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CAPITAL QUALITY AND REGIONAL DISPARITIES: EVIDENCE FROM COMMERCIAL VEHICLE TRANSACTIONS

by Marta Crispino*, Michele Loberto* and Riccardo Russo*

Abstract

We investigate regional heterogeneity in capital quality between Southern and Northern Italy using a new dataset covering all transactions of commercial motor vehicles by Italian firms. The regional distribution of motor-vehicle quality – measured by vehicle age and environmental efficiency – closely mirrors the geography of labour productivity. Observable firm attributes and physical vehicle characteristics together account for approximately one third of the cross-regional variation in the quality of the motor vehicle stock, leaving a substantial residual attributable to structural and market-level factors. Geographic market segmentation and lower inflows of newly registered vehicles contribute to the lower quality of Southern Italy's stock, although inflows of newer second-hand vehicles from the North partially mitigate this gap. Regional disparities in the quality of motor vehicles widened between 2015 and 2024.

JEL Classification: D24, E22, R11, R12, L62.

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* Banca d'Italia.

1 Introduction¹

Since unification in 1861, Italy has experienced significant development disparities between its Southern and Northern regions (Felice, 2018; De Philippis et al., 2022), and these disparities remain large today.² The academic literature attributes the underdevelopment of the South to gaps in both employment and total factor productivity (Cannari and Franco, 2010; Accetturo et al., 2022). Meanwhile, the role of capital accumulation has received less attention, as capital deepening (i.e., the capital-labor ratio) in the South is comparable to, or even slightly higher than, that in the North. In this paper, we revisit the importance of capital by investigating regional disparities in its quality.

Capital quality refers to the extent to which capital goods incorporate technological progress (Solow, 1960; Hulten, 1992). Traditional development accounting assumes capital is uniform across countries and firms. However, capital quality varies significantly across firms, sectors, and countries, creating substantial heterogeneity that impacts both firm-level and aggregate productivity. Accounting for these differences is crucial for a more accurate assessment of the roles of capital and TFP in explaining development disparities and for identifying effective policies to address these inequalities (Greenwood et al., 1997; Caunedo and Keller, 2021). Unfortunately, the lack of detailed information on the capital stock has hindered these efforts.³

In this study, we investigate the degree of quality heterogeneity in the capital stock between Southern and Northern Italy, drawing on a newly constructed dataset encompassing all transactions of commercial and industrial motor vehicles conducted by legal entities from 2015 through 2024 (Crispino et al., 2026). Although transport equipment as a whole is a limited component of the total capital stock, motor vehicles are widely used across sectors

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²In 2024, the South's GDP per capita was approximately 25 thousand euros, compared with 45 thousand euros in the North (Istat, 2025a).

³Comparing the quality of different capital goods is a difficult task because it requires observing a rich set of characteristics of the assets and developing a ranking that takes into account several dimensions. The quality-adjusted price of investment goods provides a direct empirical measure of investment-specific technical progress (Greenwood et al., 1997). Capital-embodied technology increases the efficiency with which investment goods convert consumption into capital stocks. Therefore, technological advancements in the production of investment goods should reduce their constant-quality relative prices compared to those of consumption goods.

and exhibit a wide range of varieties, each characterized by distinct technological features and asset specificity. Compared to more specific assets, they are general-purpose capital goods adopted by firms with very different production technologies and that operate within a large and liquid secondary market, which makes their characteristics and prices highly comparable across users. For this reason, differences in the quality of vehicles purchased by firms are likely to reflect broader investment strategies and their propensity to adopt more advanced capital, making them informative about investment choices in other types of assets as well.⁴ Importantly, it is possible to derive precise and direct measures of capital quality at the individual asset level.

We assess motor vehicle quality through two complementary proxies. The first is vehicle age, measured from the date of first registration to the transaction date. This measure captures physical depreciation and provides a proxy for the technological vintage of the vehicle, although the date of first registration does not necessarily coincide with the introduction date of the model: newer models generally incorporate more advanced, capital-embedded technologies than their older counterparts (Bertolotti et al., 2023). The second proxy is a CO₂ emissions-based indicator à la Knittel (2011), designed to capture environmental efficiency conditional on observable vehicle characteristics. According to both variables, there are significant regional disparities in the quality of motor vehicles. Companies in the South acquire significantly older vehicles on average (about 9 years) than firms in the North (about 6 years). This gap is partly explained by a greater reliance on the used market: approximately two-thirds of acquisitions in the South involve second-hand vehicles, compared with about one-half in the North. However, compositional differences are not the whole story. Conditional on purchasing used vehicles, southern firms select assets that are themselves older (roughly 12 years on average, versus about 9.5 years in the North), indicating a shift toward lower-quality vintages within the secondary market as well. Consistent with these patterns, vehicles owned by southern firms remain in operation longer before exit: the average retirement age is about 15 years in the South, compared with roughly 12 years in the North. These longer service lives are also associated with significantly lower environmental efficiency, as reflected in higher emissions intensity holding other characteristics constant.⁵

⁴We will argue that our results could extend qualitatively to other physical asset classes, and we provide evidence supporting this conclusion. Clearly, we cannot claim that our quantitative results can be extrapolated to other asset classes.

⁵Our analysis focuses on transactions carried out by non-financial companies. We exclude dealers and firms operating in the automotive industry, for which motor vehicles are classified as inventories rather than fixed assets. We also omit rental companies, as their vehicle acquisition decisions are unlikely to be representative of investment choices for other types of capital goods.

The regional distribution of capital quality closely reflects the geographical dispersion of labor productivity. Regions with higher labor productivity also tend to exhibit a motor vehicle fleet of superior quality. Although our analysis does not establish the direction of causality, the evidence suggests that firm-specific characteristics play a substantial role in shaping this heterogeneity. To investigate this relationship more deeply, we estimate a series of regression models aimed at quantifying the extent to which variation in the quality of both acquired and retired capital can be attributed to differences in sectoral composition, firm characteristics (such as age, size, and profitability), and the technical attributes of vehicles. Our findings indicate that the combined influence of firm and vehicle characteristics accounts for approximately one-third of the observed variation in motor vehicle quality across regions.

These findings highlight that, while firm-specific and technical factors play a significant role, a large portion of the variation remains unexplained, suggesting that other structural or region-specific determinants may also influence the distribution of capital quality. One potential channel is access to finance: firms in the South are often documented to face higher borrowing costs and tighter credit conditions than their Northern counterparts, which may limit their ability to invest in newer capital.⁶ A second determinant may be played by regional heterogeneity in maintenance and adjustment costs. Lower maintenance costs in the South may increase the relative profitability of retaining older vehicles, while adjustment costs – typically higher for more specific assets – can reinforce the incentive to extend their service lives. Finally, the slow renewal of capital at the firm level is further exacerbated by the segmentation of secondary markets, which limits the reallocation of newer vintages across regions. Although some higher-quality vehicles flow from the North to the South, the predominance of older assets in local transactions prevents full convergence in capital quality.

Furthermore, our analysis documents another salient empirical fact: regional disparities in motor vehicle quality are not static but evolve over time. Specifically, we document that between 2015 and 2024, the quality of motor vehicles improved significantly more in the North than in the South. This asymmetric evolution is relevant because both the initial level and the temporal trajectory of capital quality directly shape the measurement of regional TFP disparities.

Related literature. This paper contributes to the extensive literature on the development

⁶We partly account for differences in firms' access to credit by incorporating a composite indicator of financial soundness, as calculated by CERVED, the data provider. However, even accounting for firms' characteristics, the cost of credit is higher in the South (Bottoni et al., 2022).

gaps between the South and the North in Italy. Accetturo et al. (2022) provide a comprehensive survey, while Accetturo et al. (2025) analyze the most recent trends. To summarize the main findings, the main factors determining lower GDP per capita in the South are as follows: (i) low labor market participation and lower availability of skilled labor, (ii) poorer infrastructure and lower quality public services, (iii) specialization in less advanced sectors and smaller businesses, (iv) greater difficulty in accessing credit, and (v) the spread of organized crime. An additional factor is the gradual reduction in capital intensity since the 1990s, which nevertheless remains higher than in the North. In this paper, we look at the quality of capital employed by companies in the South, focusing on motor vehicles acquired and disposed of by firms.

Our paper contributes to the literature on the role of capital-embodied technology in economic growth. Solow (1960) introduced the first model where different vintages of capital incorporate varying levels of technological innovation. Hulten (1992) showed that total factor productivity growth can be decomposed into capital-embodied technical change and disembodied technical change, estimating that a significant share of total factor productivity growth in the U.S. was due to embodied technological change in equipment. Also Greenwood et al. (1997) and Cummins and Violante (2002) estimated that investment-specific technological change accounted for a larger share of postwar U.S. growth than previously thought. Gordon (1990) provides empirical evidence about the quality improvement of capital goods over time. Several other works have shown the importance of capital embodied technology for economic growth (Caunedo et al., 2023; Greenwood et al., 2000; Samaniego, 2010; Krusell, 1998; Jones and Liu, 2024; Sakellaris and Vijselaar, 2005). Our work is particularly related to Caunedo and Keller (2021). Focusing on the agricultural sector, they provide evidence of systematic and significant cross-country differences in capital quality. Importantly, they reveal that, when adjusting for quality differences, the contribution of capital to explaining cross-country variation in agricultural labor productivity nearly doubles. We document notable differences in capital quality across Italy’s regions, which correspond to significant variations in labor productivity. Additionally, we observe a pattern of capital reallocation from more developed to less developed areas, aligning with the predictions of the literature on international trade in capital goods Smith (1976); Eaton and Kortum (2001).

This paper is organized as follows. Section 2 provides a brief exposition of the main development indicators at the regional level. Section 3 outlines the dataset. Section 4 examines the differences in vehicle quality across various regions and explores the reasons behind these differences. Section 5 concludes and discusses potential avenues for future

research.

2 Regional heterogeneity in economic development

Since the end of World War II, Italy has exhibited pronounced and persistent regional disparities in economic development, particularly between the South (*Mezzogiorno*) and the North. As documented by De Philippis et al. (2022), the South’s GDP per capita has consistently fluctuated between 50 and 60 percent of the level observed in the North. Between 2000 and 2022, the South’s average GDP per capita was approximately 56 percent of the North’s. The divide is even starker when comparing the poorest and richest regions (Figure 1a). For example, over the same period, the average per capita GDP was about €19,000 in Calabria and about €41,000 in Lombardy. Several structural and historical factors contribute to these persistent disparities. In this paper, we focus on the role of labor productivity and capital accumulation.

Labor productivity, measured as value added per hour worked, exhibits a regional distribution that closely mirrors GDP per capita differences (Figure 1b). Although the gap in labor productivity between the North and the South is narrower than the gap in GDP per capita, it remains economically significant. On average, from 2000 to 2022, labor productivity in the South was roughly 75 percent of that in the North.

Standard growth accounting frameworks decompose labor productivity into two components: capital deepening – proxied by the capital-labor ratio – and TFP. Figure 1c presents the regional distribution of the capital-labor ratio for 2000-2022.⁷ Interestingly, capital deepening does not align with the spatial pattern of labor productivity. On the contrary, the South displays a higher capital-labor ratio than the North, reflecting also the legacy of public investment in Southern regions before the 2000s. Therefore, at first glance, these data suggest that the South’s persistently lower labor productivity is attributable solely to its significantly lower TFP, rather than to a lack of physical capital.

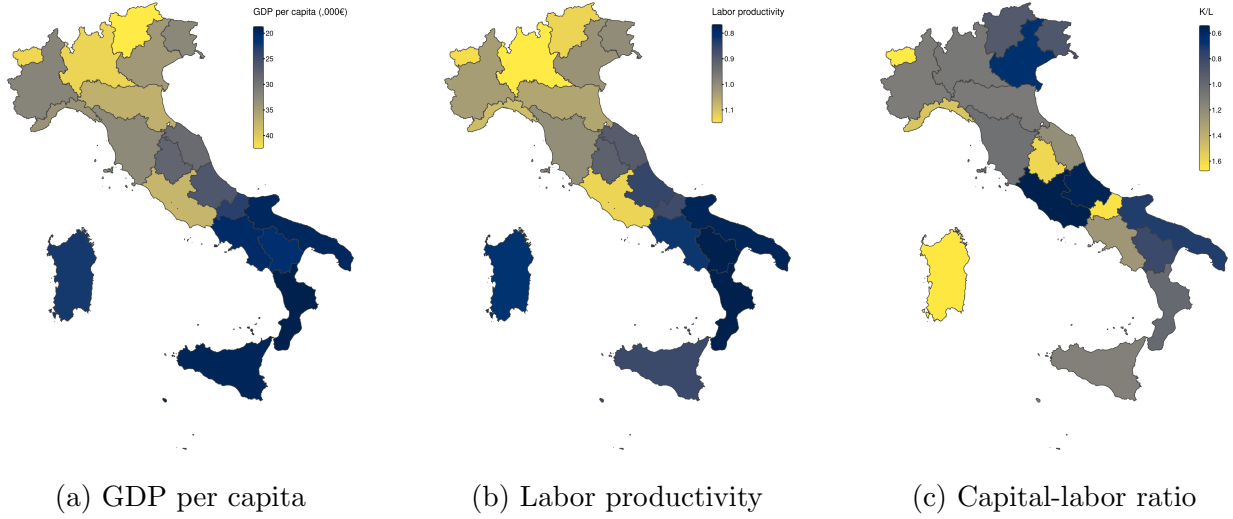
Unfortunately, the standard approach to estimating TFP treats capital as homogeneous and fails to account for quality improvements in new capital goods.⁸ Failing to account for capital-embedded technology leads to significant measurement errors in estimating the

⁷We exploit the constant-price regional capital stock estimates from the European Commission’s ARDECO dataset. For the labor input, we use the number of hours worked.

