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Input Price Effect on Productivity Gains in the United States Railroad Industry

(Kesan Harga Input terhadap Peningkatan Produktiviti dalam Industri Kereta Api di Amerika Syarikat)

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ABSTRACT

This study examines factor input price effects on productivity in the railroad industry. Past research examining productivity trends in this industry limit their analysis to the effect of non-factor input prices. This study contributes to the literature by considering the effect of input prices on railroad productivity. Such an analysis significant in part because of the importance of fuel prices and wages as drivers of cost in this industry. Findings suggest that price effects are not the main source of changes in productivity. However, among the price effects, the price of material and price of way and structures show larger and significant magnitudes in explaining the sources of changes in productivity compared to other prices. Interestingly, price of labor and price of fuel are the input prices that contribute the least to changes in unit cost.

Keywords: Price effect; productivity; Class-1 railroad; factor input price

ABSTRAK

Kajian ini mengkaji kesan harga faktor input terhadap produktiviti industri kereta api. Dalam menganalisa tren produktiviti industri ini, kajian lepas telah menghadkan analisis kepada kesan bukan harga faktor input. Kajian ini menyumbang kepada literatur kerana mengambil kira kesan harga faktor input terhadap produktiviti kereta api. Analisis ini adalah signifikan kerana harga bahan api dan upah merupakan penggerak kos dalam industri ini. Hasil kajian menunjukkan bahawa kesan harga bukanlah punca utama kepada perubahan dalam produktiviti. Walau bagaimanapun, harga bahan dan harga laluan dan struktur menunjukkan magnitud yang lebih besar dan signifikan dalam menerangkan punca perubahan dalam produktiviti berbanding dengan harga faktor input yang lain. Menariknya, harga buruh dan harga bahan api merupakan harga faktor input yang paling kecil menyumbang dalam perubahan kos seunit.

Kata kunci: Kesan harga; produktiviti; kereta api Kelas-1; harga faktor input

INTRODUCTION

A substantial amount of research examines railroad productivity growth following passage of the Staggers Rail Act of 1980 (See for instance, Bereskin 1996; Berndt et al. 1993; Bitzan & Keeler 2003; Bitzan & Peoples 2014; Martland 1997, 2010; Shi, Lim & Chi 2011; Wilson 1997). Most of the findings from past research suggest that following regulatory reform the railroad industry experienced improvement in productivity (Bereskin 1996; Bitzan & Keeler 2003; Vellturo et al. 1992). In this more competitive post deregulation environment understanding factors contributing to enhanced productivity is important, in part to identify sources of cost savings as well as identifying factors contributing to higher costs. Past research by Bitzan and Peoples (2014) examines the influence of changes in density, firm size, movement characteristics and technical change on the Class-1 railroad productivity growth. Density and technical change are found to be the main contributors for the changes in the productivity growth. The density factor contributed to a 47 percent reduction in average cost for the 1983 to 2008 observation period and technical change contributes to an almost 56 percent reduction in average cost for the 1983 to 2008 observation period. While these findings provide new information on the determinants of productivity changes in the railroad industry, the effect of factor input price are not directly tested in their research. However, the examination of input price effects is significant when decomposing the factors influencing productivity growth, in part, because of their direct effect on the ray of average cost. Standard economic theory suggest decreases in input prices lowers the ray of average cost and, increases in input prices raises the ray of average cost (Wilson & Zhou 1997). The dramatic change in collective bargaining settlements following regulatory reform and the volatility of fuel prices underscore the importance of examining input price effects when examining determinants of productivity growth.

Factor input prices that are commonly examined in most research on railroad costs are the price of labor, price of equipment, price of fuel, price of material and price of way and structure. Past research of productivity growth in the US railroad industry estimates a cost function using a translog specification to obtain information on factor input prices. When using this estimation approach factor price coefficients represent the factor input share of total cost. Recent research by Bitzan and Keeler (2003) that uses this approach find that labor accounts for 34.86 percent of total cost, followed by ways and structure at 25.36 percent, materials at 18.6 percent, equipment at 14.62 percent and fuel at 6.57 percent[1]. These results provide some insight on the importance of input price changes as determinants of productivity in the railroad industry, when noting that changes in average costs depict changes in productivity. Evidence of non-trivial changes in input prices in the railroad industry reported by Waters and William (2007) suggest the importance of examining the productivity effect of input price changes in this industry. Therefore, at issue is whether changes in input prices significantly affect costs. *A priori*, it is not obvious that cost would change appreciably with changes in input prices. For instance, increase in fuel prices might not contribute significantly to higher total cost due to the introduction of fuel efficient locomotives which lowers fuel consumption, all else equal.

Incorporating the empirical approach used by Wilson and Zhou (1997) to decompose productivity effects in telecommunications, this study isolates the effect of changes in factor price, scale, and investment in technology on productivity growth in the US railroad industry. Past research by Bitzan and Peoples (2014) is the only other study to decompose productivity effects for this industry. However, they use the empirical approach developed by Gollop and Roberts (1981), which differs slightly from the approach used in this study. Their approach does not allow for analysis of the productivity effect of input prices. This study's approach does allow for analysis of factor input price effect on productivity gains and therefore, contributes to existing railroad literature by focusing on the significance of input price effects on railroad productivity. The factor price effects consist of labor price, equipment price, fuel price, material price and way and structures price. The price effect for each input on the ray of average cost is directly examined. This study uses information derived from estimating the translog cost specification used by Bitzan and Peoples (2014) to examine railroad costs. The findings from the translog estimation are used to calculate cost elasticities which is used to capture the price effect on productivity. Results from this study enable us to compare decomposition results using a different technique developed by Gollop and Roberts (1981). Since Gollop and Roberts' (1981) approach does not allow for the isolation of price effects, using the approach used by Wilson and Zhou (1997) reveals distortions in productivity effects arising from confounding the effects of factor input prices.

This paper consists of six sections. The preceding section provides reviews on research that examine production gains in the railroad industry. This follows with section that comprises the presentation of conceptual framework. Then, the next section represents the empirical approach used and followed by explanation on the results in examining the factors that affect productivity growth in the railroad industry. The last section elaborates on the concluding remarks.

LITERATURE REVIEW

Passage of the Staggers act created a business environment that promotes productivity gains in the railroad industry. The growth in railroad productivity is a result, in part, of flexible regulatory rules such as the freedom to set rates and abandon unprofitable lines. Berndt et al. (1993) mentioned that these freedoms in rate setting, abandonment of profitable lines and mergers act as catalysts opening the door for the railroad carriers to reduce cost and increase revenue. They examine the contribution of deregulation and stepped-up merger activity to cost savings for the Class-1 railroads from 1974 to 1986. Their findings suggest that by 1986, 91 percent of the cost savings was attributable to deregulation and the 9 percent was attributable to mergers and acquisition.

