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Convergence in transportation measures across the EU-15

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Abstract This is the first study in the literature to investigate the convergence in transportation measures. To this end, we conjectured a transportation convergence equation and tested it via Difference GMM and System GMM methods, using 4-year span panel data from 15 European Union countries (EU-15) for the period 1970–2013. The results provide strong evidence for the existence of unconditional convergence among the EU-15 countries in two transportation measures, namely, inland freight transportation per capita, and inland passenger transportation per capita. The estimates show that the convergence is even stronger when control variables are used. We conclude that the income convergence of EU-15 in the process of economic integration is also strongly evident in the transportation sector.

Keywords Transportation convergence · EU-15 countries · Panel data analysis · Difference GMM · System GMM

Introduction

Income convergence conjectures that economies with similar characteristics will reach similar income per capita levels in the long run, because those with initially higher (lower) income per capita will grow at a lower (higher) rate due to the law of diminishing returns. After early development by Baumol (1986), Abramovitz (1986) and de Long (1988), this research field became fully established through the works of Mankiw et al. (1992), Islam (1995) and Caselli et al. (1996). As income is the front-end of an array of economic

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activities in various sectors, e.g., mining, wholesale trade, and transportation, a prospective question is whether a similar convergence process exists in the back-end sectors. Intuition suggests that any back-end sector will depict a convergence behavior as long as it is (i) subject to the law of diminishing returns á la income per capita, (ii) has a considerable share in income. The latter signifies the mutual interaction between the dynamics of income and a back-end sector: convergence in one feeds back into the other. There are indeed growing number of studies in the convergence of back-end sectors, such as Hitiris and Nixon (2001) for the health sector, and Bahadır and Valev (2015) for the banking and finance sector.

In this empirical study, we investigate the convergence in transportation measures in EU-15 countries. Our motivation for choosing EU-15 is that the EU project constitutes a natural laboratory for measuring convergence in income and in its back-end sectors, because the success of the project is based on the integration of economies, which include a range of markets, such as final and intermediate goods and services, raw material, and factors of production. Several studies on income convergence across EU-15 in particular, and among EU member countries in general, provide concrete evidence on the economic integration of EU-15 members (e.g., Beugelsdijk and Eijffinger 2005), new EU members (e.g., Reza and Zahra 2008), and between EU-15 and new members (e.g., Matkowski and Próchniak 2007). In particular, the study of Beugelsdijk and Eijffinger (2005) shows evidence of income convergence in EU-15 for the period 1995–2001. Reza and Zahra (2008) present evidence that the ten new EU members show absolute income convergence to the EU average income in the 1995–2005 period. Matkowski and Próchniak (2007) show strong income convergence toward the EU-15 of the Central and East European (CEE) countries recently acceded by the EU. Hence, income convergence is likely to provide a solid background for testing the transportation convergence hypothesis.

The transportation literature also provides evidence on the mutual interaction between income and transportation, which supports the idea of convergence in transportation, as proposed in this paper. This evidence consists of two main aspects. The first relates to the mechanisms by which transportation affects income dynamics. Three such mechanisms have been discussed. First, improved transportation facilitates economic growth and welfare by reducing the cost of accessing goods and services (e.g., Patterson 1985) and stimulating trade (e.g., Baier and Bergstrand 2001). Second, better transportation encourages the mobility of the production factors (e.g., Jiang et al. 2015) draws foreign direct investment (e.g., Hong 2007), and increasing the quality of travelling (e.g., Banister 2012). Finally, the availability of transportation has a strong influence on knowledge diffusion, technological spillover, and hence plays an important role in improving human capital formation through its effects on the idea of distance (for a thorough review of the literature, see, for example, Deng 2013). Country-level (e.g., Hong et al. 2011 and Beyzatlar et al. 2014), sectoral-level (e.g., Banerjee et al. 2012), and local-level (e.g., Zhang 2008 and Deng et al. 2014) also show that transportation has a positive effect on GDP per capita. In all, there is comprehensive evidence in the direction that transportation measures have positive interaction with income dynamics. The second aspect of the evidence relates to the positive effect of productivity and income on transportation. For example, Paulley et al. (2006) show that the demand for transportation is increased by income growth. Yu et al. (2012) show that transportation is significantly affected by economic growth in China, both at regional and national levels. In a cross-country study, Bose and Haque (2005) demonstrate that public investment in transportation and communication is positively affected by economic growth. Finally, Beyzatlar et al. (2014)

show that economic growth has a positive effect on freight and passenger transportation in EU countries.