⁸With capital embedded technology, standard growth accounting based on a Cobb-Douglas production function implies that the change in output also depends on the rate of improvement in capital quality:

$$\Delta \ln Y = \alpha(\Delta \ln K + \Delta \ln q) + (1 - \alpha)\Delta \ln L + \Delta \ln A_d \quad (1)$$

Figure 1: HETEROGENEITY IN ECONOMIC DEVELOPMENT ACROSS ITALIAN REGIONS



Note: This chart presents the regional distribution of GDP per capita (panel a), labor productivity (panel b), and the capital to labor ratio (panel c) over the 2000-2022 period. GDP per capita is shown in thousands of euros, and labor productivity is measured as value added per hour worked. The capital-to-labor ratio is calculated as the capital stock divided by the number of hours worked. Both labor productivity and the capital-to-labor ratio are normalised by the national average. All data are sourced from ISTAT, except for the capital stock, which is sourced from the ARDECO database.

contributions of both capital and TFP to output growth. Specifically, neglecting the quality improvements embedded in new capital assets implies that TFP's contribution is inflated, as TFP implicitly captures gains that should be attributed to enhanced capital quality.⁹ Furthermore, when the rate of capital quality improvement varies across regions, this omission introduces bias into the regional comparison of TFP contributions. In such cases, regions with faster capital quality upgrading may appear to experience superior TFP growth, even though capital-embedded technological advances actually drive part of the observed performance.

Statistics on the regional capital stocks may not be sufficiently accurate to address this measurement issue. Therefore, we aim to gain insights into potential differences in capital quality across regions, focusing on a category of capital goods widely used: motor vehicles.

where K is the quantity of capital (measured in physical units), q is the efficiency index of new capital (capturing the extent to which each unit of newly invested capital embodies a higher level of technology relative to older vintages) and $\Delta \ln q$ is the rate of capital-quality improvement. $\Delta \ln A_d$ is the rate of disembodied TFP growth, i.e., the component of productivity improvement that is not attributable to improvements in the quality of capital goods.. See Hulten (1992) and Greenwood et al. (1997) for the derivation.

⁹Mistretta and Zollino (2021) show that accounting for technical progress embodied in capital goods has relevant implications for the assessment of TFP developments in Italy.

More broadly, our analysis provides evidence on both the absolute levels and the temporal dynamics of the average quality of motor vehicles across Italian regions.

3 Data

We exploit a comprehensive administrative dataset of motor vehicle transactions involving legal persons – whether as buyers, sellers, or both – across Italy from 2015 to 2024.¹⁰ This dataset encompasses all motor vehicle-related operations, including new vehicle registrations, used vehicle purchases and sales, capital and operating (rental) leases, and scrapping procedures.¹¹ For each operation, we identify the legal entities involved through the unique tax identifier number.¹²

The dataset comprises about 4 million vehicles used for passenger or goods transport. Our analysis focuses exclusively on vehicles acquired or disposed of by non-financial firms. Firms operating within the automotive sector – such as vehicle manufacturers, dealers, and leasing companies – are excluded, as motor vehicles represent inventory rather than capital assets for these entities. While the dataset contains transactions involving automotive industry participants, we include only transactions in which the buyer or the seller is a non-financial firm outside the automotive sector.¹³ Passenger cars are excluded from the sample because they may represent employee benefits-in-kind rather than productive capital assets. This approach ensures that the dataset reflects vehicle acquisitions and disposals relevant to the analysis of capital investments by non-financial firms.

In our baseline analysis, we exclude acquisitions conducted through leasing arrangements. The rationale for this exclusion is that, under leasing agreements, firms do not obtain legal ownership of the assets. Under prevailing accounting standards, only vehicles directly owned by the firm qualify as part of its capital stock. However, to ensure the robustness of our findings, these acquisitions will be incorporated into a supplementary analysis; we will account for all vehicles that firms can employ in their production processes, regardless of ownership status. This approach allows us to evaluate whether including leased assets materially alters

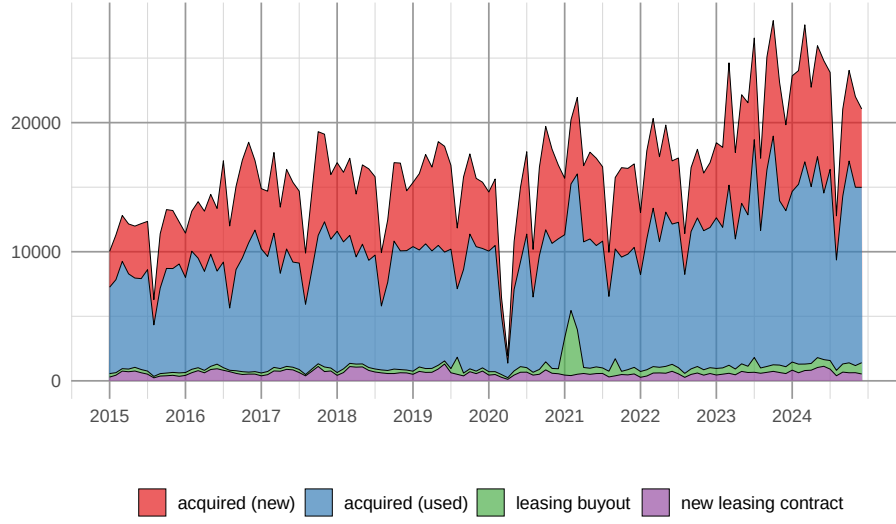
¹⁰These data are regularly collected by the Italian Department of Transport. See Crispino et al. (2026) for an extensive description of the dataset.

¹¹By scrapping procedures, we mean all those procedures that cause the cancellation of the license plate. Then, the vehicle can no longer be driven in Italy. These reasons include scrapping, sales abroad, and other circumstances in which the owner cannot use the vehicle (e.g., theft).

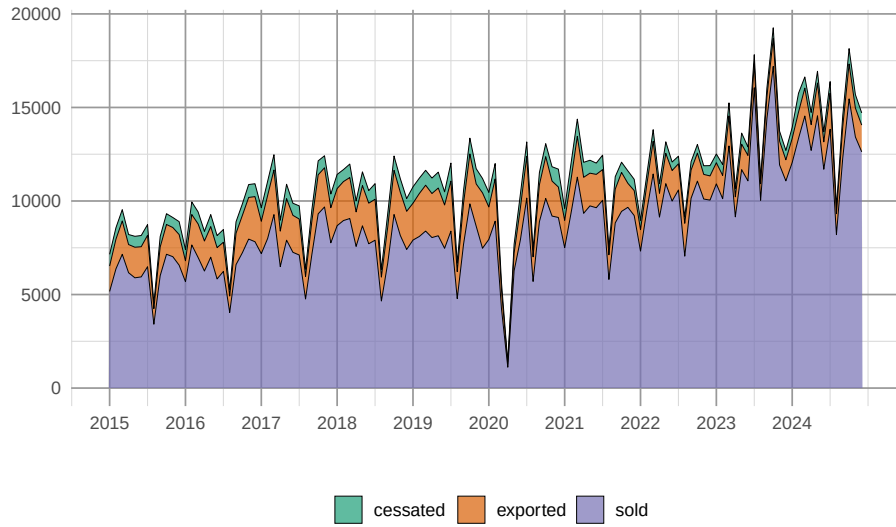
¹²For capital and operating leases, we only identify the lessee.

¹³Specifically, we exclude all transactions conducted by automotive firms with financial institutions, private individuals, or other automotive firms.

Figure 2: TEMPORAL TRENDS IN VEHICLES' OPERATIONS



(a) Acquisitions



(b) Disposals

Note: This chart reports the evolution of vehicle acquisitions (panel a) and disposals (panel b) made by non-financial firms between 2015 and 2024. Operations by dealers, renters, vehicle manufacturers, and financial intermediaries are excluded. Acquisitions of used vehicles include imports. New leasing contracts refer to new vehicles acquired under a capital lease. Monthly data.

results and to capture firms' broader operational capacity beyond their owned capital assets.

For each vehicle in the sample, we record its unique Vehicle Identification Number (VIN) along with a comprehensive set of descriptive attributes. These attributes include the official

UNECE/EU vehicle category, body type, make and model, engine horsepower, fuel type, European emissions standard classification, detailed pollutant emission data, date of first registration, and gross vehicle weight. Approximately 79 percent of the vehicles in the sample are light-duty commercial trucks (Table B1), 13 percent are medium- or heavy-duty trucks, and around 8 percent are buses or small passenger vans. Leveraging information on body type, we can assign different levels of specificity to vehicles, ranging from a standard light commercial van to highly specialized vehicles such as concrete mixer trucks. Roughly 12 percent of the vehicles are categorized at a high level of specificity (Table B2).¹⁴

As of December, 2024, approximately 1.9 million vehicles (out of the 4 million observed over the 2015-2024 period) were still held by non-financial, non-automotive firms. The remaining 2.1 million vehicles were no longer in these firms' possession, primarily because they had been sold to other types of buyers (e.g., households, public administrations, financial or automotive firms), exported, or scrapped. The average age of these vehicles was 9.4 years; however, considerable heterogeneity exists across vehicle types. Light-duty commercial vehicles were, on average, 9 years old, whereas heavy-duty trucks were 12 years old.

On average, approximately 56 percent of vehicle acquisitions observed between 2015 and 2024 are used-vehicle purchases (Figure 2a and Table B3). By contrast, purchases of newly registered vehicles represent only 30 percent of total acquisitions. The remaining acquisitions are new leasing contracts and leasing buyouts. Regarding vehicle disposals (Figure 2b), most operations involve the sale of used vehicles on the domestic market. Scrapped or exported vehicles account for only 23 percent of total disposals. Following the onset of the COVID-19 pandemic, data indicate a decline in both the share of newly registered vehicles and the share of vehicles scrapped or sold abroad. At the same time, the number of transactions in the domestic used-vehicle market has increased markedly. These patterns are likely due to supply bottlenecks observed since 2021 (Darmouni and Sutherland, 2024).

In addition to vehicle-level data, the dataset incorporates comprehensive firm-level information compiled from multiple sources. We leverage the Italian business registry (Info-Camere) to identify each firm's NACE industry classification, as well as its dates of incorporation and, where applicable, termination. Overall, the dataset encompasses 863,362 firms that conducted at least one vehicle-related activity between 2015 and 2024. We obtain data

¹⁴The specificity classification is based on the body type of the vehicle, which is used to determine its level of specialization. General-purpose vehicles, such as small commercial vans and trucks without specific features, are assigned a lower specificity rank (1-2). Highly specialized vehicles, such as refrigerated trucks, concrete mixers, and specialized transport vehicles (e.g., animal transport or hazardous goods vehicles) are assigned higher specificity ranks (3-4-5). In Table B4, we report the full classification.

on the number of employees for each firm from the National Institute for Social Security (INPS). For approximately half of the firms, we also have access to their financial statements (CERVED). These statements enable the computation of firm-level productivity and financial soundness indicators. Table B5 presents descriptive statistics on the composition of the firm-level database, including the distribution of firms by age, employment size, and financial data availability. Figure B1 shows how firms' vehicle acquisitions and disposal are distributed across activity macrosectors.

4 The heterogeneity in the quality of motor vehicles

Motor vehicles are widely used across sectors and exhibit a wide range of varieties, each characterized by distinct features and asset specificity.¹⁵ Therefore, observing how their quality varies across firms can be informative about firms' choices regarding other asset types.¹⁶

We measure motor vehicle quality by using two complementary proxies. The first is vehicle age, which captures depreciation but also technological vintage: newer models typically embody more advanced capital-embedded technologies than older vehicles (Bertolotti et al., 2023). The second proxy is a CO₂ emissions-based indicator designed to capture environmental efficiency. A lower value of this indicator indicates that a vehicle produces less CO₂ for a given set of characteristics. This indicator also reflects fuel efficiency, given the close relationship between fuel consumption and CO₂ emissions.¹⁷

The two measures are closely interrelated, as newer vehicles typically exhibit higher environmental efficiency. Nevertheless, each measure possesses limitations and advantages. The environmental efficiency indicator is more precise because vehicles of the same age can vary significantly in efficiency. However, this measure applies only to light-duty commercial vehicles, as standardized data on emissions and fuel consumption are available exclusively for this category and passenger cars. Instead, the age is available for all vehicles. Consequently, we will use vehicle age as our principal proxy for asset quality, but we will show that similar

¹⁵Between 2015 and 2024, transport equipment accounted on average for nearly 19 percent of the stock of machinery and equipment in the Italian private sector (Table B6). However, its importance varied substantially across industries. In manufacturing, transport equipment represented only 2.7 percent of the stock of machinery and equipment, whereas in the transportation sector its share reached 76.1 percent. Motor vehicles constitute the predominant component of transport equipment in most industries, but in the transportation sector other relevant assets are ships and aircraft.

¹⁶We will discuss to what extent our results could be generalized to other assets in Section 4.3.

¹⁷We follow the methodology proposed by Knittel (2011). We provide the details in Appendix A.

Figure 3: QUALITY OF VEHICLES AT THE MOMENT OF ACQUISITION AND DISPOSAL



(a) Acquisitions

(b) Disposals

Note: Average age (top panels) and average CO₂ emission index (bottom panels) of all vehicles at the moment of operation (left: acquisition; right: disposal). Acquisitions include the following operations: purchase of a new or used vehicle, lease buyout, and imports. Disposals include: demolition, sale of a used vehicle, exportation, and other deregistrations. Intermediaries are excluded from the analysis. Similar results are shown in Figures B2a and B2b using median values.

conclusions can be drawn using the indicator of emission efficiency.

