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Firm-level circular innovations in European transition economies

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Abstract: Circular innovation enables firms to achieve environmentally sustainable growth through new products and processes that maximize resource efficiency and minimize pollution. Several factors influence the decision of firms to innovate and eventually transition to circular models to reduce environmental impacts and generate a sustainable growth model. This study analyzes the drivers of circular innovation using Flash Eurobarometer firm survey data across European Transition Economies. This study employs a binary choice model to examine such drivers, focusing on two types of innovation: the first type is measured as actions of firms in selling residues or waste to other companies, and the second type of innovation is measured as actions of firms in recycling or reusing materials or waste within the company. Our empirical results suggest that larger and older firms, those with high annual turnover, and those with higher investment in resource efficiency are more likely to innovate. Overall, the study outlines the importance of firm characteristics such as size in terms of the number of employees and turnover, age, and sector of operation for circular innovation adoption in transition economies. The findings supplement the understanding of the drivers enabling the transition towards sustainability in emerging regional contexts.
Keywords: *Circular economy, drivers, Eco-innovation, European transition economies, firm-level circular innovation.*

1. Introduction

The circular economy minimizes waste and decouples growth from resource use and pollution through practices like recycling and industrial symbiosis. It promotes efficiency, reduction, and sustainability to transition towards resilient, sustainable development while decoupling economic growth from resource depletion. Circular principles present new business opportunities that can enhance competitiveness and domestic job creation in emerging sustainability technologies. Understanding innovation adoption patterns enables knowledge transfer to accelerate scaling across firms, industries, and geographies. Insights inform policies tailored to the maturity and priorities of target industries within governmental circular economy roadmaps and programs.

The circular economy aims to create sustainable systems by revitalizing the use of energy and materials within their lifecycles, minimizing the need for additional primary resource inputs. It ensures the maximum presence of products in economic activity through extensive reuse. As an innovative concept that promises efficient utilization of resources, the circular economy has gained research and policy interest as an inherent part of sustainable growth. Circular innovations constitute eco-friendly products, technologies, or processes introduced by firms to spur growth while reducing environmental footprints [1]. Key factors driving the adoption of circular practices include policy and regulatory frameworks, market demand, public awareness, accessible resources, and organizational capabilities regarding financial and technological feasibility. Furthermore, active stakeholder participation across businesses, government, and civil society is essential.

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Depending on the specific regional and industry context, these drivers vary in their relative influence on advancement towards circular economic systems that regenerate resources while sustaining product lifecycles and economic activity. Multiple studies have examined determinants influencing the adoption of circular economy practices across different contexts. Exporting firms are likely to adopt circular economy innovations in European Transition Economies (ETEs). Adopting circular practices can also improve efficiency and supply chain collaboration to enhance global competitiveness. Firms from countries with strong environmental regulations and a culture of sustainability are more likely to prioritize circular innovations. Access to green technologies and networks as well as environmentally conscious consumers also motivate adoption to meet stakeholder expectations. Higher firm turnover is positively associated with circular economy innovation engagement. Greater adaptability, dynamic resource reallocation, diverse learning, and entrepreneurial orientation of high turnover firms contribute to embracing innovative sustainability practices. Manufacturing sectors are more prone to circular economy innovation compared to services. Factors like higher material intensity, product lifecycle considerations, consumer perceptions, complex supply chains, and regulatory pressures incentivize manufacturing firms to optimize resources, reduce costs, and meet evolving demands through circular practices. By minimizing waste generation and pollution impacts, innovations advancing circular resource usage and recovery hold macro-level promise in addressing pressing challenges like resource scarcity, energy security, climate change, and environmental degradation. However, barriers around financing, skills, technical capacities, and policy frameworks have led to uneven firm-level adoption of water, material, and energy efficiency solutions or circular capabilities [2]. While the circular economy has global attention, firm-level innovation empirical research is lacking, especially in the European transition context. The study identifies drivers of circular innovations in European transition economy firms. Combining quantitative and qualitative methods, the study provides empirical evidence on determinants in the context of ETEs. The study aims to analyse firm-level circular innovation drivers and inform transition promotion efforts through a localized lens focusing on the European transition economy context. Analysing factors influencing the adoption of circular practices contributes to understanding sustainable business circular economy advancement in the region. The study aims to make contributions around the drivers enabling firm-level circular innovations in the context of ETEs. First, it addresses critical literature gaps by providing original, empirical insights on motivators influencing domestic companies to pursue sustainability-focused innovations. Second, the multi-country comparative case analysis allows a nuanced understanding across economies at differing development trajectories, both in terms of descriptive statistics and empirical results. The research expands existing theory while informing priorities for practitioners, supporting accelerated diffusion of impactful circular innovations across regions striving for environmentally sound growth.

The reminder of this study proceeds as follows. In the next section, the theoretical background and research hypotheses are presented. Then, the study's methodology and sample characteristics and variables are described. The subsequent section reports upon the results, while the final section discusses this paper's implications for theory and practice.

2. Literature Review and Hypothesis Development

The circular economy promotes effective resource flows, waste reduction, resilience, and renewables shift across micro (firms, products), meso (industrial parks), and macro (cities, regions) levels for balanced environmental, economic, and social outcomes while decoupling from finite resource use. Firm-level circular innovations refer to new products, processes, services, and business models implemented within an individual firm to transition towards and embed circular economy principles through internal capabilities, technologies, operations, and culture. Such types of innovations refer to new approaches or improvements in products, processes, or business models to transition towards a circular configuration of resources and economic activity. Key features that qualify an innovation as circular include extended lifecycles [3] preserving the value of resources [4] using wastes/by-products as valuable inputs for other processes [5] deploying renewable or less carbon-intensive energy sources [6] and adoption of technologies supporting material circularity like IoT, Block chain, AI [7].

Innovations are categorized as circular value innovations (product-service systems); circular material innovations (collection, recycling, and remanufacturing technologies); and circular system innovations (infrastructure, digital traceability solutions) [8]. Incremental innovations drive adaptation, while radical innovations transform systems and societies [9]. EU policies have increased governmental and industry attention to Baltic circular opportunities [10] centered on waste use over complex product-service shifts [11]. Regulations and extended producer responsibility motivate manufacturing processes and packaging innovations [12]. However, Visegrad circular innovation evidence is limited [13] but shows slower circular economy adaptation in Slovakia and Hungary than in Poland and Czechia [14]. Industry 4.0 solutions may advance Romanian recycling and reuse [15] but adoption evidence is sparse, though informal sectors present plastic and e-waste innovation opportunities.

Circular models offer revenue streams appealing to environmentally conscious consumers while improving efficiency, reducing dependencies, and enabling growth [9].

Drivers of circular innovations are regulatory pressures [16] market demand [17] cost savings (Garcés-Ayerbe, Rivera-Torres, Suárez-Perales, & Leyva-de la Hiz, 2019), and leadership commitment [18]. Enablers include policies, funding, culture [19] knowledge capabilities [20] and emphasis from top management [21]. Adoption barriers encompass inadequate infrastructure, administrative burdens, skill constraints, and investment uncertainty [22].

Transition economies face demographic, climate, and digitalization challenges amid industrial inefficiency from Soviet-era legacy infrastructure and electricity gaps [23, 24]. However, circular economy momentum builds through policies and infrastructure enabling resource and waste practices [25] as circular business models emerge in textiles and tourism applying lifecycle thinking [26]. Cross-sector collaboration drives critical innovation, entrepreneurship, and knowledge exchange [27]. Growing commitment signals promise, but informal sectors, gaps, and financing access pose barriers [28]. Targeted interventions addressing competitiveness, technology, and governance while leveraging sustainability opportunities are vital [29]. Circular pathways can address multidimensional priorities if infrastructure, institution, and financing challenges are overcome through collaboration [30].