The descriptive evidence on the behavior of income and transportation in EU-15 also supports our hypothesis convergence in transportation measures among EU-15 may come true. Firstly, the transportation sector has a considerable share in total economic activity of EU-15. In particular, it accounts for 4.5 % (10 million) of employment and 4.6 % of GDP and manufacture of transport equipment provides an additional 1.5 % of employment and 1.7 % GDP. Second, the transportation measures and income appear to be associated. Inland freight transportation per capita in EU-15 increased from 2603 tonne-km in 1970s to 4585 in 2013, and inland passenger transportation per capita in EU-15 grew from 5625 to 11583 passenger-km over the same period (see Bosch (2003) and Huggins (2009) for further evidence).These figures correspond to 176 and 194 % growth in inland freight and passenger transportation per capita, while GDP per capita doubled in the same period. Our argument is substantiated by the plot of log of GDP per capita and the log of respective transportation measure for 1970–2013 in EU-15, shown in Figs. 1 and 2 below.

More concrete descriptive evidence is obtained when the average growth rate of a transportation measure of EU-15 is plotted against its initial value, which we term 'transportation convergence'. In particular, Fig. 3 plots each EU-15 member's average inland freight transportation per capita growth between the period 1970–2013 against its initial value (1970 or the earliest observation). The figure reveals a negative relationship between average growth rates and initial values, which suggests transportation convergence in terms of freight transportation per capita. The plot shows that there are four outliers: Ireland and Luxembourg out lie above the average trend, and France and Portugal, below.

Figure 4 plots the average growth rate for inland passenger transportation per capita for EU-15 members for the period 1970–2013, against its initial value, 1970 or the earliest observation. The negative slope of the average trend indicates a convergence behavior. The plot shows that Austria is an outlier, with a negative growth rate.

In this study, a dynamic panel convergence process is formulated, and the Difference GMM and System GMM methods were employed, in order to show the existence of transportation convergence across EU-15 countries. Two types of transportation data are

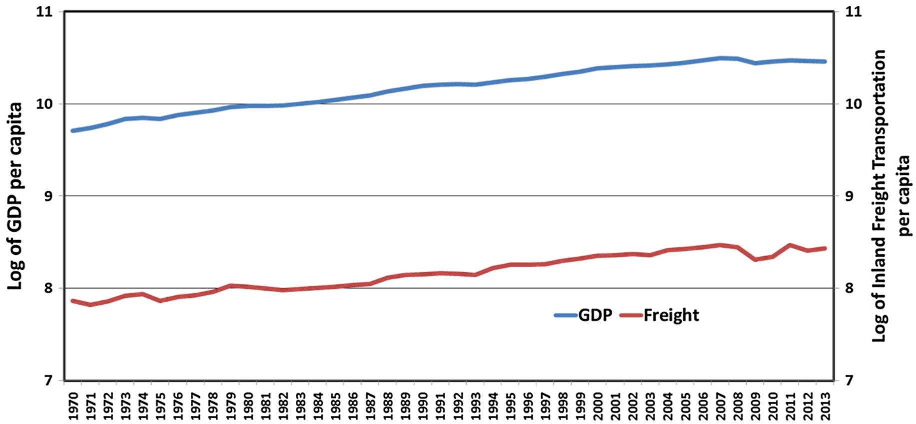

Fig. 1 Inland freight transportation per capita and GDP per capita. *Source* OECD.StatExtracts

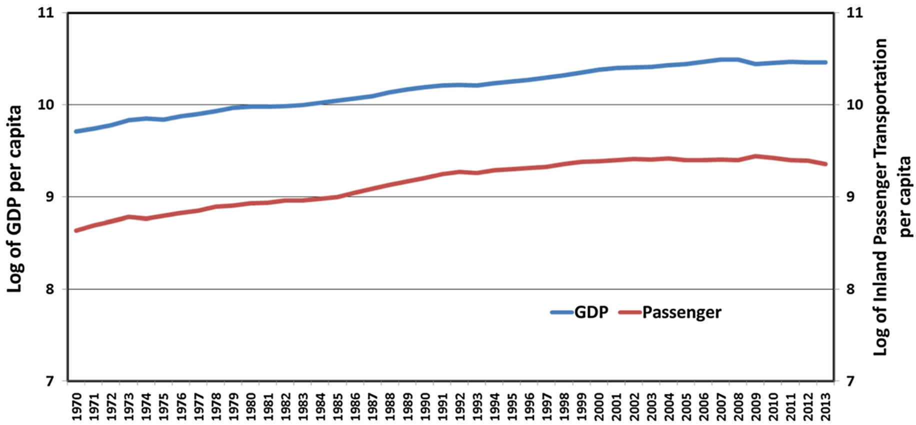

Fig. 2 Inland passenger transportation per capita and GDP per capita. *Source* OECD.StatExtracts