We begin our analysis by examining the average vehicle age across regions. At the time of acquisition, vehicles in the North are, on average, younger than in the South (5.7 and 8.9 years old, respectively). A qualitatively similar pattern emerges when considering the age of vehicles at disposal. Vehicles in the Northern regions tend to be dismissed earlier (12.2 years), whereas those in the Southern regions remain in use longer (14.8 years). Figure 3 (top panels) illustrates that these regional disparities in vehicle age – both at acquisition and at disposal – not only persist over time but have widened. For instance, during the 2015-2016 period, the difference in vehicle acquisition age between the South and the North was 2.8 years, while the difference at disposal was 2 years. By 2023-2024, these gaps had

expanded to 3.4 and 3.6 years, respectively, suggesting an increasing divergence in vehicle life cycles across regions. These differences in average age partly reflect heterogeneity in the composition of acquisitions across regions. As shown in Figure B8, Southern firms rely much more heavily on the purchase of used vehicles, which account for roughly two-thirds of acquisitions, compared with about one-half in the North. We replicate the analysis restricting the sample to transactions in the secondary market only. The results are qualitatively unchanged, with similar North-South gaps in age. The corresponding figure is reported in the Appendix (Figure B3).

Our CO₂ emissions-based indicator yields results that closely mirror the age-based analysis (Figure 3, bottom panels). The average environmental efficiency is structurally lower in the South than in the North. Over time, both regions have exhibited notable improvements in vehicle quality, reflecting the progressive incorporation of new technology into new models. Overall, compared to 2015, the efficiency of acquired (disposed) vehicles has improved by 25 (28) percent in the North and by only 21 (22) percent in the South, illustrating both improvements in vehicle quality and the uneven pace of technological adoption across regions.¹⁸

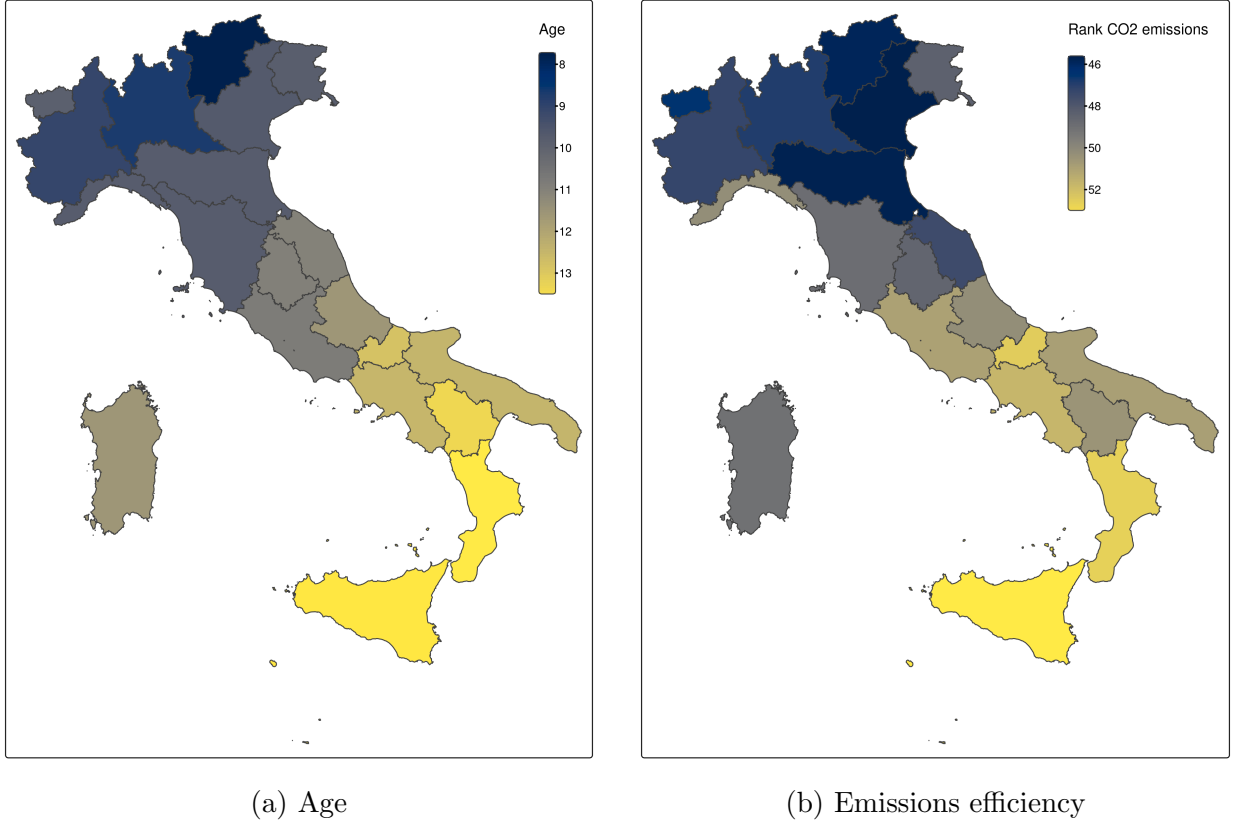
These acquisition and disposal patterns suggest that the overall stock of motor vehicles in the Southern regions is significantly lower in quality than in the North. To provide a quantitative assessment of these differences, we leverage the full transaction dataset and estimate each firm’s vehicle stock as of the end of 2024.¹⁹ Figure 4a illustrates the pronounced geographical heterogeneity in these quality measures. Northern regions maintain a younger motor vehicle fleet, with an average vehicle age of approximately 9.1 years at the end of 2024. In contrast, the stock in the South is on average 12.7 years old. Looking at the emissions-efficiency indicator (Figure 4b), we find similar results in the spatial patterns of vehicle quality. At the same time, however, the number of vehicles per employee is higher in the South, consistently with the spatial distribution of the capital-labor ratio implied by the Regional accounts (Figure B5).²⁰

¹⁸As a robustness check, we replicate the analysis focusing on a homogeneous subset of vehicles (N1) and excluding electric vehicles. As shown in Figure B4, the results remain unchanged: vehicle quality improves over time in all regions, but the North consistently exhibits a faster pace of improvement than the South.

¹⁹These estimates are necessarily partial, as they reflect only vehicles purchased or decommissioned within the preceding ten years. However, the 10-year horizon provides a sufficiently robust basis for a comparison across regions.

²⁰The estimate of the ratio of vehicles to employees is based on our estimate of the vehicle stock of non-financial companies at the end of 2024, inferred from observed flows over the past 10 years. Employee data refers to companies with at least one vehicle and corresponds to 2023. A potential problem with this estimate is that employee irregularity rates are much higher in the South than in the North, which

Figure 4: QUALITY OF THE VEHICLE FLEET



Note: Average age (a) and average CO₂ rank index (b) of the estimated vehicle stock as of December 2024 over Italian regions. Electric vehicles have rank zero.

Most importantly, unlike the conventional capital-labor ratio, our measures of capital stock quality exhibit a strong correlation with labor productivity. Specifically, at the NUTS-2 regional level, the correlation between labor productivity and the average age of the capital stock is -0.87 (Figure 5).²¹ This correlation is consistent with evidence on the operational performance of commercial vehicles. For example, a light-duty commercial vehicle less than 5 years old travels approximately 21,000 km per year, while a vehicle aged 10-19 years travels

may lead to an overestimation of vehicles per employee in the South. To address this, we also used total hours worked in the private non-financial sector from the Regional Accounts, which account for the different rates of irregularity. Even using this alternative measure, the vehicle-to-labor ratio remains higher in the South. Another limitation is that the reconstructed stock provides a lower bound on the actual capital stock, because vehicles acquired before 2015 that do not appear in any post-2015 transaction remain unobserved. This underestimation occurs in all regions but it is likely more pronounced in the South, where the average vehicle age at disposal is higher, and less severe in the North, where turnover is higher and the fleet is younger.

²¹The correlation between labor productivity and the average emission efficiency of the capital stock is -0.65.

only about 11,000 km (Istat, 2025b).

Figure B6 shows that the negative correlation between labor productivity and the age of the vehicle stock also emerges when the analysis is conducted separately by sector. The sectors considered differ substantially in their reliance on transport equipment, ranging from manufacturing, where transport assets represent a relatively small share of the capital stock, to transportation and storage, where vehicles constitute the core production input (Table B6). Intermediate cases include construction and wholesale and retail trade, where transport equipment plays a more relevant, although not dominant, role in production. The relationship is visible across most sectors, suggesting that the aggregate pattern documented in Figure 5 is not driven by a single industry. If anything, the correlation appears somewhat weaker in the transportation sector.²² From an economic perspective, this evidence reinforces the interpretation that the aggregate correlation between capital quality and labor productivity reflects a broad phenomenon affecting multiple sectors rather than being mechanically driven by industries with the highest intensity of motor-vehicle use.

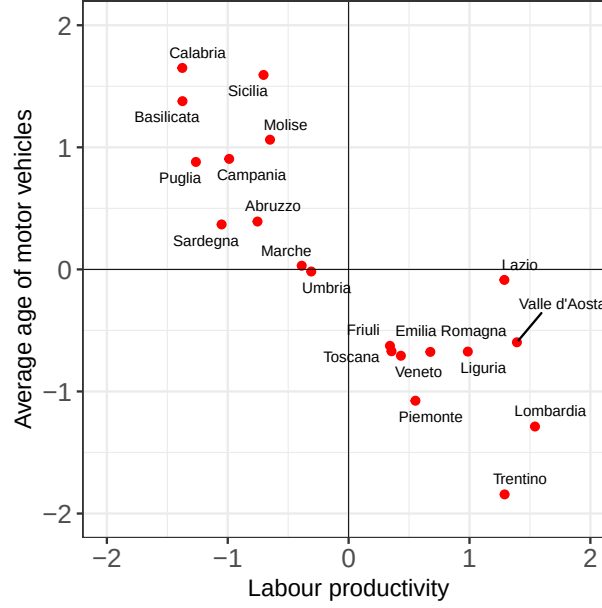
As outlined in the preceding section, our analysis focuses exclusively on vehicles directly owned by non-financial firms. However, companies in the Southern regions may rely more on leasing to acquire newer, higher-quality capital assets. Consequently, by considering only owned vehicles, we may underestimate the actual quality of capital employed by southern firms. To address this potential bias, we repeated the previous analysis to include leased vehicles, both capital and operating leases.²³ When leased vehicles are included, the average vehicle age decreases, reflecting the fact that a considerable share of newly acquired vehicles enters firms' stock through leasing arrangements rather than direct purchases. Nonetheless, this leasing practice is common to all regions. As a result, the relative quality differences between northern and southern firms, as well as the temporal trend in these differences, remain largely unchanged (see Figure B7).

This heterogeneity in capital quality, if widespread across physical assets, would hold significant implications for growth accounting and our understanding of the developmental disparities between the Southern and Northern regions. We will elaborate on these issues in Section 5. In the next section, instead, we will explore the underlying causes of these

²²This result is influenced by a small number of outliers. In particular, Calabria and Valle d'Aosta display unusually high levels of labor productivity in the transportation and storage sector. A plausible explanation is the presence of major transport and logistics infrastructures in these regions, such as the Port of Gioia Tauro in Calabria and the Alpine transit corridors crossing Valle d'Aosta, which may disproportionately increase measured productivity in the transportation sector.

²³To prevent double counting, vehicles that had been fully redeemed from leases were excluded from the calculation.

Figure 5: LABOR PRODUCTIVITY AND THE AGE OF VEHICLE STOCK



Note: This chart reports a scatter plot of the labor productivity and the average age of the stock of vehicles at the NUTS-2 administrative level. Labor productivity is computed as the average ratio of value added to hours worked over the 2000-2022 period. Both statistics are available in the Regional accounts (Istat). The average age of the vehicle fleet is computed on the stock of vehicles at the end of 2024. Labor productivity and the average age of the vehicle fleet are standardized.

substantial differences in motor vehicle quality.

4.1 Capital quality and firms' characteristics

Several interrelated factors can explain differences in motor vehicle quality between the North and the South. One potential factor is sectoral specialization, which can affect the types of vehicles utilized in the production process.²⁴ Within the same production sector, vehicle quality can vary significantly due to differences in firms' characteristics between the North and the South. The more productive firms are likely to invest in the most efficient capital vintages, which are also the most expensive. Financially constrained firms are more likely to purchase old capital because they typically have lower liquidity and are in a more fragile financial position (Ma et al., 2022; Lanteri and Rampini, 2023; Crispino et al., 2026). Finally, an additional factor is the possible regional differences in the adjustment costs, especially

²⁴For instance, heavy-duty trucks employed in the construction sector tend to be older on average compared to light-duty trucks used in the retail trade sector. Consequently, the greater relevance of the construction sector in the South may contribute to the observed heterogeneity in vehicle age across these regions.

for upgrading to the most efficient capital vintages.²⁵

In this study, we employ microdata on individual vehicle acquisitions and disposals to evaluate the extent to which these factors account for the regional quality differentials we documented in the previous section. Specifically, we assume the following model for the choice of the quality of physical capital:

$$y_{i,j,k,t} = F(\alpha_k, \delta_t, R_j, \mathbf{X}_i, \mathbf{Z}_j) \quad (2)$$

where $y_{i,j,k,t}$ is the proxy of quality (the age or the indicator of emission efficiency) of vehicle i , acquired or dismissed by firm j , belonging to sector k , in year t ; α_k is a set of 3-digit NACE sectors fixed effects and δ_t are year fixed effects;²⁶ R_j is a categorical variable for the NUTS-1 region (North, Center, South); $\mathbf{X}_i$ is a vector including a set of characteristics of the vehicle, and $\mathbf{Z}_j$ is a vector of the characteristics of the firm. The function $F(\cdot)$ is a reduced-form relationship approximated through parametric regression models, whose specification is explicitly specified case by case in the empirical exercises and varies depending on the nature of the dependent variable.