Transitioning linear production models requires circular innovations for material flows, lifecycle extension like reuse and remanufacturing [31] and system changes enabling equitable and sustainable growth [32]. Drivers include environmental regulations and market demand sustaining resource efficiency adoption [33]. A circular economy enables inclusive, sustainable urban transitions [34]. Market factors positively correlate with eco-innovations but lag policy interventions and regulations [35]. Performances vary – leaders couple environmental and industrial policies amid uncertainty, while laggards must accelerate learning [36]. Possibilities exist for viable and equitable sustainability transformations through rapidly upscaled, demonstrated green technologies. Lagging countries must build robust, large-scale policy packages accelerating peer learning, otherwise, a divided landscape unable to meet commitments could emerge.

In Visegrad countries, policies, directives, and regulations drive sustainability innovation [13]. Economic and market factors also motivate changes – industrial symbiosis for cost savings [37] customer demand and values enabling SME eco-innovations [38] and public pressure encouraging local solutions [39]. Enablers are public subsidies, infrastructure, and EU compliance [29]. Barriers around policy stability, secondary materials, and information constrain adoption [28]. Baltic advances are traced to regulations and economic motivators [40]. Determinants include policies, leadership, characteristics, demands, technologies, knowledge exchange, and finances. Findings highlight EU integration, policies, readiness, partnerships, capabilities, engagement, and incentives. Further research should explore unique regional challenges and opportunities.

Technologies like IoT, blockchain, and robotics hold the potential to aid Romanian and Bulgarian innovation around traceability, waste valorization, and renewables [41]. EU strategies and financing may encourage advancements in eco-design and industrial symbiosis. However, evidence explicitly tying policies to business initiatives remains limited – factors tend aspirational rather than grounded in documented incentivization cases. Further research could strengthen this evidence base.

Slovenian and Croatian roadmaps lack concrete innovation links [14] while EU packages theoretically incentivize experimentation. Slovenia excels in waste separation but lags in promoting reuse due to the absence of systemic solutions and societal attitudes favouring reuse in principle but not in practice. The country's high standard of living contributes to a consumer mentality prioritizing new purchases over repairing or reusing existing items. However, reshaping this mindset through systemic measures and increased awareness can positively impact personal finances and the environment. Circular production methods face financial challenges in Slovenia, but opportunities exist in materials recycling, waste utilization, and reducing reliance on primary materials [42]. Current strategic documents in Croatia lack adequate coverage of Circular Economy (CE) topics, mainly because these documents were developed before the CE gained prominence at the EU level. However, with the opportunity arising from the ongoing drafting of new strategic documents, there is potential to incorporate CE policies into Croatia's national strategic framework. Despite acknowledging the importance of resource efficiency for long-term economic and environmental sustainability, Croatia's circular development model has yet to gain traction since data reveals that Croatia's economy is only 2.7% circular, indicating a significant gap in material reuse within the economy [43]. While Croatia shows promise in establishing a CE, current strategic integration and sectoral activities are often inadequate. A successful CE implementation requires collaboration and coordination among all relevant sectors and stakeholders, necessitating an integrated CE strategy developed through broad stakeholder engagement. Such an approach could effectively support and promote CE initiatives in Croatia.

Similarly, Western Balkan national policies theoretically aim to incentivize business innovations yet concrete data remains sparse. EU association prospects may nudge innovations in areas like eco-design and stewardship models, but evidence directly attributing EU factors to business initiatives thus far is limited. While high-level regulatory, policy, association, and technology enablers exist, granular evidence connecting these drivers to local innovations is lacking in the literature. Further analysis on this could be insightful.

Aspects of general sustainability transitions receive some examination, but critical organizational change driver knowledge gaps persist for enabling circular innovation adoption in transition economies [44]. Greater local context sensitivity on institutions, governance, and transition stage influences is vital [30]. Research should ultimately inform intervention strategies promoting business models, processes, and product innovations for circularity across value chains.

The study aims to shed light on drivers of circular economy innovations in ETE. Based on recent studies the hypotheses to be tested are as follows:

H1: Larger firms exhibit higher circular innovation adoption than SMEs across transition economies. Greater resources enable value chain remaking [45] capabilities building [46] and economies of scale benefits [47]. Size increases implementation likelihood for recycling, remanufacturing, and industrial symbiosis [48]. Large firms create and coordinate circular supply chain partnerships around product life extension [49] whilst SMEs play integral roles across circular chains. Firms with higher turnover better afford innovations, benefitting more from cost savings and revenue opportunities that smaller firms' financial barriers hinder [50]. Firm-scale resources contribute to the willingness and capability to pursue enhanced recyclability, material efficiency, and waste recovery innovations [51].

H2: An inverted U-shaped relationship exists between firm age and innovation likelihood. Very young firms lack resources while very old one's face inertia. Intermediate-aged firms balance experience and openness for innovations. Older firms face traditional model-shifting challenges [52]. Younger firms are more adaptable, influencing the embracement of innovations (Sapienza, Autio, George, & Zahra, 2006), often with a higher entrepreneurial orientation conducive to adopting innovations [53]. Older firms' incremental changes pose lower risks than entirely new models that younger start-ups pioneer until commercially proven [54]. Firm age square correlations show intermediate-aged firms pursue more radical innovations [48].

H3: Greater export market reliance heightens innovation pursuit pressures. Exporters adopt waste, and emission reduction technologies to meet international requirements [55]. Export orientation incentivizes manufacturers towards innovations, though robustness across contexts could improve [50].

H4: Manufacturing firms demonstrate higher incremental process innovation orientation and services show higher radical model innovation likelihood. Manufacturing favors optimization unaffected by equipment lock-ins, while services attempt alternate value delivery [56]. Adoption rates vary by sector [57] with differences in motives, barriers, and capabilities supporting tailored policies [48].

H5: Strong environmental policy and infrastructure regimes see increased firm innovation orientation. Delayed Western European adoption hinders domestic innovations [9]. Consumer awareness differences across regions also alter pressures [58]. Location induces innovation investments [50] with significant cross-country variation in motives, priorities, and challenges [48]. Institutions enable manufacturers to divert more waste into recycling streams and achieve better material efficiency outcomes [59]. Testing could reveal how regional contexts shape orientation.

3. Methodology

To explore the drivers of circular innovation in transition economies, this study uses the Flash Eurobarometer 498 survey of the European Commission (SMEs, Resource Efficiency, and Green Markets) for its empirical analysis. Drawing upon 15 ETEs, this dataset is limited to firm data in 2021, as the latest data available, for Albania, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Montenegro, North Macedonia, Poland, Romania, Serbia, Slovakia, and Slovenia. The sample consists of firms with weight-adjusted responses to questions on circular economy-aligned changes introduced spanning products, processes, distribution models, and recovery systems. Firm size predictors (micro, small, medium, large by employees), export exposure, sector, turnover amounts, age, and country location are key independent variables examined against the dependent innovation adoption variable. The final sample (number of firms) has been reduced to 6346 SMEs after excluding nonresponses cases or inappropriate answers (from 7222 in the original dataset).

To examine the factors influencing circular innovation, a binary choice model has been employed due to the dependent variable being a dummy variable (taking values of 0 or 1). Such model is crucial in investigating the relationship between the independent variables and the likelihood of adoption of circular innovation. Probit models are used to analyse binary or categorical dependent variables, providing estimates for the probability of an event based on predictor variables [60]. In probit regression, these models discern the relationship between independent variables and the likelihood of the event, employing the cumulative distribution function of the standard normal distribution. Particularly advantageous when the normal distribution assumption is deemed more appropriate than the logistic distribution, probit models offer a natural probabilistic interpretation, wherein coefficients signify changes in the probability of the dependent variable being 1 for a one-unit change in the independent variable.

Robustness to outliers in the dependent variable enhances the applicability of probit models, making them suitable for scenarios where extreme values might impact other model types. These models assume a linear relationship between independent variables and the latent variable, transformed using the standard normal cumulative distribution function to derive the probability of the dependent variable being 1. Probit modelling finds utility across various contexts, including studies on innovation outcomes, technology adoption decisions, and consumer choices [61].