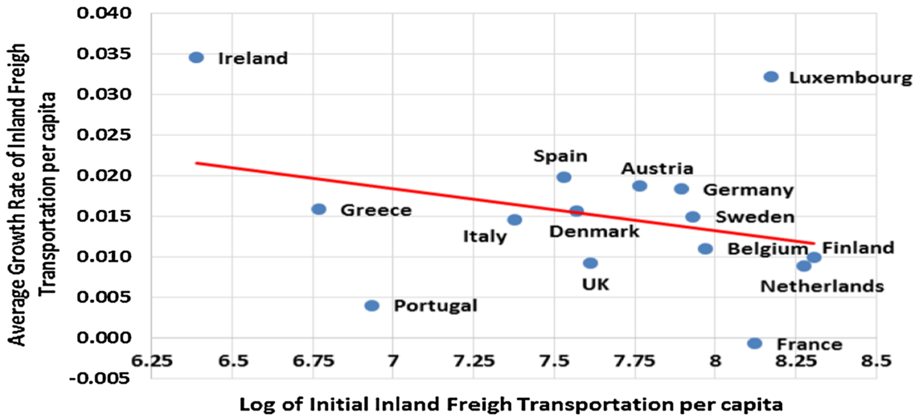

Fig. 3 Inland freight transportation convergence. *Source* OECD.StatExtracts

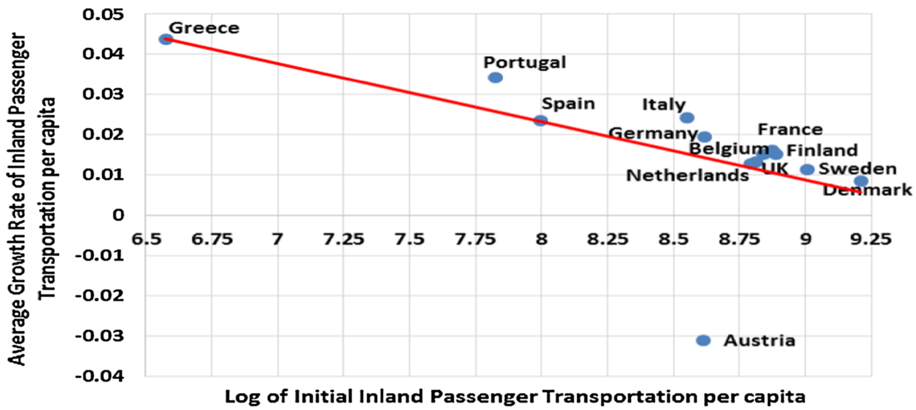

Fig. 4 Inland passenger transportation convergence. *Source* OECD.StatExtracts

used in estimations: inland freight transportation per capita and inland passenger transportation per capita. The data is transformed into 4-year span data, covering the period 1970–2013 in estimations. Inspired by the income convergence literature, for each estimation method, two types of convergence equations are run: first, the absolute (unconditional) transportation convergence, and next, conditional transportation convergence for various control variables, namely GDP per capita, urbanization, openness, and inward FDI stock. All runs show strong evidence for transportation convergence, and a higher (implicit) convergence rate when a control variable is used (although not all control variables are necessarily statistically significant in every run). Our results suggest that the convergence behavior in transportation can be considered robust, as the lag of both transportation measures are always negative and statistically significant. One important policy implication of our study is the empirical verification of the convergence in transportation, a back-end sector of income. We argued that convergence in transportation is not only due to the law of diminishing returns, but also because income (convergence) and transportation (convergence) feed back into each other. Hence, from a policy perspective, isolating transportation policies from the dynamics of income may lead to the failure of these policies. The second important policy implication of our study is specific to the EU economic integration project. We believe that the strong evidence in transportation convergence in EU-15 may also reflect the overall success of this integration policy in transportation, in spite of a few rather extreme examples of failure.

The importance of this work for the transportation literature is two-fold. First, it conjectures a testable 'transportation convergence' equation, and, specifically, supports it with empirical evidence, which has not been attempted previously. Second, it presents concrete evidence on the success of the integration of transportation sector in EU-15, which reveals that the EU integration project not only leads to in convergence of income, but also that this convergence extends to back-end sectors, including transportation sector. In all, this work is expected to trigger further research on transportation convergence, by extending the work towards groups of economies classified by income, by membership, by region, and so on. The organization of the paper is as follows: "Methodology, data, and findings" section presents the methodology, data and findings. "Concluding remarks and policy implications" section concludes the paper.