In this analysis, we examine a sample of 1.6 million transactions (acquisitions and disposals) conducted by incorporated firms for which comprehensive financial statement data are available.²⁷ Our primary focus is on the coefficients of variable R , which quantify the average difference in the dependent variable between the North and the other two macro regions, the Center and the South. We will incrementally incorporate variables $\mathbf{X}$ and $\mathbf{Z}$ to determine which variable accounts for the regional disparities.²⁸

Given that vehicle age is a non-negative integer variable with a markedly right-skewed distribution and variance exceeding the mean, we estimate a set of negative binomial models. This specification is used as a flexible generalized linear model for non-negative outcomes (Cameron and Trivedi, 2013), accommodating overdispersion and allowing the conditional

²⁵Firms may incur substantial expenses when replacing old capital or altering their capital stock size. This is especially relevant if there is a scarcity of suppliers specialized in installing the most advanced capital. Consequently, if there is less supply of these services in the South, firms might encounter greater challenges in acquiring the latest capital.

²⁶The inclusion of a year-by-sector interaction fixed effect does not change the results.

²⁷The results retrieved from this sample would remain consistent with those obtained from the entire dataset, provided we restrict our analysis to the variables available in the full sample. These variables include the 3-digit NACE sector, firm age, and the number of employees. The results are available on request.

²⁸The coefficients associated with individual variables do not have a causal interpretation due to the presence of selection bias in our sample. It is highly likely that the factors influencing the decision regarding vehicle quality also impact the decision to acquire or dispose of vehicles.

mean of vehicle age to depend multiplicatively on firm-level and regional characteristics. This approach avoids the restrictive functional-form and homoskedasticity assumptions of a linear model while providing a direct characterization of differences in expected age across observational units.

Column 1 of Table 1 reports the unconditional average differences in vehicle age for both purchased vehicles (Panel A) and dismissed vehicles (Panel B). The results align with the patterns illustrated in Figure 3. In the South, the average age of acquired vehicles is approximately 50 percent higher than in the North.²⁹ Similarly, for dismissed vehicles, the average age is higher by roughly 20 percent compared to the North.

We focus on differences in outcomes between the South and the North; results for the Center relative to the North are qualitatively similar and therefore omitted for brevity. In the first specification, we control for the vehicles' physical characteristics (Column 2).³⁰ The average difference in vehicle age between the South and the North declines to 40 percent for acquisitions and 12 percent for disposals. Next, we enrich the model by incorporating firm-level characteristics, including firm age, NACE 3-digit sector fixed effects, and the number of employees (Column 3). With the introduction of these controls, the South-North difference further decreases to 32 percent for acquisitions and remains at 12 percent for disposals. In the last specification, we include an extended set of firm-level variables: total assets, labor productivity, the cash-to-assets ratio, and a composite indicator of financial soundness.³¹ As reported in Column 4, even after controlling for this comprehensive array of firm attributes, a statistically significant difference in the average age of both acquired and disposed vehicles persists (30 and 12 percent, respectively). Overall, the combined influence of vehicle and firm characteristics accounts for approximately one-third of the observed variation in the average age of motor vehicles, suggesting that regional disparities are only partially explained by these observable factors.³² Results do not change even if we account for potential replacement needs or the occurrence of other similar operations (column 5).³³

²⁹We get this estimate by taking the exponential of the parameter of the negative binomial regression.

³⁰The physical characteristics of the vehicles included in the regressions are the following: weight, horsepower, body type, vehicle type, and fuel type.

³¹The indicator of financial soundness is a score classifying firms into three categories according to the probability of default. The score is a discretization of the probability of default, and it is computed by CERVED, the data provider. Further information can be found in Rodano et al. (2018).

³²The results would be robust even when controlling for TFP deciles rather than linearly for labor productivity.

³³We incorporate as covariates both the number of acquisitions and disposals occurring in year t , as well as two dummy variables indicating whether the firm acquired or disposed of at least one vehicle in the previous year. These variables control for firm-specific dynamics that may influence asset turnover.

Table 1: DETERMINANTS OF THE HETEROGENEITY. AGE

Dependent Variable:	Age of the vehicle (days)				
	(1)	(2)	(3)	(4)	(5)
<i>Panel A - Acquisitions</i>					
<i>Variables</i>					
Center	0.20*** (0.03)	0.18*** (0.03)	0.15*** (0.02)	0.13*** (0.02)	0.14*** (0.02)
South	0.45*** (0.04)	0.39*** (0.03)	0.32*** (0.03)	0.31*** (0.03)	0.31*** (0.03)
Observations	896,980	896,970	896,950	896,950	896,950
<i>Panel B - Disposals</i>					
Center	0.05*** (0.009)	0.04*** (0.007)	0.04*** (0.006)	0.03*** (0.006)	0.03*** (0.006)
South	0.19*** (0.01)	0.12*** (0.010)	0.12*** (0.007)	0.11*** (0.007)	0.11*** (0.007)
Observations	723,645	723,645	723,645	723,645	723,645
<i>Controls</i>					
Year	Yes	Yes	Yes	Yes	Yes
Vehicle characteristics		Yes	Yes	Yes	Yes
Sector			Yes	Yes	Yes
Size (employees)			Yes	Yes	Yes
Other firms' characteristics				Yes	Yes
Other operations					Yes

Note: This table presents the results of a negative binomial regression of the age of a motor vehicle on a set of firms and vehicle characteristics. Panel (a) reports the results for the acquisition operations (new vehicle purchases, used vehicle purchases, and lease buyout). Panel (b) refers to disposal operations (used vehicle sales, sales abroad, scrapping). The age of the vehicle is measured at the day of the operation. Vehicle characteristics include weight, horsepower, body type, vehicle type, and fuel type. We control for the sector of economic activity by including NACE 3-digit sector fixed effects. Other firm characteristics include total assets, labor productivity, the cash-to-assets ratio, and a composite indicator of financial soundness. We control for the occurrence of other operations by including as covariates the number of acquisitions and disposals occurring in year t , as well as two dummy variables indicating whether the firm acquired or disposed of at least one vehicle in the previous year. Standard errors are clustered at the sector and year level. Tables B7 and B8 show the estimates of the other coefficients.

As a robustness check, we re-estimate our baseline specifications using alternative econometric models. The results are largely unchanged when the negative binomial model is replaced by a Poisson specification (Table B9), suggesting that our findings are not driven by the particular distributional assumptions imposed by the baseline estimator. By contrast, the OLS specification based on the logarithm of vehicle age performs less satisfactorily in the acquisition sample. The reason is that acquisitions include newly registered vehicles,

generating a large mass of observations at zero age.³⁴ The comparison across estimators is considerably more favorable when focusing on vehicle disposals. In this case, the dependent variable does not exhibit a mass point at zero because disposed vehicles are vehicles that have already spent at least one period in the fleet before being sold or scrapped, so their age cannot in general be equal to zero at the time of disposal. As a result, the logarithmic transformation is well defined for (virtually) the entire sample, and the OLS estimates align more closely with those obtained from the Poisson and negative binomial specifications, as shown in Table B9.

Our analysis yields comparable results when we use as a proxy for vehicle quality the emissions efficiency indicator (Table B10).³⁵ Firm and vehicle characteristics explain approximately one-third of the observed unconditional variation in emissions efficiency of the acquired vehicles between the South and the North, consistent with the results about the age of the vehicles. Regarding disposals, the share of variation in vehicle efficiency explained by the same observables is much lower, but this may reflect some limitations of our data.³⁶

To account for the potential role of heterogeneous adjustment costs, we re-estimate our baseline specification across assets with varying degrees of specificity. While adjustment costs are not expected to be a major constraint for motor-vehicle investment, replacing or adapting less specific assets is plausibly easier than replacing highly specialized ones. Moreover, highly specific capital is typically supplied by specialized producers, who are likely more prevalent in the North than in the South. If adjustment costs significantly affected firms' investment decisions, we would expect the North-South differences in vehicle age to be more pronounced for assets with higher specificity.

Table 2 reports the results of these regressions.³⁷ Focusing first on acquisitions (Panel A), vehicles acquired in the South are consistently older than those acquired in the North,

³⁴This concentration at the lower bound makes the logarithmic transformation less appropriate from a statistical perspective and weakens the comparability between the OLS estimates and those obtained from count-data models. As shown in Table B9, the quantitative differences between the OLS and count-model estimates are indeed larger in the acquisition sample.

³⁵Given that the emission efficiency indicator is approximately normally distributed, we apply a standard Ordinary Least Squares (OLS) regression. For this specification, the set of vehicle characteristics included in the regression differs from that considered in the analysis of vehicle age. Specifically, we exclude vehicle weight and horsepower because they are already incorporated into the construction of the emission efficiency indicator.

³⁶This result could be influenced by the fact that emissions data is often unavailable for older vehicles. This could introduce sample selection bias, reducing the accuracy of the estimates.

³⁷We focus on the average vehicle age because most of the highly specific vehicles in our sample consist of medium- and heavy-duty trucks. For these vehicles, there are no clearly defined emission standards, which prevents us from calculating our efficiency indicator.

Table 2: DETERMINANTS OF THE HETEROGENEITY AND VEHICLE SPECIFICITY

Dependent Variable:	Age of the vehicle (days)			
	Low specificity (1)	High specificity (2)	Low specificity (3)	High specificity (4)
<i>Panel A - Acquisitions</i>				
<i>Variables</i>				
Center	0.20*** (0.03)	0.15*** (0.02)	0.12*** (0.04)	0.09*** (0.03)
South	0.47*** (0.04)	0.32*** (0.03)	0.35*** (0.03)	0.22*** (0.03)
Observations	794,171	794,150	102,809	102,769
<i>Panel B - Disposals</i>				
Center	0.05*** (0.009)	0.03*** (0.005)	0.07*** (0.02)	0.04** (0.02)
South	0.16*** (0.01)	0.11*** (0.007)	0.21*** (0.02)	0.13*** (0.01)
Observations	635,645	635,645	88,000	88,000
<i>Controls</i>				
Year	Yes	Yes	Yes	Yes
Vehicle characteristics		Yes		Yes
Sector		Yes		Yes
Size (employees)		Yes		Yes
Other firms characteristics		Yes		Yes
Other operations		Yes		Yes

Note: This table presents the results of a negative binomial regression of the age of a motor vehicle on a set of firms and vehicle characteristics. Panel (a) reports the results for the acquisition operations (new vehicle purchases, used vehicle purchases, and lease buyout). Panel (b) refers to disposal operations (used vehicle sales, sales abroad, and scrapping). The age of the vehicle is measured at the day of the operation. Vehicle characteristics include weight, horsepower, body type, vehicle type, and fuel type. Vehicle specificity is determined based on the body type. We control for the sector of economic activity by including NACE 3-digit sector fixed effects. Other firm characteristics include total assets, labor productivity, the cash-to-assets ratio, and a composite indicator of financial soundness. We control for the occurrence of other operations by including as covariates the number of acquisitions and disposals occurring in year t , as well as two dummy variables indicating whether the firm acquired or disposed of at least one vehicle in the previous year. Standard errors are clustered at the sector and year level.

irrespective of the level of asset specificity. However, the South-North gap is smaller for highly specific vehicles, which rules out the possibility that adjustment costs are systematically higher in the South.³⁸ For disposals (Panel B), the South-North gap in vehicle age increases with asset specificity, although this difference is not statistically significant once

³⁸Wald tests indicate that the difference in the South-North gap between low- and high-specificity vehicles is statistically significant for acquisitions, indicating that the gap is indeed smaller for highly specific assets.

firm- and vehicle-level controls are included.³⁹ Overall, these findings suggest that heterogeneous adjustment costs are unlikely to account for the regional disparities in vehicle age.

In summary, the characteristics of vehicles and firms account for only a limited portion of the disparities in vehicle quality between the North and the South. Additional factors – closely tied to the structural differences between the North and the South – may explain the remaining variation (at least in part). First, it is essential to consider supply-side constraints that may impede southern firms’ access to advanced technologies. In particular, firms in the South face higher borrowing costs and more restrictive credit conditions than their Northern counterparts, which can limit their ability to invest in new capital (Accetturo et al., 2022; Bottoni et al., 2022). Second, a central factor in the decision between new and used vehicles is maintenance costs. While older vehicles are cheaper upfront, they generally require more frequent repairs. If maintenance costs are relatively lower in the South, firms may have stronger incentives to acquire and retain older vehicles, which, in turn, helps explain the region’s older average capital stock. Finally, differences in the functioning of the used-capital market may increase the degree of irreversibility of investments in motor vehicles in the South and could discourage investment in more technologically advanced motor vehicles. We will explore the role of the secondary market in more detail in the next section.⁴⁰

4.2 The role of reallocation

One key factor contributing to the lower quality of motor vehicles in the South is the higher proportion of used-vehicle purchases relative to total acquisitions compared to the North. In the South, 65 percent of acquisitions are used-vehicle purchases on the secondary market, while the share of new-vehicle purchases is 19 percent (Figure B8).⁴¹ In the North, the share of used vehicles is lower (52 percent), and new-vehicle purchases account for approximately 33 percent of total acquisitions.⁴² Therefore, the functioning of the used-vehicle market and

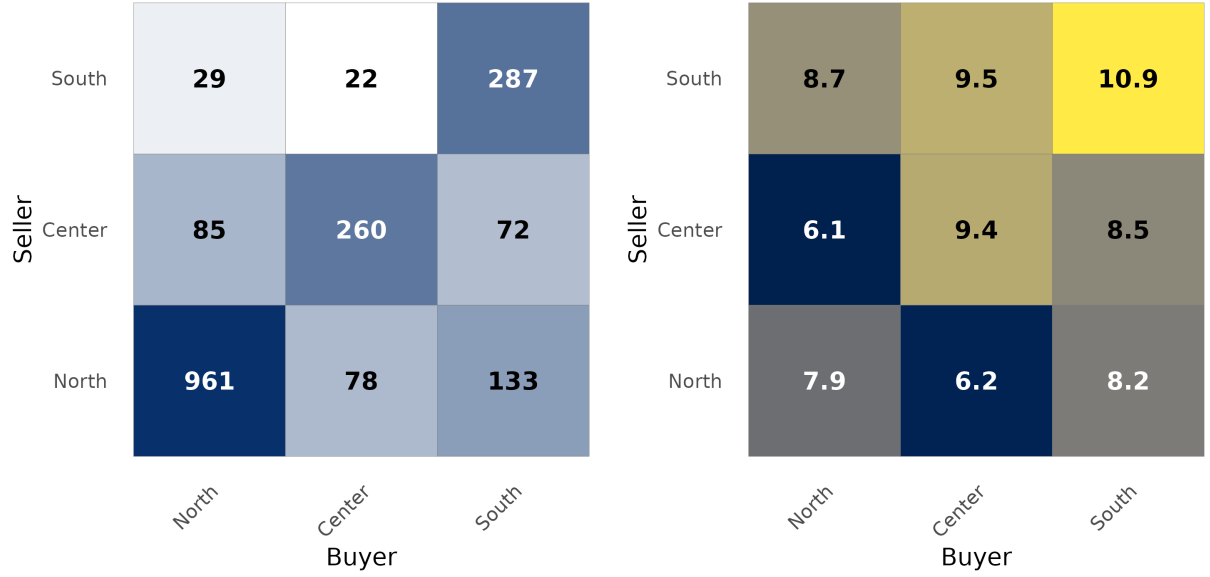
³⁹Several factors may explain the longer retention of highly specific vehicles in the South. These include lower utilization intensity, lower maintenance costs, and a less liquid secondary market, which can discourage timely disposal.