In innovation decisions analysis, probit models offer practical and interpretable results, facilitating an understanding of factors influencing decisions and predicting adoption likelihoods, especially in sustainability transitions. These models are beneficial for assessing the likelihood of firms adopting sustainability innovations, considering influential drivers such as policy, markets, and capabilities [62].

Additionally, probit models enable estimation of marginal effects for each driver variable on adoption probabilities.

Despite their advantages, probit models come with limitations. Nonlinear relationships between independent variables and the latent variable may render interpretation less intuitive than linear models. The critical assumption of a normal distribution for the latent variable requires careful consideration, as violations could impact the reliability of parameter estimates. Probit models may also present computational challenges, particularly with large datasets, due to the computational intensity of their estimation. Unlike linear regression, probit models lack a closed-form solution, necessitating numerical methods like maximum likelihood estimation, which can be computationally demanding. The model is estimated as follows:

$$P\,(circular\_innovation_{\,i} = 1) = f\,(\beta_i\, X_i + \delta\ Country_i) \qquad (1)$$

Where circular innovation is limited to variables measuring firms' involvement in activities contributing to circular economy through resource-efficient actions. More specifically, this variable is measured either as a dummy variable which shows whether a firm is selling residues and waste to another company (circular_inno1), or a dummy variable which shows whether a firm is recycling by reusing materials or waste within the company (circular_inno2). The probability of circular economy is a function of the right-hand side variables in Equation (1) as turnover (the percentage of investment in resource efficiency on firm's turnover), year (year of establishing), and year2 (the square of year, testing for any potential nonlinear relationship of the circular innovation over time), export (a dummy variable taking the value 1 if a firm is exporting, 0 otherwise), employees (a categorical variable with a number of a firm's full-time employees), investment (a categorical variable with investment in resource efficient as a percentage of turnover), sector (defined as either NACE sector of activity, either as a categorization of 12 sectors or grouped in 4 large sectors), and country to account for any remaining unobserved country heterogeneity not captured by the abovementioned variables.

To estimate the drivers of circular innovation, different specifications are used, not only in terms of independent variables (defined as either circular_inno1 or circular_inno2) but also in terms of independent variables. Probit models are used to analyse binary or categorical dependent variables, providing estimates for the probability of an event based on predictor variables [60]. In Probit regression, these models discern the relationship between independent variables and the likelihood of the event, employing the cumulative distribution function of the standard normal distribution. Particularly advantageous when the normal distribution assumption is deemed more appropriate than the logistic distribution, Probit models offer a natural probabilistic interpretation, wherein coefficients signify changes in the probability of the dependent variable being 1 for a one-unit change in the independent variable.

Using diagnostics through various tests such as overall model fit, goodness of fit, and collinearity (see appendix, tables 1-3), 4 specifications have been selected and presented in the result section. Diagnostics Favor specifications 2 and 4 in terms of goodness of fit, which suggests using sectors of activities disaggregated rather than grouped into four main groups. In all the cases, the odds ratios are reported for logit regressions (see Appendix Table 4), and marginal effects have been calculated for Probit regression models (reported in the main text, section 4).

4. Descriptive Statistics

Data was collected via the 2021 Flash Eurobarometer survey of 17,500 firms across 27 EU states, neighbouring countries, and the US. The survey examined company performance on resource efficiency, climate neutrality actions, barriers and transition needs. Fielding occurred between November 8th to December 10th, 2021. The goal was assessing circular economy practices among European firms plus select non-EU players. Information gathered covered country, sector, employees, founding year, turnover changes and levels, and output types. Participants indicated if nine specific circular practices were adopted over the preceding two years including areas like recycling, material substitution, industrial symbiosis, and product-service systems. Additional dimensions captured involved associated costs, investments, financial support received, green hires made, and difficulties or requirements related to sustainability transitions. Key variables for comparative analysis across firms include size, age, industry sector, profit levels, and country. These factors are hypothesized to directly influence propensity to implement circular innovations enhancing resource productivity and climate resilience. The rich dataset facilitates profiling leaders versus laggards on sustainability metrics while revealing transition pain points needing policy or commercial solutions. Firms that participated in the survey are SMEs and large companies: 41.7% of them have between 1 and 9 employees, 36% between 10 and 49, 17.1% between 50 and 249, and 5.2%, large companies, have more than 250 employees. As already introduced, the survey aimed at measuring the adoption of specific circular economy practices by European firms. The most adopted efficiency action in European transition economies was saving energy undertaken by 61.3% of firms; minimizing waste was adopted by 57.4% of them, saving materials regards 53.6% of firms, and minimization of water waste is adopted by 47.1%. Recycling inside company through reuse and use of waste was undertaken by 36.9% of companies; switching to greener supplier of materials is adopted by 36.6% of them; the sale of own residues and waste to other companies is done by 36.2% firms in transition economies. The choice to use mainly renewable energy is applied by 33.7% of firms, while the least adopted sustainability practice is designing products that are easier to maintain, repair or reuse is applied by 28.3% of firms.

Focusing on our two variables of interest measuring circular innovation (recycling by reusing materials or waste within the company, and selling residues and waste to another company), statistics displayed in Table 1 are presented as percentages of the overall firms. The data suggests that larger firms in terms of number of employees and those in the manufacturing sector tend to have higher percentages of both types of circular innovation. On the contrary, firms in the services sector seem to have lower percentages in both categories. Regarding the age of firms, it seems that there is no apparent alteration in recycling practices based on the firm's establishment period.

Table 1.
Descriptive statistics on circular innovation in ETEs by firm size, sector, and period of establishment

Firm size (by employees' number)	**Recycling, by reusing material or waste within the company (% of firms)**	**Selling your residues and waste to another company (% of firms)**
1 - 9 employees (micro)	38.40	27.11
10 – 49 employees (small)	37.35	43.08
50 – 249 employees (medium)	39.42	53.46
More than 250 employees (large)	44.07	66.86
Sector	Recycling, by reusing material or waste within the company (% of firms)	Selling your residues and waste to another company (% of firms)
Manufacturing	45.73	58.11
Retail	37.39	36.87
Industry	41.25	38.472
Services	31.37	27.2
Period of firm establishment	Recycling. by reusing material or waste within the company (% of firms)	Selling your residues and waste to another company (% of firms)
Before 1 January 2014	38.91	41.02
Between 1 January 2014 and 31 December 2016	36.81	35.48
Between 1 January 2017 and 1 January 2021	37.15	30.18
After 1 January 2021	30	50

Source: Authors' calculation based on Flash Eurobarometer (2021).

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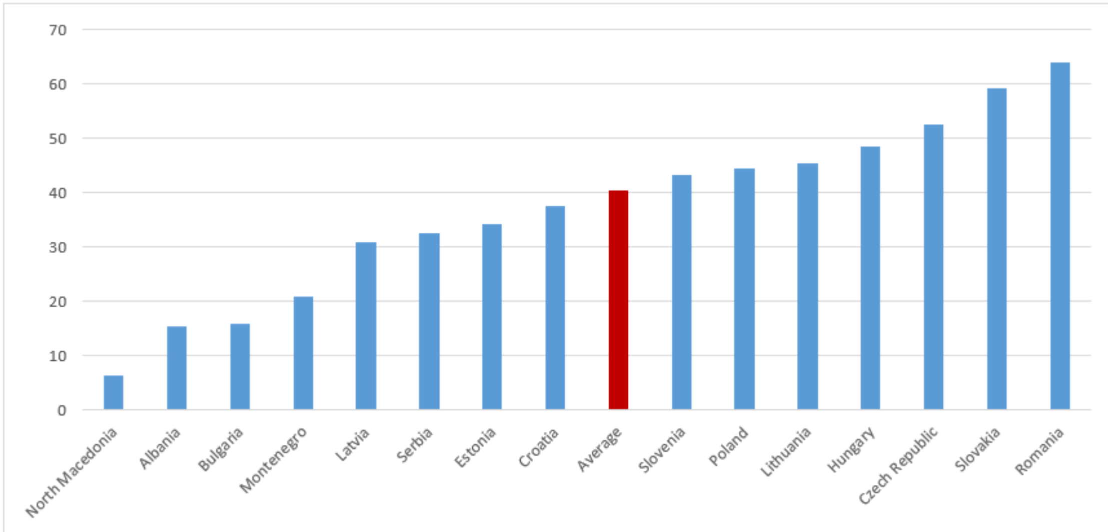