Another paper by Wilson (1997) examined empirically the effects of deregulation on costs and productivity growth in railroad industry. He finds that "pricing innovations" for factor inputs in the non-regulated period promotes cost savings. Examples of the pricing innovations mentioned are contract rates and multi-car rates. The direct and indirect effects of deregulation on cost are the difference between the cost under partially[2] deregulated setting the cost under regulated setting. Wilson further examined the effect of deregulation on productivity gains adapting Caves, Christensen and Swanson (1981) approach. Caves et al. (1981) uses two types of productivity measures, the rate when all inputs can be decreased over time with outputs held fixed and the rate when all outputs can grow over time with inputs held fixed. The productivity measure used by Wilson (1997) is the yearly percentage change in costs. He suggested from the findings that deregulation has caused a "dramatic downward shift" of the cost function where by 1989, the cost reduction reached 44 percent. Productivity rose with an average of six to seven percent decrease in costs. More recent study by Martland (2012) suggests that productivity in railroad industry is not mainly due to the passage of Staggers Act but through the development in information technology, new labor agreements and improved management, which has little to do with deregulation. Research finding by Mayo and Sappington (2016) also points that Staggers Act does not completely eliminate the regulations in railroad industry but does indeed greatly contribute to productivity.

Another crucial aspect regarding railroad productivity gains is the components of the productivity growth. Decomposing productivity gains and analyzing the magnitude and significance for each source is important. According to Tolliver, Bitzan and Benson (2010) railroad productivity may be improved through higher net load, increases in train size, longer hauls which the latter can be achieved by mergers and consolidation. Shi, Lim and Chi (2011) examine the decomposition of productivity growth of Class-1 railroad companies individually rather than using industry averages. The sources for changes in productivity are technical efficiency change, technical change and scale efficiency change. The data covers the period between 2002 and 2007. Sequential data envelopment analysis is used and Malmquist productivity indexes are calculated using sequential frontiers[3]. The decomposition method used in that study distinguishes the cause for changes in productivity. Results suggest that Chessie Seaboard (CSX), Norfolk Southern (NS) and Kansas City Southern (KCS) seemed to be the least efficient railroad carriers. Burlington Northern and Santa Fe (BNSF) and Union Pacific (UP) productivity growth are found to be primarily determined by technological advancement. Technological advancement in CSX and NS productivity growth are not evident.

Research by Bitzan and Peoples (2014) also identifies the underlying sources of productivity gains and cost savings in the railroad industry. The main sources of productivity gains considered are scale/density, firm size, movement characteristics and technological changes. Contrast to Shi et al. (2011), their analysis is based on the estimation of a long-run cost function. They specify the cost function such that total cost is dependent on factor input prices (price of labor, price of fuel, price of equipment, price of materials and supplies and price of way and structures), revenue ton-miles (density), technological characteristics and time variable (technical change). The technological characteristics consist of route miles (firm size), average length of haul (movement characteristic), percent of tons originated, loss/damage expense per ton-mile and speed. A system of seemingly unrelated equations is estimated and the decomposition of productivity gains developed by Gollop and Roberts (1981) is attained by estimating the reduction in average costs while holding factor prices constant. The results suggest that over the 15 year observation period, average cost savings is reduced by 47 percent due to density, reduced by nine percent due to movement characteristics and reduced by almost 56 percent due to changes in technical changes. Average cost increased around 23 percent due to increase in route miles. Overall for the observation years 1983 to 2008, the results suggest in total, around 90 percent of productivity growth is due to factors chosen in that study.

While the model of decomposing productivity growth in previous railroad studies does not consider input price effects directly, these studies do examine the contribution of input price effects on productivity growth by interpreting information gleaned from the interaction variables between time and input prices (Bitzan & Peoples 2014). Their results from estimating a translog cost function showed a negative sign for time input price interaction labor and equipment and positive sign for time input price interaction for fuel, material and way and structures. These findings suggest that in the sample period, the unexplained technological advancement are labor saving, equipment saving, fuel using, material using, and way and structure using. For instance, over time an increase in labor price, or equipment price, or way and structure price increases the usage of technology that use less labor, or less equipment, or more way and structure. Evidence of such technology- factor input effects on costs is depicted by the elimination of caboose which is labor saving (Bitzan & Keeler 2003), double-stack cars which is equipment saving (Schwarz-Miller & Talley 2002) and improvement of tracks for higher capacity cars which are way and structure using (Schwarz-Miller & Talley 2002). In other words, an increase in input price that creates an incentive for investing in input-saving technologies decreases cost whereas increases in input prices that lead to input-using technologies increases cost. Realizing the importance of input price effect as one of the sources affecting the changes in productivity gain, this study adopts the approach by Wilson and Zhou (1997) that decomposes explicitly the price effects and the non-price effects when examining the telecommunication industry. This study contributes to literature by applying Wilson and Zhou's approach to the railroad industry.

THEORETICAL FRAMEWORK

In order to develop a framework for empirically testing the effects of changes of factor input prices on cost, the analysis for one output setting is firstly considered. The "economic environment" of an industry can be influenced by various factors such as technological advancement, market conditions, government regulations and also changes in the factor input prices (Freeman et al. 1987). An increase in factor input price can be initially thought as a cost past-through to customers, where any changes in factor input is transferred to customer in order to maintain the same profit margin. However, what only matters is the change in relative factor input prices. In the long run, changes in relative factor input prices stimulate changes in the "relative input utilization" (Freeman et al. 1987).

A change in an input price affects the firms in two ways; through the substitution effect and scale effect. The substitution effect measures the change in the combination of inputs used with output held constant whereas the scale effect measures the change in output produced with input price held constant. Suppose there is an increase in price of labor. There will be a reduction in the usage of input (labor) that experiences a price increase (wage) and an increase in the usage of substitute input (non-labor). The magnitude of the substitution effect depends on the level of substitutability between the two inputs. However, the effect of a change in the price of labor is not purely substitution. Scale effects suggests that an increase in an input price will reduce the scale of operation. As wages increases, the production cost and the output price will also increase. Less output will be demanded which then reduces the amount of production and therefore reduce the inputs usage. At the optimal factor input combination, the firm experiences a reduction in output with lower labor usage and lower non-labor usage. At this new production level, there will be a shift in the isocost curve. The shift magnitude may be influenced by the marginal productivity of the input that experiences the price change (labor). If marginal productivity increases with the increase in its price, average cost should not increase substantially. For example, paying labor a higher wage may promote greater productivity and eventually offset the effect of increase in wage.