⁴⁰A related channel through which regional labor market conditions may affect capital quality choices operates through the elasticity of substitution between labor and capital. In Southern Italy, lower wages and higher rates of informal employment reduce the relative cost of labor, shifting the optimal capital-labor ratio toward more labor-intensive production methods. If new, high-quality capital goods are more complementary to skilled labor, then lower skilled wage premia in the South would reduce the returns to investing in high-quality capital vintages.

⁴¹The remaining operations are leasing buyout and purchases of used vehicles from abroad.

⁴²The lower propensity to purchase new vehicles in the South is partly explained by firms and vehicles characteristics. However, even accounting for all these factors, the share of new vehicle purchases over total

Figure 6: INTERREGIONAL FLOWS OF USED VEHICLES: VOLUMES AND AGE



Note: Left panel shows transaction volumes (in thousands) between seller (rows) and buyer (columns) macro-regions. The right panel shows the average age (in years) of vehicles traded in each bilateral flow. Darker colors indicate larger volumes or younger vehicles. Off-diagonal cells report interregional flows. Only transactions between firms are considered.

the patterns of within- and inter-regional reallocation of vehicles can be critical for explaining the observed heterogeneity in vehicle quality across regions.

For this analysis, we focus on transactions for which we observe the NUTS-1 region of both the buyer and the seller.⁴³ For each region, we then classify transactions between those within the same area and those with companies from different areas. Four key facts are noteworthy.

First, the quality of used vehicles is noticeably higher in the North than in the South. In Northern regions, the average age of purchased used vehicles is 7.78 years, while in the South it is 9.82 years. This rules out the hypothesis that the differences in quality are exclusively due to the higher share of used vehicles bought in the South. Second, transactions are highly localized. Most vehicle exchanges occur within the same macro-region, consistently with previous evidence about the geographic segmentation of second-hand markets (Figure 6).⁴⁴

acquisitions would be 7 percent lower than in the North (Table B11).

⁴³As mentioned in section 3, we consider exclusively transactions in which the buyer or the seller is a non-financial firm and is not a dealer. Instead, we exclude exchanges involving individuals or households because we do not observe their regions.

⁴⁴We refer to Crispino et al. (2026) for a detailed analysis of vehicle reallocation across firms and the

This implies that most vehicles remain in the same region during their lifetime. Third, the age profile of these intra-regional transactions varies significantly. In Northern regions, vehicles exchanged are typically 7.9 years old, whereas in the South, they average 10.9 years (Figure 6). Finally, when inter-regional flows do occur, they are predominantly unidirectional, moving from the North to the South. About 27 percent of used vehicles bought from southern firms are sold by northern firms, while the opposite flow accounts for only 3 percent of the used vehicles bought by northern firms. These vehicles moving to the South are substantially younger than those already circulating in the recipient regions. For instance, used vehicles sold from the North to the South are, on average, about 8.2 years old, compared with 10.9 years for transactions that occur entirely within the South.

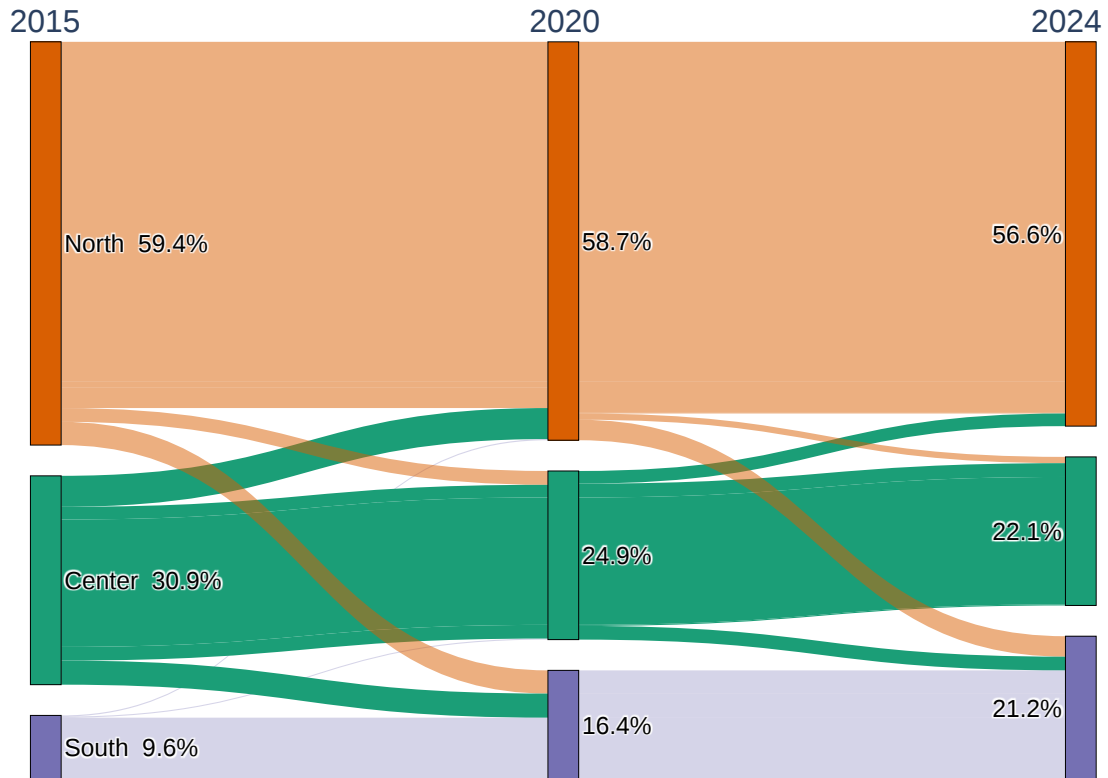
The pattern of inter-regional reallocation flows can also be mapped by tracking the path of a specific cohort of motor vehicles. In particular, we focus on the subset of new vehicles registered in 2015 that were still owned by non-financial firms in 2024 and for which we can track their full transaction history (approximately 77,000 vehicles). The left side of Figure 7 shows the initial distribution of new vehicle acquisitions in 2015. The central blocks depict the redistribution of the same vehicles in 2020, when they were five years old. Although most vehicles remain in their original macro-region, a significant reallocation is observed between the Northern and Central regions, as well as toward the South. The right side shows the distribution of the original 2015 cohort in 2024, when the vehicles are 10 years old. The displacement pattern largely mirrors that of the previous five-year period. The Southern regions nearly double their original shares: about 12 percent of the vehicles originally acquired in the Northern and Central regions in 2015 are owned by southern firms after ten years.

Summing up, these facts highlight how the structure of the used-vehicle market not only reflects but also reinforces existing regional inequalities in capital quality. The coexistence of geographic market segmentation and lower inflows of newly registered vehicles is the main cause of the lower quality of motor vehicles in the South. The younger, higher-quality vehicles flowing from the North to the South improve the latter's stock quality, though the dominance of older vehicles in local southern exchanges keeps quality low.

Finally, there is an additional subtle reason why the functioning of the used vehicles mar-

role played by dealers. When we restrict our sample to firm-to-firm transactions only, the total number of operations drops to about 20% of the baseline. Of these transactions, only 10% are interregional, while the large majority (around 23%) occur within the same region. This pattern is consistent with dealers acting as intermediaries that facilitate long-distance reallocation, whereas direct firm-to-firm trades tend to involve geographically close firms.

Figure 7: THE REALLOCATION OF NEW MOTOR VEHICLES



Note: This figure shows vehicle flows between macro-regions. The sample comprises 76716 vehicles that a) were new in 2015, b) are still in the stock of a non-financial firm, and c) we can keep track of the location of the owner. Because of the latter condition, we exclude vehicles that were sold to households at some point.

ket affects firms' decisions about the technological vintages in which to invest. Markets for used capital are inherently subject to frictions: the efficiency of the secondary market can be impaired by search frictions and asymmetric information about vehicle quality. Reallocation occurs more slowly in less liquid markets, which discourages the purchase of newer assets, as lower secondary-market liquidity increases the degree of an investment's irreversibility. Differences in the frictions in the used-vehicle market between the South and the North could partly explain why companies in the South buy fewer new vehicles and generally opt for older ones. Unfortunately, we cannot draw any conclusions about the relevance of these mechanisms, which requires more detailed information on individual transactions (e.g., sale prices) or on the time elapsed between the vehicle's listing and its sale. We will explore this research question in the future.

4.3 Insights about other asset types

Motor vehicles constitute a significant component of firms' machinery and equipment investment. However, their relative importance varies considerably across sectors, raising the question of whether our findings are representative of investment decisions regarding other types of capital assets. Although our results are unlikely to generalize uniformly to all asset classes, we argue that they remain informative about firms' choices regarding physical capital quality and the existence of regional gaps.

Two considerations support this interpretation. First, technologically more advanced vintages of capital goods are generally more expensive and are therefore more likely to be acquired by the most productive and financially sound firms. Our findings on motor-vehicle investment are consistent with this pattern, and there is no clear reason to expect a qualitatively different relationship for other types of physical assets. As long as there are systematic differences in firm quality across regions, these differences are likely to translate into disparities in the quality of the capital stock. Second, our analysis encompasses both general-purpose vehicles, such as vans, and more specialized vehicles that play a central role in production processes (such as concrete trucks, refrigerated trucks, and tow trucks). Even for these highly specific assets, southern firms continue to purchase lower-quality vehicles, suggesting that our results may extend to capital goods critical to specific business activities.

A potential concern when extrapolating these findings to other asset types is that southern firms may deliberately purchase lower-quality vehicles in order to save financial resources, reallocating liquidity toward higher-quality capital goods that are more central to their core production processes. This behavior aligns with earlier evidence indicating that southern firms typically face tighter access to external financing. If such a substitution mechanism were quantitatively important, the patterns observed in motor-vehicle investments might not generalize to other asset-acquisition decisions. In that case, firms could optimally differentiate the quality of their capital across asset categories depending on their relative productive importance.

Although the results on asset specificity in Section 4.1 partly alleviate this concern, we conduct an additional exercise. We estimate separate negative binomial regressions – following the specification in Section 4.1 – for four major industries: manufacturing, construction, retail and wholesale trade, and transportation. As discussed before, the intensity of transport equipment on total capital stock varies considerably across these sectors. Motor vehicles are core production assets in the transportation and construction sectors, whereas their role is

far less central in manufacturing. While we cannot fully rule out this substitution mechanism with the data available, the estimates indicate that firms in Southern regions consistently acquire lower-quality vehicles across all industries, also those where motor vehicles are by far the most important asset (Table B12).⁴⁵

An additional dimension concerns the extent to which our findings on traditional tangible assets can be generalized to investment in new technologies, particularly those with a significant intangible component. The literature emphasizes that investments in technologies such as artificial intelligence (AI) and advanced robotics can have significant implications for firm productivity and long-run growth. To investigate this relationship, we use data from the Survey of industrial and service firms (INVIND) conducted in early 2025, which asked firms whether they had already adopted AI or advanced robotics in their production processes. Based on the survey responses, we construct a binary indicator equal to one if a firm reported the adoption of any of these technologies, and zero otherwise.⁴⁶ We merge the survey data with firm-level information on motor vehicle acquisitions since 2021. We then estimate a logistic regression in which the dependent variable is a dummy for technology adoption, and the key explanatory variable is the average age of the vehicles the firm purchased. To preserve comparability, we restrict the sample to firms that acquired at least one vehicle since 2021, corresponding to approximately half of the surveyed firms.⁴⁷ The results indicate that an additional year in the average age of purchased vehicles is associated with a lower probability of adopting advanced technologies (Table B13). In other words, firms that acquire newer and presumably higher-quality vehicles also exhibit a significantly greater propensity to adopt advanced technologies such as AI and robotics.

We acknowledge that the INVIND survey’s technology adoption indicator – covering AI and advanced robotics – captures a broader notion of technological adoption than capital-embedded technical change specifically. Nevertheless, we interpret this finding as consistent with the view that capital quality choices reflect underlying firm-level propensities to adopt

⁴⁵An additional consideration when extrapolating our findings to the broader capital stock concerns the role of infrastructure quality. Poor road networks in the South may reduce the returns to investing in high-quality, technologically advanced vehicles – for instance, by increasing wear and maintenance costs for sophisticated electronic systems, or by limiting the productivity gains from fuel-efficient models on poorly maintained roads. Under this interpretation, Southern firms’ preference for older, simpler vehicles may represent an adaptation to local infrastructure constraints.