Figure 1.
Circular actions taken by firms in ETEs
Source: Authors' calculation based on Flash Eurobarometer (2021)

5. Results

The estimation of drivers of circular innovation at the firm level for ETEs is presented in Table 2. The first two specifications (columns 1 and 2) estimate the model presented in Equation (1) using circular_inno1 as the dependent variable, all mentioned independent variables, whereas differ in terms of sectors of activities measurement. The first specification uses grouped sectors of activities, whereas the second uses a more detailed categorization. The third and fourth specification (column 2) estimates the mode in Equation 1 using circular_inno2 as the dependent variable, all mentioned independent variables and similar to the first two specifications, using a grouped (column 3) and a detailed categorization of sectors of activities (column 4).

The result suggests that turnover is a significant driver of the first type of innovation, mostly for firms with high turnover (more than 250,000 euros). More precisely, firms with higher turnover, starting from this threshold, have a higher probability of making circular innovations through selling residues or waste to other companies. The results further indicate that this probability increases with a firm turnover (from 30% to 60%). Indeed, firms with higher turnover are generally more financially stable and thus more likely to embark on innovative practices of selling residues or waste to other companies. Likewise, firms with higher turnover and financial capability can better afford investments in circular changes and benefit more from potential cost savings or revenue opportunities. On the other side, results on companies' turnover that focus on the second type of circular innovation appear mixed. Small and high turnover firms do not affect the probability of a firm to innovate. A significant negative relationship between turnover and the second type of innovation is suggested for firms with a medium level of turnover.

Regarding selling residues and waste to another company, export does not appear to be significant, showing no relationship with this type of innovation. Thus, rejecting our hypothesis that export-reliant firms face pressures to pursue circular innovations with higher export intensity linked to greater adoption, especially for manufacturers.

In contrast to companies with more than 250 employees, those with fewer than 250 employees are less likely to engage in circular innovation, particularly in selling residues or waste to other firms. This accepts our hypothesis that larger firms by employee number and turnover exhibit a higher propensity for circular innovation adoption than smaller companies across ETEs. As to the second type of innovation, results are insignificant, indicating no relationship between the size of firms and recycling by reusing materials or waste within the company. This could be attributed to the structural nature of this innovation within firms, suggesting that it is not inherently tied to firm size.

In terms of the age of firms, in line with the hypothesis, testing the relationship between company maturity and orientation towards radical or sustaining circular innovations, the result indicates that firms younger than 2 years have a lower probability of circular innovation, irrespective of the type of innovation (turning point=2.1 years). After the second year, firms are more likely to introduce innovative actions. SMEs that export in international markets are more likely to innovate in terms of recycling within the company. This might be linked to experience, knowledge gained during the first two years of the firm, and, specifically to the first type of innovation, to the established network and adoption to change.

Table 2.
Empirical results of drivers of circular innovation in ETEs models 1-4

	(Circular_Inno1)				**(Circular_Inno2)**			
Variables	**Margins**	**Se**	**Margins**	**Se**	**Margins**	**Se**	**Margins**	**Se**
year	0.257**	(0.109)	0.237**	(0.109)	0.238**	(0.103)	0.243**	(0.103)
year2	-0.061**	(0.028)	-0.058**	(0.028)	-0.059**	(0.026)	-0.060**	(0.026)
export	0.080	(0.053)	0.076	(0.054)	0.209***	(0.052)	0.206***	(0.052)
Turnover								
More than 25,000 to 50,000 euro	0.051	(0.070)	0.065	(0.070)	-0.071	(0.067)	-0.078	(0.066)
More than 50,000 to 100,000 euro	0.114	(0.070)	0.125*	(0.070)	-0.072	(0.067)	-0.076	(0.067)
More than 100,000 to 250,000 euro	0.084	(0.065)	0.088	(0.065)	-0.188***	(0.063)	- 0.192***	(0.063)
More than 250,000 to 500,000 euro	0.133**	(0.066)	0.138**	(0.066)	-0.134**	(0.065)	-0.141**	(0.065)
More than 500,000 to 2 million euro	0.303***	(0.057)	0.317***	(0.058)	-0.107*	(0.056)	-0.111**	(0.056)
More than 2 to 10 million euro	0.434***	(0.061)	0.462***	(0.062)	-0.100	(0.061)	-0.104*	(0.062)
More than 10 to 50 million euro	0.507***	(0.080)	0.540***	(0.081)	-0.108	(0.080)	-0.109	(0.080)
More than 50 million euro	0.617***	(0.143)	0.668***	(0.143)	0.092	(0.143)	0.087	(0.143)
Number of employees								
1 to 9 employees	- 0.570***	(0.082)	- 0.529***	(0.082)	0.016	(0.080)	0.005	(0.081)
10 to 49 employees	- 0.308***	(0.079)	- 0.304***	(0.080)	-0.012	(0.079)	-0.013	(0.079)
50 to 249 employees	-0.202**	(0.079)	-0.193**	(0.080)	-0.001	(0.079)	-0.009	(0.079)
Investment								
1- 5% of annual turnover	0.208***	(0.038)	0.198***	(0.038)	0.212***	(0.038)	0.216***	(0.038)
6- 10% of annual turnover	0.075	(0.059)	0.063	(0.059)	0.203***	(0.057)	0.208***	(0.057)
11- 30% of annual turnover	0.129	(0.084)	0.114	(0.085)	0.283***	(0.083)	0.291***	(0.084)
More than 30% of annual turnover	0.103	(0.121)	0.083	(0.122)	0.219*	(0.118)	0.243**	(0.119)
Sectors of activities grouped								
Retail	- 0.397***	(0.047)			-0.155***	(0.047)		
Services	- 0.649***	(0.048)			-0.344***	(0.047)		
Industry	- 0.400***	(0.049)			-0.071	(0.049)		
Sectors of activities details								
Profes/scient. and technical activities			- 0.732***	(0.098)			-0.219**	(0.093)
Real estate activities			-	(0.152)			-	(0.136)

