarz (1999) Chapter 40 The analysis of labor markets using matched employer-employee data, In: Orley C. Ashenfelter and David Card, Editor(s), *Handbook of Labor Economics*, Elsevier, Volume 3, Part B, Pages 2629-2710

Ausubel, J.H. and Grübler, A. (1995) Working Less and Living Longer: Long-Term Trends in Working Time and Time Budgets. *Technological Forecasting and Social Change* **50**, pp195-213

Badinger, H. (2007) Has the EU's Single Market Programme Fostered Competition? Testing for a Decrease in Mark-up Ratios in EU Industries. *Oxford Bulletin of Economics and Statistics,* **69**(4), pp.497-519.

Barrington, A. (1977) Valuing Time Savings in Developing Countries – A Comment. *Journal of Transport Economics and Policy*, **11**(2) pp195-201.

Boardman, A.E., D.H. Greenberg, A.R. Vining and D.L. Weimer (2011) *Cost-Benefit Analysis Concepts and Practice*. Fourth Edition. Upper Saddle River: New Jersey.

Christopoulou, R., and P. Vermeulen. 2008. *Markups in the Euro Area and the US Over the Period 1981-2004: A Comparison of 50 Sectors*. ECB Working Paper No. 856. Report dated January 2008.

Coburn, T.M., Beesley, M.E. and Reynolds, D.J. (1960) The London-Birmingham Motorway. *Road Research Technical Paper 46*. London, HMSO.

Department for Transport (2005) Transport, Wider Economic Benefits, and Impacts on GDP. Discussion Paper. July 2005.

Department for Transport (DfT) (2011) *Transport User Benefit Calculation TAG Unit 3.5.3*. London: Department for Transport. Available online at: <http://www.dft.gov.uk/webtag/> (Accessed 23rd August 2012).

Department for Transport (DfT) (2012a) *Values of time and operating costs, TAG Unit 3.5.6 August 2012*. London: Department for Transport. Available online at: <http://www.dft.gov.uk/webtag/> (Accessed 23rd August 2012).

Department for Transport (DfT) (2012b) *The Wider Impacts Sub-Objective, TAG Unit 3.5.14*. Draft, May 2012. London: Department for Transport. Available online at: <http://www.dft.gov.uk/webtag/> (Accessed 23rd August 2012).

Galindo-Rueda, F. and J. Haskel (2005) Skills, Workforce Characteristics and Firm-Level Productivity: Evidence from the Matched ABI/Employer Skills Survey, IZA discussion paper 1542, IZA Bonn
Haskel, J., Hawkes, D. and Pereira, S. (2005), How much do skills raise productivity? UK evidence from matched plant, worker and workforce data. CEPPR discussion paper 5334

Hellerstein, J.K, D. Neumark and K.R.Troske (1999) Wages, Productivity and Worker Characteristics: Evidence from Plant-Level Production Functions and Wage Equations, *Journal of Labor Economics*, 17(3) 409-446

Hibbett, A. and Meager, N. (2003) Key indicators of women's position in Britain. In: Office for National Statistics (ed) *Labour Market Trends*, October 2003, pp503-511.

Howe, J. (1976) Valuing time in developing countries. *Journal of Transport Economics and Policy*, **10**(2) pp113-125.

Fowkes, A.S., Marks, P and Nash, C.A (1986) *The value of business travel time savings.* Institute for Transport Studies, University of Leeds, Working Paper 214.

Ihlanfeldt, K.R. (1992) Intraurban wage gradients: evidence by race, gender, occupational class, and sector. *Journal of Urban Economics*, **32**, pp.70-91.

Mackie, P.J.; Nellthorp, J. and Laird, J.J. (2005) *Toolkit for the Economic Evaluation of Transport Projects.* Washington DC: World Bank: Available online at: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTTRANSPORT/EXTROADSHIGHWAYS/0,,contentMDK:20464962~pagePK:148956~piPK:216618~theSitePK:338661,00.html (accessed 26th September 2012).

Mackie, P.J., Jara-Diaz, S. and Fowkes, A.S. (2001) The value of travel time savings in evaluation *Transportation Research Part E* ***37*** pp91-106

Mackie, P.J., Wardman, M., Fowkes, A.S., Whelan, G.A., Nellthorp, J. and Bates, J. (2003) *Value of Travel Time Savings in the UK*. A report to the Department for Transport. Institute for Transport Studies, University of Leeds, UK.

Madden, J.F. (1981) Why women work closer to home. *Urban Studies*, **18**, pp.181-194.

Madden, J.F. (1985) Urban wage gradients: empirical evidence, *Journal of Urban Economics*, **18**, pp. 291-301.

Manning, A. (2003) *Monopsony in Motion: Imperfect competition in labour markets.* Princeton, NJ: Princeton University Press.

Manning, A. (2011) Imperfect Competition in Labour Markets. In (eds) Ashenfelter, O. and Card, D. *Handbook of Labor Economics*, volume 4, Chapter 11 pp976-1041.North-Holland: Amsterdam.
McQuaid, R.W., M. Greig and J. Adams (2001) Unemployed job seeker attitudes towards potential travel-to-work times. *Growth and Change*, **32**(3), pp.355-368.

Office for National Statistics (ONS) (2011) *Hours worked in the labour market – 2011*. Report dated 8th December 2011.

Rouwendal, J. and J. Van Ommeren (2007) *Recruitment in a Monopsonistic Labour Market: Will Travel Costs be reimbursed?* Tinbergen Institute Discussion Paper TI 2007-044/3. Report dated 23 April 2007. Amsterdam: Tinbergen Institute Amsterdam.

Venables, A.J. (2007) Evaluating Urban Transport Improvements. Cost–Benefit Analysis in the Presence of Agglomeration and Income Taxation. Journal of Transport Economics and Policy, 41(2), pp.173–188.

White, P., Christodoulou, G., Mackett, R., Titheridge, H., Thoreau, R. and Polak, J. (2007) The Role of Teleworking in Britain: Its Implications for the Transport System and Economic Evaluation. *European Transport Conference, Noordwijkerhout 17-19 October 2007*. London: AET Transport

Zax, J.S. (1991) Compensation for commutes in labour and housing markets. *Journal of Urban Economics*, **30**, pp.192-207