Methodology, data, and findings

Methodology

In order to estimate unconditional and conditional transportation convergence, dynamic panel methodology in the tradition of Islam (1995) and Caselli et al. (1996) is followed. In particular, we use Difference GMM estimator, proposed by Arellano and Bond (1991), and System GMM estimator, proposed by Arellano and Bover (1995) and Blundell and Bond (1998), as a two-step panel econometric analysis. Although other estimation methods, such as Pooled OLS and Within Groups are also used in the convergence literature, these may be biased and inconsistent when unobserved time invariant country effects are omitted in a dynamic panel data model (Nickell 1981; Hsiao 2003). Difference GMM and System GMM have other advantages which make them particularly appropriate when estimating dynamic panel data models, especially for convergence models with a large number of cross-sections, and a relatively small number of time constraints (Arellano and Bover

1995; Blundell and Bond 1998, 2000; Blundell et al. 2001). The endogeneity issue is solved by the use of instrumental variables, which allow consistent estimations, and avoid the omission of initial efficiency (Bond et al. 2001). Additionally, instrumental variables are uncorrelated with the fixed effects, allowing the addition of further instruments (Roodman 2008).

In several respects, System GMM is more efficient than Difference GMM (Blundell and Bond 1998; Hoeffler 2002). System GMM estimator consists of a system with the original equation in levels, and the transformed equation in first differences. The lagged first differences of the explanatory variables and the lagged levels of the regressors are added as instruments for the original and the transformed equation, respectively. In System GMM, the first differences of instruments are uncorrelated with the fixed effects, thus allowing for the inclusion of more instruments as an advantage (Roodman 2009). Difference GMM estimation starts by transforming all regressors, usually by differencing, and uses the Generalized Method of Moments (Hansen 1982; Roodman 2009). Time-invariant regressors disappear in Difference GMM, but are accounted for in System GMM. Blundell and Bond (1998) show that System GMM is more efficient when the series are close to being random walks, whereas Difference GMM estimator can be affected by large finite sample biases in these cases.

The transportation convergence equation mimics the well-known income convergence equation. For a production function $Y = K^{\alpha} \cdot (A \cdot L)^{1-\alpha}$, where K is physical capital, L and A are the labor force and the overall technological progress growing at exogenous rates n and x, respectively, the log-linearization of the fundamental equation of growth through Taylor's approximation yields $\frac{dLn[\tilde{y}_t]}{dt} \approx -v \cdot [Ln[\tilde{y}_t] - Ln[\tilde{y}_{ss}]]$, where $\tilde{y}$ is income per effective capita, $v = (1-\alpha) \cdot (n + \delta + x)$, δ is the depreciation rate, and t is time $\frac{\frac{dLn[\tilde{y}_t]}{dt}}{dLn[\tilde{y}_t]} = -v$ is called the convergence rate, as it measures the speed $Ln[\tilde{y}_t]$ approaches its long run equilibrium, $Ln[\tilde{y}_{ss}]$. The solution of the log-linearized differential equation yields $Ln[y_{t_2}] - Ln[y_{t_1}] = -(1 - e^{-v \cdot \tau}) \cdot Ln[y_{t_1}] + \gamma \cdot Ln[X_{i,t}] + \mu_i + \phi_t + \varepsilon_{it}$, which is often also expressed as $Ln[y_{t_2}] = e^{-v \cdot \tau} \cdot Ln[y_{t_1}] + \gamma \cdot Ln[X_{i,t}] + \mu_i + \phi_t + \varepsilon_{it}$ where y is income per worker (see, e.g., Mankiw et al. 1992 for details of derivations). Corresponding to the income convergence equation above, the following dynamic panel equation is conjectured in order to estimate transportation convergence:

$$Ln[TRA_{i,t}] = \beta \cdot Ln[TRA_{i,t-1}] + \gamma \cdot Ln[X_{i,t}] + \mu_i + \phi_t + \varepsilon_{it} \quad (1)$$

On the LHS of the equation, $Ln[TRA_{i,t}]$ is the measure of transportation variable (inland freight per capita or passenger transportation per capita) in a 4-year time span. On the RHS, β is the coefficient of previous 4-year span transportation variable. It is expected to be between 0 and one, which would be consistent with the idea of convergence. μ_i and ϕ_τ measure country specific effects and time specific effects, respectively. We also use several control variables with the potential to affect transportation convergence, namely GDP per capita, openness, urbanization and inward FDI stock. Hence, $Ln[X_{i,t}]$ and γ are the vector of control variables and their respective coefficients. Finally, $\varepsilon_{i,t}$ is the error term and the subscripts *t* an *i* denote the time period and the country indices, respectively.