⁴⁶The questionnaire distinguished among different types of investment activities and recorded their intensity of use. However, because these measures are self-reported, we are concerned about their reliability and cross-firm comparability, and therefore focus on a binary indicator of adoption.

⁴⁷All specifications include controls for industry sector, firm size (measured by employment), and macro-region to account for structural and geographical heterogeneity.

technology more generally. While this does not constitute direct evidence that vehicle quality proxies the quality of other physical capital classes, it suggests that the regional disparities we document are not specific to the vehicle market but are part of a broader pattern of technology adoption gaps between North and South.

5 Discussion and conclusions

This paper addresses a significant information gap in the analysis of regional disparities in Italy’s economic development by providing, to our knowledge, a first systematic quantification of differences in physical capital quality across regions. We focus on motor vehicles as a specific form of capital. Motor vehicles are widely used across multiple sectors, and their life cycles can be reliably tracked, making them a useful proxy for studying capital quality. By examining how motor vehicle quality varies across firms and regions, we gain insights into broader patterns of firms’ capital investment choices.

Our analysis uncovers substantial heterogeneity in motor vehicle quality across Italian regions, both in levels and in their evolution over time. Unlike conventional measures of capital deepening, the regional distribution of capital quality closely mirrors the spatial dispersion in labor productivity: regions with higher labor productivity are also characterized by higher-quality motor vehicles. Although our analysis does not establish the direction of causality, the evidence suggests that firm-level characteristics account for a non-negligible share of this heterogeneity. At the same time, a considerable fraction of the variation remains unexplained by observable characteristics, pointing to the potential role of deeper structural or market-specific factors. These factors include credit conditions, the quality of the institutional environment and public administration, and the prevalence of organized crime. There may also be a shortage of suppliers of new, technologically advanced capital goods. Understanding the relevance of these factors is a potential area for future research.

The implications of heterogeneity in capital quality are potentially far-reaching. While this paper primarily documents stylized facts and does not attempt to provide a comprehensive assessment of their causal economic consequences, three broad implications emerge. First, differences in both the level and the trajectory of capital quality directly affect the measurement of regional disparities in TFP. Ignoring these differences may lead to biased assessments of relative regional performance, as improvements embedded in capital may be incorrectly attributed to disembodied productivity. Second, the observed dispersion in capital quality has implications for the design of regional development policies, particularly

for policies aimed at stimulating investment through subsidies or tax incentives. If firms in lagging regions systematically adopt lower-quality capital vintages, standard investment incentives may have limited effectiveness in narrowing productivity gaps. Third, our findings highlight a potentially relevant role for inter-regional capital reallocation in improving allocative efficiency. However, such reallocation currently appears constrained by geographic market segmentation and other frictions.

Regarding growth accounting, the primary caveat is that our analysis focuses on a specific asset class. While we argue that similar mechanisms may operate for other types of physical capital, a precise quantification of the contribution of capital quality to aggregate productivity would require much broader data on the composition and quality of the entire capital stock. Nevertheless, our findings offer valuable guidance for interpreting conventional TFP estimates that assume homogeneous capital. In particular, although standard measures indicate relatively stronger capital deepening in the South, the effective quality of capital employed there is likely lower. This implies that the contribution of capital to regional GDP differentials may be underestimated when quality differences are ignored. Moreover, because capital quality evolves unevenly across regions, measured TFP dynamics may also be distorted over time.

Further research is required to better understand why firms located in Southern regions persistently select lower-quality capital assets, even when their observable characteristics are similar to those of firms in Northern regions. Clarifying these mechanisms is essential for designing effective policies aimed at mitigating regional disparities in capital quality and productivity. One potential policy avenue involves targeted incentives to accelerate the renewal of physical capital in economically lagging areas. Given the geographic segmentation of secondary markets for capital goods, such interventions could gradually improve the average quality of capital in these regions, particularly for younger and financially constrained firms that rely more on used assets. However, the effectiveness of these policies remains uncertain. A substantial portion of the observed regional variation in capital quality cannot be fully explained by firm-level characteristics alone, suggesting that financial – or operational – constraints are not the sole determinants of investment quality. Consequently, subsidies or other financial incentives may not automatically translate into higher-quality capital adoption, raising concerns about their cost-effectiveness.

Addressing these issues requires moving beyond the descriptive framework adopted in this paper toward more structural approaches that explicitly model firms' investment decisions, market frictions, and mechanisms of capital reallocation. To this end, it would also be useful

to incorporate vehicle prices into our information set. We leave this important line of inquiry for future research.

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Appendix

A Data

This appendix describes the construction of the CO₂ emissions indicator used in the analysis. The indicator is designed to measure relative environmental performance by isolating variation in tailpipe CO₂ emissions that is not mechanically driven by observable vehicle characteristics. The indicator is constructed using a regression-based (hedonic) approach. We begin by estimating the following model by ordinary least squares:

$$\text{CO}_{2,i} = \beta_1, \text{Mass}_i + \beta_2, \text{Power}_i + \beta_3, \text{Displacement}_i + \alpha_{b(i)} + \varepsilon_i,$$

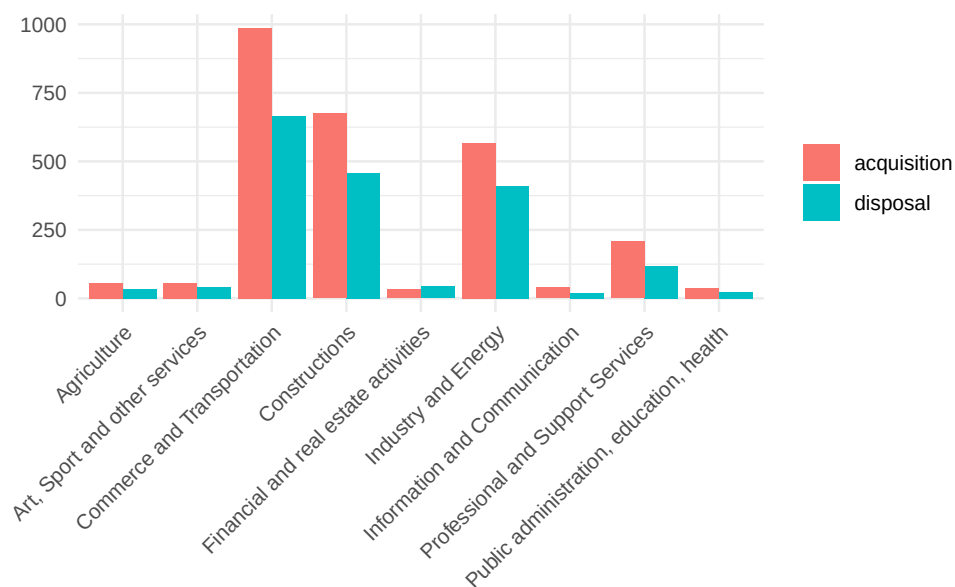
where CO_{2,*i*} denotes tailpipe CO₂ emissions of vehicle *i*. The control variables include total vehicle mass, engine power, and engine displacement. The term $\alpha_{b(i)}$ denotes body-type fixed effects, capturing persistent differences across vehicle designs, while ε_i is an idiosyncratic error term.

To mitigate the influence of extreme observations, emissions are trimmed within each body type by excluding values below the 1st percentile and above the 99th percentile. Using the estimated coefficients, we compute residual emissions as the difference between observed and predicted emissions. These residuals capture deviations from expected emissions conditional on observable characteristics and body type, and are interpreted as a measure of relative emissions efficiency. Residuals are then winsorized within cells defined by year of first registration, fuel type, and body type, and observations with extreme residuals are further excluded within each year.

The final indicator is obtained by transforming the winsorized residuals into a percentile rank ranging from 1 to 100. Lower values correspond to lower residual emissions and therefore indicate better environmental performance relative to comparable vehicles. Electric vehicles, which generate zero tailpipe CO₂ emissions, are assigned a rank of zero by construction. To account for structural heterogeneity across vehicle types, the entire procedure is performed separately within each vehicle category.

B Additional Figures and Tables

Figure B1: OPERATIONS BY MACROSECTOR



Note: Acquisitions and disposals by firms activity macrosector, based on 2-digits ATECO codes

Figure B2: QUALITY OF VEHICLES AT THE MOMENT OF ACQUISITION AND DISPOSAL.
MEDIAN VALUES

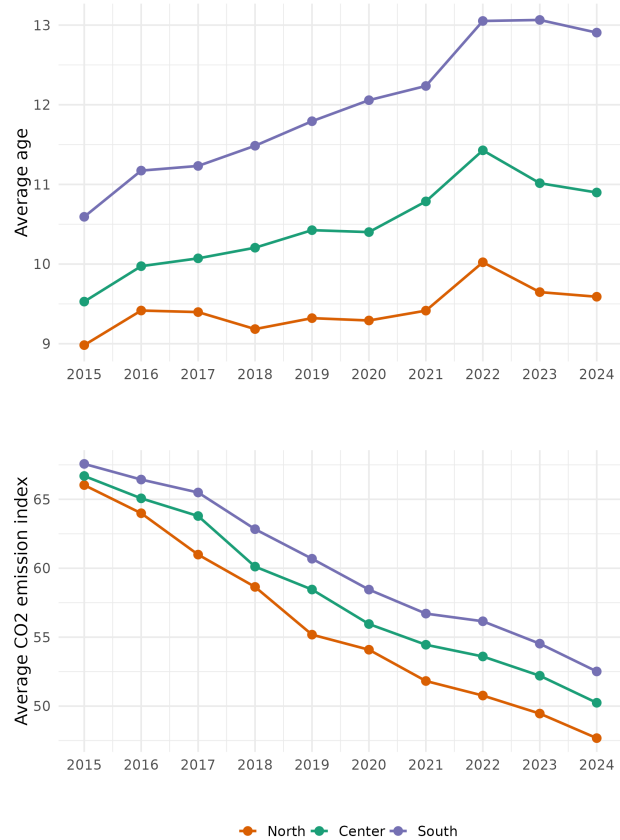


(a) Acquisitions

(b) Disposals

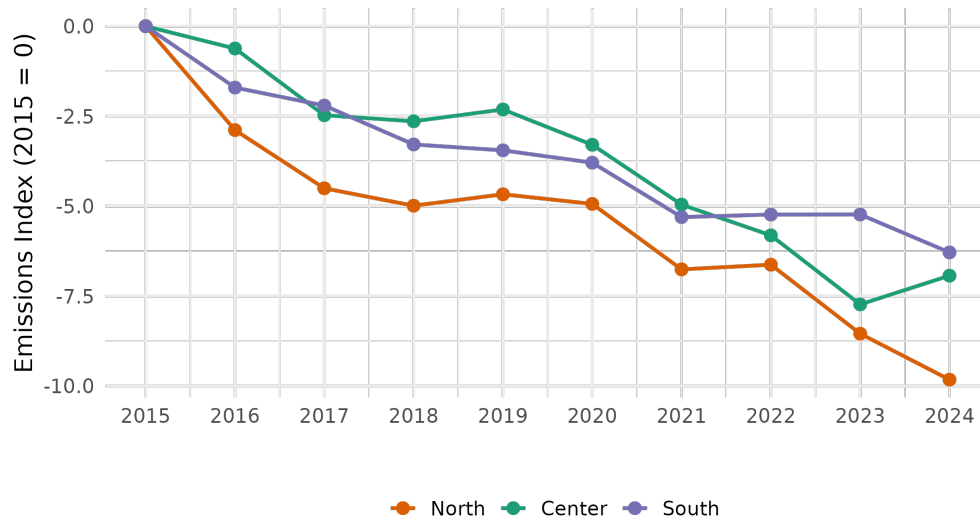
Note: Median age (top panels) and median CO₂ emission index (bottom panels) of all vehicles at the moment of operation (left: acquisition; right: disposal). Acquisitions include the following operations: purchase of a new or used vehicle, lease buyout, and imports. Disposals include: demolition, sale of a used vehicle, exportation, and other de-registrations. Intermediaries are excluded from the analysis.

Figure B3: QUALITY OF VEHICLES AT THE MOMENT OF ACQUISITION. TRANSACTIONS OF USED VEHICLES ONLY



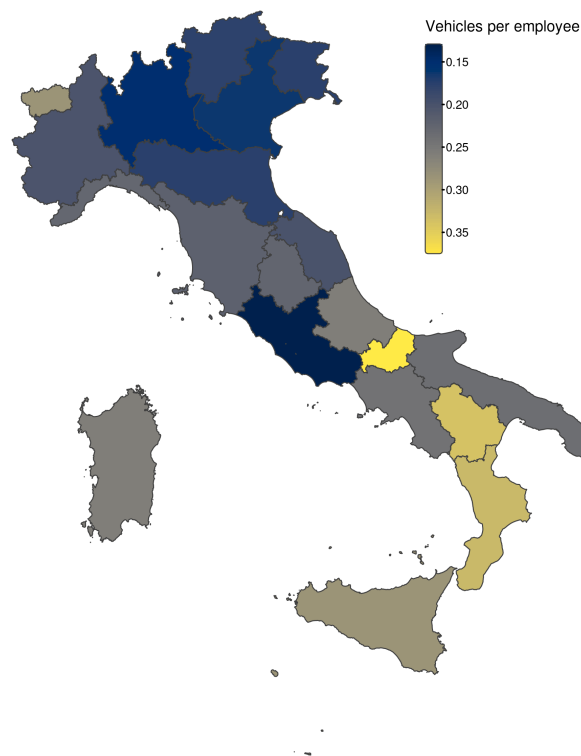
Note: Average age (top panel) and average CO₂ emission index (bottom panel) of used vehicles at the time of acquisition.