Freeman et al. (1987) highlight that the relationship between changes in factor prices and its cost share is not straight forward. Input substitution, "productivity-enhancing technological change" and combined changes in cost share of other inputs are the three elements that are considered when examining the relationship. Similar to declining average cost for single product, the concept of ray average cost can be used to analyze the effect of changes in factor prices in a multi-product setting. Baumol, Panzar and Willing (1988) define ray average cost[4] as:

$$RAC = C(ty^0)/t$$

where RAC represents ray average cost, y^0 represents the unit bundle for a specific mixture of outputs and t represents the number of outputs in the bundle. In other words, a bundle of outputs is chosen arbitrarily as a reference point where its quantity is assigned with the value of unity. From here, this reference point is used to measure the size of the composite commodity by a fixed proportion analysis. According to Baumol et al. (1988), the ray average cost is declining when "a small proportional change in output leads to a less than proportional change in total cost". The graphical presentation of the ray average cost is further illustrated in the following Figure 1. The ray average cost and total cost intersect at unit output level $y°$. The ray average cost is minimum at output level y^m. At this point, the total cost curve is tangent to ray OT in the hyper plane of ray OR. Ray OR depicts the composite commodity. The cost behavior for the ray average cost is "analytically equivalent" to the cost behavior in a single product setting

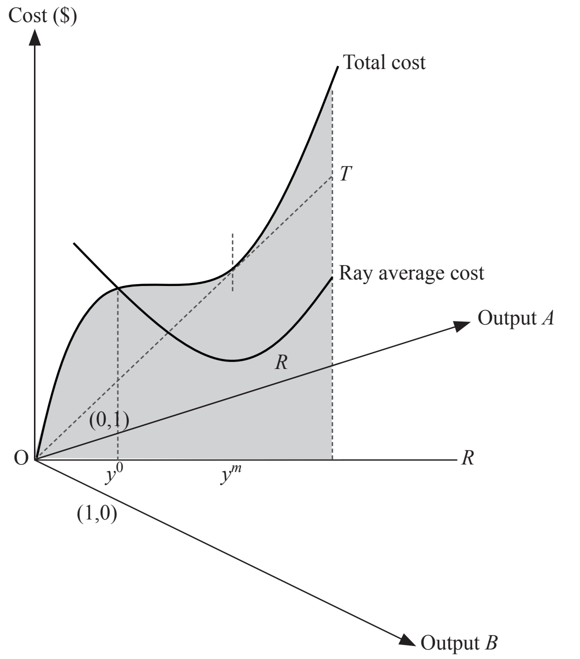

FIGURE 1. Ray average cost. Adapted from Contestable Markets and the Theory of Industry Structure (p.50), Baumol, W. J., Panzar, J. C., & Willig, R. D., 1988, New York, Harcourt, Brace Jovanovich, Inc.

(Baumol et al. 1988). This is shown in Figure 1 where the ray average curve is U-shaped which represents the composite commodity.

Examining factors that contribute to a reduction in average cost over time is similar to examining the sources of productivity growth. A general construct for productivity measurement is the index number procedures. Oum, Waters and Yu (1999) discussed the index number procedures and one of the categories is total factor productivity[5]. The total factor productivity index is defined as "the ratio of a total (aggregate) output quantity index to a total (aggregate) input quantity index" (pp. 16). Oum et al. (1999) further emphasizes the requirement to decompose total factor productivity index in several components. They argue that changes in "operating environments" and scale economies may mislead any inferences made on productive efficiency. Two procedures are discussed by Oum et al. (1999) in decomposing total factor productivity. The first procedure is a formula derived by Denny et al. (1981) and the second procedure is by using regression techniques. In their paper, Denny et al. (1981) examine the sources of changes in the unit production costs for Bell Canada for the years 1952-1976. The cost function is differentiated with respect to time, and the expression of changes in the unit production cost is shown as the following:

$$\dot{C} - \dot{Q}^C = \Sigma_i\left(\frac{P_iX_i}{C}\right)P\iota + (\Sigma_j\varepsilon_{Q_j} - 1)\dot{Q}^C + \dot{B} \tag{1}$$

where X are inputs, Q are outputs, T are technical change indicators.

$$\dot{C} = \frac{1}{C}\frac{dC}{dt}; \tag{2}$$

$$\dot{Q}^C = \Sigma_j\left(\frac{\varepsilon_{CQj}}{\Sigma\varepsilon_{CQj}}\right)\left(\frac{1}{Q_j}\frac{dQ_j}{dt}\right); \tag{3}$$

$$\dot{P}_\iota = \frac{1}{P_i}\frac{dP_i}{dt}; \tag{4}$$

$$\dot{B} = \Sigma_k\varepsilon_{CT_k}\left(\frac{1}{T_k}\frac{dT_k}{dt}\right); \tag{5}$$

where ε_{CQ_j} is the cost elasticity with respect to Q_j
ε_{CT_k} is the cost elasticity with respect to T_k

The left hand side of the equation depicts the change in the unit production costs. The first term in right hand side represents the effect of change in factor prices, the second term represents the scale effect and the third term represents the technical change effect. The task of decomposing productivity growth into various sources can be accomplished when using the translog specification when estimating cost. Past research on rail productivity using results derived from estimating the translog specification of the cost function presents mixed findings. These finding may differ extensively due to estimation procedure, sample period and therefore comparisons among research may not be reliable (Oum et al., 1999). For example, Bitzan and Peoples (2014) find the total productivity gains is estimated at an average of 3.6 percent yearly for the period 1983-2008. Whereas Bereskin (1996) finds the average rate of productivity growth is 1.62 percent yearly for the period 1983-1993.

The objective of this study is to provide some insight on the influence of input prices as one of the sources of productivity growth in railroad industry. Productivity growth is related to reduction in unit cost of production. In a multi-output setting, this is equivalent to examine the sources of reduction in the ray average cost. Earlier in this section, a change in the relative input price is shown to induce substitution effect and scale effect. In essence, the magnitude of the impact of input price change to average cost is influenced by the marginal productivity of the input. If the marginal productivity of the factor input increases as its price increases, the changes in average cost due to price changes may not be substantial. The most recent research on decomposition of productivity growth in the transportation industry is done by Bitzan and Peoples (2014). However in their paper, the decomposition of productivity growth does not include factor input price effects. Therefore, examining the sources of productivity growths in the railroad industry with explicit contribution of factor input price effect is a natural extension to previous work presented in railroad productivity literature. This paper follows the method used by Wilson and Zhou (1997) where input price effect is considered as one of components affecting the changes in ray average cost.