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			1.024***				0.512***	
Financial and insurance activities			-1.237***	(0.135)			-0.214**	(0.105)
Information and communication			-0.906***	(0.097)			-0.197**	(0.086)
Accommodation and food service activities			-0.343***	(0.071)			-0.392***	(0.074)
Transportation and storage			-0.546***	(0.069)			-0.440***	(0.070)
Wholesale and retail trade, repair of motorcycles			-0.397***	(0.047)			-0.149***	(0.047)
Construction			-0.395***	(0.052)			-0.076	(0.052)
Water supply, sewerage, waste management			-0.293**	(0.125)			0.043	(0.123)
Electricity, gas, steam, and air conditioning			-0.575***	(0.125)			-0.079	(0.123)
Countries								
Estonia	-0.187**	(0.084)	-0.212**	(0.085)	-0.302***	(0.080)	-0.293***	(0.081)
Hungary	-0.159**	(0.080)	-0.174**	(0.080)	-0.363***	(0.077)	-0.358***	(0.077)
Latvia	-0.108	(0.085)	-0.120	(0.086)	-0.680***	(0.083)	-0.675***	(0.084)
Lithuania	-0.015	(0.082)	-0.033	(0.082)	-0.684***	(0.081)	-0.677***	(0.081)
Poland	-0.086	(0.079)	-0.077	(0.080)	-0.396***	(0.076)	-0.399***	(0.076)
Slovakia	-0.174**	(0.082)	-0.194**	(0.082)	0.041	(0.077)	0.040	(0.077)
Slovenia	0.023	(0.079)	0.021	(0.080)	-0.200***	(0.077)	-0.203***	(0.077)
Bulgaria	-0.161*	(0.084)	-0.178**	(0.085)	-0.617***	(0.082)	-0.623***	(0.083)
Romania	0.318***	(0.076)	0.305***	(0.076)	-0.127*	(0.074)	-0.128*	(0.075)
Croatia	-0.029	(0.077)	-0.043	(0.078)	-0.345***	(0.076)	-0.354***	(0.076)
North Macedonia	0.102	(0.089)	0.079	(0.090)	-1.039***	(0.094)	-1.042***	(0.094)
Montenegro	-0.209	(0.150)	-0.235	(0.153)	-0.820***	(0.162)	-0.835***	(0.161)
Serbia	0.193**	(0.081)	0.176**	(0.082)	-0.468***	(0.081)	-0.473***	(0.081)
Albania	-0.226	(0.172)	-0.191	(0.176)	-0.500***	(0.163)	-0.524***	(0.162)
Observations	6,346		6,346		6,346		6,346	

Regarding investment in resource-efficient activities, for the first type of innovation, firms with a range from 1-5% share of total turnover are more likely to sell residues or waste to another company. Results for firms with higher investment share show no significant relationship with this type of innovation. On the contrary, for the second type of innovation, recycling or reusing waste within the company, all firms with a higher share of investment than 1% (the base category is investment less than 1% of total turnover) show a higher probability of undertaking this type of innovation. Further exploration into the source of such investments, whether firms utilize their financial resources or receive funds and grants, will be a subject of investigation in future research.

In terms of sectors of activities, results suggest that firms working in retail, services, and industry are less likely to innovate compared to those in manufacturing. Also, testing our hypothesis that manufacturing firms exhibit a higher propensity for circular innovation adoption than companies in other sectors across ETEs. This might be linked particularly to circular innovation, primarily led by manufacturing firms. Since manufacturing is often linked to the production of a physical product, innovation can be more tangible as involves production processes, design, and development. This seems to be in line with both theoretical and empirical literature review, given that higher material intensity, product lifecycle considerations, complex supply chains, and regulatory pressures incentivize manufacturing firms to optimize resources and reduce costs through circular practices. On the contrary (for instance service sector), the nature of the product makes it challenging to reuse or recycle waste easily in another company. A more disaggregated grouping of sectors of activities does not yield any additional or contradictory findings, irrespective of the type of circular innovation considered.

Last, the research results suggest a distinct pattern where all European transition countries (except Romania for the first type of innovation) exhibit a lower propensity for innovation when compared to the Czech Republic. This tests our hypothesis, namely Firms in countries with strong environmental policies and circular economy infrastructure demonstrate increased orientation towards circular innovations relative to peers in countries lacking or weak regulation. A rationale for this might be the fact that the Czech Republic is the most developed economy compared to all other transition economies. It is now no longer under the ETEs group, with a high level of per capita income, institutional frameworks, and indeed innovation ecosystems. As to Romania, as reviewed in the literature review, the emergence of technologies and advanced recycling robotic systems has contributed to corporate transitions towards innovations in areas like product lifecycle traceability, waste valorisation, and renewables.

6. Conclusions

Circular innovations enable firms to achieve sustainable growth through new products and processes that maximize resource efficiency and minimize pollution. By minimizing waste generation and pollution impacts, innovations advancing circular resource usage and recovery hold macro-level promise in addressing pressing challenges like resource scarcity, energy security, climate change, and environmental degradation. The transition to circular innovation is driven by several factors influencing the decision of firms to adopt practices accordingly. To the best of the authors' knowledge, empirical research in the context of transition economies is lacking and this is the first study that delves into the drivers of circular innovation in ETEs.

To empirically investigate these drivers, this study used the Flash Eurobarometer survey for 2021 by conducting a binary choice model (probit) focusing on two types of innovation. The first type of circular innovation is measured as actions of firms in selling residues or waste to other companies, whereas the second type of innovation is measured as actions of firms in recycling or reusing materials or waste within the company. The empirical results suggest that higher turnover, particularly for firms with over 250,000 euros, is found to significantly drive circular innovation related to selling residues or waste to other companies. The study suggests that larger firms with higher turnover and financial stability are more likely to adopt innovative practices, while the probability increases with a firm turnover. In terms of the second type of innovation, results are mixed, with medium-sized firms showing a significant negative relationship.

The study found that firms younger than 2 years are less likely to engage in circular innovation, regardless of the innovation type, with a turning point at 2.1 years where firms become more inclined to introduce innovative actions. Furthermore, firms exporting in international markets have a higher probability of recycling within the company, possibly attributed to experience gained in the initial two years and the influence of established networks on adapting to change. Manufacturing firms, influenced by factors like material intensity and regulations, exhibit a higher likelihood to adopt circular innovation, while most European transition countries, except Romania, display a lower inclination compared to the Czech Republic, supporting the role of robust environmental policies in driving innovation.

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By highlighting the importance of firm characteristics such as size in terms of number of employees and turnover, age, and sector of operation for circular innovation adoption in transition economies, this study carries several theoretical and practical implications. For scholars, it extends resource-based theory perspectives on strategic drivers by encompassing institutional and capability considerations more aligned to emerging market environments characterized by uncertainty. For policymakers, the findings suggest interventions and incentives targeting the enhancement of domestic knowledge and research systems related to circular principles may bolster firm-level activity by enhancing intangible capital stocks accessible locally. Furthermore, developing programs aimed at capability building around appropriate valuation techniques and circular business case modeling can equip executives to pursue opportunities. For businesses, results indicate that anchoring sustainability commitments through the formalization of the circular economy into performance measurement frameworks and strategic planning processes could drive internal momentum for innovations addressing them.

This study aims to make multiple vital contributions around the specific drivers enabling firm-level circular innovations within the context of European transition economies. First, it addresses critical literature gaps by providing original, empirical insights on motivators influencing companies to pursue sustainability-focused innovations. Second, the multi-country comparative analysis allows a nuanced understanding of variations across economies at differing development stages. Third, the focus on incumbent, established firms provides an inside-out strategic perspective distinct from the growing entrepreneurial space receiving attention. Fourth, the research combines internal capability and managerial cognition factors with an assessment of external conditions to develop a systems view of interdependencies required to scale innovations. Fifth, the integration of survey data with scholarly literature develops a contextualized theoretical framework to explain adoption decisions. Overall, this research expands existing theory while informing high-impact pathways for regions striving for environmentally sound and socially equitable economic growth.

While providing novel insights, this study contains certain limitations that offer avenues for further research. First, the sample is confined to large, medium, and small firms in general, whilst exploring dynamics within SMEs would strengthen the generalizability of findings. Second, relying solely on self-reported survey data for the identification of innovation drivers presents possibilities for social desirability and recall biases that must be considered in interpreting results. Supplementing with secondary financial or operational data would improve validity. Third, the cross-sectional research design offers just a snapshot rather than longitudinal trends in capabilities, managerial interpretations, and innovation orientations. Long-term ethnographic studies could better capture evolution trajectories. Fourth, only explicitly declared circular economy innovations were examined, meaning incremental solutions go unobserved. Future research could examine decoupling relationships between economic and environmental performance to address sustainability outcomes more holistically. Finally, the focus on European transition markets limits applicability to other regional contexts. Some potential directions for future research based on examining drivers of firm-level circular innovations in European transition economies could be comparative assessments of circular innovation orientations between state-owned enterprises (SOEs) and private companies within transition economies to determine how goals and incentive structures influence sustainability strategies. Exploring the role of multinational subsidiaries based in transition economies can help better understand how headquarters' sustainability priorities shape decisions to allocate resources and develop local capabilities for circular innovations. Profiling small and medium-sized enterprises (SMEs) across transition economies and overcoming barriers to access circular knowledge, collaborators, and customers would shed light on alternative non-conventional innovation drivers. While the focus of this study was on the key drivers of circular innovation, another type of innovation might be of interest to investigate in the future, as well as expanding the focus on financial support firms receive and its influence on the firms' decision to innovate.