Figure B4: EMISSION INDEX



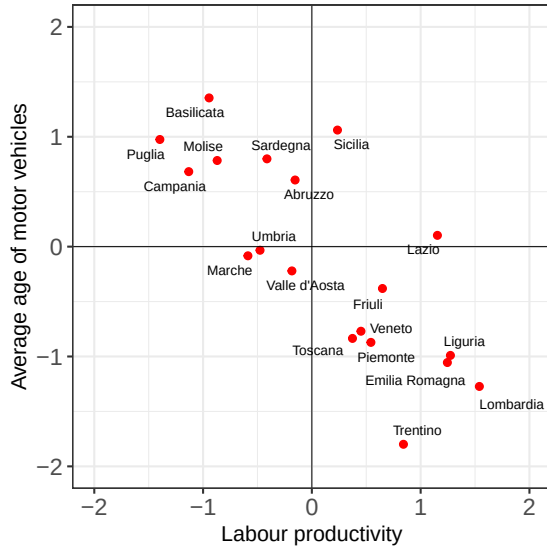
Note: Index of CO₂ emissions reflecting technological progress in vehicles, by macroarea. Calculated as the annual average of emissions adjusted for total mass, power, engine displacement, and body type. Values are normalized to 2015 (base year = 0, 100%). We restrict the sample to the N1 category vehicles. The following operations are considered: the purchase of a new or used vehicle, leasing buyouts, and imports.

Figure B5: VEHICLES PER EMPLOYEE

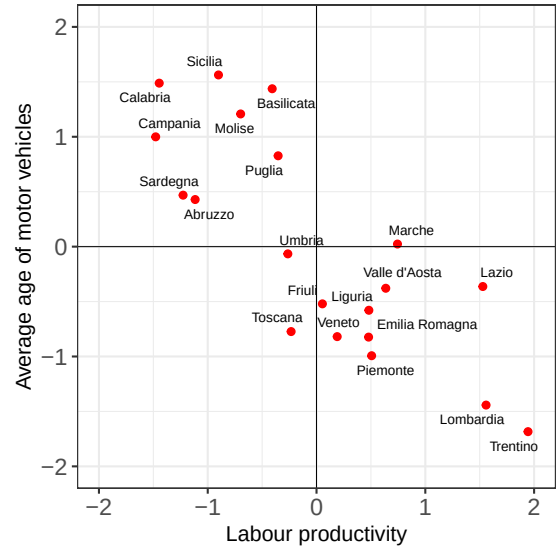


Note: This chart reports the spatial distribution of the ratio between the number of vehicles and the number of employees. The number of vehicles is the estimated vehicle stock of the non-financial (and not-dealer) firms as of the end of 2024. The number of employees is related to 2023 and refers only to firms that own at least one vehicle. Using the total number of employees would not alter the spatial distribution of the ratio.

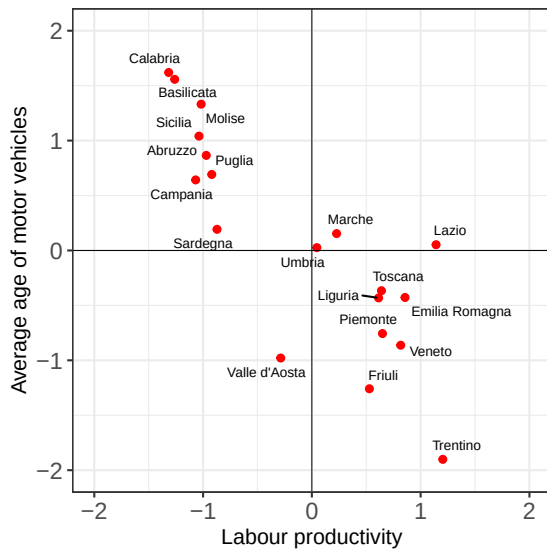
Figure B6: LABOR PRODUCTIVITY AND THE AGE OF VEHICLE STOCK BY SECTOR



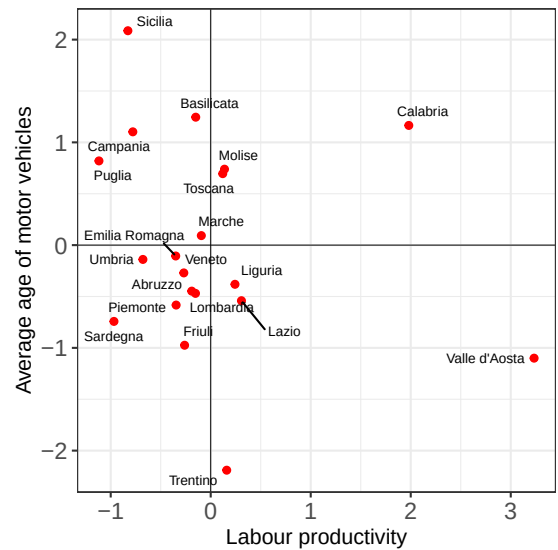
(a) Manufacturing



(b) Construction



(c) Wholesale and retail trade



(d) Transports

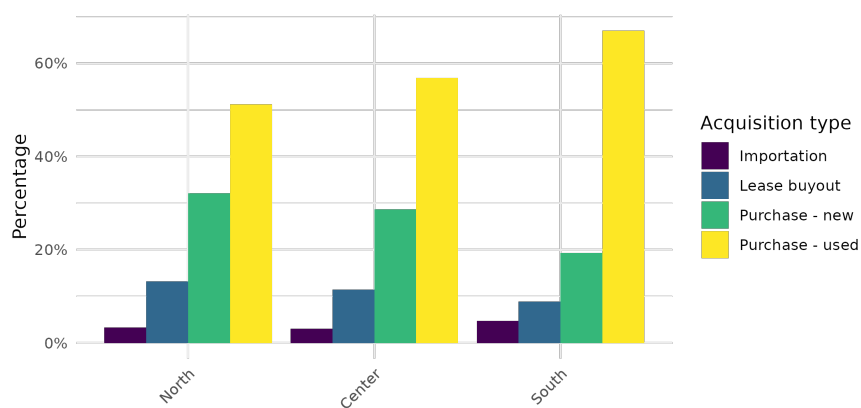
Note: This chart reports a scatter plot of the labor productivity and the average age of the stock of vehicles at the NUTS-2 administrative level by sector. Labor productivity is computed as the average ratio of value added to hours worked over the 2000-2022 period. Both statistics are available in the Regional accounts (Istat). The average age of the vehicle fleet is computed on the stock of vehicles at the end of 2024. Labor productivity and the average age of the vehicle fleet are standardized.

Figure B7: QUALITY OF VEHICLES AT THE MOMENT OF ACQUISITION, INCLUDING RENTALS



Note: Age (top panel) and CO₂ emission index (bottom panel) of all vehicles at the moment of acquisition. Acquisitions include the following operations: purchase of a new or used vehicle, acquisition through leasing, imports, and rental. Intermediaries are excluded from the analysis.

Figure B8: COMPOSITION OF ACQUISITIONS BY MACRO-REGION



Note: Proportion of vehicle acquisitions corresponding to new vehicles, used vehicles, lease buyouts, and imports. Calculated as a share of all acquisitions within each macro-region. Intermediaries are excluded from the analysis.

Table B1: VEHICLE CATEGORIES

Category	Description	Examples	Total (thousands)	Age (years)
Passenger Vehicles (M)				
M1	Up to 8 passengers	Small vans	98 (5.2%)	9.4
M2	>8 passengers, m <5 t	Minibuses	3 (0.1%)	10.1
M3	>8 passengers, m >5 t	Large buses	33 (1.8%)	6.7
Goods Vehicles (N)				
N1	m <3.5 t	Light commercial trucks Small vans	1479 (79.3%)	8.7
N2	3.5 <m <12	Medium trucks	73 (3.9%)	16.5
N3	m >12 t	Heavy trucks Articulated lorries	179 (9.6%)	11.8

Note: The adopted selection excludes passenger cars. Numbers refer to the vehicle stock as of December 31, 2024.

Table B2: DESCRIPTIVE STATISTICS

	Min	1	25	50	75	99	Max	Mean	St.dev.	Missing
Weight	500.00	1360.00	2040.00	3000.00	3500.00	28000.00	360000.00	5159.17	6362.19	59
Horsepower	20.00	40.00	70.00	88.00	110.00	375.00	950.00	112.94	81.50	3153
Engine displacement	22.9	999.00	1560.00	1999.00	2800.00	13798.00	17174.00	3254.54	3327.55	27603
Emissions - ENEDC	0.00	0.00	119.00	154.00	196.00	285.20	999.00	161.06	51.86	1969745
Nox - ENEDC	0.00	0.00	20.90	51.40	150.00	1668.50	9930.00	110.64	267.30	1619430
Emissions - WLTP	0.00	0.00	141.00	174.00	226.00	366.00	445.00	183.15	64.11	3119869
Nox - WLTP	0.00	0.00	27.90	40.80	52.00	104.70	172.30	41.52	20.84	3126511
	Value	N	Freq							
Power supply	DIESEL	3488169	90.1							
	GASOLINE	148648	3.8							
	OTHERS	234129	6.1							
European Standard	EURO6	961028	24.8							
	EURO4	567549	14.7							
	EURO3	496151	12.8							
	EURO5B	411909	10.6							
	EURO6B	344250	8.9							
	EURO2	262586	6.8							
Specificity	EURO5	213301	5.5							
	OTHERS	443731	11.4							
	Low	3385876	87.7							
	High	473113	12.3							

Note: This table reports summary statistics about the characteristics of commercial and passenger vehicles in the sample.

Table B3: VEHICLE OPERATIONS

Category	Total (thousands)	Age	Category	Total (thousands)	Age
Acquired (new)	1252	0.0	Imported	95	5.2
Cessated	102	17.1	Leasing	488	0.1
Demolited	349	17.8	Rental	435	1.1
Exported	326	10.9	Transaction	2290	9.2

Note: Totals refer to number of operations; age expressed in years.

Table B4: VEHICLE SPECIFICITY LEVELS BY BODY TYPE

Rank	Body Types
1	Generic automobile, Sedan, Coupe
2	Convertible, Van, Flatbed, Cabin, Motorhome
3	Platform, Tanker, Tow Truck, Refrigerated Vehicle
4	Single-Decker Bus, Urban Bus, Intercity Bus, School Bus Double-Decker Bus, Articulated Bus, Ambulance Animal Transport, Hazardous Goods Transport, Vehicle Transport Food Transport, Concrete Mixer, Garbage Truck, Road Assistance Vehicle Vehicle with Crane, Crane
5	Specialized Vehicles, Other

Note: Vehicles with lower specificity ranks (1-2) are general-purpose, while those with higher specificity ranks (3-4-5) are tailored for specialized functions.

Table B5: SUMMARY STATISTICS ON FIRMS' CHARACTERISTICS

	N	Min	1	25	50	75	99	Max	Mean	St.dev.
<i>Panel A: Full sample</i>										
Employees	1,911,560	0	0	0	3	9	203	145,954	17	327
Age	1,911,557	0	0	6	13	25	72	218	18	16
<i>Panel B: Firms with balance sheet data</i>										
Employees	912,102	0	0	2	7	15	176	7,232	18	63
Age	912,102	0	2	6	12	23	58	156	16	14
Total assets	912,102	1	31	325	885	2,484	31,222	460,162	2,889	7,811
Tangible investments	912,102	0	0	1	17	63	1,569	122,644	109	529
Turnover	912,102	1	14	377	1,017	2,767	33,746	2,932,137	3,165	9,308
Value added	912,102	-45,120	-62	102	300	788	8,049	306,874	832	2,055
Cashflow	912,102	0	0	14	60	230	3,993	135,310	309	966
Return on assets	912,102	-574	-50	2	5	11	53	109	7	20

Note: This table reports descriptive statistics about the non-financial firms in our dataset. Each observation is a firm-year tuple. Panel A shows the statistics for the full sample. Panel B shows the descriptive statistics for companies for which we can retrieve balance sheet data from the CERVED dataset. The monetary variables in panel B are in thousands of euros. Return on assets is reported as percentage points.

Table B6: RELEVANCE OF THE TRANSPORT EQUIPMENT ON CAPITAL STOCK

	Transport equipment	Machinery and equipment	% of machin. and equip.	Total assets	% of total assets
Total economic activities	152090	810129	18.8	6096529	2.5
Agriculture, forestry and fishing	1585	42437	3.7	141889	1.1
Mining and quarrying	122	4518	2.7	42195	0.3
Manufacturing	7575	282786	2.7	466083	1.6
Electricity, gas, steam and air conditioning supply	251	39634	0.6	259882	0.1
Water supply; sewerage, waste management and remediation activities	2051	22234	9.2	61731	3.3
Construction	7047	28847	24.4	60120	11.7
Wholesale and retail trade; repair of motor vehicles and motorcycles	13999	69522	20.1	169977	8.2
Transportation and storage	64689	84960	76.1	440428	14.7
Accommodation and food service activities	1240	20045	6.2	95359	1.3
Information and communication	1908	23250	8.2	116760	1.6
Financial and insurance activities	1410	6739	20.9	83482	1.7
Real estate activities	966	7038	13.7	3163444	0.0
Professional, scientific and technical activities	1669	13976	11.9	90070	1.9
Administrative and support service activities	32960	42873	76.9	52751	62.5

Note: This table reports the average value of the stock (net of depreciation) in transport equipment, machinery and equipment, and all assets owned by the private sector. Annual National Account data (Istat), average 2015-2024. Data at constant prices and in million of euros.