EMPIRICAL APPROACH AND DATA

This study examines the decomposition of productivity gains in the railroad industry considering price effects as one of the factors. Other factors taken into account are scale and technical change. As discussed before, there are various approaches used to decompose the effects of determinants on productivity gains. Duality theory that links the production function and cost function is applied in this study where a cost function is firstly estimated and later used in decomposing the productivity gains. Transcendental logarithmic (translog) is the specific functional form of cost function applied in this study. The specification cost function is adapted from Bitzan and Keeler (2003) and shown in the following equation:

$$C = f(w_i, y_k, a_m, t) \tag{6}$$

$$w_i = (w_L, w_E, w_F, w_M, w_{WS}) \tag{7}$$

$$y_k = (y_U, y_W, y_T) \tag{8}$$

$$a_m = F(a_{miles}, a_{speed}, a_{haul}, a_{caboose}) \tag{9}$$

where C is the total cost. The symbol w_i denotes a vector of input cost such that w_L is the labor price, w_E is the equipment price, w_F is the fuel price, w_M is the material and supplies price, w_{WS} is the way and structures price. The symbol y_k denotes a vector of railroad output such that y_U is the adjusted unit train gross ton miles, y_W is the adjusted way train gross ton miles, y_T is the adjusted through train gross ton miles. The symbol a_m denotes a vector of railroad movement characteristics such that a_{miles} is the miles of road, a_{speed} is the train miles per train hour, a_{haul} is the average length of haul, $a_{caboose}$ is the fraction of train miles operated with caboose[6] and t represent time trend capturing the technological change. The above cost function is then specified using second order Taylor approximation around the mean. The expansion is simplified by taking the natural logarithms on both sides of the equations and replacing partial derivative with parameters shown in the following equation:

$$lnC = \alpha_0 + \Sigma_i\alpha_i ln\left(\frac{w_i}{\overline{w}_i}\right) + \Sigma_k\beta_k ln\left(\frac{y_k}{\overline{y}_k}\right) + \Sigma_m\sigma_m ln\left(\frac{a_m}{\overline{a}_m}\right) +$$
$$\theta t + \frac{1}{2}\Sigma_i\Sigma_j\alpha_{ij} ln\left(\frac{w_i}{\overline{w}_i}\right) ln\left(\frac{w_j}{\overline{w}_j}\right) + \Sigma_i\Sigma_k\tau_{ik} ln\left(\frac{w_i}{\overline{w}_i}\right) ln\left(\frac{y_k}{\overline{y}_k}\right) +$$
$$\Sigma_i\Sigma_m\vartheta_{im} ln\left(\frac{w_i}{\overline{w}_i}\right) ln\left(\frac{a_m}{\overline{a}_m}\right) + \Sigma_i\partial_i ln\left(\frac{w_i}{\overline{w}_i}\right) t +$$
$$\frac{1}{2}\Sigma_k\Sigma_l\beta_{kl} ln\left(\frac{y_k}{\overline{y}_k}\right) ln\left(\frac{y_l}{\overline{y}_l}\right) + \Sigma_k\Sigma_m\varphi_{km} ln\left(\frac{y_k}{\overline{y}_k}\right) ln\left(\frac{a_m}{\overline{a}_m}\right) +$$
$$\Sigma_k\pi_k ln\left(\frac{y_k}{\overline{y}_k}\right) t + \frac{1}{2}\Sigma_m\Sigma_n\sigma_{mn} ln\left(\frac{a_m}{\overline{a}_m}\right) ln\left(\frac{a_n}{\overline{a}_n}\right) +$$

$$\Sigma_m \mu_m ln\left(\frac{a_m}{\overline{a_m}}\right) t + \frac{1}{2}\gamma t^2 + \epsilon \quad (10)$$

where the symbol α_i denotes the set of estimated coefficients on the factor input price variables and represent labor's share of total cost, equipment's share of total cost, fuel's share of total cost, material's share of total cost and ways and structure's share of total cost respectively. In addition β_k depicts the effect of economies of scale on the employment of factor inputs and σ_m denotes the set of estimated coefficients on the movement characteristics variables. The symbol ∂_i depicts the effect of unexplained technological change on the employment of factor inputs. The remaining parameter estimates capture the interaction of all of the variables presented in cost equation (6).

By applying Shephard's Lemma, the input share equations are obtained shown in the following equation.

$$\frac{\partial lnC}{\partial lnw_i} = \alpha_i + \Sigma_j \alpha_{ij} lnw_j + \Sigma_k \tau_{ik} lny_k + \Sigma_m \vartheta_{im} lna_m + \gamma_i t + \epsilon \quad (11)$$

This system of equations (the cost function and input share functions) is estimated within a seemingly unrelated system[7]. One of the input share equations is left out to avoid perfect collinearity. Linear homogeneity with respect to factor input prices is imposed where holding output constants, any proportional increase in all factor input prices raises the cost by the same proportion. The homogeneity and symmetry restrictions on the parameters require that $\Sigma_i\alpha_i = 1$, $\Sigma_i\alpha_{ij} = \Sigma_j\alpha_{ij} = 0$, $\Sigma_i\alpha_{ik} = \Sigma_i\tau_{ik} = \Sigma_i\gamma_i = 0$, $\alpha_{ij} = \alpha_{ji}$. The estimation of the system of equation, which gives the values of cost elasticity enables to further adapt the approach by Wilson and Zhou (1997) in decomposing productivity gains.

Assuming cost minimizing behavior, the cost function in equation (6) is differentiated with respect to time. Dividing both sides with total cost and applying Sheppard's Lemma, the rate of change in the minimum cost function is given in the following equation (Wilson and Zhou 1997):

$$\dot{C} = \Sigma_{i=1}^{I} \frac{x_i w_i}{C} \dot{w}_l + \Sigma_{k=1}^{K} \frac{\partial f}{\partial y_k}\frac{y_k}{C} \dot{y}_k + \Sigma_{m=1}^{M} \frac{\partial f}{\partial a_m}\frac{a_m}{C} \dot{a}_m + \tau \quad (12)$$