Data

This study covers EU-15 countries for the period between 1970 and 2013 as a panel data set.[1] The dependent variable is either inland freight transportation per capita or inland passenger transportation per capita. The list of transportation measures is restricted by data availability. The data for inland freight transportation (in million tonne-km) and inland passenger transportation (in million passenger-km) were taken from OECD statistics database. Inland freight transportation includes the transportation of freight through rail, road, waterways and pipelines within country borders, while inland passenger transportation includes the transportation of passengers through rail and road within country borders. The data for GDP (in million US Dollars at 2005 constant prices), urban population, total population and inward FDI stock as a percentage of GDP were extracted from United Nations statistics database. Inland freight transportation per capita, inland passenger transportation per capita, GDP per capita, and urbanization were calculated by dividing the respective data by total population. The openness data was retrieved from Penn World Tables. Following Islam (1995), data is transformed into 4-year spans to eliminate the effect of business cycle fluctuations, and to minimizeserial correlation. Hence, 11 data (time) points for the 15 countries were obtained. All series are in their natural logs.

In Table 1, the average, the minimum, the maximum, standard deviation, and the dispersion statistics of the series are presented as fundamental descriptive statistics. Evidently, all variables are free from collinearity, as the variance inflation factor (VIF) is less than 10, and the tolerance value (TV) is greater than 0.10, the critical value at 10 % level.

Results

Difference GMM and System GMM estimation results of 4-year span data for EU-15 countries for the period 1970-2013 are summarized in Tables 2, 3, 4 and 5, respectively.[2] For System GMM, the two-step estimator is more efficient than one-step estimator; however, we report the results of one-step System GMM estimators because the asymptotic standard errors relating the two-step GMM estimators can be biased downwards (Hoeffler 2002; Blundell and Bond 1998). For estimations in Tables 2 and 3, the left hand side variable is the inland freight transportation per capita, and for estimations in Tables 4 and 5, it is the inland passenger transportation per capita. The first row is $\hat{\beta}$, the estimated coefficient of the lagged inland freight transportation per capita in Tables 2 and 3 and the lagged inland passenger transportation per capita in Tables 4 and 5. It is expected to be between 0 and 1; implying $\hat{\beta} - 1$ is between -1 and 0, an indication of convergence. Since the expansion of β is not known in (1), the only comment that can be made is the strength of the convergence process: the higher the $\hat{\beta} - 1$ in absolute value, the stronger the convergence. In all tables, column (1) shows absolute convergence results, while columns (2) to (5) present conditional convergence results using different control variables.

The results of estimating Eq. (1) by Difference GMM using inland freight transportation per capita as a dependent variable are presented in Table 2. The highly significant lagged inland freight transportation coefficients between 0 and 1 in all regressions indicate

[1] EU-15 are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom.

[2] The command “xtabond2” is used in Stata (v.13) for Difference GMM and System GMM estimations, and the instrument matrix is collapsed with the command “collapse” available in Stata, as mentioned in Roodman (2009).

Table 1 Descriptive statistics of data (in natural log form)

Variable	Number of observations	Mean	Min.	Max.	St. Dev.	VIF	TV
Inland freight transportation per capita (tonne-km)	156	8.153	6.901	10.043	0.557	2.63	0.38
Inland passenger transportation per capita (passenger-km)	138	8.976	6.615	9.594	0.656	1.40	0.72
GDP per capita (US dollars in 2005 prices)	165	10.200	9.026	11.334	0.411	3.62	0.28
Openness (%)	165	4.069	2.726	5.749	0.627	4.18	0.24
Inward FDI stock share (%)	129	2.930	0.513	5.593	1.162	2.91	0.34
Urbanization (%)	165	4.289	3.674	4.582	0.169	1.39	0.72

Min., Max., St. Dev., VIF and TV denote minimum, maximum, standard deviation, variance inflation factor, and tolerance value, respectively