Based on empirical findings on drivers of firm-level circular innovations in European transition economies, the study recommends policy and practical measures as follows:

i. Developing dedicated public-private financing facilities will offer low-cost capital for validation and piloting of circular innovations to alleviate funding barriers.
ii. Innovation grants and tax incentives need to be structured around lifecycle assessments and waste-reduction metrics to motivate circular designs.
iii. Supporting circular economy skills training and managerial capacity building through subsidized university programs and industry partnerships will help wider adoption of innovations.
iv. Policymakers can enable scaling by addressing knowledge barriers, providing risk capital, and facilitating coordination.
v. Companies must orient strategies, conduct opportunity analyses, and engage partners and customers to drive innovations successfully in accordance.

Data Availability Statement:
The data presented in this study are available in the website https://doi.org/10.4232/1.13934.

Author Contributions:
Conceptualization, E.J.; methodology, A.G.; software, A.G.; validation, D.K., E.J. and A.G.; formal analysis, D.K.; resources, E.J.; writing—original draft preparation, E.J.; writing—review and editing, D.K and A.G..; visualization, E.J.; supervision, E.J. and A.G. All authors have read and agreed to the published version of the manuscript.

Transparency:
The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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References
[1] C. Díaz-García, Á. González-Moreno, and F. J. Sáez-Martínez, "Eco-innovation: insights from a literature review," *Innovation*, vol. 17, no. 1, pp. 6-23, 2015. https://doi.org/10.1080/14479338.2015.1020104
[2] Y.-S. Chen, S.-B. Lai, and C.-T. Wen, "The influence of green innovation performance on corporate advantage in Taiwan," *Journal of Business Ethics*, vol. 67, pp. 331-339, 2006. https://doi.org/10.1007/s10551-006-9045-5
[3] N. M. Bocken, C. S. Schuit, and C. Kraaijenhagen, "Experimenting with a circular business model: Lessons from eight cases," *Environmental Innovation and Societal Transitions*, vol. 28, pp. 79-95, 2018. https://doi.org/10.1016/j.eist.2018.01.003
[4] M. Linder and M. Williander, "Circular business model innovation: Inherent uncertainties," *Business Strategy and the Environment*, vol. 26, no. 2, pp. 182-196, 2017.
[5] M. Saidani, B. Yannou, Y. Leroy, F. Cluzel, and A. Kendall, "A taxonomy of circular economy indicators," *Journal of Cleaner Production*, vol. 207, pp. 542-559, 2019.
[6] M. Geissdoerfer, P. Savaget, N. M. Bocken, and E. J. Hultink, "The circular economy–A new sustainability paradigm?," *Journal of Cleaner Production*, vol. 143, pp. 757-768, 2017. https://doi.org/10.1016/j.jclepro.2016.12.048
[7] J. Kirchherr, "Circular economy and growth: A critical review of "post-growth" circularity and a plea for a circular economy that grows," *Resources, Conservation and Recycling*, vol. 179, p. 106033, 2022. https://doi.org/10.1016/j.resconrec.2022.106135
[8] M. Antikainen and K. Valkokari, "A framework for sustainable circular business model innovation," *Technology Innovation Management Review*, vol. 6, no. 7, pp. 5–12, 2016. https://doi.org/10.22215/timreview/1012
[9] J. Kirchherr *et al.*, "Barriers to the circular economy: Evidence from the European Union (EU)," *Ecological Economics*, vol. 150, pp. 264-272, 2018. https://doi.org/10.1016/j.ecolecon.2018.04.026

[10] W. Leal Filho *et al.*, "An overview of the problems posed by plastic products and the role of extended producer responsibility in Europe," *Journal of Cleaner Production*, vol. 214, pp. 550-558, 2019. https://doi.org/10.1016/j.jclepro.2018.12.171

[11] J. Korhonen, A. Honkasalo, and J. Seppälä, "Circular economy: The concept and its limitations," *Ecological Economics*, vol. 143, pp. 37-46, 2018. https://doi.org/10.1016/j.ecolecon.2017.06.041

[12] V. Rizos, K. Tuokko, and A. Behrens, "The Circular Economy: A review of definitions, processes and impacts," in "CEPS Research Report No. 2017/8," 2017.

[13] R. Lacko, Z. Hajduova, and M. Zawada, "The efficiency of circular economies: A comparison of Visegrád Group Countries," *Energies*, vol. 14, no. 6, p. 1680, 2021. https://doi.org/10.3390/en14061680

[14] A. Marino and P. Pariso, "The transition towards to the circular economy: European SMEs' trajectories," *Entrepreneurship and Sustainability Issues*, vol. 8, no. 4, pp. 1-16, 2021.

[15] M. C. Türkeş, I. Oncioiu, H. D. Aslam, A. Marin-Pantelescu, D. I. Topor, and S. Căpuşneanu, "Drivers and barriers in using industry 4.0: A perspective of SMEs in Romania," *Processes*, vol. 7, no. 3, p. 153, 2019. https://doi.org/10.3390/pr7030153

[16] L. Milios, "Towards a circular economy taxation framework: Expectations and challenges of implementation," *Circular Economy and Sustainability*, vol. 1, no. 2, pp. 477-498, 2021.

[17] M. Lewandowski, "Designing the business models for circular economy—Towards the conceptual framework," *Sustainability*, vol. 8, no. 1, pp. 1-43, 2016. https://doi.org/10.3390/su8010043

[18] U. Awan and R. Sroufe, "Sustainability in the circular economy: Insights and dynamics of designing circular business models," *Applied Sciences*, vol. 12, no. 3, p. 1521, 2022. https://doi.org/10.3390/app12031521

[19] V. De Marchi, "Environmental innovation and R&D cooperation: Empirical evidence from Spanish manufacturing firms," *Research Policy*, vol. 41, no. 3, pp. 614-623, 2012. https://doi.org/10.1016/j.respol.2011.10.004

[20] M. Robaina, J. Villar, and E. T. Pereira, "The determinants for a circular economy in Europe," *Environmental Science and Pollution Research*, vol. 27, no. 11, pp. 12566-12578, 2020.

[21] A. Montanaro, "SMEs and circular economy drivers: Empirical evidence from Italy," *Sinappsi*, vol. 12, no. 3, pp. 92-111 2023.

[22] A. Pinget, R. Bocquet, and C. Mothe, "Barriers to environmental innovation in SMEs: Empirical evidence from French firms," *M@ n@ gement*, vol. 18, no. 2, pp. 132-155, 2015.

[23] J. G. D. Gorzelany, L. Luty, K. Firlej, M. Gaisch, O. Dudziak, and C. Scott, "Finding links between organisation's culture and innovation. The impact of organisational culture on university innovativeness," *PloS One*, vol. 16, no. 10, p. e0257962, 2021.

[24] F. Nwaiwu, M. Duduci, F. Chromjakova, and C.-A. F. Otekhile, "Industry 4.0 concepts within the Czech SME manufacturing sector: An empirical assessment of critical success factors," *Business: Theory and Practice*, vol. 21, no. 1, pp. 58-70, 2020. https://doi.org/10.3846/btp.2020.10712

[25] B. Fura, M. Stec, and T. Miś, "Statistical evaluation of the level of development of circular economy in European Union member countries," *Energies*, vol. 13, no. 23, p. 6401, 2020. https://doi.org/10.3390/en13236401

[26] D. Streimikiene, T. Baležentis, A. Volkov, M. Morkūnas, A. Žičkienė, and J. Streimikis, "Barriers and drivers of renewable energy penetration in rural areas," *Energies*, vol. 14, no. 20, pp. 1-28, 2021.