Where

$$\dot{C} = \frac{1}{C}\frac{\partial C}{\partial t};$$

$$\dot{w}_l = \frac{1}{w_i}\frac{\partial w_i}{\partial t};$$

$$\dot{y}_k = \frac{1}{y_k}\frac{\partial y_k}{\partial t};$$

$$\dot{a}_m = \frac{1}{a_m}\frac{\partial a_m}{\partial t};$$

$$\tau = \frac{1}{C}\frac{\partial f}{\partial t};$$

The cost share of factor input i-th is given as

$$S_i = \frac{x_i w_i}{C} \quad (13)$$

The cost elasticity with respect to output is given as

$$\mu_{CY_k} = \frac{\partial f}{\partial y_k}\frac{y_k}{C} \quad (14)$$

The cost elasticity with respect to technological characteristics is

$$\mu_{CA_m} = \frac{\partial f}{\partial a_m}\frac{a_m}{C} \quad (15)$$

Therefore, equation (16) can be written as:

$$\dot{C} = \Sigma_{i=1}^{I} S_i \dot{w}_l + \Sigma_{k=1}^{K} \mu_{CY_K} \dot{y}_k + \Sigma_{m=1}^{M} \mu_{CA_M} \dot{a}_m + \tau \quad (16)$$

Furthermore, the rate of change in the weighted product mix is represented as

$$\dot{y}^C = \frac{\Sigma_k \mu_{CY_k} \dot{y}_k}{\Sigma_k \mu_{CY_k}} \quad (17)$$

This equation then replaces the second term in equation (16) and therefore,

$$\dot{C} = \Sigma_{i=1}^{I} S_i \dot{w}_l + \Sigma_{k=1}^{K} \mu_{CY_K} \dot{y}^C + \Sigma_{m=1}^{M} \mu_{CA_M} \dot{a}_m + \tau \quad (18)$$

Subtracting equation (17) from both sides of equation (18), the rate of change in ray average cost ($\dot{C} - \dot{Y}^C$) is shown in the following equation

$$\dot{C} - \dot{y}^C = \Sigma_{i=1}^{I} S_i \dot{w}_l + (\Sigma_k \mu_{CY_K} - 1)\, \dot{y}^C + \Sigma_{m=1}^{M} \mu_{CA_M} \dot{a}_m + \tau \quad (19)$$

where $\Sigma_{i=1}^{I} S_i \dot{w}_l$ represents factor price effects, $(\Sigma_k \mu_{CY_K} - 1)\dot{y}^C$ represents scale effect, $\Sigma_{m=1}^{M} \mu_{CA_M} \dot{a}_m$ represents movement characteristics effects and τ represents the unexplained technological change. Wilson and Zhou (1997) mentioned that the factor price effect may be negative or positive depending on its effect on the ray average cost. The scale effect also may be negative or positive. The sign for coefficient estimates on movement characteristics may be negative or positive but the sign for the coefficient estimates on technological change is expected to be negative on the ray average cost.

The empirical analysis of allocative efficiency in the US railroad industry is achieved, in part, by using data from *Class I Annual Reports* (R-I reports) from 1983 to 2008. Information on class I rail carriers total cost, price of factor inputs, outputs and movement are taken from these reports. Input prices are provided for labor, fuel, equipment materials and way and structures. Output levels are provided for unit train, way train and through train freight service. Movement characteristics include miles of road hauled, average train speed, average length of haul and percentage of train miles using a caboose. On average, the largest mean share of factor input cost is attributable to labor. Labor cost represents more than one-third of the factor input cost. This cost value is followed by way and structure[8] expense accounting for 27.8 percent of total cost, purchases of materials accounting for 22.7 percent, and investment in equipment accounting for 11.28 percent. Fuel accounts for the smallest mean share of factor input cost at slightly more than 7 percent. Such low fuel cost is consistent with the industry's movement toward increased use of fuel efficient locomotives. Freeman et al. (1987) highlighted that changes in any cost share is not only attributable to its own price and quantity, but also other input prices and quantities. However, with nearly two-third of the input cost is attributable to labor and way and structure, any increase in these input prices could have non-trivial cost effects.

RESULT

The results derived when estimating equation (10) are presented in Table 1. The emphasis of this study is to examine the productivity results calculated using the parameter estimates in Table 1. Before presenting the productivity results a brief presentation of the estimated coefficients on the first order terms and key second order terms is provided. The estimated coefficients on the factor inputs suggests labor and way and structures constitute the largest share in input costs, while fuel constitutes the smallest share of input costs. The estimated coefficients on the first order terms for railroad output suggest economies of scale in the industry since the sum of these coefficients total less than one. The estimated coefficients on the first order terms for movement characteristics reveal that only miles of road served contributes significantly to cost. The key second order terms for factor input analysis are the estimated coefficients on the time-factor input price interactions is discussed. These estimates are analyzed to specify whether unexplained technology change is input saving or input using. Findings of a negative estimated coefficient on the interaction terms between time and labor and between time and equipment suggest that technology is labor saving and equipment saving. Whereas the interaction term between time and fuel, between time and materials and between time and way and structures suggest technology is fuel using, materials using and way and structures using. Findings for the estimated coefficient on these interaction terms are consistent with findings from railroad cost research by Bitzan and Peoples (2014) and Bitzan and Keeler (2003).

Contents in Table 2 depict the results of decomposing productivity growth into price effects and non-price effects. From 1983 to 2008, the unit cost has changed in total by 22.09 percent. The component that most affects productivity growth is the scale effect, followed by changes in miles of road, input prices and unexplained technology. Summary results presented in the second to last row of Table 2 suggest the factor input prices are associated with an increase in average cost (decrease in productivity). However, the magnitude of the average annual factor input price effect on productivity is relatively small. Indeed, productivity decline due to changing input prices declines less than a half of a percent annually for three out of five factor inputs. Only price changes of materials and way structures contribute to a decrease in annual productivity growth exceeding a half of a percent. For instance, annual changes in the price of way and structures reduce productivity by an annual average of 0.97 percent. Changes in the price of materials reduce productivity by an average of 0.8 percent annually. In contrast, changes in the price of equipment are found to reduce productivity by only 0.5 percent annually. The smallest productivity effect occurs from changes in labor and fuel prices. For the non-price effects, the results suggest that scale effects are apparently the dominant factor contributes to the unit cost changes. Scale effects have reduced the ray average cost by an average of 6.29 percent and have become the major source of changes. The yearly findings for average length of haul, speed and caboose suggest that these variables have a relatively small productivity effect. The average length of haul is expected to have negative relationship with cost. When