Table 2 Panel regression of 4-year span data, difference GMM estimations

Dependent Variable: Inland Freight Transportation per capita	(1)	(2)	(3)	(4)	(5)
Inland freight transportation per capita of the previous period	0.777*** (0.037)	0.265*** (0.089)	0.464*** (0.097)	0.486*** (0.119)	0.359*** (0.079)
GDP per capita	–	0.478*** (0.137)	–	–	–
Openness (%)	–	–	0.255*** (0.056)	–	–
Inward FDI stock (%)	–	–	–	0.074** (0.036)	–
Urbanization (%)	–	–	–	–	1.995** (0.911)
Number of observations	126	126	126	108	126
Number of groups	15	15	15	15	15
Number of Instruments	5	10	14	8	10
Hansen test p value	0.179	0.138	0.243	0.120	0.143
AR(2)	0.679	0.229	0.564	0.434	0.728

Heteroscedasticity-consistent standard errors are in parentheses. Windmeijer (2005) finite sample correction for standard errors is employed. All GMM regressions treat the inland freight transportation per capita of the previous period as predetermined, and all control variables as endogenous regressors. The values reported for AR(2) are the p values for the second order autocorrelated disturbances in the first differences equations

***, ** and * denote the significance at 1, 5 and 10 % level, respectively

convergence in inland freight transportation per capita between EU-15 countries, in both absolute and conditional senses. The unconditional run implies the lowest (in absolute value) coefficient of lagged freight transportation, −0.223 (=0.777–1), when the dependent variable is the first difference of inland freight transportation per capita. Convergence in inland freight transportation is faster when the control variables are added. In accordance with Fig. 3, a steeper slope occurs when control variables are used. The highest (in absolute value) convergence is observed in column (2), −0.735, in which GDP per capita is

Table 3 Panel regression of 4-year span data, system GMM estimations

Dependent Variable: Inland Freight Transportation per capita

	(1)	(2)	(3)	(4)	(5)
Inland freight transportation per capita of the previous period	0.878*** (0.037)	0.524*** (0.134)	0.598*** (0.074)	0.736*** (0.074)	0.777*** (0.049)
GDP per capita	–	0.343*** (0.115)	–	–	–
Openness (%)	–	–	0.255* (0.133)	–	–
Inward FDI stock (%)	–	–	–	0.024 (0.023)	–
Urbanization (%)	–	–	–	–	0.541** (0.211)
Number of observations	141	141	141	123	141
Number of groups	15	15	15	15	15
Number of instruments	21	23	16	13	22
Hansen test p value	0.772	0.828	0.360	0.207	0.754
Difference-in-Hansen test p value	0.711	0.726	0.274	0.102	0.613
AR(2)	0.721	0.317	0.743	0.354	0.685

Heteroscedasticity-consistent standard errors are in parentheses. Windmeijer (2005) finite sample correction for standard errors is employed. All GMM regressions treat the inland freight transportation per capita of the previous period as predetermined and all control variables as endogenous regressors. The values reported for AR(2) are the p-values for the second order autocorrelated disturbances in the first differences equations

***, ** and * denote the significance at 1, 5 and 10 % level, respectively

the control variable. We also find that the coefficients of all control variables are positive, as expected, and statistically significant at 1 and 5 % levels.

Table 3 presents the results from estimating Eq. (1) by System GMM, using inland freight transportation per capita as the dependent variable. In all regressions, the coefficient of lagged inland freight transportation is highly significant and between 0 and 1, indicating that EU-15 countries converge in terms of inland freight transportation, in both absolute and conditional senses. The convergence process is again slowest in the absolute convergence run and the fastest, −0.476, when GDP per capita is used as a control variable, in accordance with the Difference GMM results. The more rapid convergence process when GDP per capita is used as the control variable provides strong support for our position on the significance of the impact of income (the front-end) on convergence of the inland freight transportation per capita (the back-end).Finally, coefficients of GDP per capita, urbanization and openness are found positive and statistically significant at 1, 5 and 10 % levels, respectively. However, inward FDI stock is found statistically insignificant. We nonetheless continue to consider the transportation convergence where FDI stock is the control variable in our presentation, in line with Hoeffler (2002), who argues that retaining an insignificant regressor appears to strengthen the instrument set significantly.