[27] F. U. Rehman, B. M. Al-Ghazali, A. G. Haddad, E. A. Qahwash, and M. S. Sohail, "Exploring the reverse relationship between circular economy innovation and digital sustainability—the dual mediation of government incentives," *Sustainability*, vol. 15, no. 6, p. 5181, 2023. https://doi.org/10.3390/su15065181

[28] E. Pawlik, W. Ijomah, J. Corney, and D. Powell, "Exploring the application of lean best practices in remanufacturing: Empirical insights into the benefits and barriers," *Sustainability*, vol. 14, no. 1, p. 149, 2021.

[29] J. Tóth, G. Migliore, J. M. Balogh, and G. Rizzo, "Exploring innovation adoption behavior for sustainable development: The case of Hungarian food sector," *Agronomy*, vol. 10, no. 4, p. 612, 2020. https://doi.org/10.3390/agronomy10040612

[30] M. Simionescu, "The circular economy and sustainable development in the European Union's new member states," *Economics, Management and Sustainability*, vol. 8, no. 1, pp. 6-15, 2023. https://doi.org/10.14254/jems.2023.8-1.1

[31] N. Gregson, M. Crang, S. Fuller, and H. Holmes, "Interrogating the circular economy: the moral economy of resource recovery in the EU," *Economy and Society*, vol. 44, no. 2, pp. 218-243, 2015.

[32] D. Lazarevic and H. Valve, "Narrating expectations for the circular economy: Towards a common and contested European transition," *Energy Research & Social Science*, vol. 31, pp. 60-69, 2017. https://doi.org/10.1016/j.erss.2017.06.001

[33] G. Cainelli, A. D'Amato, and M. Mazzanti, "Resource efficient eco-innovations for a circular economy: Evidence from EU firms," *Research Policy*, vol. 49, no. 1, p. 103827, 2020. https://doi.org/10.1016/j.respol.2019.103827

[34] C. F. Fratini, S. Georg, and M. S. Jørgensen, "Exploring circular economy imaginaries in European cities: A research agenda for the governance of urban sustainability transitions," *Journal of Cleaner Production*, vol. 228, pp. 974-989, 2019. https://doi.org/10.1016/j.jclepro.2019.04.061

[35] A. Biscione, R. Caruso, and A. de Felice, "Environmental innovation in European transition countries," *Applied Economics*, vol. 53, no. 5, pp. 521-535, 2021. https://doi.org/10.1080/00036846.2020.1746875

[36] A. A. Davidescu, A. M. Vass Paul, R.-M. Gogonea, and M. Zaharia, "Evaluating Romanian eco-innovation performances in European context," *Sustainability*, vol. 7, no. 9, pp. 12723-12757, 2015. https://doi.org/10.3390/su70912723

[37] T. Domenech, R. Bleischwitz, A. Doranova, D. Panayotopoulos, and L. Roman, "Mapping industrial symbiosis development in Europe: typologies of networks, characteristics, performance and contribution to the Circular Economy," *Resources, Conservation and Recycling*, vol. 141, pp. 76-98, 2019. https://doi.org/10.1016/j.resconrec.2018.10.024

[38] M. Proczek and M. Garbarczyk, "EU involvement in the financing of the blue economy," *Studia Europejskie-Studies in European Affairs*, vol. 27, no. 1, pp. 149-161, 2023.

[39] M. Wołek, A. Szmelter-Jarosz, M. Koniak, and A. Golejewska, "Transformation of trolleybus transport in Poland. Does in-motion charging (technology) matter?," *Sustainability*, vol. 12, no. 22, p. 9744, 2020. https://doi.org/10.3390/su12229744

[40] I. Taranic, A. Behrens, and C. Topi, "Understanding the circular economy in Europe, from resource efficiency to sharing platforms: The CEPS framework," CEPS Special Reports, No. (143), 2016.

[41] L. Melece, "Eco-innovation and its development in Baltic states," *Management Theory & Studies for Rural Business & Infrastructure Development*, vol. 37, no. 3, pp. 415-424, 2015.

[42] PTUJ Development Centre (RCP), "Progress Report Slovenia. SDG12 responsible consumption and production," Retrieved: https://www.sdgwatcheurope.org/wp-content/uploads/2020/09/SDG-12-Progress-report.pdf. [Accessed December 5, 2024], 2020.

[43] EEA, "Circular economy country profile – Croatia. ETC CE Report 2022/5 – Croatia ", Retrieved: https://www.eionet.europa.eu/etcs/etc-ce/products/etc-ce-products/etc-ce-report-5-2022-country-profiles-on-circular-economy/croatia-ce-country-profile-2022_for-publication.pdf. [Accessed December 10, 2024], 2022.

[44] A. Muscio, A. Reid, and L. Rivera Leon, "An empirical test of the regional innovation paradox: can smart specialisation overcome the paradox in Central and Eastern Europe?," *Journal of Economic Policy Reform*, vol. 18, no. 2, pp. 153-171, 2015. https://doi.org/10.1080/17487870.2015.1013545

[45] C. Garcés-Ayerbe, P. Rivera-Torres, I. Suárez-Perales, and D. I. Leyva-de la Hiz, "Is it possible to change from a linear to a circular economy? An overview of opportunities and barriers for European small and medium-sized enterprise companies," *International Journal of Environmental Research and Public Health*, vol. 16, no. 5, p. 851, 2019. https://doi.org/10.3390/ijerph16050851

[46] S. Lahane, R. Kant, and R. Shankar, "Circular supply chain management: A state-of-art review and future opportunities," *Journal of Cleaner Production*, vol. 258, p. 120859, 2020. https://doi.org/10.1016/j.jclepro.2020.120859

[47] S. Bag, S. Gupta, and C. Foropon, "Examining the role of dynamic remanufacturing capability on supply chain resilience in circular economy," *Management Decision*, vol. 57, no. 4, pp. 863-885, 2019. https://doi.org/10.1108/MD-03-2018-0242

[48] V. Ranta, L. Aarikka-Stenroos, P. Ritala, and S. J. Mäkinen, "Exploring institutional drivers and barriers of the circular economy: A cross-regional comparison of China, the US, and Europe," *Resources, Conservation and Recycling*, vol. 135, pp. 70-82, 2018. https://doi.org/10.1016/j.resconrec.2017.08.017

[49] A. Urbinati, P. Rosa, C. Sassanelli, D. Chiaroni, and S. Terzi, "Circular business models in the European manufacturing industry: A multiple case study analysis," *Journal of Cleaner Production*, vol. 274, p. 122964, 2020. https://doi.org/10.1016/j.jclepro.2020.122964

[50] C. Ghisetti and F. Pontoni, "Investigating policy and R&D effects on environmental innovation: A meta-analysis," *Ecological Economics*, vol. 118, pp. 57-66, 2015.

[51] F. Bassi and J. G. Dias, "The use of circular economy practices in SMEs across the EU," *Resources, Conservation and Recycling*, vol. 146, pp. 523-533, 2019. https://doi.org/10.1016/j.resconrec.2019.03.028

[52] R. Chaganti and F. Damanpour, "Institutional ownership, capital structure, and firm performance," *Strategic management journal*, vol. 12, no. 7, pp. 479-491, 1991. https://doi.org/10.1002/smj.4250120703

[53] M.-J. Chen and D. Miller, "The relational perspective as a business mindset: Managerial implications for East and West," *Academy of Management Perspectives*, vol. 25, no. 3, pp. 6-18, 2011. https://doi.org/10.5465/amp.2011.62741403

[54] A. De Jesus and S. Mendonça, "Lost in transition? Drivers and barriers in the eco-innovation road to the circular economy," *Ecological Economics*, vol. 145, pp. 75-89, 2018. https://doi.org/10.1016/j.ecolecon.2017.08.023

[55] P. Demirel and E. Kesidou, "Stimulating different types of eco-innovation in the UK: Government policies and firm motivations," *Ecological Economics*, vol. 70, no. 8, pp. 1546-1557, 2011. https://doi.org/10.1016/j.ecolecon.2011.04.019

[56] E. S. Roudbari, S. F. Ghomi, and M. S. Sajadieh, "Reverse logistics network design for product reuse, remanufacturing, recycling and refurbishing under uncertainty," *Journal of Manufacturing Systems*, vol. 60, pp. 473-486, 2021.