TABLE 1. Results from translog estimation

Variables	*Coefficient*	*t-value*	*Variables*	*Coefficient*	*t-value*
Intercept	15.88369***	131.18	w_E*w_{WS}	-0.02348***	-5.53
w_L	0.332219***	40.34	w_E*y_U	0.005456***	2.75
w_E	0.141867***	20.47	w_E*y_W	0.009492***	2.93
w_F	0.062492***	3.95	w_E*y_T	0.012769**	2.21
w_M	0.19176***	9.9	w_E*a_{miles}	-0.03202***	-3.85
w_{ws}	0.271662***	35.72	w_E*a_{speed}	0.003568	0.37
y_u	0.021608	0.63	w_E*a_{haul}	-0.02442***	-2.97
y_w	0.021277	0.64	w_E*$a_{caboose}$	0.00000114	1.21
y_t	0.410915***	6.04	w_E*t	-0.00189***	-4.51

Variables	*Coefficient*	*t-value*	*Variables*	*Coefficient*	*t-value*
a_{miles}	0.599511***	5.42	w_F*w_M	0.032329***	2.85
a_{speed}	-0.05144	-0.41	w_F*w_{WS}	-0.03429***	-6.83
a_{haul}	-0.08859	-0.78	w_F*y_U	0.005817	1.24
$a_{caboose}$	0.00395	0.91	w_F*y_W	-0.00055	-0.07
T	-0.02819***	-4.75	w_F*y_T	-0.00699	-0.55
$0.5(y_U)^2$	0.017508	1.46	w_F*a_{miles}	-0.00368	-0.19
$0.5(y_W)^2$	0.025872	1.12	w_F*a_{speed}	-0.01883	-0.91
$0.5(y_T)^2$	0.405719***	5.81	w_F*a_{haul}	0.03661**	2.1
$0.5(w_L)^2$	0.101467***	8.87	y_T*t	-0.00919**	-2.26
$0.5(w_E)^2$	0.021605***	4.56	$a_{miles}*a_{speed}$	-0.19674	-1.58
$0.5(w_F)^2$	-0.00974	-1.14	$a_{miles}*a_{haul}$	0.317286**	2.15
$0.5(w_M)^2$	-0.02792	-1.19	$a_{miles}*a_{caboose}$	-0.00000914	-0.62
$0.5(w_{WS})^2$	0.156698***	18.82	$a_{miles}*t$	0.007011	1.11
$0.5(a_{miles})^2$	0.144284	1.25	$a_{speed}*a_{haul}$	-0.59909***	-3.2
$0.5(a_{speed})^2$	0.356505*	1.75	$a_{speed}*a_{caboose}$	-0.00002	-1.55
$0.5(a_{haul})^2$	0.774069***	3.31	$a_{speeds}*t$	0.001409	0.22
$0.5(a_{caboose})^2$	0.000000784	0.91	$a_{haul}*a_{caboose}$	-0.00003	-0.94
$0.5(t)^2$	0.000455	1.56	$a_{haul}*t$	-0.00013	-0.02
w_L*w_E	-0.02179***	-4.68	$a_{caboose}*t$	-0.000000648	-0.52
w_L*w_F	0.004	0.79	$w_F*a_{caboose}$	-0.0000033	-1.35
w_L*w_M	-0.00256	-0.2	w_F*t	0.00023	0.24
w_L*w_{WS}	-0.08111***	-11.95	w_M*w_{WS}	-0.01782*	-1.78
w_L*y_U	-0.00458**	-2.19	w_M*y_U	-0.0144**	-2.61
w_L*y_W	-0.00505	-1.5	w_M*y_W	-0.0149	-1.6
w_L*y_T	0.021262***	3.32	w_M*y_T	0.01505	0.97
w_L*a_{miles}	0.004015	0.44	w_M*a_{miles}	0.005476	0.24
w_L*a_{speed}	0.011017	1.11	w_M*a_{speed}	0.028979	1.13
w_L*a_{haul}	-0.04281***	-5.05	w_M*a_{haul}	0.000982	0.05
$w_L*a_{caboose}$	0.00000209**	2.11	$w_M*a_{caboose}$	0.00000042	0.15
w_L*t	-0.00277***	-5.18	w_M*t	0.003085**	2.59
w_E*w_F	0.007701*	1.69	$w_{WS}*y_U$	0.0077***	3.64
w_E*w_M	0.015968**	1.99	$w_{WS}*y_W$	0.011009***	3.21
$y_U*a_{caboose}$	-0.00000883	-0.75	$w_{WS}*y_T$	-0.04209***	-6.1
y_U*t	0.005097***	2.82	$w_{WS}*a_{miles}$	0.026211***	2.73
y_W*y_T	-0.03031	-1.29	$w_{WS}*a_{speed}$	-0.02474**	-2.46
y_W*a_{miles}	0.058338	1.31	$w_{WS}*a_{haul}$	0.029632***	3.46
y_W*a_{speed}	-0.02817	-0.7	$w_{WS}*a_{caboose}$	-0.000000353	-0.35
y_W*a_{haul}	-0.06164	-1.45	$w_{WS}*t$	0.001346***	2.92
$y_W*a_{caboose}$	0.00000624	1.15	y_U*y_W	-0.01806	-1.54
y_W*t	0.001061	0.54	y_U*y_T	-0.10382***	-4.06
y_T*a_{miles}	-0.26305***	-3.66	y_U*a_{miles}	0.081328**	2.3
y_T*a_{speed}	0.268759**	2.62	y_U*a_{speed}	0.041548	1.11
y_T*a_{haul}	-0.24484***	-1.92	y_U*a_{haul}	0.063843*	1.95
$y_T*a_{caboose}$	0.000021	1.49			

Note: ***, **, * significant at 1, 5 and 10 percent respectively.

the average length of haul is longer, the fixed costs are likely to spread over more miles and therefore reduce the cost (Wilson 1997). On the other hand, results in Table 2 suggest in total the changes in average length of haul increase the ray average cost by 18.43 percent with an average of 0.74 percent. It is important to note that the annual rate of change for average length of haul is not necessarily positive. The annual rate of change is positive consistently between the year 2001 and 2007. Similarly, the speed and caboose are predicted to have positive relationship with cost. As the train increases the speed, the more cost incurs and as more caboose are used in train operation, the more cost needed to operate. Results in Table 2 suggest that in total, speed decreases ray average cost by 1.43 percent with an average of 0.06 percent and caboose decreases ray average cost by almost 2 percent in total with an average of 0.08 percent. For some years speed experience positive annual rate of change but some are negative. However, the annual rate of change for the usage of caboose is negative except for a very few years. Therefore, result for caboose is expected since with lesser fraction of train operated by caboose every year, the lesser the cost will be. However, these three technological and movement characteristics are initially found not statistically significant in the translog estimation results.

