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Measurement of Value of Time for Freight Trips and its Benefit by Market Information

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Abstract

This paper focuses on how value of time and its accrued time saving benefits for freight trips can be expressed and measured in terms of market information such as freight fee, freight time, observable freight service consumption and observable freight service production within a framework of general equilibrium rather than individual user analysis which most previous studies adopt. In order to satisfy the weak complementarity assumption, we specifies freight time externality as product form of quality index of freight time and freight consumption $S^h(t)x$ and $S^0(t)X$ into the utility function of non-business users and production function of business users, respectively. And for freight operators the product of quality index of freight time and labour and capital inputs $S(t)l, S(t)k$ are introduced into the production function of freight operators. Then we define VOT as marginal substitution rate between price and time and expressed it as the freight service fee per freight time multiplied by the elasticity of quality level indicator with respect to freight time for each of non-business and business users, respectively. The freight service providers' VOT is expressed as average labour and capital cost per freight time. Thus we can measure three VOTs in terms of market information such as freight fee, freight time and average labour and capital cost and the elasticity of quality level indicator with respect to freight time although we need to estimate quality index of freight time by estimating freight demand functions of users. Next we derive an "origin" formula to measure social freight time saving benefits including its repercussion effects expressed by the change in equilibrium freight price, wage and capital rent, where we adopted the concept of equivalent variation as the social benefit definition. The proposed origin (or shortcut) formula is the weighted general equilibrium consumers' surplus of the freight demand multiplied by VOTs with respect to freight time. The weight after the change can be approximately expressed as $1 +$ (income effect of marginal freight time saving benefit for non-business), so that it is also possible to calculate from the market information. Furthermore VOT to be applied to the benefit measurement formula is a sum of VOT for shippers and operators. Therefore we can say that conventional trapezoidal formula with the weight of

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one and VOT for only operators underestimates the benefit in two points. First is missing the weight e_m^B and second is neglecting VOT for shippers.

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Keywords: value of time for freight service users, value of time for freight service providers, freight time saving benefit measurement, marginal time saving benefit, marginal utility ratio of income, general equilibrium

1. Introduction

The subjective value of time for freight is the marginal rate of substitution between freight time and freight cost under constant utility or profit, or cost level, which is defined for freight service consumers as well as freight service providers. It is commonly referred to as the monetary appraisal of value of time or the willingness to pay for savings in freight time.

This paper focuses on how value of time and its accrued time saving benefits for freight trips can be expressed and measured in terms of market information such as freight fee, freight time, observable freight service consumption and observable freight service production within a framework of general equilibrium rather than individual user analysis which most previous studies adopt.

For general equilibrium analysis we suppose a simple economic society composed of households, two sectors of production, firms producing composite goods, and firms producing freight transportation with a given level of freight time even for freight providers. The reason of above simplicity is for simple and clear derivation of VOT and time saving benefit measurement formula. It is quite possible to construct a more realistic complicated economy with many goods, labor, time constraint and capital, heterogeneous households, government, investment and many regions as SCGE (spatial computable general equilibrium) modeling. Furthermore for freight transportation production sectors it is also possible to introduce multi-mode networks for both person and freight trips, With this complication the basic formula is exactly same as the simple case above except for appearance of many types of VOT and time saving benefit formula.

Next in order to satisfy the weak complementarity assumption, we specifies freight time externality as product form of quality index of freight time and freight consumption $s^h(t)x$ and $s^0(t)X$ into the utility function of non-business users and production function of business users, respectively. And for freight operators the product of quality index of freight time and labour and capital inputs $s(t)l$, $s(t)k$ are introduced into the production function of freight operators.

Then we define VOT as marginal substitution rate between price and time and expressed it as the freight service fee per freight time multiplied by the elasticity of quality level indicator with respect to freight time for each of non-business users and business users, respectively. The freight service providers' VOT is expressed as average labour and capital cost per freight time multiplied by the elasticity of quality level indicator with respect to freight time. Thus we can measure three VOTs in terms of market information such as freight fee, freight time and sum of average labour and capital cost and the elasticity of quality level indicator with respect to freight time although we need to estimate quality index of freight time by estimating freight demand functions of users. The author believes it is the first time to succeed in defining VOT for shippers and their expression by observable market information. As for the VOT for operators, our derivation looks similar to the conventional practice.

Next within the framework of general equilibrium rather than individual behaviour analysis we derive a "origin" formula to measure social freight time saving benefits including its repercussion effects expressed by the change in equilibrium freight price, wage and capital rent, where we adopted the concept of equivalent variation as the social benefit definition. The formula is the integration of sum of weighted marginal freight time saving benefit functions with respect to simply freight time only, where the weight is the marginal utility ratio of income, and sum of marginal freight time saving benefit function for non-business and business users are the product of freight demand function and sum of VOTS for users and operators. Thus proposed "origin" (or "shortcut") formula is the weighted general equilibrium consumers' surplus of the freight demand multiplied by VOTs with respect to freight time. The author

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