Table B7: DETERMINANTS OF VEHICLE AGE. ACQUISITIONS

Dependent Variable: Model:	Age of the vehicle (days)				
	(1)	(2)	(3)	(4)	(5)
<i>Variables</i>					
Center	0.20*** (0.03)	0.18*** (0.03)	0.15*** (0.02)	0.13*** (0.02)	0.14*** (0.02)
South	0.45*** (0.04)	0.39*** (0.03)	0.32*** (0.03)	0.31*** (0.03)	0.31*** (0.03)
Vehicle weight		1.8*** (0.10)	1.6*** (0.10)	1.6*** (0.10)	1.6*** (0.10)
Horsepower		-2.4*** (0.08)	-2.3*** (0.08)	-2.3*** (0.07)	-2.3*** (0.08)
Firm's age			-0.30*** (0.02)	-0.25*** (0.02)	-0.24*** (0.02)
Number of employees			-0.04*** (0.01)	-0.004 (0.02)	-0.01 (0.02)
Cash-to-total assets				-0.53*** (0.05)	-0.54*** (0.05)
Total assets				-0.10*** (0.009)	-0.11*** (0.009)
Labor productivity				-0.03*** (0.009)	-0.03*** (0.009)
Medium risk				0.19*** (0.02)	0.19*** (0.02)
High risk				0.30*** (0.03)	0.30*** (0.03)
Number of acquisitions at t					0.003** (0.002)
Acquisitions at t-1					0.02* (0.01)
Number of disposals at t					-0.001 (0.001)
Disposals at t-1					0.04*** (0.01)
<i>Fixed-effects</i>					
Year	Yes	Yes	Yes	Yes	Yes
Vehicle characteristics		Yes	Yes	Yes	Yes
NACE 3-digit			Yes	Yes	Yes
Size (employees)			Yes	Yes	Yes
Observations	914,503	914,493	914,473	914,473	914,473

Note: This table presents the results of a negative binomial regression of the age of a motor vehicle on a set of firms and vehicle characteristics. We include all acquisition operations (new-vehicle purchases, used-vehicle purchases, and lease buyouts). The age of the vehicle is measured at the day of the operation. Vehicle characteristics include weight, horsepower, body type, vehicle type, and fuel type. We control for the sector of economic activity by including NACE 3-digit sector fixed effects. Other firm characteristics include total assets, labor productivity, the cash-to-assets ratio, and a composite indicator of financial soundness. We control for the occurrence of other operations by including as covariates the number of acquisitions and disposals occurring in year t , as well as two dummy variables indicating whether the firm acquired or disposed of at least one vehicle in the previous year. Standard errors are clustered at the sector and year level.

Table B8: DETERMINANTS OF VEHICLE AGE. DISPOSALS

Dependent Variable: Model:	Age of the vehicle (days)				
	(1)	(2)	(3)	(4)	(5)
<i>Variables</i>					
Center	0.05*** (0.009)	0.04*** (0.007)	0.04*** (0.006)	0.03*** (0.006)	0.03*** (0.006)
South	0.19*** (0.01)	0.12*** (0.010)	0.12*** (0.007)	0.11*** (0.007)	0.11*** (0.007)
Vehicle weight		0.88*** (0.03)	0.88*** (0.02)	0.87*** (0.02)	0.87*** (0.02)
Horsepower		-1.3*** (0.03)	-1.2*** (0.03)	-1.2*** (0.03)	-1.2*** (0.03)
Firm's age			0.04*** (0.005)	0.06*** (0.003)	0.06*** (0.004)
Number of employees			-0.02*** (0.005)	0.02*** (0.003)	0.02*** (0.004)
Cash-to-total assets				-0.09*** (0.01)	-0.09*** (0.01)
Total assets				-0.03*** (0.003)	-0.02*** (0.003)
Labor productivity				0.03*** (0.006)	0.03*** (0.005)
Medium risk				0.010*** (0.003)	0.01*** (0.004)
High risk				-0.002 (0.004)	0.002 (0.003)
Number of acquisitions at t					0.0001 (0.0006)
Acquisitions at t-1					-0.0003 (0.005)
Number of disposals at t					-0.0009 (0.0008)
Disposals at t-1					-0.05*** (0.005)
<i>Fixed-effects</i>					
Year	Yes	Yes	Yes	Yes	Yes
Vehicle characteristics		Yes	Yes	Yes	Yes
NACE 3-digit			Yes	Yes	Yes
Size (employees)			Yes	Yes	Yes
Observations	758,474	758,474	758,474	758,474	758,474

Note: This table presents the results of a negative binomial regression of the age of a motor vehicle on a set of firms and vehicle characteristics. We include all disposal operations (used vehicle sales, sales abroad, and scrapping). The age of the vehicle is measured at the day of the operation. Vehicle characteristics include weight, horsepower, body type, vehicle type, and fuel type. We control for the sector of economic activity by including NACE 3-digit sector fixed effects. Other firm characteristics include total assets, labor productivity, the cash-to-assets ratio, and a composite indicator of financial soundness. We control for the occurrence of other operations by including as covariates the number of acquisitions and disposals occurring in year t , as well as two dummy variables indicating whether the firm acquired or disposed of at least one vehicle in the previous year. Standard errors are clustered at the sector and year level.

Table B9: DETERMINANTS OF VEHICLE AGE. ALTERNATIVE MODELS

Dependent Variable:	Age of the vehicles (days)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Neg. Bin.	Neg. Bin.	Poisson	Poisson	OLS	OLS
<i>Panel A - Acquisitions</i>						
<i>Variables</i>						
Center	0.20*** (0.03)	0.15*** (0.02)	0.20*** (0.03)	0.12*** (0.01)	0.59*** (0.12)	0.32*** (0.06)
South	0.46*** (0.04)	0.32*** (0.03)	0.45*** (0.04)	0.26*** (0.02)	1.4*** (0.15)	0.78*** (0.09)
Observations	899,830	899,796	899,830	899,796	899,830	899,825
<i>Panel B - Acquisitions (only used vehicles)</i>						
<i>Variables</i>						
Center	0.11*** (0.01)	0.09*** (0.01)	0.11*** (0.01)	0.07*** (0.008)	0.19*** (0.03)	0.15*** (0.02)
South	0.25*** (0.03)	0.19*** (0.02)	0.25*** (0.03)	0.17*** (0.01)	0.38*** (0.05)	0.28*** (0.03)
Observations	618,125	618,115	618,125	618,115	618,125	618,115
<i>Panel C - Disposals</i>						
<i>Variables</i>						
Center	0.05*** (0.009)	0.04*** (0.006)	0.05*** (0.009)	0.04*** (0.006)	0.06*** (0.01)	0.04*** (0.007)
South	0.19*** (0.01)	0.12*** (0.007)	0.19*** (0.01)	0.12*** (0.007)	0.18*** (0.01)	0.13*** (0.007)
Observations	726,060	726,054	726,060	726,054	726,060	726,054
<i>Controls</i>						
Year	Yes	Yes	Yes	Yes	Yes	Yes
Vehicle characteristics		Yes		Yes		Yes
Firms' characteristics		Yes		Yes		Yes

Note: This table presents the analysis of the choice about motor vehicle age by firms using alternative models: negative binomial (columns 1-2), Poisson (columns 3-4), OLS (columns 5-6). In the OLS specification the dependent variable is the logarithm of the age (plus 1). Panel (a) reports the results for all acquisitions. Panel (b) presents the results when the sample is restricted to the acquisitions of used vehicles (we exclude vehicles with age lower than one week). Vehicle characteristics include weight, horsepower, body type, vehicle type, and fuel type. We control for the sector of economic activity by including NACE 3-digit sector fixed effects. Other firm characteristics include age and the number of employees (both in logarithms). Standard errors are clustered at the sector and year level.

Table B10: DETERMINANTS OF THE HETEROGENEITY. EMISSIONS EFFICIENCY

Dependent Variable:	Emission efficiency				
	(1)	(2)	(3)	(4)	(5)
<i>Panel A - Acquisitions</i>					
<i>Variables</i>					
Center	3.4*** (0.50)	3.3*** (0.52)	2.9*** (0.49)	2.7*** (0.45)	2.7*** (0.43)
South	6.0*** (0.69)	5.8*** (0.67)	4.3*** (0.70)	4.1*** (0.62)	4.1*** (0.62)
Observations	584,286	584,286	584,286	584,286	584,286
<i>Panel B - Disposals</i>					
Center	1.8*** (0.37)	1.7*** (0.37)	1.8*** (0.37)	1.7*** (0.35)	1.7*** (0.36)
South	2.0*** (0.49)	1.9*** (0.48)	1.8*** (0.43)	1.7*** (0.41)	1.7*** (0.41)
Observations	357,891	357,891	357,891	357,891	357,891
<i>Controls</i>					
Year	Yes	Yes	Yes	Yes	Yes
Vehicle characteristics		Yes	Yes	Yes	Yes
Sector			Yes	Yes	Yes
Size (employees)			Yes	Yes	Yes
Other firms' characteristics				Yes	Yes
Other operations					Yes

Note: This table presents the results of an OLS regression of an indicator of emission efficiency of the motor vehicle on a set of firms and vehicle characteristics. Panel (a) reports the results for acquisition operations (new vehicle purchases, used vehicle purchases, and lease buyout). Panel (b) refers to disposal operations (used vehicle sales, sales abroad, scrapping). Vehicle characteristics include body type, vehicle type, and fuel type. We control for the sector of economic activity by including NACE 3-digit sector fixed effects. Other firm characteristics include total assets, labor productivity, the cash-to-assets ratio, and a composite indicator of financial soundness. We control for the occurrence of other operations by including as covariates the number of acquisitions and disposals in year t , as well as two dummy variables indicating whether the firm acquired or disposed of at least one vehicle in the previous year. Standard errors are clustered at the sector and year level.

Table B11: LIKELIHOOD TO PURCHASE NEW VEHICLES

Dependent Variable:	New vehicle				
	(1)	(2)	(3)	(4)	(5)
<i>Panel A - Acquisitions</i>					
<i>Variables</i>					
Center	-0.06*** (0.01)	-0.05*** (0.01)	-0.03*** (0.007)	-0.03*** (0.006)	-0.03*** (0.006)
South	-0.15*** (0.02)	-0.12*** (0.01)	-0.08*** (0.01)	-0.07*** (0.01)	-0.07*** (0.010)
Observations	896,980	896,980	896,980	896,980	896,980
<i>Controls</i>					
Year	Yes	Yes	Yes	Yes	Yes
Vehicle characteristics		Yes	Yes	Yes	Yes
Sector			Yes	Yes	Yes
Size (employees)			Yes	Yes	Yes
Other firms' characteristics				Yes	Yes
Other operations					Yes

Note: This table presents the results of a linear probability model for the purchase of a new vehicle. We include all acquisition operations (new-vehicle purchases, used-vehicle purchases, and lease buyouts). The dependent variable is a dummy equal to 1 if the acquisition is a new vehicle. Vehicle characteristics include weight, horsepower, body type, vehicle type, and fuel type. We control for the sector of economic activity by including NACE 3-digit sector fixed effects. Other firm characteristics include total assets, labor productivity, the cash-to-assets ratio, and a composite indicator of financial soundness. We control for the occurrence of other operations by including as covariates the number of acquisitions and disposals occurring in year t , as well as two dummy variables indicating whether the firm acquired or disposed of at least one vehicle in the previous year. Standard errors are clustered at the sector and year level.

Table B12: DETERMINANTS OF VEHICLE AGE BY SECTOR

Dependent Variable:	Age of the vehicles (days)			
	Manufacturing (1)	Constructions (2)	Wholesale and retail trade (3)	Transports (4)
<i>Variables</i>				
Center	0.16*** (0.02)	0.16*** (0.01)	0.15*** (0.03)	0.06*** (0.01)
South	0.39*** (0.02)	0.36*** (0.04)	0.33*** (0.04)	0.21*** (0.005)
Observations	155,045	271,258	144,763	147,832
<i>Controls</i>				
Year	Yes	Yes	Yes	Yes
Vehicle characteristics	Yes	Yes	Yes	Yes
Sector	Yes	Yes	Yes	Yes
Size (employees)	Yes	Yes	Yes	Yes
Other firms characteristics	Yes	Yes	Yes	Yes
Other operations	Yes	Yes	Yes	Yes

Note: This table presents the results of a negative binomial regression of the age of a motor vehicle on a set of firms and vehicle characteristics by sector of economic activity. We include all acquisition operations (new-vehicle purchases, used-vehicle purchases, and lease buyouts). The age of the vehicle is measured at the day of the operation. Vehicle characteristics include weight, horsepower, body type, vehicle type, and fuel type. We control for the sector of economic activity by including NACE 3-digit sector fixed effects. Other firm characteristics include total assets, labor productivity, the cash-to-assets ratio, and a composite indicator of financial soundness. We control for the occurrence of other operations by including as covariates the number of acquisitions and disposals occurring in year t , as well as two dummy variables indicating whether the firm acquired or disposed of at least one vehicle in the previous year. Standard errors are clustered at the sector and year level.

Table B13: ADOPTION OF ADVANCED TECHNOLOGIES AND THE QUALITY OF MOTOR VEHICLES

Dependent Variable:	Investments in advanced technologies			
	(1)	(2)	(3)	(4)
<i>Variables</i>				
Age	-0.0182** (0.0085)	-0.0218** (0.0097)	-0.0245** (0.0097)	-0.0186** (0.0089)
<i>Controls</i>				
Sector		Yes	Yes	Yes
Size (employees)			Yes	Yes
NUTS-1 region				Yes
Observations	1,469	1,469	1,469	1,469

Note: This table presents the results of a logistic regression of a proxy of adoption of advanced technology on a measure of quality of the motor vehicle acquisitions. The dependent variable is a dummy equal to one if the firm adopted artificial intelligence (AI) and robotics to improve their production processes. The variable age is the average age of the vehicles acquired between 2021 and 2024 on the day of acquisition. Other controls include the economic activity sector (only 11 sectors), the number of employees, and the NUTS-1 administrative level. The sample includes firms participating in the 2025 wave of the Bank of Italy's Survey of industrial and service firms (INVIND) which acquired vehicles between 2021 and 2024. Standard errors are clustered at the sector level.