Changes in miles of road is the second pronounced source affecting the changes in ray average cost. In total, miles of road have increased the unit cost by almost 108 percent. Miles of road is expected to increase cost since it is associated with firm size or as a degree of network size (Bitzan & Peoples 2014). Furthermore, since 1983, changes in unobserved technology affects the change in ray average cost by 57.14 percent with an average of approximately 2.29 percent yearly. This technological effect, which is proxied by time trend, is consistently decreasing the unit cost every year.

CONCLUDING REMARKS

A substantial amount of research has examined productivity growth in the US railroad industry following passage of the 1980 Staggers Act. This literature includes research that decomposes productivity growth by determinants of cost. Recent research on decomposition of productivity growth by Bitzan and Peoples (2014) adopts Gollop and Roberts (1981) approach for their analysis. In their paper, the annual rate productivity growth is decomposed into density, firm size, movement characteristics and technical change. Technological advancement generally is believed as the most important factor in reducing the ray average cost. However, factor price effect should not be excluded in discussing the sources of changes in ray average cost. Grifell-Tatjé and Lovell (2000) highlight an important benefit decomposing productivity is it acts as an industry cost benchmark for the producers. It also gives an insight on the sources that contribute to cost variation that are within managerial control. Moreover Grifell-Tatjé and Lovell (2000, p:29) mention the analysis on input price effect are useful when "long term contracts with relatively efficient suppliers are under management control". Therefore, following the approach used by Wilson and Zhou (1997), this study highlights the price effects as one of the sources in productivity gains.

Findings from this study reveal the magnitude as well as the direction of the sources of productivity effects. A negative (positive) sign indicates the source that contributes to productivity growth (loss). The non-price determinants include scale effect, miles of road, average length of haul, speed, caboose and unexplained technological effect. In total within the sample period, four of them contribute to productivity growth; scale, speed, caboose and unexplained technology with the largest source of changes in productivity gains comes scale effects. In total, the scale effect contributes around 157 percent with a yearly average of 6.29 percent to the changes in ray average cost, followed by unexplained technology by 57.1 percent with a yearly average of 2.29 percent. The other two non-price sources; miles of road and average length of haul contributes to productivity loss. In total, miles of road increases the ray average cost by approximately 107 percent with an average of 4.30 percent and average length of haul by 18.43 percent with an average of 0.74 percent. From the overall productivity change attributable to non-price determinants, Table 2 suggests two factors; scale and miles of road, contribute in a large magnitude to the changes of the ray average cost. The unobserved technological change is also found to be consistently reducing the ray average cost every year. In other words, a continual investment in technology is still expected to boost productivity growth in the railroad industry.

Furthermore, Table 2 depicts factor input price contribution in cost variation. In total, changes in the factor input price increase the ray average cost by almost 70 percent with a yearly average of approximately 3 percent. The average price effect for each factor input is not the same. Among the price effects, the price of way and structures and the price of material show larger and significant magnitudes in explaining the sources of changes in unit cost compared to other prices. On average, the changes in price of way and structure contributes to a 0.97 percent decline in productivity growth. This is followed by the changes in price of material with an average of 0.8 percent. The changes in price of labor, price of equipment and price of fuel contributes on average of less than 0.5 percent in productivity loss. Interestingly, the changes in price of labor and price of fuel are the factor input prices that contribute the least to changes in unit cost. These input price effect on productivity is consistent with the notion that high marginal productivity of labor[9] and fuel contribute to relatively low increases

TABLE 2. Decomposition of productivity growth due to factor price effects, scale effects, movement characteristic effects and unexplained technology effect.

									Movement Characteristic Effects				Unexplained Technology Effect
	Cost Changes	PL effect	PE effect	PF effect	PM effect	PW effect	Price effect	Scale effect	Mileroad	Speed	Avehaul	Caboose	
83-84	-0.2410	0.0026	-0.0129	-0.0103	-0.0007	0.0204	-0.0009	-0.2336	0.0515	0.0042	0.0009	-0.0006	-0.0626
84-85	-0.0003	-0.0073	0.0180	-0.0027	0.0075	-0.0015	0.0139	-0.0787	0.1041	0.0018	0.0111	-0.0006	-0.0519
85-86	-0.1139	-0.0010	-0.0148	-0.0293	-0.0026	-0.0187	-0.0663	-0.0833	0.1180	-0.0236	-0.0015	-0.0011	-0.0560
86-87	-0.0568	0.0203	0.0027	-0.0061	-0.0110	0.0082	0.0141	-0.1396	0.0914	0.0164	0.0039	-0.0008	-0.0422
87-88	-0.0632	0.0153	0.0047	-0.0015	0.0097	0.0031	0.0313	-0.0540	-0.0032	-0.0076	0.0108	-0.0009	-0.0397
88-89	-0.0791	-0.0008	0.0129	0.0075	0.0117	-0.0043	0.0270	-0.0162	-0.0415	-0.0068	0.0026	-0.0010	-0.0432
89-90	-0.0168	0.0043	-0.0008	0.0142	0.0088	0.0185	0.0450	-0.0360	0.0190	-0.0026	-0.0018	-0.0009	-0.0394
90-91	0.0068	-0.0087	0.0207	-0.0042	0.0293	0.0110	0.0482	-0.0190	0.0147	-0.0012	0.0003	-0.0003	-0.0358
91-92	-0.0057	-0.0015	0.0012	-0.0065	0.0123	0.0023	0.0079	-0.0876	0.0953	-0.0017	0.0078	-0.0006	-0.0268
92-93	-0.0277	-0.0085	0.0042	0.0002	0.0081	0.0169	0.0210	-0.0224	-0.0167	0.0124	0.0041	-0.0005	-0.0256
93-94	0.0058	0.0110	0.0195	-0.0052	0.0038	0.0277	0.0569	-0.1014	0.0652	0.0039	0.0019	-0.0011	-0.0197
94-95	0.0422	-0.0005	0.0104	-0.0041	0.0076	0.0554	0.0687	-0.0104	0.0122	-0.0005	-0.0054	-0.0021	-0.0202
95-96	-0.1418	0.1216	0.0326	0.0088	-0.0013	0.0200	0.1816	-0.4043	0.1057	-0.0029	0.0004	-0.0021	-0.0202
96-97	0.2164	-0.0640	-0.0246	-0.0019	0.0038	-0.0289	-0.1156	0.1490	0.1557	0.0155	0.0282	-0.0012	-0.0152
97-98	-0.1569	-0.0267	-0.0072	-0.0171	0.0021	-0.0157	-0.0646	0.0153	-0.0759	-0.0029	-0.0088	-0.0020	-0.0180
98-99	0.2755	0.0093	0.0250	0.0028	0.0089	0.0052	0.0512	-0.2564	0.4230	-0.0142	0.0773	0.0006	-0.0060
99-00	-0.0116	-0.0078	-0.0039	0.0452	-0.0017	0.0054	0.0372	-0.0313	-0.0027	-0.0119	0.0054	-0.0001	-0.0083
00-01	-0.0169	0.0025	0.0039	-0.0045	0.0053	-0.0054	0.0019	-0.0099	0.0034	0.0001	-0.0040	-0.0012	-0.0071
01-02	-0.0336	0.0065	0.0010	-0.0107	-0.0042	0.0015	-0.0058	-0.0048	-0.0095	-0.0106	0.0054	-0.0009	-0.0073
02-03	0.0007	0.0049	-0.0002	0.0123	0.0003	0.0026	0.0199	-0.0185	-0.0073	0.0104	0.0044	-0.0011	-0.0073
03-04	0.0470	0.0098	0.0087	0.0154	0.0165	0.0478	0.0981	-0.0463	-0.0103	0.0061	0.0062	-0.0009	-0.0059
04-05	0.0974	-0.0016	0.0113	0.0260	0.0225	0.0499	0.1080	-0.0155	-0.0065	0.0114	0.0057	-0.0009	-0.0049
05-06	-0.0533	-0.0008	-0.0172	0.0154	0.0236	-0.0287	-0.0077	-0.0377	-0.0077	-0.0045	0.0084	0.0001	-0.0042
06-07	0.0703	-0.0171	0.0259	0.0050	0.0172	0.0347	0.0658	-0.0088	-0.0006	-0.0057	0.0219	0.0006	-0.0029
07-08	0.0357	-0.0074	0.0019	0.0316	0.0217	0.0140	0.0618	-0.0218	-0.0023	0.0004	-0.0007	-0.0006	-0.0011
Average	-0.0088	0.0022	0.0049	0.0032	0.0080	0.0097	0.0279	-0.0629	0.0430	-0.0006	0.0074	-0.0008	-0.0229
Total	-0.2209	0.0545	0.1231	0.0801	0.1993	0.2415	0.6984	-1.5733	1.0752	-0.0143	0.1843	-0.0199	-0.5714