[57] Y. Qin, J. Harrison, and L. Chen, "A framework for the practice of corporate environmental responsibility in China," *Journal of Cleaner Production*, vol. 235, pp. 426-452, 2019. https://doi.org/10.1016/j.jclepro.2019.06.245

[58] D. Masi, V. Kumar, J. A. Garza-Reyes, and J. Godsell, "Towards a more circular economy: Exploring the awareness, practices, and barriers from a focal firm perspective," *Production Planning & Control*, vol. 29, no. 6, pp. 539-550, 2018. https://doi.org/10.1080/09537287.2018.1449246

[59] A. D. Tantau, M. A. Maassen, and L. Fratila, "Models for analyzing the dependencies between indicators for a circular economy in the European Union," *Sustainability*, vol. 10, no. 7, pp. 1-13, 2018.

[60] S. J. Long and J. Freese, *Regression models for categorical dependent variables using Stata*. Texas: Stata Press, 2006.

[61] A. Arundel and R. Kemp, "Measuring eco-innovation. UNU-MERIT Working Papers ISSN 1871-9872," Retrieved: https://kemp.unu-merit.nl/Arundel%20and%20Kemp%202009-017.pdf. [Accessed December 10, 2024], 2009.

[62] P. Del Río González, "The empirical analysis of the determinants for environmental technological change: A research agenda," *Ecological Economics*, vol. 68, no. 3, pp. 861-878, 2009. https://doi.org/10.1016/j.ecolecon.2008.06.015

Table 4.
Empirical results using logit estimations (Model 1-Model4)

	(circular_inno1)				***(circular_inno2)***			
VARIABLES	margins	SE	margins	SE	margins	SE	margins	SE
year	0.434**	(0.191)	0.395**	(0.190)	0.395**	(0.173)	0.404**	(0.173)
year2	-0.105**	(0.051)	-0.097*	(0.050)	-0.098**	(0.045)	-0.100**	(0.045)
export	0.132	(0.088)	0.126	(0.088)	0.340***	(0.084)	0.337***	(0.084)
Turnover								
More than 25,000 to 50,000 euro	0.096	(0.117)	0.111	(0.118)	-0.116	(0.109)	-0.126	(0.109)
More than 50,000 to 100,000 euro	0.193*	(0.117)	0.208*	(0.117)	-0.119	(0.110)	-0.127	(0.110)
More than 100,000 to 250,000 euro	0.144	(0.109)	0.147	(0.109)	-0.313***	(0.104)	-0.320***	(0.104)
More than 250,000 to 500,000 euro	0.229**	(0.110)	0.237**	(0.110)	-0.222**	(0.106)	-0.234**	(0.106)
More than 500,000 to 2 million euro	0.499***	(0.096)	0.517***	(0.096)	-0.176*	(0.091)	-0.183**	(0.092)
More than 2 to 10 million euro	0.708***	(0.101)	0.751***	(0.102)	-0.171*	(0.101)	-0.178*	(0.101)
More than 10 to 50 million euro	0.816***	(0.131)	0.871***	(0.133)	-0.181	(0.131)	-0.184	(0.131)
More than 50 million euro	0.985***	(0.235)	1.072***	(0.235)	0.143	(0.234)	0.134	(0.235)
Number of employees								
1 to 9 employees	-0.947***	(0.137)	-0.877***	(0.138)	0.029	(0.132)	0.011	(0.133)
10 to 49 employees	-0.511***	(0.132)	-0.499***	(0.133)	-0.021	(0.131)	-0.024	(0.131)
50 to 249 employees	-0.336**	(0.132)	-0.315**	(0.132)	0.001	(0.130)	-0.012	(0.131)
Investment								
1- 5% of annual turnover	0.342***	(0.063)	0.326***	(0.063)	0.348***	(0.061)	0.354***	(0.061)
6- 10% of annual turnover	0.119	(0.097)	0.101	(0.097)	0.335***	(0.094)	0.344***	(0.094)
11- 30% of annual turnover	0.213	(0.139)	0.181	(0.141)	0.462***	(0.137)	0.476***	(0.137)
More than 30% of annual turnover	0.169	(0.201)	0.132	(0.200)	0.367*	(0.194)	0.407**	(0.194)
Sectors of activities grouped								
Retail	-0.643***	(0.078)			-0.252***	(0.077)		
Services	-1.068***	(0.079)			-0.567***	(0.077)		
Industry	-0.652***	(0.080)			-0.118	(0.079)		
Sectors of activities details								
Profes/scient. and technical activities			-1.209***	(0.166)			-0.363**	(0.152)
Real estate activities			-1.709***	(0.273)			-0.848***	(0.230)
Financial and insurance activities			-2.118***	(0.260)			-0.349**	(0.173)
Information and communication			-1.519***	(0.169)			-0.321**	(0.139)
Accommodation and food service			-	(0.116)			-	(0.123)

activities			0.555***				0.649***	
Transportation and storage			-0.900***	(0.116)			-0.729***	(0.116)
Wholesale and retail trade, repair of motorcycles			-0.643***	(0.077)			-0.242***	(0.077)
Construction			-0.644***	(0.086)			-0.125	(0.084)
Water supply, sewerage, waste management			-0.474**	(0.204)			0.064	(0.199)
Electricity, gas, steam, and air conditioning			-0.936***	(0.208)			-0.129	(0.201)
Countries								
Estonia	-0.310**	(0.140)	-0.354**	(0.141)	-0.487***	(0.129)	-0.474***	(0.130)
Hungary	-0.262**	(0.132)	-0.288**	(0.134)	-0.586***	(0.124)	-0.579***	(0.124)
Latvia	-0.183	(0.142)	-0.202	(0.143)	-1.109***	(0.138)	-1.102***	(0.138)
Lithuania	-0.028	(0.136)	-0.053	(0.137)	-1.110***	(0.133)	-1.100***	(0.134)
Poland	-0.145	(0.132)	-0.130	(0.134)	-0.642***	(0.123)	-0.648***	(0.123)
Slovakia	-0.292**	(0.136)	-0.320**	(0.136)	0.061	(0.124)	0.058	(0.125)
Slovenia	0.042	(0.130)	0.041	(0.131)	-0.325***	(0.124)	-0.331***	(0.125)
Bulgaria	-0.265*	(0.139)	-0.293**	(0.141)	-1.008***	(0.136)	-1.019***	(0.137)
Romania	0.515***	(0.124)	0.497***	(0.125)	-0.210*	(0.120)	-0.211*	(0.120)
Croatia	-0.044	(0.128)	-0.064	(0.128)	-0.562***	(0.123)	-0.576***	(0.124)
North Macedonia	0.166	(0.150)	0.129	(0.150)	-1.730***	(0.162)	-1.736***	(0.163)
Montenegro	-0.339	(0.245)	-0.382	(0.253)	-1.362***	(0.278)	-1.379***	(0.276)
Serbia	0.314**	(0.134)	0.290**	(0.134)	-0.764***	(0.131)	-0.771***	(0.132)
Albania	-0.385	(0.291)	-0.342	(0.298)	-0.814***	(0.265)	-0.852***	(0.264)
Observations	6,346		6,346		6,346		6,346	

Note: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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