Table 4 shows the results from estimating Eq. (1) by Difference GMM using inland passenger transportation per capita as the dependent variable. In all regressions, the highly significant inland passenger transportation per capita coefficient between 0 and 1 indicates the existence of convergence in inland passenger transportation per capita across EU-15 countries. The absolute run, presented in column (1), has the lowest (in absolute value)

Table 4 Panel regression of 4-year span data, difference GMM estimations

Dependent Variable: Inland Passenger Transportation per capita					
	(1)	(2)	(3)	(4)	(5)
Inland passenger transportation per capita of the previous period	0.818*** (0.026)	0.457*** (0.060)	0.609*** (0.112)	0.647*** (0.093)	0.584*** (0.096)
GDP per capita	–	0.288[1] (0.176)	–	–	–
Openness (%)	–	–	0.103 (0.152)	–	–
Inward FDI stock (%)	–	–	–	0.017 (0.059)	–
Urbanization (%)	–	–	–	–	0.070 (0.648)
Number of observations	112	112	112	100	112
Number of groups	13	13	13	13	13
Number of Instruments	2	4	8	10	8
Hansen test p value	0.150	0.274	0.186	0.196	0.123
AR(2)	0.760	0.809	0.801	0.499	0.823

Heteroscedasticity-consistent standard errors are in parentheses. Windmeijer (2005) finite sample correction for standard errors is employed. The superscript [1] denotes the significance at 5 % level with one-tailed test. All GMM regressions treat the inland passenger transportation per capita of the previous period as predetermined and all control variables as endogenous regressors. The values reported for AR(2) are the p-values for the second order autocorrelated disturbances in the first differences equations. Ireland and Luxembourg are excluded due to missing data

***, ** and * denote the significance at 1, 5 and 10 % level, respectively

implied convergence rate, −0.182. The rate increases when the control variables are added, and the highest implied rate, −0.543, is observed when GDP per capita is considered, cf., column (2).Although insignificant when inland passenger transportation per capita is the dependent variable, we retain all control variables in our presentation, in line with Hoeffler (2002), who argues that their inclusion as a regressor appears to significantly strengthen the instrument set. We therefore refrained from using different control variables in this study, because, rather than finding the best equation for explaining inland passenger transportation convergence in EU-15, our specific aim was to highlight the existence of this convergence.

Table 5 shows the results from estimating Eq. (1) by System GMM using inland passenger transportation per capita as dependent variable. The highly significant lagged inland passenger transportation coefficients between 0 and 1 indicate that inland passenger transportation was in a process of convergence among EU-15 countries between 1970 and 2013. The results support both the unconditional and conditional convergence hypotheses, with the former having the lowest (in absolute value) convergence speed,−0.108. The convergence process increases when the control variables are added, and it is highest, −0.669, when GDP per capita is considered. Nonetheless, coefficients of all control variables are found statistically insignificant, although, as expected, positive. We nevertheless refrained from using different control variables, because, rather than finding the best equation for explaining inland passenger transportation convergence in EU-15, our specific aim was to highlight the existence of this convergence.

Table 5 Panel regression of 4-year span data, system GMM estimations

Dependent variable: inland passenger transportation per capita					
	(1)	(2)	(3)	(4)	(5)
Inland passenger transportation per capita of the previous period	0.892*** (0.019)	0.331*** (0.113)	0.628*** (0.273)	0.647*** (0.039)	0.576*** (0.118)
GDP per capita	–	0.294 (0.341)	–	–	–
Openness (%)	–	–	0.042 (0.069)	–	–
Inward FDI stock (%)	–	–	–	0.047[1] (0.028)	–
Urbanization (%)	–	–	–	–	0.487 (0.398)
Number of observations	125	125	125	113	125
Number of groups	13	13	13	13	13
Number of instruments	17	16	16	17	18
Hansen test p value	0.603	0.637	0.498	0.571	0.762
Difference-in-Hansen test p value	0.548	0.442	0.367	0.466	0.622
AR(2)	0.737	0.645	0.766	0.403	0.128

Heteroscedasticity-consistent standard errors are in parentheses. Windmeijer (2005) finite sample correction for standard errors is employed. The superscript [1] denotes the significance at 5 % level with one-tailed test. All GMM regressions treat the inland passenger transportation per capita of the previous period as predetermined and all control variables as endogenous regressors. The values reported for AR(2) are the p-values for the second order autocorrelated disturbances in the first differences equations. Ireland and Luxembourg are excluded due to missing data

***, ** and * denote the significance at 1, 5 and 10 % level, respectively

In summary, in all specifications $\hat{\beta}$'s, the convergence coefficients of lagged inland freight transportation per capita and inland passenger transportation per capita, are found to be between 0 and 1, and statistically significant at 1 % level. This provides strong evidence for both unconditional and conditional convergence in the transportation measures used. In case of inland freight transportation per capita, cf., Tables 2 and 3, the estimated coefficients of all control variables except inward FDI stock are both positive and statistically significant. Additionally, for both Difference GMM and System GMM analysis, urbanization has the highest positive coefficient and GDP per capita, the second highest. Convergence analyses using inland passenger transportation per capita, cf., Tables 4 and 5 also provide clear evidence of transportation convergence, despite statistically insignificant control variables. Since the aim of this paper was to show the existence of transportation convergence rather than to find the best convergence equation, no attempt has been made to employ other potentially statistically significant control variables. For the purposes of this paper, focusing on the estimated coefficients of lagged passenger transportation is sufficient to affirm the existence of conditional convergence, and that all control variables are effective (cf., Mankiw et al. 1992; Islam 1995).