in average cost due to increases in labor and fuel prices. In examining productivity growth, the inclusion of price effects highlights several significant revelations on the determinants of such growth in the railroad industry. For instance, while labor's share of total cost is non-trivial, findings suggest that fairly stagnant changes in real wages have helped carriers to avoid relatively large productivity losses[10]. Input price findings also reveal that despite increasingly higher fuel prices for the 2003-2008 sample observation period, the productivity loss was relatively small.

Changes in the price of equipment, price of material and price of way and structure resemble the pattern of increasing fuel prices for the period 2003-2008. Yet, unlike productivity trends for fuel, productivity trends for these inputs suggest relatively large declines in productivity compared to losses due to changes in labor and fuel prices for the 2003-2008 observation period. Such productivity losses may be attributable to a business environment that requires huge expenditure and investment in infrastructure, especially compared to the trucking industry. For instance, railroad companies generally need to set-up their own building structures and lay their own tracks whilst trucking industry use roads that are constructed by the government. At the same time, the expense of renewal and maintenance of track ties and locomotives ties is proportional to traffic volume as mentioned by Martland (2010). Nonetheless findings from this study suggest that annual productivity loss due to changes in these prices have been limited to an average of less than one percent for the entire observation period. An explanation for such constrained productivity loss is offered by Duke, Litz and Usher (1992) who highlight the contribution of technology improvement to the construction and maintenance of rail infrastructure. For example, advancement in rail and yard design, computerized and automatic system in operation and highly mechanized equipment have eventually increased the efficiency and productivity of equipment, material and way and structure.

In sum, findings from this study underscore the importance of including factor prices in the decomposition exercise in part because doing so reveals the key role these cost determinants play in rail companies' ability to attain rates of productivity growth that allow them to compete with low cost competitors in the trucking industry. Notable among these findings is uncovering evidence suggesting that it is the price of materials and way and structures, not wages and fuel prices that are the main input price impediments to productivity growth. Policy implications derived from these results should focus on addressing the relatively high unit cost of materials and way and structures. Government subsidization of infrastructure is an example of such policy. Indeed, the returns from such an investment would contribute to economic growth by lowering the cost of shipping freight by rail.

ENDNOTES

1 The cost function specification follows Bitzan and Keeler (2003), however, it is estimated using information from a population sample that includes more years of information. This study covers the period between 1983 and 2008 whereas Bitzan and Keeler's (2003) sample population covers years 1983 – 1997.

2 The Staggers Rail Act is considered as partially deregulation. All regulatory rules were not totally terminated for this industry.

3 Data envelopment analysis (DEA) is a non-parametric estimation approach that examines technical efficiency. It does not rely on any production or cost function, therefore does not need to specify any functional form. A linear programming is conducted and sample data representing firms are observed whether it lies on a production frontier. Sample points that lie on the production frontier depict efficient firms (Oum et al. 1999). The Malmquist productivity index is a measurement of productivity change over time and is calculated based on distance functions.

4 Baumol et al. (1988) are referring to the average cost of the composite goods.

5 The two other categories are partial factor productivities and data envelopment analysis method (Oum et al., 1999)

6 Bitzan and Keeler (2003) considered eliminating caboose as a technological innovation in post-deregulation period for two reasons. Automated and electronic safety and controls eradicate the role of caboose. Diesel locomotive replacing steam locomotives eliminates the need for firemen and therefore reduced crew size and caboose space.

7 The variable caboose consists of zero values. Box-Cox transformations is applied to this variable where $y_i^{\omega} = \frac{y_i^{\omega} = 1}{\omega}$ if $\omega \neq 0$ and $y_i^{\omega} = ln y_i$ if $\omega = 0$. A very small value of ω (0.0001) is selected since it gives almost same results with log.

8 American Railway Engineering and Maintenance-of-Way Association (2003) explains the term of way and structure. Railway structures encompass a wide array of construction intended to support the track itself or house railway operations. Common examples of track carrying structures are bridges, trestles, viaducts, culverts, scales, inspection pits, unloading pits and similar construction. Examples of common ancillary structures are drainage structures, retaining walls, tunnels, snow sheds, repair shops, loading docks, fueling facilities, towers, catenary frames and the like. (p. 320)

9 High labor productivity is mainly due to "technological and institutional innovation" (Martland, 2012).

10 The productivity loss comports with Martland (2010) findings that suggest the increasing fuel price is "more than offset all the fuel economy gains" for the period 1995-2004. Prior to 1995, he finds net benefit for the rail industry due to the combination of decreasing fuel price and fuel efficiency.

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