Three tests were undertaken to check for consistency of the Difference GMM and System GMM estimators. The Hansen test illustrates the p-values for the null hypothesis of the validity of the over-identifying restrictions (Hansen 1982). In all specifications, we do not reject the null hypothesis. The additional moment conditions are valid since the null hypothesis of Difference-in-Hansen test is not rejected. The p values given by AR(2) provide no evidence for significant second order autocorrelated disturbances. In addition, in all specifications, the rule of thumb is satisfied, because over-fitting bias is overcome due to the number of cross sections being greater than the number of instruments. To sum up, the overall performances of five specifications are robust in terms of validity of instruments, and of the expected signs and significance levels of coefficients on variables.

Concluding remarks and policy implications

In this study, we conjectured a transportation convergence equation and tested it in absolute and conditional forms for EU-15 countries over the period 1970–2013, based on 4-year span panel data. Our Difference GMM and System GMM estimates for absolute and conditional convergence showed convergence for both the inland freight and passenger transportation per capita in these countries, and that this convergence is more rapid when the control variables are included. The overall performances of all specifications of the model are generally robust in terms of the validity of instruments, the expected signs and significance levels of the lagged convergence variable, and the control variables used.We concluded that the previously found pattern of income convergence of EU-15 in the process of economic integration is also clearly seen in the transportation sector.

One important policy implication of our study is the empirical verification of the convergence in transportation, a back-end sector of income. We argued that convergence in transportation is not only due to the law of diminishing returns, but also because income (convergence) and transportation (convergence) feed back into each other. That is, there is mutual interaction between income at the front-end with transportation at the back-end. Hence, from a policy perspective, isolating transportation policies from the dynamics of income may lead to the failure of these policies. That is, when attempting to identify the optimum levels of transportation or an economy or for a group of economies which are in the process of integration, it is essential that income dynamics are not overlooked. This is illustrated by certain transportation investments which have massively failed during periods of recession, while they were considered *sine qua non* during the boom periods. A very recent example, now symbolic of Spain's economic boom and bust, is the Ciudad Real Airport, opened in 2008 at a cost of 1 billion Euros, but which was bankrupt and abandoned in 2012, and sold for as little as 10 thousand Euros, 0.001 % of its original cost in 2015. The Spanish policy makers made this enormously costly miscalculation assuming that the convergence process across the leading high-income countries continues would never interrupted. The recent contraction in the Spanish economy however meant that these transportation investments were unproductive and wasteful in the short term. The lesson for policy makers is that any understanding of the transportation sector which overlooks the corresponding process in income may turn out to be potentially extremely costly.

The second important policy implication of our study is specific to the EU economic integration project. Transportation has always been considered as an important part of the integration project due to its critical role in regional development and economic efficiency, and successful policies and projects are pursued in light with Common Transport Policy (CTP). EU has (co-)funded many transportation projects, especially in relatively backward regions of the union, with the expectation that transportation improvements will stimulate economic growth, thus increasing income. For example, "Trans-European Transport Network (TEN-T)" and "Scanning the Potential of Intermodal Transport (SPIN)" are purposive breakthroughs to ensure efficient, safe, and free movement of people and goods throughout the EU by using all modes of transportation. EU enhanced investment in transportation infrastructure, so between 1987 and 1995 the EU-15 Member States spent more than 450 billion Euros on transport infrastructures (Bosch 2003), and this amount increased to 826 billion Euros in 2000–2006 (Gleave 2008). We believe that the strong evidence in transportation convergence in EU-15 may also reflect the overall success of this integration policy in transportation, in spite of a few rather extreme examples of failure.

Several issues for further exploration emerge from this study. The income convergence literature started with evidence from which theory has subsequently been developed. Analogously, the convergence in transportation measures requires the development of such a theoretical framework. Second, there is a need for further research on transportation convergence towards groups of economies classified in various ways; by income (e.g., World Bank's income classification of economies), membership of organizations (e.g., OECD), and at regional and state-level of an individual economy. These areas of research will be able to verify the robustness of our results.

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